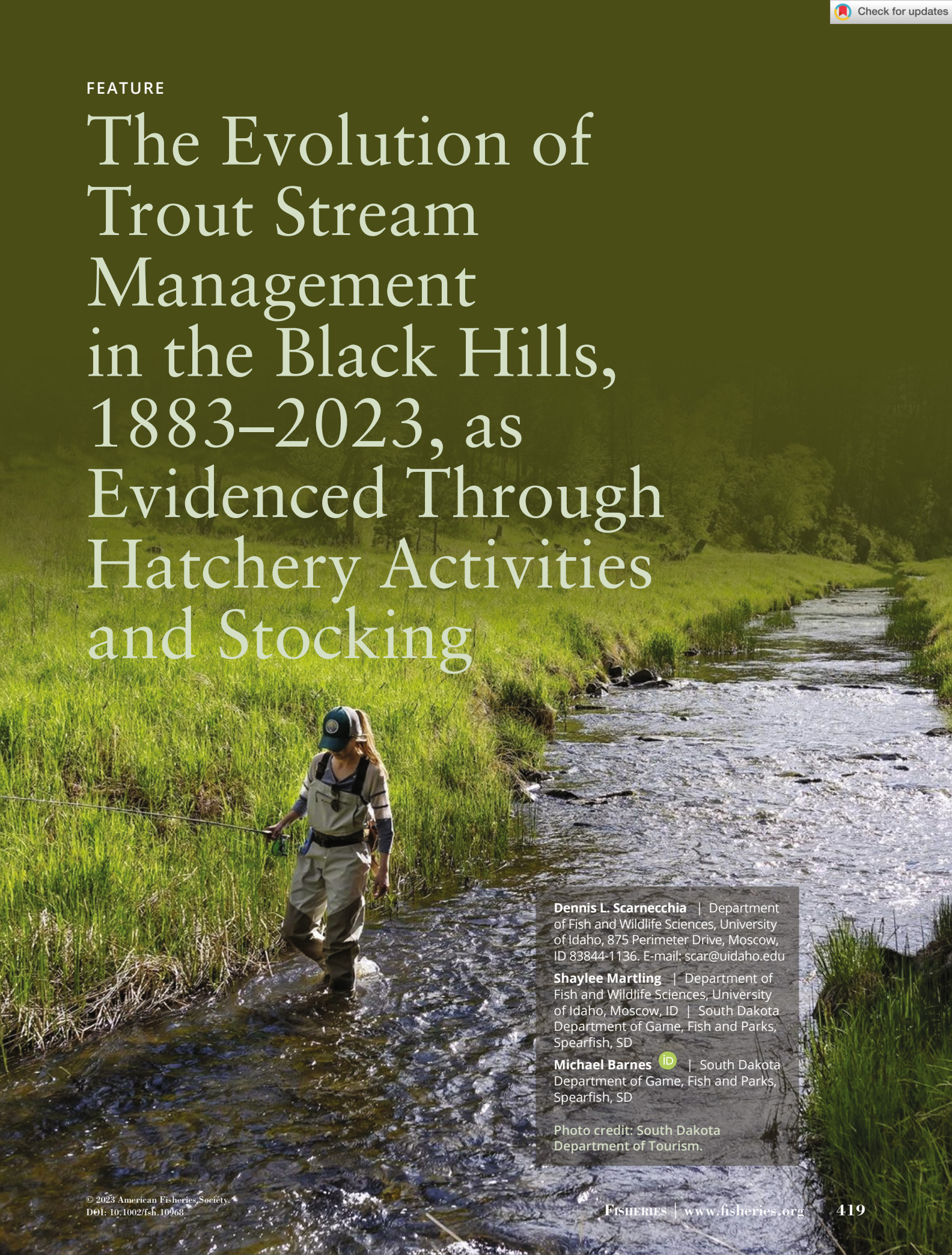
FEATURE

The Evolution of Trout Stream Management in the Black Hills, 1883–2023, as Evidenced Through Hatchery Activities and Stocking



Dennis L. Scarnecchia | Department of Fish and Wildlife Sciences, University of Idaho, 875 Perimeter Drive, Moscow, ID 83844-1136. E-mail: scar@uidaho.edu

Shaylee Martling | Department of Fish and Wildlife Sciences, University of Idaho, Moscow, ID | South Dakota Department of Game, Fish and Parks, Spearfish, SD

Michael Barnes | South Dakota Department of Game, Fish and Parks, Spearfish, SD

Photo credit: South Dakota Department of Tourism.

DOI: 10.1002/fsh.10968

In this paper, we review and synthesize trout management philosophy and policies for Black Hills streams in the states of South Dakota and Wyoming through the roles of hatcheries, fish stocking, and natural production from 1883 to 2023. We identified three specific fisheries management time periods (eras) in the Black Hills: (1) the early management–fry stocking era (pre-1950), (2) the catchable-trout stocking era (1950s to mid-1990s), and (3) the integrated management era (mid-1990s to present). The first era emphasized juvenile trout stocking, with little evaluation of effectiveness in terms of return to creel. The second era was characterized by greater emphasis on stocking catchable-sized trout and a substantial increase in hatchery rearing capabilities. In the first two eras, instead of fish stocking being one of many potentially useful tools for managers of Black Hills streams, stocking was the dominant activity—leading and directing fisheries management rather than supporting it. By the third era, trout management began to embody a more encompassing and complex national ideology and philosophy that more fully considered ecology, including habitat improvement, natural reproduction of trout, defining the role of fish stocking, and understanding the relationship of trout to the depauperate native (nongame) fish fauna. We also discuss the three eras in the Black Hills in relation to national trends in trout management. In contrast to many other localities, the lack of any native salmonids and the lack of native game fish species have facilitated the development of valuable, self-sustaining recreational fisheries in streams that support trout, with less concern for native species than in many areas with harvestable native fish species. The cultural ideology that brought western expansion of settlers to the Black Hills in search of gold, land, freedom, and prosperity was emboldened by a science-based belief and confidence in technology and industry to rapidly shape lands and waters to improve the human condition. In part, the sculpting and shaping of Mount Rushmore symbolize that ideology. In the context of fisheries management in the Black Hills, the introduction of trout, development of stream fisheries, and investment in hatchery technology to produce catchable trout for an expanding tourist economy also exemplify that prevailing ideology, modulated by improved ecological understanding and an accompanying shift toward a more ecological management philosophy.

INTRODUCTION

Trout and Hatcheries

> Mr. Gehin, one of the authors of the great discovery of the artificial production, fecundation, incubation and hatching of the eggs of fish, … [obtained] the eggs of l'ombre chevalier; a very rare species of trout …. This is the most beautiful of French fishes, and by epicures is considered more delicate than any other fish taken in fresh water …. In the course of his journey, Mr. Gehin prepared more than two hundred boxes of eggs and deposited them in well selected places to effect the artificial hatching….
>
> (From W. H. Fry's translation of Gehin 1854)

> It should not be surprising that the subject [of fish culture] is attracting the attention of some of the best minds in our own country; more especially when we consider the impoverished condition of our rivers and streams, many of which are susceptible of being inhabited by innumerable salmon and trout, and since a replenishment is now no longer problematical.
>
> (From Garlick 1857)

Trout, salmon, and charr in the family Salmonidae are the most widely introduced coldwater fish species in the world. Once confined to north temperate regions, their naturalized range has expanded through hatchery rearing and stocking to include vast areas of the Southern Hemisphere and uncounted waters worldwide (Crawford and Muir 2008). Introductions into coldwater habitats in the United States, including those containing native salmonids, have included Brown Trout *Salmo trutta* from Europe, Brook Trout *Salvelinus fontinalis* from eastern North America, and Rainbow Trout *Oncorhynchus mykiss* from western North America (Crawford and Muir 2008; Halverson 2010). No other coldwater fish taxa have been subjected to such a wide and conflicting array of management actions, including planting of eggs, stocking of juvenile fish for put and grow, stocking of catchable-sized fish, invasive trout removal, habitat management, harvest management regulations, and catch-and-release angling (Meehan 1991; Hansen et al. 2019; Kershner et al. 2019; Lyach 2020).

Over the past 140 years, federal, state, and tribal fisheries managers in the United States have implemented a variety of actions and written numerous management plans for trout in response to recreational and commercial harvest, other ecological issues, and conservation of native species or specific stocks (Kershner et al. 2019). Fisheries management philosophies and policies, manifested through plans and actions, can and often do change over time (Lichatowich 1999; Hansen et al. 2019), typically in relation to new social, economic, or scientific (e.g., biological or ecological) information. In practice, evolving philosophies regarding trout can involve conflicting goals in fisheries management. Two examples include (1) the production of hatchery-reared fish for stocking versus a wild-fish policy and (2) the management of popular nonnative recreational species versus less-popular native species (Hansen et al. 2019). Within state fisheries management agencies, documentation of these changing philosophies and rationales, as evidenced by hatchery production, fish stocking, fish population surveys, creel surveys, and habitat improvement projects, is essential (Epifanio 2000). Such an understanding enables agencies to maintain institutional knowledge amid staffing changes, clarify managerial decisions and thinking, and avoid previous mistakes (Hilborn 1992; Mahon and McConney 2004). It is also useful to understand how and why management actions compare to those of other agencies or regions in different management contexts.

The Black Hills constitute a geologically and biogeographically isolated region in the northern Great Plains of western South Dakota and northeastern Wyoming (Figure 1; Parrish et al. 1996; Cordes 2007; Koth 2007). It is a temperate, mountainous area drained by cold streams with only about 15 native fish species (Evermann 1893; Evermann and Cox 1896), none of them historically of interest to anglers. The Black Hills have sustained a recreational trout fishery since the introduction of salmonids in the 1880s (Parrish et al. 1996; Koth 2007; Henris 2015).

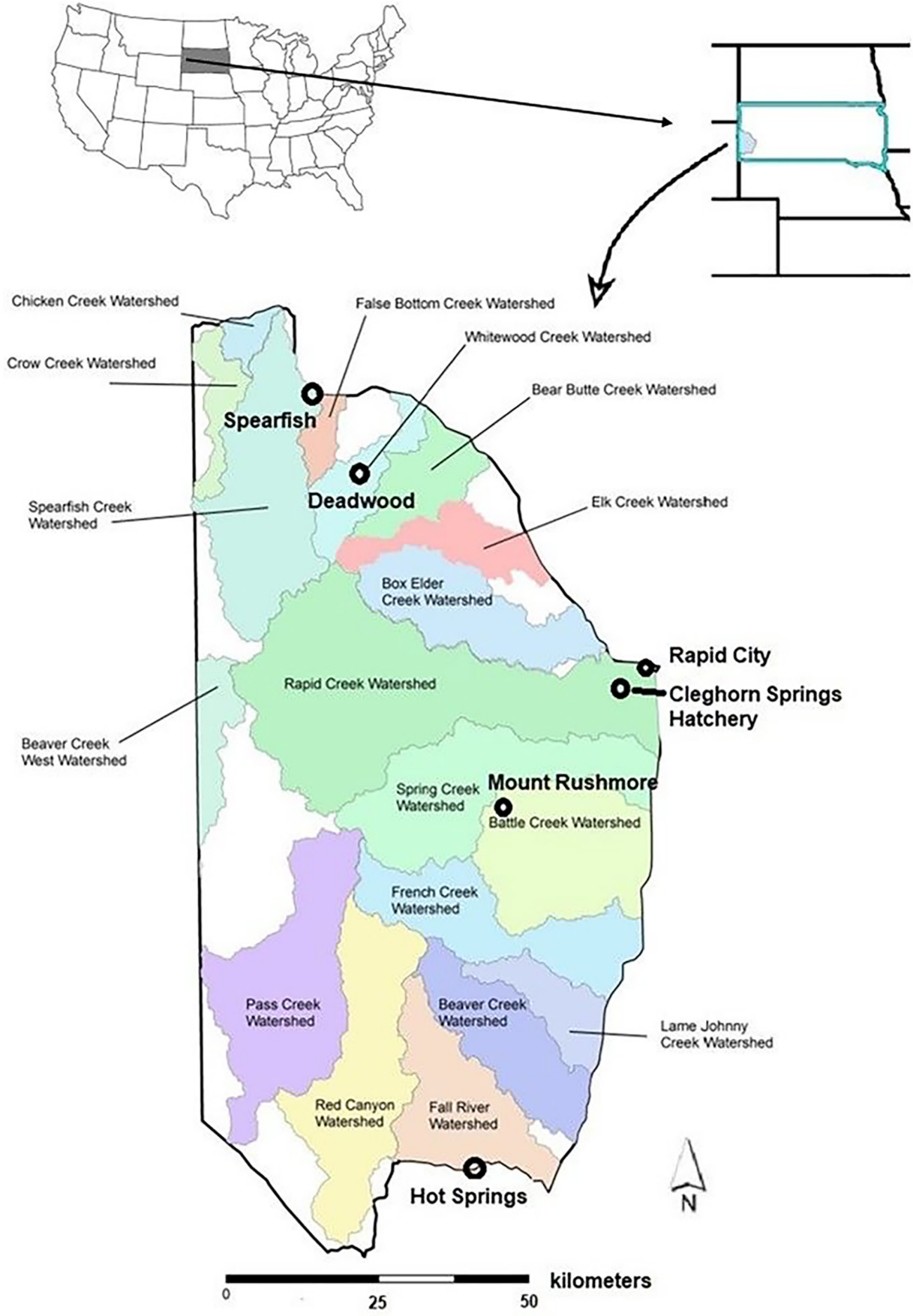


Figure 1. The Black Hills, South Dakota, and watersheds managed under the stream management plans (Galinat et al. 2015).

About 1,078 km of the roughly 1,288 km of coldwater stream reaches in the Black Hills are deemed manageable for trout (Erickson et al. 1993). Of these reaches, about 869 km have naturally spawning trout populations and about 386 km support major perennial trout fisheries (Erickson et al. 1993; SDGFP 2020). Although trout are not native to the Black Hills (Evermann and Cox 1896; Cordes 2007), the recreational trout fishery established through stocking has a complex history. Sociocultural, economic, and ecological interconnections involving trout, particularly in relation to mining, logging, agriculture, tourism, and recreation, have been a prominent part of the Black Hills (SDGFP 1959; Clow 1992; Henris 2015). The development of the Black Hills as a scenic tourist destination in the last half of the 19th century (Julin 2001), the innate recreational and aesthetic appeal of trout to Europeans and American easterners (Behnke 2002; Crawford and Muir 2008; Halverson 2010), and the comparatively new technology of trout culture (Gehin 1854; Garlick 1857; Wood 1953; Bowen 1970) have all contributed to the historical trajectory of stream fisheries management. The introduction of trout into the Black Hills and the subsequent construction of fish hatcheries can be interpreted as part of a broader national ideology that includes but transcends fisheries: a westward, primarily agricultural and industrial European-American expansion and settlement, along with a technological reshaping of the natural environment (Billington 1967; White 1991; Lichatowich 1999; Dobson 2013).

In this paper, we review and synthesize Black Hills trout stream management philosophies and policies—especially as evidenced through the comparative roles of trout stocking and natural production—from 1883 to 2023. The philosophies guiding trout management in Black Hills streams over this period have evolved under a technology-based expansionist ideology and the region's own biogeographical, social, and economic conditions. However, the isolation of the Black Hills from regions containing native trout makes it a unique case study for interpreting management actions, particularly in comparison to other areas where nonnative salmonids were stocked into systems inhabited by native wild salmonid populations (Hansen et al. 2019). Over the 140-year period since the first Dakota Territory fish and game laws, the evolving philosophy of stream trout management in the Black Hills is interpreted through the initial stocking of trout; subsequent increases in the availability of hatchery-reared fish; and recent, more ecologically informed actions, such as habitat restoration, consideration of natural trout reproduction, and consideration of native nongame species. Nationally, this philosophy is also interpreted in the context of a broader American ideology that is reflected in key fisheries legislation, agency development, evolving philosophies toward wild versus hatchery-reared trout and native versus nonnative trout, evolving public and angler attitudes and sentiment, and selected socioeconomic aspects of recreational anglers and the general public.

NATURAL AND HUMAN HISTORY OF THE BLACK HILLS IN RELATION TO FISHERIES MANAGEMENT

The Black Hills as an Island of Trout Habitat

> We were continually looking for trout in these streams, which seemed as though made expressly for that fish, which requires an unfailing flow of cold pure water. There could be no finer trout-streams in the world than these were they once stocked. As it was, we found nothing but some small chub, and a species of sucker perhaps a pound (sic) weight.
>
> (From Ludlow 1875)

> Before mining began in the Hills in 1875 and 1876, nearly every stream possessed all of the natural conditions necessary to make it an excellent trout stream …. Among the many regions of the United States which possess the necessary conditions for trout, The Black Hills District is the only one of any considerable area, if we except portions of Yellowstone National Park, in which one or more species of Salmonidae are not or have not been indigenous.
>
> (From Evermann and Cox 1896)

Understanding how and why Black Hills trout management evolved and trout hatchery activities occurred requires some knowledge of the distinctive, isolated habitat into which the trout were stocked. New York-born and educated William Ludlow (Ludlow 1875), the chief engineer for the U.S. Army Corps of Engineers' Department of the Dakotas, was a sportsman and water expert (McAndrews 1969). He correctly recognized during the Custer expedition that the Black Hills waters were highly suitable trout habitat. Ichthyologists Barton Evermann and Ulysses Cox concurred two decades later (Evermann and Cox 1896); however, no native trout were to be found in the Black Hills. Geologically and biogeographically isolated, the Black Hills represent a disjunct extension of the Rocky Mountains, an uplifted core of granitic and metamorphic rocks from the Precambrian period, surrounded by rings of limestone and other sedimentary rocks that have eroded through time (Dodge 1876; Carter et al. 2002; Cordes 2007; Koth 2007). The Black Hills are elevated by up to 1,200 m above the adjacent areas, leading to increased precipitation compared to surrounding lowlands (Clow 1992; Cordes 2007). Hence, they constitute an elevated, forested island in the plains, with coldwater streams flowing amid an otherwise semi-arid region characterized by seasonally warmer waters that are unsuitable for trout (Figure 1; USGS 1909; Cordes 2007; Koth 2007; SDGFP 2020).

The habitat quality of Black Hills coldwater streams is strongly influenced by streamflow conditions. Flows originate around the granitic core. Near their origins, the streams are typically perennial. Further downhill from the impervious granite, the flows seep into the surrounding ring of porous limestone (Carter et al. 2002). In wet years and during shorter periods of heavy precipitation or snowmelt, the streams may flow through this limestone loss zone out to the prairie. However, during drier conditions, which commonly occur on the Great Plains, streams typically go dry. In certain places, groundwater springs from fractures in the limestone supplement streamflows against drought, creating a more stable coldwater habitat (Dodge 1876; USGS 1909; Kinsella 2000; Cordes 2007). In the past century, aqueducts and mine tailing discharges have also created continuous flows in certain watersheds (Barnes 2007; Koth 2007; SDGFP 2020).

Many Black Hills streams, described by Lt. Colonel R. Irving Dodge (Dodge 1876) as "… clear, cool and pure" have been influenced by European-American settlement, timber harvest, mining, irrigation, power generation, and

livestock grazing (Parrish et al. 1996; Evans-Hatch and Evans-Hatch 2006; Koth 2007). Beginning with the gold rush in 1876, timber harvesting and mining went hand in hand. Wood was needed for fuel, construction, and securing mine tunnels. Between mining and town building, 139 million m^3 (1.5×10^9 board feet) of timber were logged from Black Hills forests during a 20-year period (Clow 1992; Evans-Hatch and Evans-Hatch 2006). Some forest-related legislation benefited coldwater habitat, however. In 1897, the Black Hills Forest Reserve was created by President Grover Cleveland. Homestake Mining Company's logging actions also changed during this time period from destroying large swaths of forest and illegally harvesting large trees to helping guide the conservation forestry principles that are practiced today (Clow 1992). In 1897, Gifford Pinchot, the father of American conservation and forestry, facilitated the first timber sale agreement between a private company (Homestake Mining Company) and the U.S. Government. Pinchot convinced the superintendent and the attorney of the Homestake Mining Company that conservation of the forest was in their best interest. Another result of this meeting was that Homestake Mining Company offered to fund government timber sales because there were yet no means by which the government might authorize and sell publicly owned timber (Clow 1992). This marked the beginning of American forestry (Clow 1992). Homestake Mining Company also diverted streamflows via aqueducts for power generation (Barnes 2007). The Black Hills Forest Reserve, which was transferred to the U.S. Forest Service in 1905, became the Black Hills National Forest in 1907. Early effects on stream habitat for fishes were not a major consideration and were largely undocumented.

Agriculture and expanded human settlement led to changes in stream habitat in the Black Hills region. Food requirements for miners, loggers, and others spurred agriculture, and in 1880, the number of farmers equaled the number of miners in Custer County in the southern Black Hills (Evans-Hatch and Evans-Hatch 2006). Several land acts, including the Preemption Act (1841–1891), Homestead Act (1862), Timber Culture Act (1873), and Desert Land Act (1877), contributed to the settlement, cultivation, and development of the Black Hills (Evans-Hatch and Evans-Hatch 2006). These land acts offered substantial acreages of inexpensive or free land—with the stipulation that irrigation, tree planting, cropping, or other land changes would occur. Although initial farming efforts were successful, farm profitability declined by the 1920s and land use shifted to ranching (Evans-Hatch and Evans-Hatch 2006; Barnes 2007). Again, effects of agricultural development on stream habitat were not a major consideration.

Since as early as the mid-1880s, competition for water resources has occurred between settlement, agriculture, and industry (Evans-Hatch and Evans-Hatch 2006). Irrigation, railroads, and grazing had an impact on water resources in the area, and urban development and grazing continue to impact the watersheds of the Black Hills (Parrish et al. 1996). By 1970, up to 85% of the original trout stream habitat was estimated to have been degraded (Stewart and Thilenius 1964; Parrish et al. 1996; Koth 2007).

Historic fish species in streams were few. Native coldwater-tolerant fishes residing in Black Hills streams, many described by Evermann and Cox (1896), include the Longnose Dace *Rhinichthys cataractae*, Lake Chub *Couesius plumbeus*, Creek Chub *Semotilus atromaculatus*, White Sucker *Catostomus commersonii*, Mountain Sucker *C. platyrhynchus*, and Longnose Sucker *C. catostomus*. These species still exist in the Black Hills (Cordes 2007). The Mountain Sucker is currently listed as a species of greatest conservation need by the South Dakota Natural Heritage Program (Backlund and Shearer 2007; Cordes 2007; Breeggemann et al. 2014; SDGFP 2020). The Longnose Sucker has the most extensive range of all sucker species in North America, but its range is limited in the Black Hills. It is also listed as a species of greatest conservation need in South Dakota, along with being a state threatened species (Backlund and Shearer 2007; Cordes 2007; SDGFP 2020). Along with the Longnose Sucker, the Lake Chub is likely a glacial relict (Bailey and Allum 1962; Taylor et al. 2013). It historically inhabited four drainages in the Black Hills but now is found only in Deerfield Reservoir (Backlund and Shearer 2007; Cordes 2007; SDGFP 2014). None of the native fish species in the Black Hills streams are game species of interest to traditional sport anglers.

Although fishing for these native species by various native American tribes residing in or moving through the Black Hills cannot be ruled out, we have been unable to find any historical recorded evidence of such uses in the Black Hills per se (e.g., Rau 1884; Rostlund 1952; and numerous other sources). Some early evidence of prehistoric fishing is found *near* the Black Hills in southwestern South Dakota, with minnow bones being interspersed with mammoth bones (Parris et al. 2007). More recently, South Dakota tribes fished Great Plains rivers in times of a shortage of buffalo *Bison bison* (Jensen 2007). The absence of evidence for fishing in the Black Hills is in sharp contrast to many other areas of North America where fishing was a recognized and important—sometimes central—aspect of tribal culture (Gunther 1926, 1928; Birkes 1990; Marshall 2006). An archeological factor leading to this absence of evidence in the Black Hills may include the tendency for fish bones to not persist in the archeological record under many circumstances (Parris et al. 2007). Ethnological factors in more recent times might include the small size of the current native species and the abundance of small bones in suckers and minnows (Olson 1963), since both characteristics reduce the desirability of these fish as food. Another factor may be that with the introduction of the horse (Hämäläinen 2003), there was greater access to more available and abundant alternative terrestrial foods relative to the comparatively small native fish in the Black Hills. Current tribal regulations elsewhere in South Dakota involve larger native and nonnative recreational species that are not native to the Black Hills (Jensen 2007).

STREAM FISHERIES MANAGEMENT HISTORY

Trout management in Black Hills streams, as evidenced by stocking activities, evolved amid the broader national evolution of trout management philosophy, although not necessarily on exactly the same time frame. Based on our qualitative assessment of the historical data, three specific fisheries management time periods in the Black Hills, reflecting an evolving philosophy, are evident: (1) the early management–fry stocking era (pre-1950), (2) the catchable-trout stocking era (1950s to mid-1990s), and (3) the integrated management era (mid-1990s to present). The first era emphasized the stocking of large numbers of small fish without sufficient evaluation. In the second era, a greater emphasis on raising catchable-sized trout coincided with a substantial increase in hatchery rearing capabilities. The third era more fully considered ecological aspects, such as habitat, natural reproduction, and defining the role of stocking.

Early Management–Fry Stocking Era (Pre-1950)

> That wonderland of natural attractions, the Black Hills of South Dakota, … with well stocked trout streams, with fine highways, and majestic mountain scenery will soon become a strong competitor for the summer tourists.
>
> (From Booth 1925)

> By the middle of the last [19th] century it had become evident that man must evolve means to control fishing effort and to assist nature in the production of fish… the 1860s saw the beginning of fish culture… on the East Coast …. Hatcheries were publicized far and wide as the solution to every depletion problem. Faith in fish culture grew to such proportions that continued despoliation of fishery resources seemed to cause no alarm.
>
> (From Lucas 1939)

Although fisheries activities in the newly settled Black Hills chronologically lagged behind developments in the eastern United States, fisheries legislative actions preceded South Dakota statehood in 1889. The 1883 session of the Dakota Territory (the precursor to the states of North Dakota and South Dakota) Legislature established the first game and fish law enforcement. A fish commissioner was appointed and given the responsibility to distribute fish fry from the U.S. Commissioner of Fisheries. Six fish wardens were also appointed. Another territorial law mandated fishways on all dams on the Sioux, Cheyenne, and Dakota rivers. The territorial laws were not respected, however, and wildlife populations continued to decline (SDGFP 1959). Little information exists to determine the changes in fisheries populations during this time period (Parrish et al. 1996).

Private citizens first introduced trout into the Black Hills region prior to statehood. Henris (2015) identified possible stockings as early as 1882 or 1883. In 1886, Samuel Scott and Richard Hughes brought milk cans of juvenile Brook Trout by buggy from Leadville, Colorado (SDGFP 1959; Barnes 2007; Cordes 2007). Hughes saw trout as a potential benefit to Black Hills tourism (Barnes 2007) given that this fish taxon was well known and highly esteemed by easterners moving and visiting westward (Henris 2015). Even during the earliest years of this first era, great emphasis was placed on turning the Black Hills into a tourist destination. As the first stop for easterners heading into the West, the development of Black Hills trout fishing can be seen as one of several initiatives in the subsequent decades (e.g., Hot Springs, Custer State Park, Jewel Cave National Monument, Wind Cave National Park, and Mount Rushmore) that were promoted to attract tourists (Parker 1981; Julin 2005). Trout fishing in scenic Black Hills streams was promoted as a hobby of presidents (Figure 2) that was also available to tourists.

In terms of ideology, the initial trout introduction and subsequent stocking in Black Hills streams can be seen as part of what Brown (2014) called the "Rocky Mountain Trout Culture." With trout being one of the most popular game fish taxa, their introduction was part and parcel of a national ideology: a science- and technology-based expansion of American settlement into the unspoiled, mythical West, intent on improving nature and its existing native fish assemblages

Figure 2. President Calvin Coolidge, an avid angler, weighing his trout during his 3-month stay at the State Game Lodge at Custer State Park, South Dakota, in 1927. His visit was actively sought by tourist- and development-minded business interests. His visit and support helped to jumpstart the construction of Mount Rushmore (Julin 2009). Photo from a tourist postcard; Rise Studio, Rapid City, South Dakota.

(Brown 2014). In the fisheries realm, both nationally and in the Black Hills, belief in fish rearing technology and fish stocking was an important, even implicit, aspect of that ideology (Lichatowich 1999).

After the introduction of trout, increased stocking by the federal government soon followed. Between 1890 and 1892, the U.S. Fish Commission stocked juvenile Brook Trout, Brown Trout, and Cutthroat Trout *O. clarkii* in Black Hills streams (SDGFP 1959; Barnes 2007; Cordes 2007). Private stockings were also common during this period (Figure 3). As described by Henris (2015), "privately stocked springs, ditches and ice ponds near Spearfish were likely the point of origin for the first large-scale introduction of trout into publicly accessible waters"; floods released fish into Spearfish Creek. Rainbow Trout were first stocked in the Black Hills in 1896. Brook Trout, Brown Trout, and, to a lesser extent, Rainbow Trout subsequently became naturalized in Black Hills streams (Cordes 2007).

Because the initial trout stockings proved successful in some localities, the U.S. Congress authorized construction of a fish hatchery at Spearfish, South Dakota. In 1898, land near the mouth of Spearfish Canyon was acquired from homesteader John S. Johnston, who had already been stocking "troutlings" since 1895 (Barnes 2007). This hatchery, originally known as the Spearfish Fish Cultural Station, eventually became known for many years as the Spearfish National Fish Hatchery. It is now known as the D. C. Booth Historic National Fish Hatchery (Barnes 2007). Between 1900 and 1911, D. C. Booth, the hatchery's first superintendent, reported stocking 665,000 Brown Trout, 888,000 Rainbow Trout, 6.1 million Brook Trout, and 10.1 million Cutthroat Trout in the Black Hills region (Booth 1912). The Spearfish National Fish Hatchery was, for a time, the center of federal fish culture operations in the western United States (Barnes 2007). Fish railcars, another key technological advance, greatly facilitated fish distribution for stocking in and beyond the Black Hills during this time (U.S. Fish and Wildlife Service 1979; Henris 2015).

Figure 3. Early trout stocking in the Black Hills: (**A**) reaching the site via horse-drawn wagon and (**B**) stocking fry out of milk cans. Photo credit: South Dakota Department of Game, Fish and Parks.

State of South Dakota fisheries management actions in the Black Hills occurred shortly after the establishment of the South Dakota Department of Game and Fish in 1889. After statehood, fish wardens became game wardens whose salary was half of the fines from the convictions of violators that they apprehended. The other half of the fines was deposited into the Fish Fund, which by 1901 had become substantial. In 1909, the appointment of the first State Game Warden, W. F. Bancroft, along with the establishment of a Game and Fish Commission, marked the inception of the South Dakota Department of Game, Fish and Parks (SDGFP 1959). Bancroft lobbied for a state-owned fish hatchery in 1915. Between 1916 and 1920, with Frank Purcell as the Superintendent of Fisheries, two temporary state fish hatcheries were set up in the Rapid City area (SDGFP 1959; Barnes 2007). Under the new state Superintendent of Fisheries, Robert L. Ripple (SDGFP 1959; Barnes 2007), permanent hatchery buildings were subsequently constructed at Cleghorn Springs near Rapid City, close to where Hughes and Scott stocked their trout more than 40 years earlier. The construction of the Cleghorn Springs State Fish Hatchery and Ripple's appointment as the first hatchery superintendent marked the beginning of state fish production and the start of state trout stocking records (Figure 4; SDGFP 1959; Barnes 2007).

In North America during the first part of the 20th century, efforts at evaluating the effectiveness of trout stocking were minimal and were likely influenced by economic and political factors (Foerster 1938; Lucas 1939; Halverson 2010). Early fish culture efforts in the United States from the 1870s to the 1930s emphasized supplying and giving eggs and fry to states and other entities. From the earliest days of the U.S. Fish Commission, increased stocking numbers were essential to secure more funding and assuage concerns about reductions in abundance of wild fish. Stocking numbers were equated with program success, with high numbers of stocked fish applauded by supervisors and justifying funding for more fish production (Halverson 2010).

By the 1920s, some hatchery managers nationally began to question the overall success of stocking eggs and fry. In the Black Hills, Booth (1925) stated that

> The planting of trout fry is no longer considered good fish cultural policy although there are some exceptions. The headwaters of some very desirable trout streams are inaccessible for trout …. In such places it is often advisable to plant either the well-developed egg or small fry.

Clearly, as expressed by Wood (1953), some knew or suspected the limitations of fry stocking early on:

> The field of [biological–environmental investigations] developed when the sharper minds among our predecessors realized that artificial propagation was not an

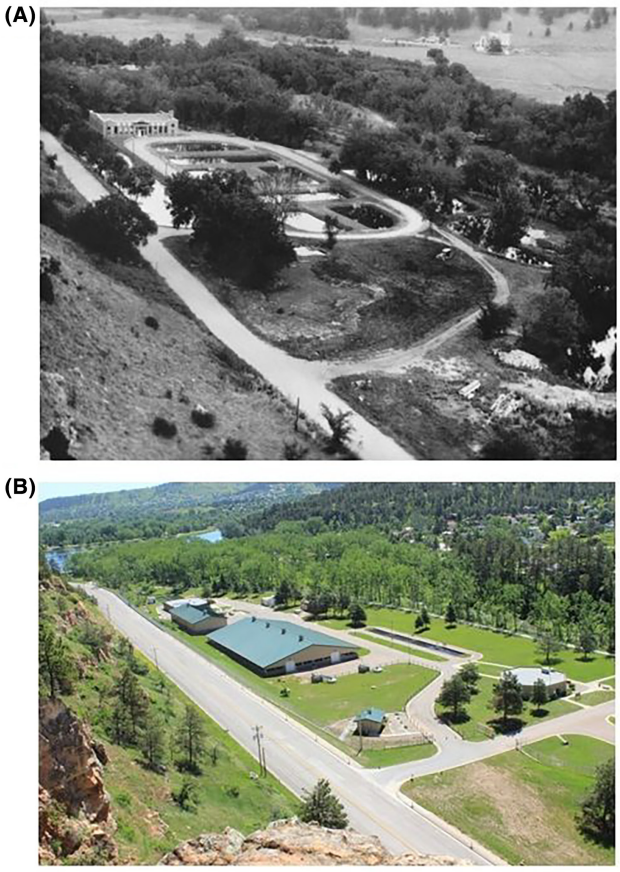


Figure 4. Cleghorn Springs State Fish Hatchery, South Dakota: (**A**) circa 1951 and (**B**) circa 2010. Photo credit: South Dakota Department of Game, Fish and Parks.

> end in itself …. Since artificial propagation met with such universal acceptance, however, it was not until well after 1900, when deficiencies became apparent—that biological investigations received their greatest impetus.

Stockings were also poorly evaluated in the Black Hills during this period.

In the Black Hills, stocking of fry and somewhat larger juveniles (fingerlings) continued to predominate before 1950. The problem was twofold, with limited hatchery capacity and the lack of economically viable feeds. Whelan (2004) noted a trend in Michigan during the 1930s and 1940s toward producing more fingerlings and fewer fry. Similarly, most of the trout stocked into Black Hills streams in the 1930s were fry or juveniles. Very few catchable trout were stocked (Table 1), probably reflecting the lack of availability given the limited hatchery resources and difficulties in growing trout to a larger size.

Catchable-Trout Stocking Era (1950s to Mid-1990s)

> Faith in the fish hatchery has remained strong through the years …. As early as 1913, however, it was becoming increasingly evident to conservationists that artificial propagation alone was not sufficient to stem the tide of depletion. The chief difficulty lay in the failure to attain the expected results from the unsystematic planting of fish. The large number of unsuccessful plants made it evident to some that we should know more about the natural requirements of fishes… before we could make reasonably successful plantings. Gradually, federal and state fisheries departments responded to the needs of biological study of the waters.
>
> (From Lucas 1939)

> Trout culture, as an institution, is approaching its hundredth birthday, and it is indeed surprising that in this long period few serious attempts have been made to evaluate the efficiency of the hatchery system … the most satisfactory results from trout culture should be realized from reading a maximum number of trout to a minimum length of three inches at the lowest possible cost…. From the standpoint of the number of legal-sized trout produced, these data on hatchery production coupled with those of Davis (1938) on natural [i.e., in the wild] losses, further emphasize the superior results to be obtained from rearing trout to the larger sizes in the hatchery.
>
> (From Fish 1940)

By the 1940s and 1950s, hatchery managers nationally were paying increased attention to the *internal* efficiency of fish hatcheries by enhancing hatchery infrastructure, improving rearing techniques, and effectively using hatchery labor to reduce the cost per weight of fish produced (Tunison 1957). They were also paying more attention to the *external* efficiency in terms of the optimal size of stocked fish to supply to recreational anglers. By the 1930s and early 1940s, some studies had examined releasing larger trout (Fish 1940; Shetter and Hazzard 1940, 1942; Shetter 1947). Fish (1940) noted that the stocking of larger fish provided more return to harvest. Stocking size evaluations increased after World War II and again indicated a better return to creel from larger trout (Butler and Borgeson 1965). Coinciding with the results of these studies were an increase in leisure time and greater participation in recreational fishing—a trend that was accelerated by postwar affluence and advances in transportation (especially automobiles and roads), which facilitated access to recreational destinations (Figure 5; Wood 1953).

Table 1. Number of catchable-sized trout stocked in Black Hills streams prior to 1950.

Stream	1927	1928	1931	1932	1933	1936	1937	Total
Box Elder Creek			200			520		720
Newton Fork Creek							65	65
Rapid Creek	131	400	1,200	614	1,925			4,270
Redwater River					200			200
Spearfish Creek				400	542	2,601		3,543
Total	131	400	1,400	1,014	2,667	3,121	65	8,798

Figure 5. Post-World War II magazine ad for Black Hills trout stream fishing (1958), aptly sponsored by the South Dakota Department of Highways. Improved roads and automobiles (and rail improvements) greatly facilitated access to and expansion of trout fishing opportunities and other tourist activities.

In 1950, the passage of the Federal Aid in Sport Fish Restoration Act (hereafter, Sport Fish Restoration Program; Radonski 2000) provided timely and much-needed support to chronically underfunded state agencies and their fisheries programs (King 1952; Scarnecchia et al. 2021). The federal excise tax on fishing tackle generated funding that was disbursed to states, thereby stabilizing state fisheries programs and allowing their diversification into research, management, and hatchery production (King 1952; Scarnecchia et al. 2021). The timing of the program was favorable. In the Black Hills, Mount Rushmore, completed in 1941, celebrated freedom, democracy, and the founding principles of the United States. World War II victory validated that ideology and was followed by years of economic expansion. Mount Rushmore also symbolized for many a national ideology involving American technology, industry, and the American way of life. In Black Hills fisheries management, this way of life was also exemplified by high-quality trout fishing in scenic public waters for residents and tourists (Figure 6). American technological prowess in fisheries was evident in the trout hatcheries contributing to that fishing. In this era, the trout management emphasis, both nationally and in the Black Hills, focused on meeting the demands of recreational anglers, an expanding economy, and the tourism industry.

During this era, hatchery capacity and the stocking of catchable-sized trout increased substantially, fulfilling the national trend of stocking larger fish (i.e., from fry to small juveniles to large juveniles to catchable sizes), which began in the 1930s (Langlois 1942). The increase in catchable-trout stocking in the Black Hills began in the 1950s. In 1943, the state of South Dakota purchased land near the Wyoming border from Judge James McNenny. Because of water supply problems at Spearfish National Fish Hatchery, the U.S. Fish and Wildlife Service entered into a lease agreement with the state of South Dakota in 1946 to construct what would become McNenny National Fish Hatchery. That hatchery was completed in 1952 (Barnes 2007). As per the lease agreement, a percentage of the fish produced there were stocked in state waters. In 1953, McNenny National Fish Hatchery became operational, with catchable-sized trout stocking in Black Hills streams reaching an all-time high of 202,831 the following year (Figure 7). Catchable-sized trout stocking continued, with 179,530 stocked in 1964. Hatchery production changes influenced stream stocking numbers. In 1983, the U.S. Fish and Wildlife Service abandoned McNenny National Fish Hatchery and converted the Spearfish National Fish Hatchery into a museum and educational facility that

Figure 6. President Dwight Eisenhower, an avid fly fisherman, unhooks a Brook Trout caught in June 1953 in French Creek, Custer State Park, South Dakota, during his visit to the Black Hills. He was the first U.S. President to visit the Black Hills via airplane. Photo credit: United Press Telephoto.

was eventually renamed the D. C. Booth Historic National Fish Hatchery. Because the state of South Dakota owned McNenny National Fish Hatchery, the state assumed control, immediately renovated the hatchery, and renamed it McNenny State Fish Hatchery. All subsequent trout production was stocked into state fishing waters. In addition, from

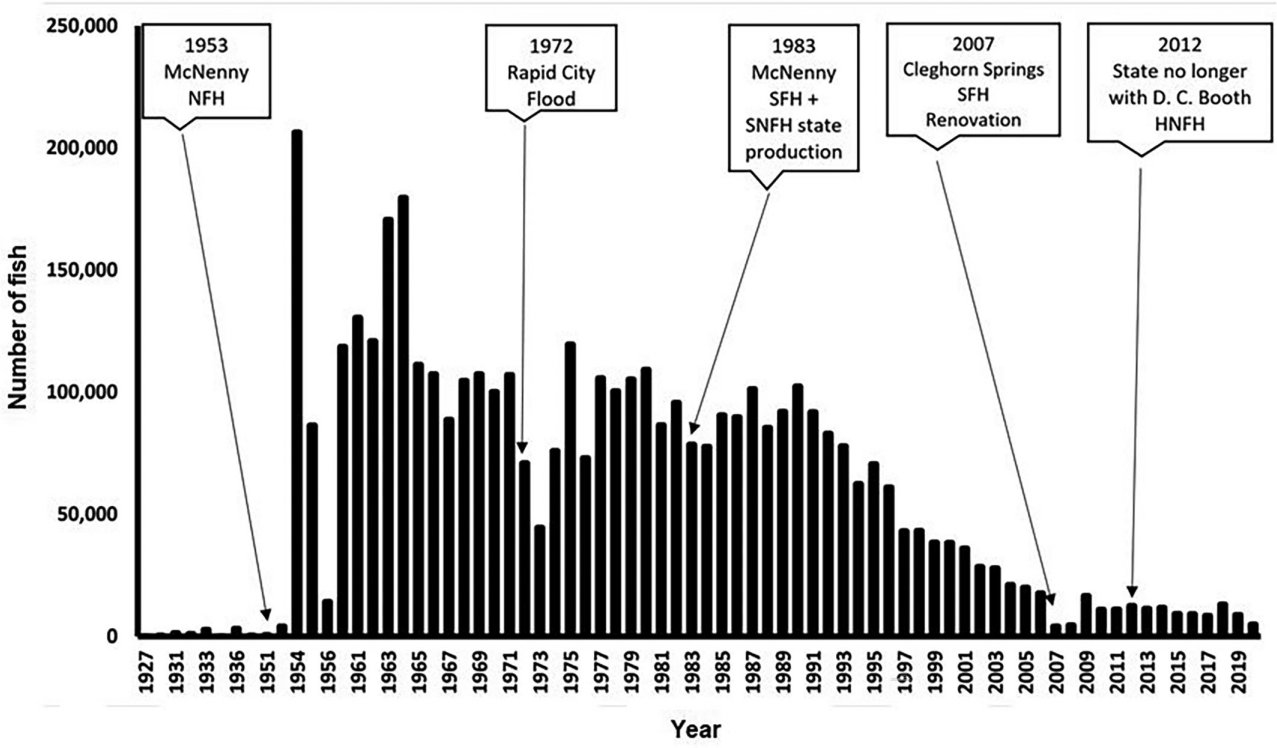


Figure 7. Total number of catchable trout stocked in streams of the Black Hills region, South Dakota, overlaid with hatchery infrastructure events (HNFH = Historic National Fish Hatchery; NFH = National Fish Hatchery; SFH = State Fish Hatchery; SNFH = Spearfish National Fish Hatchery).

1983 through 2012, the state used the ponds at the federally owned D. C. Booth Historic National Fish Hatchery for trout production during the summer. Tourists could see and feed the fish, and the catchable trout held there were all stocked at the end of the summer. Trout production continued at Cleghorn Springs State Fish Hatchery, with a substantial interruption. ln 1972, the Rapid City flood completely destroyed the hatchery, causing a significant drop in stocking numbers statewide from 1972 through 1974 (Figure 7). The hatchery was rebuilt, incorporating newer technology to facilitate an increase in catchable-trout production.

During this second era in the Black Hills chronology, many questions were raised nationally about the efficacy of catchable-trout stockings. Although the need for evaluating catchable programs was identified, such assessments were limited by financial constraints, the lack of clearly defined goals, an increased focus on natural reproduction, and a reliance on old, likely dated, evaluations (Hartzler 1988). In Michigan, Trout Unlimited was critical of catchable-trout stockings as early as 1959 (Johnson et al. 1995). Questions about the necessity, economic efficiency, and ecological impacts of stocking catchable trout persisted (Johnson et al. 1995; Hyman et al. 2016). Whereas Lucas (1939) identified the need to be more concerned about the "biological study of the waters," in many situations the stocking of catchable trout for anglers to quickly harvest and eat remained the highest priority. There is little evidence for evaluations of catchable-trout stocking in the Black Hills during this time.

During the latter part of this second era, however, fisheries management in the Black Hills changed substantially. A gradual post-World War II shift occurred coincidently with the development of the Sport Fish Restoration Program and, ironically, in conjunction with continued hatchery expansion and improvements. The shift was manifested by changes in the fisheries administrative structure of the South Dakota Department of Game, Fish and Parks as well as new job titles and descriptions. In 1950, a half-century after the first hatchery and 64 years after the first trout stocking in the Black Hills, the first fisheries biologist was hired, marking the "beginning of scientific game management and fisheries programs" (SDGFP 1959; Bouchard and Higgins 2007). In 1959, James T. Shields, the Deputy Superintendent of the South Dakota Department of Game, Fish and Parks, reorganized the Fisheries Division into equal-status *research* and *management* sections and divided the state into districts to facilitate effective management (SDGFP 1959). Coincident with this reorganization, catchable-trout stream stocking numbers dropped. Thenceforth, from the 1960s to the 1990s, Richard Ford oversaw Black Hills stream fisheries management, and stream stocking numbers were nearly constant. The first inventories of stream habitat occurred during Ford's tenure, marking a shift in management philosophy.

New personnel with new titles took on new tasks. The first aquatic habitat inventories in the Black Hills occurred in 1964, with the publication of *The Stream and Lake Inventory and Classification in the Black Hills of South Dakota* (Stewart and Thilenius 1964). This inventory was followed by a more comprehensive Black Hills stream inventory project in 1984 and 1985, with the interagency Black Hills Stream and Riparian Habitat and Classification Project (Ford 1985). Although it was not a complete inventory of all Black Hills streams, fish populations in 65 streams were sampled, with naturally reproducing trout populations documented in 563 stream kilometers. A fisheries classification system was then created based

on the species, numbers, and sizes of naturally produced trout present (Ford 1985). Fisheries managers used these inventories to match stocking with angler use, angler expectations, habitat quality, and natural trout reproduction.

Even with this increased emphasis on habitat and natural production, catchable-trout stocking numbers in Black Hills streams were high from the 1950s through the 1970s (Figure 7). The high stocking numbers reflected the availability of hatchery-reared catchable trout along with the possible benefits of anglers anticipating abundant catchable (stocked or naturally produced) trout in streams. Improvements in pelleted salmonid diets also led to more efficient hatchery rearing of catchable trout nationally and in the Black Hills (Willoughby 1953; Maxwell 1958; Schumacher 1958; Hublou et al. 1959). Prior to the 1960s, 305,233 total catchable-sized trout were stocked in Black Hills streams (Figure 7). Stocking increased substantially in the 1960s, with 846,013 catchable trout stocked in major streams (Table 2) and 275,886 stocked in minor streams (Table 3). The number of catchable trout stocked in major streams declined by approximately 25% in the 1970s, with a more pronounced 45% reduction in minor streams. Compared to the 1970s, stocking numbers were relatively similar in major streams during the 1980s, but increased 25% to over 200,000 catchable trout in minor streams. Brown Trout eventually became the primary species of catchable trout stocked in streams. Fisheries managers at the time believed that Brown Trout could better tolerate higher water temperatures and were less likely to migrate than Rainbow Trout. Smaller numbers of Brook and Rainbow trouts were also stocked. Stocking of catchable Brook Trout in Black Hills streams peaked in 1960 at 16,818 (Figure 8A). Brook Trout stocking eventually ceased when it became apparent that natural reproduction could sustain the fishery. Stocking of catchable Brown Trout peaked at 194,199 in 1954 (Figure 8B), while the number of stocked Rainbow Trout peaked at 78,886 in 1962 (Figure 8C).

In the last portion of this second era, two major factors contributed to the gradual decrease in catchable-trout stocking in streams. An increased emphasis on habitat quality was one factor. This is evidenced by the 1985 Stream Fisheries Classification System and the several small and rudimentary habitat improvement projects on Castle, Crow, Grace Coolidge, Rapid, Spearfish, Spring, and Whitewood creeks between 1976 and 1991 (SDGFP 2015). Catch-and-release angling was the other factor reducing catchable-trout stockings in streams. Requests from recreational anglers led to the establishment of catch-and-release angling areas in selected stream sections (SDGFP 2015). Catch-and-release angling, although not a new concept (May 1977) and of increasing interest in post-World War II America, developed into a more formal management approach following an initial symposium at Humboldt State University in 1977 (Barnhart and Roelofs 1977). It subsequently became an established philosophy itself in recreational fishing for many fish species (Barnhart and Roelofs 1987; Arlinghaus et al. 2007; Brownscombe et al. 2017; Cutthroat Trout in Wyoming: Rahel 2016). Desired catch-and-release outcomes included increasing angler catch rates and improving the size structure of desired species (Brownscombe et al. 2017).

In a review of Rainbow Trout stocked nationally, Halverson (2010) found that the percentage of stocked fish that were of catchable size continued to increase from 1947 to 2010. Over this period, increased interest in creating conditions for natural production in many waters nationally led to decreased releases of smaller fish, with catchable-sized fish increasingly released into waters with heavy fishing effort, few or no native trout (Cooper 1970), or poor natural reproduction and into lakes.

The Integrated Management Era (Mid-1990s to Present)

By the mid-1990s, the philosophical shift that began in the catchable-trout era had matured. The integrated management era has embodied a more encompassing and complex national ideology and trout management philosophy that more fully consider ecology, including habitat quality and improvement, natural reproduction, and defining the role of stocking. Although there remained little emphasis on native fish species management, research on the biology and ecology of native fishes was initiated. Stream habitat evaluations also provided useful information for managing both native and nonnative species.

More Naturally Spawning Trout, Fewer Stocked Trout in Streams

In 1993, stream fisheries management in the Black Hills shifted toward naturally reproducing populations,

Table 2. Number of catchable-sized trout stocked in major streams within the Black Hills region, South Dakota, by decade.

Stream	1930–1939	1940–1949	1950–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2009	2010–2019	Total
Cascade Creek			1,410	42,447	36,949	28,680	20,717	3,807	2,900	136,910
Castle Creek			8,837	97,867	47,235	24,576	2,000	3,390		183,905
Castle Creek–South Fork				3,601	10,680	13,585	13,000	3,610	50	44,526
Cold Brook Canyon Creek				27,151	27,099	49,217	73,663	21,858		198,988
Ditch Creek				4,023	6,254	10,295	8,675	2,380		31,627
Fall River				16,215	26,750	29,273	26,939	2,325		101,502
French Creek			5,212	28,448	25,625	42,300	35,112	12,785	11,600	161,082
Grace Coolidge Creek			14,543	26,057	13,550	29,235	39,300	19,720	24,911	167,316
Newton Fork Creek	65				1,900	3,300	680	1,250		7,195
Rapid Creek	3,739		102,785	374,892	262,013	216,301	93,130	46,027	11,714	1,110,601
Spearfish Creek	3,543		71,793	203,959	117,264	42,832	2,400			441,791
Spring Creek				21,353	42,325	60,015	93,531	26,211	25,015	268,450
Total	7,347		204,580	846,013	617,644	549,609	409,147	143,363	76,190	2,853,893

Table 3. Number of catchable-sized trout stocked in minor streams within the Black Hills region, South Dakota, by decade.

Stream	1930–1939	1940–1949	1950–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2009	2010–2019	Total
Battle Creek			10,782	18,353	8,400	14,900	10,625	2,051		65,111
Bear Butte Creek			1,260	10,261	4,550	6,107	5,900	1,050		29,128
Beaver Creek			3,615	25,818	2,900	300				32,633
Boxelder Creek–Middle Fork				800		224		100		1,124
Boxelder Creek–South Fork				1,200	4,400	5,010	2,600	360		13,570
Boxelder Creek	720		27,854	48,327	39,140	61,147	60,212	12,175		249,575
Carroll Creek				300		75				375
Cheyenne River			570					500		1,070
Chicken Creek				600	570	995	50			2,215
Cold Spring Creek			504	9,492	7,600	10,000	8,700	1,100		37,396
Crow Creek–Redwater Tributary			2,949	10,885	8,700	9,264	1,612	199		33,609
Deer Creek				8,278	1,600					9,878
Elk Creek			9,454	8,294		600	500	100		18,948
Glen Erin Creek				1,501	6,100					7,601
Grizzly Bear Creek			398	11,568	2,350	1,800	1,400			17,516
Horse Creek						910	352			1,262
Iron Creek North						17,036	14,650		3,720	35,406
Iron Creek South			5,796	21,455	11,400	11,500	6,125	600		56,876
Lake Creek				5,185	4,102	4,600	774			14,661
Lime Creek			266	2,583		3,400	375		140	6,764
Marshall Gulch						2,160	4,575			6,735
North Beaver Creek			1,140	8,656				300		10,096
Park Creek				75	200					275
Prairie Creek						824	543			1,367
Rapid Creek–North Fork				450		1,242		450		2,142
Rapid Creek–Rhodes Fork				2,297	8,785	9,704	5,031	1,405		27,222
Rapid Creek–South Fork				5,570	12,570	4,581	25,087	9,800		57,608
Redwater River	200		24,984	13,756	2,025	7,425	1,850			50,240
Slate Creek				1,385	8,450	12,510	13,450	3,634	1,075	40,504
Spring Creek (Redwater)				860	345					1,205
Swede Gulch						1,402				1,402
Vanocker Creek					410					410
Victoria Creek				57,937	17,865					75,802
Whitewood Creek						16,258	12,710	830	800	30,598
Total	920		89,572	275,886	152,462	203,974	177,121	34,654	5,735	940,324

with decreased catchable-trout stocking in streams and increased stocking in small lakes and reservoirs (Erickson et al. 1993). An inflection point occurred in 1990, when stocking numbers began to drop before stabilizing around 2005 (Figure 7). These management changes coincided with personnel changes in the South Dakota Department of Game, Fish and Parks. In 1992, new Black Hills Fisheries Manager Jack Erickson began reducing the stocking of catchable trout in streams. Jerry Wilhite became the manager in 2007 and reduced catchable-trout stream stocking numbers even further. New managers Jake Davis (in 2015) and Jeremy Kientz (in 2021) continued these reductions, albeit to a lesser extent. In a small agency like the South Dakota Department of Game, Fish and Parks, the influence of a single manager on stocking can be substantial.

Since 1990, stocking of catchable trout in both major and minor Black Hills streams has been dramatically reduced. During the 1990s, 409,147 catchable-sized trout were stocked in major streams, with peak stocking at 54,802 in 1991 (Table 2). In minor streams over the same period, 177,121 catchable-sized trout were stocked, with peak stocking at 29,000 in 1993 (Table 3). Stream stocking decreased in the 2000s, with 143,363 catchable-sized trout stocked in major streams and only 34,654 stocked in minor streams. Further reductions occurred in the decade beginning in 2010. In major streams, 76,190 catchable-sized trout were stocked, with peak stocking of only 8,919 fish in 2012. In minor streams, only 5,735 catchable-sized trout were stocked for the entire decade, with peak stocking at 3,720 in 2018. Stocking in many individual major and minor streams was discontinued entirely.

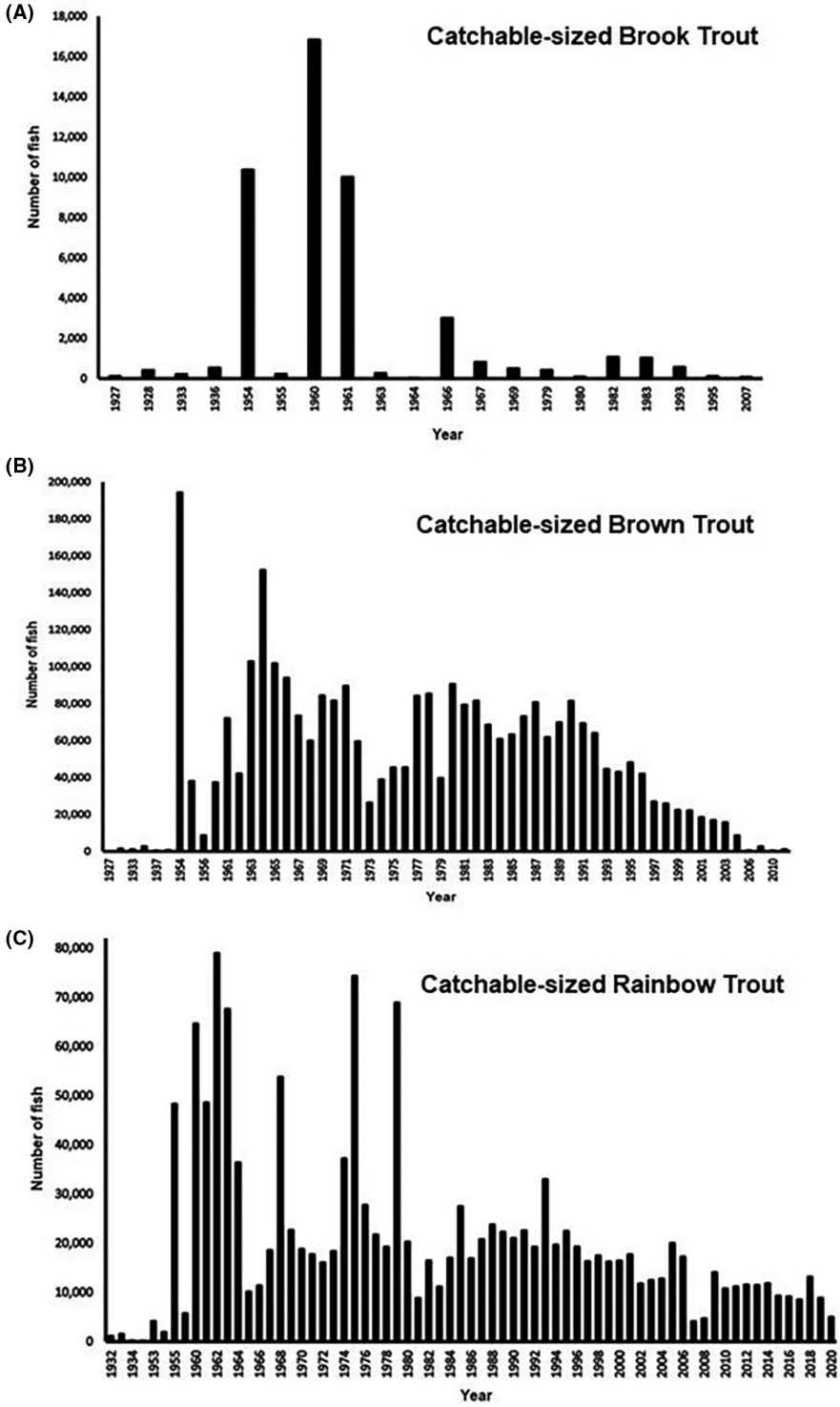


Figure 8. Numbers of catchable-sized (**A**) Brook Trout, (**B**) Brown Trout, and (**C**) Rainbow Trout stocked per year in streams of the Black Hills region, South Dakota, between 1927 and 2020.

By 2010, half of the 12 major streams were no longer being stocked, and only 4 of the 36 minor streams were still being stocked. As of 2022, stocking of trout has declined so greatly that McNenny State Fish Hatchery no longer produces any catchable-sized trout for stocking into Black Hills streams. Brown Trout stocking has ceased entirely because natural reproduction was deemed adequate to sustain the fisheries (SDGFP 2015). Only hatchery-produced catchable Rainbow Trout are currently stocked into a few selected streams.

Amid the large decline in stream stocking, overall catchable-trout production has actually increased at state fish hatcheries. Stocking into ponds, small lakes, reservoirs, and urban fisheries has increased (Simpson et al. 2015). By 2000, 80% of trout stocked nationally were catchable sized

(Epifanio 2000), and catchable sizes also dominated Black Hills trout stocking in lentic waters.

Habitat improvements have impacted the decision to reduce and nearly eliminate catchable-trout stocking in Black Hills streams. In 1991, the first extensive fish habitat project in a major Black Hills stream was completed. Subsequently, a large number of stream habitat improvements occurred throughout the 1990s and early 2000s (Table 4). Instream habitat improvement has been shown to increase Brown Trout populations in groundwater-fed streams (Dieterman et al. 2020). In South Dakota, stocking was typically discontinued after a stream habitat project to observe whether natural reproduction was occurring (Koth 1995). However, due to the potentially negative effect of hatchery fish stocking on natural populations (Meyer et al. 2012), it is uncertain whether the habitat project or the cessation of stocking led to the presence of or increase in natural reproduction. In addition, more effort has been expended to apply ecological principles to the management of self-reproducing populations (e.g., Ketelsen et al. 2017). For example, Rehm et al. (2020) studied density dependence in Brown Trout in Spearfish Creek, reducing trout numbers in an effort to enhance the age-specific growth of the remaining fish to sizes that are desired by anglers.

Table 4. Habitat projects completed in Black Hills streams.

Year	Stream	Description
1991	Castle Creek	Instream cover
1992	Rapid Creek, Griffith	Instream fish habitat
1993	French Creek	Instream fish cover, holding areas
1994	Castle Creek	Instream cover, stream meanders
	Castle Creek, Barte	Instream fish habitat
1995	Rapid Creek, McKie	Instream fish habitat
1996	Deerfield Valves	Castle Creek winter flow enhancement
	French Creek	Instream fish habitat
	Galena Creek	Stream channel relocation
	Spearfish Creek, Painter	Instream fish habitat
	Rapid Creek, O'Brien	Instream fish habitat
1997	Pactola Basin	Holding cover
	Spearfish Creek	Bank work, instream fish structure
1999	Pactola Basin	Fish passage
	Spearfish Creek, Maurice	Instream fish habitat repair
	Spring Creek, Hill City Park	Instream fish habitat and riparian zone
2001	Castle Creek	Riparian zone protection
2002	Grace Coolidge Creek	Structure repair, removal
	Rapid Creek in Rapid City	Holding cover, fish passage
2003	Castle and Rapid creeks	Willow plantings
	Grace Coolidge Creek	Sediment removal
	Spearfish Creek, Savoy	Culvert, water right
2005	Little Spearfish Creek	Rehabilitate old weir
2007	Savoy intake rehabilitation/rapids	Rehabilitate old weir, rapids on Spearfish Creek

A timeline of catchable-trout stockings in Rapid Creek, a major Black Hills stream, from 1990 to 2020 illustrates the relationship between fish habitat projects and declines in stream stocking. Instream fish habitat projects on Rapid Creek occurred in 1992, 1995, 1996, 2002, and 2003. The trend in the stocking numbers in Rapid Creek mirrors the overall steep decline in Black Hills stream stocking after 1990. More specifically, stocking decreases in Rapid Creek directly followed the first instream fish habitat project in 1992, dropping from 15,937 fish in 1992 to 7,580 in 1993. In 2007, 4 years after the last instream fish habitat project on Rapid Creek, Cleghorn Springs State Fish Hatchery was shut down for renovation. Rapid Creek stocking numbers dropped further and then persisted at an even lower level. By the late 2010s, stocking numbers had decreased by over 95% from 1990 levels (Figure 9).

Native Fish Ecology

> Only 15 species of fish were secured, and no other species has ever been reported from any definite locality of this region. The 15 species known from the Black Hills represent but 4 families, viz, 2 catfishes, 4 suckers, 8 cyprinoids and one member of the codfish family. Not a single species of spiny-rayed fish has ever been found in any of the streams in or about the Hills….
>
> (From Evermann and Cox 1896)

In the 21st century, increasing attention has been given nationally to the potentially negative effects on native species from the stocking of nonnative game fish (Knapp et al. 2001; Cambray 2003). Globally, the stocking of salmonids has been especially problematic for native fish biodiversity (Aas et al. 2018), leading to calls for the cessation of such programs in many localities (Crawford and Muir 2008).

Native fish populations in Black Hills streams have received considerable research attention in the past 20 years (Isaak et al. 2003; Schultz et al. 2012). Studies have improved our understanding of native species, such as the Mountain Sucker (conservation assessment: Isaak et al. 2003; factors affecting distribution: Dauwalter and Rahel 2008; Schultz et al. 2016; Fopma 2020; trends in distribution and abundance: Schultz and Bertrand 2012; age, growth, and maturation: Breeggemann et al. 2014; genetic structure: Bertrand et al. 2016; movements and public perception; Fopma 2020), and cyprinids, such as the Finescale Dace *Chrosomus neogaeus* and Lake Chub (conservation assessment: Isaak et al. 2003).

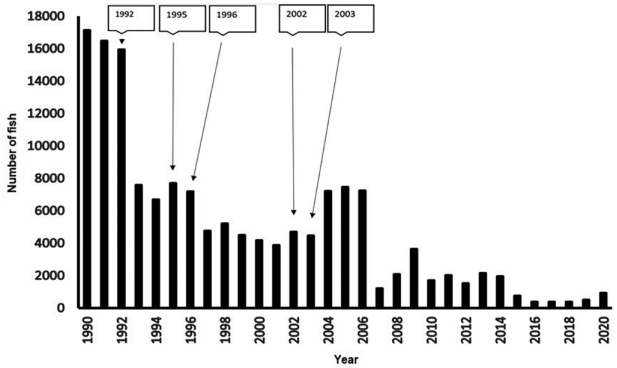


Figure 9. Total number of catchable-sized trout stocked in Rapid Creek within the Black Hills region, South Dakota, from 1990 to 2020, overlaid with completed fish habitat projects.

One manifestation of more recent interest in native nongame species is increased effort toward understanding whether and how the presence, absence, or abundance of nonnative trout influences the native fish populations. In the Black Hills, Schultz and Bertrand (2012) identified declines in the abundance of Mountain Sucker over a 50-year period (1960–2010) at reach, stream, and watershed scales; Mountain Sucker occupy less than half of their historical range (Bertrand et al. 2016). Brown Trout, the dominant trout in the Black Hills, is a globally popular sport fish and is also recognized as one of the world's most invasive fish species (Budy and Gaeta 2017). In the Black Hills, the presence of Mountain Sucker has been shown to be negatively related to the presence of Brown Trout greater than 20 cm long (Dauwalter and Rahel 2008). A similar negative relationship between trout abundance and Mountain Sucker occurrence was reported by Schultz et al. (2016). The extent to which sucker–trout interactions have directly affected Mountain Sucker distribution and abundance in various streams is not known; mechanisms for the observed interaction in the Black Hills are not yet clear. G. W. Rowles, S. J. Fompa, J. L. Davis, K. N. Bertrand, and D. B. Graeb (South Dakota State University, unpublished data) found little direct predation of Brown Trout on Mountain Sucker. In a broader community assessment, Schultz et al. (2012) suggested that distributions of native and introduced fishes appeared to be nonoverlapping across many of the reaches sampled, particularly in altered habitats. A future challenge may be to better understand the sucker–trout relationship not just in the context of the present situation, but also in the context of how it changes under climatic and other habitat changes. No studies have examined the potential effects of trout or stocking on Lake Chub and Finescale Dace, although both native species have declined essentially to extirpation in lotic Black Hills habitats (Isaak et al. 2003).

Stream stocking of trout in the Black Hills has been influenced by some highly unusual circumstances. The lack of native trout in the Black Hills *and* the lack of game fish status for native species (Evermann and Cox 1896) have allowed trout stocking and naturalization to proceed relatively unimpeded. Nationally, waters *with native salmonids* are often the focus of advocacy efforts directed toward the preservation of the native species or stocks. This, in turn, has tempered enthusiasm for nonnative introductions and has often led to removal efforts (Fausch 2008; Trushenski et al. 2010; Hansen et al. 2019). In many cases, native nongame species can also incidentally benefit from the suppression or removal of nonnative salmonids. In the Black Hills, however, no such native salmonid-centric resistance to nonnative species was present. Native fish of the Black Hills are typically small and of little interest to the public as sport fish. The Creek Chub—the only native species registering as having any sport value at all (Longmire 2015)—was less than one-tenth as popular as all three stream trout species. The Creek Chub is much better known as a bait species (Dinsmore 1962) and a trademark name for lures designed to catch game fishes, including trout (Smith 1997). In addition to being of little interest to anglers, native Black Hills fishes constitute a depauperate array of relict or marginal populations or stocks that can be viewed ecologically as "island" fauna. Like other depauperate island fauna (e.g., McDowall 1968), they may show additional disadvantages from competition and predation due to nonnative introductions (MacArthur 1965; Fopma 2020).

In other localities, fisheries activities to protect and enhance native species—especially game species but also species traditionally classified as native nongame species—are becoming more widespread in the United States (Rypel et al. 2021; Scarnecchia et al. 2021). In many cases, fisheries have developed (angling, spearing, bowfishing, and microfishing) for these nongame species, prompting calls for reclassification of species as sport fish and more consideration for their sustainable management. The Black Hills region has lagged in this trend. Recently, however, there has been an assessment of the public perceptions regarding the importance and value of native species. Fopma (2020) queried the public on their receptiveness to managing some waters for maintenance of the native Mountain Sucker and found support for such an effort among persons classified as conservationists but less support among those who were more utilitarian in orientation (i.e., fish are to be used for food, sport, etc.). Management, however, has continued to focus on the much more obvious and quantifiable benefits of nonnative salmonids for sportfishing. The unusual historical circumstances in the Black Hills provide one test case and some insight into just how much or how little concern there may be in various localities nationwide for native species inhabiting waters that are highly amenable to game fishes if none of the natives are of sporting interest to anglers or listed as endangered species. Other factors, such as potential effects of introduced salmonids on other aquatic biota (e.g., invertebrates and amphibians), have received even less public interest and research attention (Pope 2008; Alexiades and Kraft 2017).

Aquatic Invasive Species Management and Other Factors

Aquatic invasive species represent another area of rising prominence affecting trout management (Burgess and Bertrand 2008). The diatom *Didymosphenia geminata* became established in Rapid Creek (SDGFP 2020). Other nonnative aquatic species in the Black Hills include the Rudd *Scardinius erythrophthalmus*, Jack Dempsey *Rocio octofasciata*, curly-leaf pondweed *Potamogeton crispus*, red-rimmed melania *Melanoides tuberculata*, and New Zealand mud snail *Potamopyrgus antipodarum*, identified in Beaver Creek in 2019 (SDGFP 2020). Aquatic invasive species have had no discernible impact thus far, however, on Black Hills stream trout populations or catchable-trout stocking decisions.

The American mink *Mustela vison*, a native mammalian species, was observed by Davis et al. (2016) to prey on both stocked and naturalized Brown Trout. However, the predation had negligible impacts on stream trout numbers (Davis et al. 2016).

SUMMARY AND LOOKING AHEAD

> Silver is not a good adjective to describe what I felt when he told me about trout fishing …. Maybe trout steel. Steel made from trout. The clear snow-filled river acting as foundry and heat …. A steel that comes from trout, used to make buildings, trains and tunnels ….
>
> (From Brautigan 1969)

> Although fisheries managers have gone to great lengths in recent decades to emphasize the idea that fish stocking is a tool, not a panacea, the fact remains that it is still one of the largest and most important activities in which fisheries managers engage.
>
> (From Halverson 2008)

The evolution of stream fisheries management in the Black Hills has taken a course similar to that taken by other areas of the United States (e.g., Wyoming: Wiley et al. 1993; Rahel 2016; California: Lentz and Clifford 2014), albeit with some differences and lags in timing. In California (Lentz and Clifford 2014) and Wyoming, what Rahel (2016) called "sustenance fishing" was a strong early interest, whereas early emphasis in the Black Hills was on trout fishing as a recreational activity for residents and tourists (Julin 2009). In each place, hatcheries and stocking of fry, fingerlings, and, increasingly, catchable-sized trout played a significant role and did so over much the same time frame in all of these localities. In all localities, increased recent emphasis has been given to native stocks and the importance of biodiversity.

In the Black Hills and elsewhere (except perhaps in the most inhospitable localities), fish culture, whether for mitigation, food, or aesthetics, has long inspired human interest. Fish culture and stocking have always preceded—rather than followed—science-based fisheries management and meaningful scientific regulation of wild populations. Even the American Fisheries Society was first the American Fish Cultural Association (Moffitt et al. 2010). By the 1870s and 1880s, when Europeans were exploring the Black Hills for gold, fish culture already had a long history dating back millennia (Balon 1995; Nakajima et al. 2019). Meanwhile, ecology, the importance of habitat quality, and scientific fisheries management were concepts still in their infancy. In 1857, George Perkins Marsh, whose book *Man and Nature* (1864) led him to be called America's first environmentalist, even found fish stocking to be a potentially easier environmental fix to Vermont's depleted fisheries than more complex multijurisdictional regulation (Allard, Jr. 1978). Spencer Fullerton Baird, the first U.S. Commissioner of Fish and Fisheries, focused agency work starting in 1872 on fish culture techniques, including methods that had been developed for trout in France two decades earlier (Gehin 1854; Garlick 1857; Allard, Jr. 1978). As described by Lichatowich (1999) in *Salmon Without Rivers*,

> The fundamental goals of dominating, controlling, and manipulating nature for human use were deeply imbedded in western culture. Hatcheries provided the perfect vehicle for ordering and controlling the aquatic realm.

Richard Brautigan's (Brautigan 1969) paradoxical metaphor relating trout to steel in *Trout Fishing in America* was interpreted by Raglon (n.d.) as "Trout can now only be understood by using the technological lens of the industrialized world," and the industrialized world is one of business (Sugai 2017), including tourism and the infrastructure needed for it. The emphasis was pastoral rather than wilderness, with "pastoral" implying that "nature should be conquered and reconstructed by human innovation, nature molded to human desires and pleasures" (Sugai 2017). As mythically wild and natural as trout appear to successive generations of anglers, their presence in the Black Hills has technological, industrial, and, ultimately, business origins. Early trout management emphasis in the Black Hills and nationally was on fish stocking instead of on the nascent, poorly developed disciplines, such as stream ecology, habitat management, and life history-based fishery regulation. Consequently, rather than stocking being one of many potentially useful tools for fisheries managers, in the Black Hills and elsewhere stocking was the dominant manifestation of a world view, a technology-based ideology that was *leading and directing* fisheries management decisions rather than *supporting* them. Juvenile trout stocking in the Black Hills preceded a meaningful understanding of stream ecology and habitat evaluations. The stocking of catchable trout in Black Hills streams had meager beginnings, but expanded rapidly as hatchery capacity increased and as fish rearing technologies improved. What Whelan (2004) called the "instant fishery era" (1950–1964) of catchable-trout releases in Michigan paralleled the expansion of catchable-trout stocking in the Black Hills (with catchable trout peaking over the period 1954–1964).

Later (in the mid-1990s), when ecological knowledge improved, catchable-trout stocking in the Black Hills decreased, with an ideological shift away from a purely technological approach to a more ecological, natural, and holistic approach to fisheries management. Staffing changes of managers with evolving philosophies obviously played a major factor in stocking reductions. The focus on natural reproduction, habitat improvements, and angler requests for catch-and-release regulations relegated stocking to a still-important but much more supporting role to ecological considerations in Black Hills stream fisheries management.

Meanwhile, Black Hills hatcheries continue to supply more trout to an ever-increasing angler base, although stocking efforts have shifted from streams to ponds, lakes, and reservoirs. Current stockings in streams are restricted to areas with nonexistent natural reproduction and poor water quality (e.g., iron bogs, periodic dewatering, high temperatures, etc.). Widespread faith in and support for the hatcheries that developed Black Hills stream fisheries persist among most managers and the public, and fish stocking in the Black Hills continues to have a major economic impact (Martling et al. 2020).

In 2023, Black Hills trout fishing, like Mount Rushmore, remains a valuable human-created attraction for tourists and nontourists alike. Trout, as always, seem to be what anglers want. Longmire (2015) reported that among Black Hills stream anglers, the most preferred species was Brown Trout (42%)—appropriately a transplant with origins in Europe like many of the anglers fishing for them. Rainbow Trout (29.4%) and Brook Trout (23.7%) were ranked next, with no other species scoring over 2.3%. Fly fishing is the preferred angling method in streams (52%), followed by spinning/casting/lures (25%) and organic bait (23%). Angler satisfaction continues to drive management goals, and efforts to meet those goals are being exceeded (Henderson and Gigliotti 2015). The fisheries management plan for Black Hills streams (Galinat et al. 2015) involves a wide array of activities, including classification of trout streams for the purposes of determining stocking requirements (if any); fish stocking (if justified); regulations; fish surveys for assessing growth, recruitment, and mortality; angler surveys for assessing catch and satisfaction; habitat and angler access efforts; research; aquatic invasive species issues; and fish health. In the current, more complex philosophy, it is difficult to visualize any major *reductions* or major *increases* in the current stocking of catchable trout in Black Hills streams. Stream management and stocking are now more ecologically based and still trout-centric, whereas lake stocking has become the main stocking outlet for catchable trout and can more easily supply more immediate angler (resident and tourist) demands for more harvestable fish (Simpson et al. 2015).

Looking back, the evolution of fisheries management in the Black Hills can be *seen* indirectly in state agency historical documents, including hatchery archives and stocking

records. However, this evolution, as evidenced from the first trout introductions, hatchery developments, and stocking of fry and catchable trout, can best be *understood* as modest corollaries of broader ideological trends driving predominant American settlement and development over the past century and a half. The cultural ideology that brought western expansion of settlers to the scenic and timeless Black Hills in search of gold, land, freedom, and prosperity was emboldened by a science-based belief and confidence in technology applied to agriculture, forestry, mining, and other industries to rapidly shape lands and waters to improve the human condition. To many visitors, the sculpting and shaping of Mount Rushmore boldly symbolize that ideology (Fite 1952). In the context of Black Hills fisheries management, the introduction of trout, development of stream fisheries, and investment in hatchery technology to produce catchable trout for an expanding tourist economy also exemplify that prevailing ideology, with all of its past and current visions and its accomplishments as well as some ambiguities, challenges, and consequences. In the Black Hills, as elsewhere, much of this activity has been conducted in the past and even occurs in the present, in implicit agreement with that ideology, without more detailed articulation of the ethics, values, and ecology of introducing new fishes versus maintaining and restoring the native species (Scarnecchia 1988; Pister 1995). Fisheries management in the Black Hills is now conducted with greater ecological understanding, appreciation, and recognition of native species. Management, however, continues to proceed, very strongly focused on trout, using technology combined with an increasing ecological understanding to fulfill the visions and observations of Ludlow (1875), Evermann and Cox (1896), and countless other trout anglers that followed. As fly fishing expert and author Joe Brooks (1972) described it,

> These are the rewards of trout fishing. You are far from the grinding clash of traffic, the fumes of civilization. Your mind is completely engrossed in the problem at hand—how to hook that trout. You are far, far away from the tensions of earning a living. No one has as much fun as a trout fisherman.

Management of the trout and the Black Hills streams proceeds in an era of increasingly sophisticated recreation, rapid technological change, cultural (Sundstrom 1997) and habitat changes, challenges to maintaining native species diversity (Fopma 2020), climate change (Fontaine et al. 2001), and many other known and unknown future challenges.

ACKNOWLEDGMENTS

We thank the anonymous reviewers for their comments. There is no conflict of interest declared in this article.

ORCID

Michael Barnes https://orcid.org/0000-0001-9084-700X

REFERENCES

Aas, Ø., J. Cucherousset, I. A. Fleming, C. Wolter, J. Höjesjö, M. Buoro, F. Santoul, J. I. Johnsson, K. Hindar, and R. Arlinghaus. 2018. Salmonid stocking in five North Atlantic jurisdictions: identifying drivers and barriers to policy change. Aquatic Conservation: Marine and Freshwater Ecosystems 28:1451–1464.

Alexiades, A. V., and C. E. Kraft. 2017. Effects of stocked trout on stream invertebrate communities. Journal of Freshwater Ecology 32:95–102.

Allard, D. C., Jr. 1978. Spencer Fullerton Baird and the U.S. Fish Commission. Arno Press, New York.

Arlinghaus, R., S. J. Cooke, J. Lyman, D. Policansky, A. Schwab, C. Suski, S. G. Sutton, and E. B. Thorstad. 2007. Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives. Reviews in Fisheries Science 15:75–167.

Backlund, D. C., and J. S. Shearer. 2007. Threatened and endangered species. Pages 239–252 *in* C. R. Berry, Jr., K. F. Higgins, D. W. Willis, and S. R. Chipps, editors. History of fisheries and fishing in South Dakota. South Dakota Department of Game, Fish and Parks, Pierre.

Bailey, R. M., and M. O. Allum. 1962. Fishes of South Dakota. University of Michigan, Museum of Zoology, Ann Arbor.

Balon, E. K. 1995. Origin and domestication of the wild carp, *Cyprinus carpio*: from Roman gourmets to the swimming flowers. Aquaculture 129:3–48.

Barnes, M. E. 2007. Fish hatcheries and stocking practices: past and present. Pages 267–293 *in* C. R. Berry, Jr., K. F. Higgins, D. W. Willis, and S. R. Chipps, editors. History of fisheries and fishing in South Dakota. South Dakota Department of Game, Fish and Parks, Pierre.

Barnhart, R. A., and T. D. Roelofs, editors. 1977. Catch-and-release as a fishery management tool: a national sport fishing symposium, September 7–8, 1977. Humboldt State University, Arcata, California.

Barnhart, R. A., and T. D. Roelofs, editors. 1987. Catch-and-release fishing, a decade of experience: a national sport fishing symposium, September 1–October 1, 1987. Humboldt State University, Arcata, California.

Behnke, R. 2002. Trout and salmon of North America. Free Press, New York.

Bertrand, K. N., J. A. VanDeHay, T. J. Pilger, E. A. Felts, and T. F. Turner. 2016. Genetic structure of a disjunct population of Mountain Sucker *Pantosteus jordani* in the Black Hills, South Dakota. Conservation Genetics 17:775–784.

Billington, R. A. 1967. Westward expansion: a history of the American frontier, 3rd edition. MacMillan, New York.

Birkes, F. 1990. Native subsistence fisheries. Arctic 43:35–42.

Booth, D. C. 1912. Fish culture of the Black Hills. The Pahasapa Quarterly 1:13–17.

Booth, D. C. 1925. Some observations on fish culture. Transactions of the American Fisheries Society 55:161–166.

Bouchard, M. A., and K. F. Higgins. 2007. Fisheries research and monitoring. Pages 397–414 *in* C. R. Berry, Jr., K. F. Higgins, D. W. Willis, and S. R. Chipps, editors. History of fisheries and fishing in South Dakota. South Dakota Department of Game, Fish and Parks, Pierre.

Bowen, J. T. 1970. A history of fish culture as related to the development of fishery programs. Pages 71–93 *in* N. G. Benson, editor. A century of fisheries in North America. American Fisheries Society, Special Publication 7, Bethesda, Maryland.

Brautigan, R. 1969. Trout fishing in America. Delta, New York.

Breeggemann, J. J., C. Hayer, J. Krause, L. D. Schultz, K. N. Bertrand, and B. D. S. Graeb. 2014. Estimating the ages of Mountain Sucker *Catostomus platyrhynchus* from the Black Hills: precision, maturation and growth. Western North American Naturalist 74:299–310.

Brooks, J. 1972. Trout fishing. Harper and Row, New York.

Brown, J. C. 2014. Trash fish: native fish species in a Rocky Mountain trout culture. Western Historical Quarterly 45:37–58.

Brownscombe, J. W., A. J. Danylchuk, J. M. Chapman, L. F. Gutowsky, and S. J. Cooke. 2017. Best practices for catch-and-release recreational fisheries—angling tools and tactics. Fisheries Research 186:693–705.

Budy, P., and J. W. Gaeta. 2017. Brown Trout as an invader: a synthesis of problems and perspectives in North America. Pages 523–543 *in* J. Lobón-Cerviá and N. Sanz, editors. Brown Trout: biology, ecology and management. John Wiley and Sons, Hoboken, New Jersey.

Burgess, A., and K. Bertrand. 2008. State of South Dakota aquatic nuisance species management plan. State of South Dakota, Pierre.

Butler, R. L., and D. P. Borgeson. 1965. California "catchable" trout fisheries. California Department of Fish and Game, Fish Bulletin 127, Sacramento.

Cambray, J. A. 2003. Impacts on indigenous species biodiversity caused by the globalization of alien recreational freshwater species. Hydrobiologia 500:217–230.

Carter, J. M., D. G. Driscoll, and J. E. Williamson. 2002. The Black Hills hydrology study. U.S. Geological Survey, Fact Sheet FS-046-02, Rapid City, South Dakota.

Clow, R. L. 1992. Timber users, timber savers: Homestake Mining Company and the first regulated timber harvest. South Dakota History 22:213–227.
Cooper, E. L. 1970. Management of trout streams. Pages 153–162 *in* N. G. Benson, editor. A century of fisheries in North America. American Fisheries Society, Bethesda, Maryland.
Cordes, R. 2007. Cold-water fish species. Pages 201–211 *in* C. R. Berry, Jr., K. F. Higgins, D. W. Willis, and S. R. Chipps, editors. History of fisheries and fishing in South Dakota. South Dakota Department of Game, Fish and Parks, Pierre.
Crawford, S. S., and A. M. Muir. 2008. Global introductions of salmon and trout in the genus *Oncorhynchus*: 1870–2007. Reviews in Fish Biology and Fisheries 18:313–344.
Dauwalter, D. C., and F. J. Rahel. 2008. Distribution modelling to guide stream fish conservation: an example using the Mountain Sucker in the Black Hills National Forest, USA. Aquatic Conservation: Marine and Freshwater Ecosystems 18:1263–1276.
Davis, J. L., J. W. Wilhite, and S. R. Chipps. 2016. Mink predation of Brown Trout in a Black Hills stream. Prairie Naturalist 48:4–10.
Dieterman, D. J., R. J. H. Hoxmeier, J. Roloff, and D. F. Staples. 2020. Use of long-term (40+ year) trend data to evaluate management actions on Brown Trout, *Salmo trutta*, populations in groundwater-fed streams. Fisheries Management and Ecology 27:551–556.
Dinsmore, J. J. 1962. Life history of the Creek Chub, with emphasis on growth. Proceedings of the Iowa Academy of Science 69:296–301.
Dobson, D. 2013. Manifest Destiny and the environmental impacts of westward expansion. Flinders Journal of History and Politics 29:41–69.
Dodge, R. I. 1876. The Black Hills: a minute description of the routes, scenery, soil, climate, timber, gold, geology, zoölogy, etc. James Miller, New York.
Epifanio, J. 2000. The status of coldwater fishery management in the United States: an overview of state programs. Fisheries 25(7):13–27.
Erickson, J., R. Koth, and L. Vanderbush. 1993. Black Hills streams management plan. South Dakota Department of Game, Fish and Parks, Federal Aid in Sport Fish Restoration, Project F-21-R-26, Job 1, Pierre.
Evans-Hatch, G., and M. Evans-Hatch. 2006. Establishing roots; harvesting resources. Pages 93–116 *in* Place of passages: Jewel Cave National Monument historic resource study. National Park Service, Midwestern Region, Omaha, Nebraska.
Evermann, B. 1893. The ichthyologic features of the Black Hills region. Proceedings of the Indiana Academy of Science 1893:73–78.
Evermann, B. W., and U. O. Cox. 1896. Report upon the fishes of the Missouri River basin. Pages 325–349 *in* Report of the U.S. Commissioner of Fish and Fisheries for the fiscal year ending June 30, 1894. U.S. Government Printing Office, Washington, D.C.
Fausch, K. D. 2008. A paradox of trout invasions in North America. Biological Invasions 10:685–701.
Fish, F. F. 1940. An evaluation of trout culture. Transactions of the American Fisheries Society 69:85–89.
Fite, G. C. 1952. Mount Rushmore. University of Oklahoma Press, Norman.
Foerster, R. E. 1938. An investigation of the relative efficiencies of natural and artificial propagation of Sockeye Salmon (*Oncorhynchus nerka*) at Cultus Lake, British Columbia. Journal of the Fisheries Research Board of Canada 4:151–161.
Fontaine, T. A., J. F. Klassen, T. S. Cruickshank, and R. H. Hotchkiss. 2001. Hydrological response to climate change in the Black Hills of South Dakota, USA. Hydrological Sciences Journal 46:27–40.
Fopma, S. P. 2020. Distribution, density, movement, and support for management of Mountain Sucker, *Pantosteus jordani*, in the Black Hills of South Dakota. Doctoral dissertation. South Dakota State University, Brookings.
Ford, R. C. 1985. Black Hills stream inventory and classification. South Dakota Department of Game, Fish and Parks, Report 88-1, Pierre.
Galinat, G., B. Miller, M. Bucholz, D. Jones, G. Simpson, J. Davis, J. Carreiro, and S. Michals. 2015. Fisheries management plan for Black Hills streams, 2015–2019. South Dakota Department of Game, Fish and Parks, Pierre.
Garlick, T. 1857. A treatise on the artificial propagation of certain kinds of fish with description of the habits of such kinds as are the most suitable for pisciculture. Tho. Brown, Cleveland, Ohio.
Gehin, M. 1854. Treatise on the artificial fecundation and incubation of the eggs of fish. Edited and translated by W. H. Fry. D. Appleton and Company, New York.
Gunther, E. 1926. An analysis of the first salmon ceremony. American Anthropologist 28:605–617.
Gunther, E. 1928. A further analysis of the first salmon ceremony. University of Washington Publications in Anthropology 2:135–173.
Halverson, A. 2008. Stocking trends: a quantitative review of governmental fish stocking in the United States, 1931 to 2004. Fisheries 33:69–75.
Halverson, A. 2010. An entirely synthetic fish: how Rainbow Trout beguiled America and overran the world. Yale University Press, New Haven, Connecticut.
Hämäläinen, P. 2003. The rise and fall of Plains Indian horse cultures. Journal of American History 90:833–862.
Hansen, M. J., C. S. Guy, P. Budy, and T. E. McMahon. 2019. Trout as native and nonnative species: a management paradox. Pages 645–684 *in* J. L. Kershner, J. E. Williams, R. E. Gresswell, and J. Lobón-Cerviá, editors. Trout and char of the world. American Fisheries Society, Bethesda, Maryland.
Hartzler, J. R. 1988. Catchable trout fisheries: the need for assessment. Fisheries 13(2):2–8.
Henderson, K. R., and L. M. Gigliotti. 2015. Angler satisfaction in South Dakota. Proceedings of the South Dakota Academy of Science 94:171–186.
Henris, J. R. 2015. "No finer trout streams in the world than these": the making of a recreational fishery in the Black Hills Forest Reserve. South Dakota History 45:275–304.
Hilborn, R. 1992. Can fisheries agencies learn from experience? Fisheries 17(4):6–14.
Hublou, W. F., J. Wallis, T. B. McKee, D. K. Law, R. O. Sinnhuber, and T. C. Yu. 1959. Development of the Oregon Pellet diet. Fish Commission of Oregon Research Briefs 7:28–57.
Hyman, A. A., S. L. McMullin, and V. DiCenzo. 2016. Dispelling assumptions about stocked-trout fisheries and angler satisfaction. North American Journal of Fisheries Management 36:1395–1404.
Isaak, D. J., W. A. Hubert, and C. R. Berry, Jr. 2003. Conservation assessment for Lake Chub, Mountain Sucker, and Finescale Dace in the Black Hills National Forest, South Dakota and Wyoming. U.S. Forest Service, Custer, South Dakota.
Jensen, K. C. 2007. Fishing in South Dakota: reservations and tribal lands. Pages 383–396 *in* C. R. Berry, Jr., K. F. Higgins, D. W. Willis, and S. R. Chipps, editors. History of fisheries and fishing in South Dakota. South Dakota Department of Game, Fish and Parks, Pierre.
Johnson, D. M., R. J. Behnke, D. A. Harpman, and R. G. Walsh. 1995. Economic benefits and costs of stocking catchable Rainbow Trout: a synthesis of economic analysis in Colorado. North American Journal of Fisheries Management 15:26–32.
Julin, S. B. 2001. Public enterprise: politics, policy, and tourism development in the Black Hills through 1941. Doctoral dissertation. Washington State University, Pullman.
Julin, S. B. 2005. Building a vacationland: tourism development in the Black Hills during the Great Depression. South Dakota History 35:291–315.
Julin, S. B. 2009. A marvelous hundred square miles: Black Hills tourism, 1880–1941. South Dakota State Historical Society Press, Pierre.
Kershner, J. L., J. E. Williams, R. E. Gresswell, and J. Lobón-Cerviá, editors. 2019. Trout and char of the world. American Fisheries Society, Bethesda, Maryland.
Ketelsen, B., G. Simpson, and M. E. Barnes. 2017. Trout redd locations in two streams in the Black Hills, South Dakota, USA. Natural Resources 8:94–102.
King, W. 1952. The first year of Federal Aid in Fish Restoration. The Progressive Fish-Culturist 14:135–147.
Kinsella, S. 2000. Trout fishing in the Black Hills: a guide to the lakes and streams of the Black Hills of South Dakota and Wyoming. Highweather Press, St. Paul, Minnesota.
Knapp, R. A., P. S. Corn, and D. E. Schindler. 2001. The introduction of nonnative fish into wilderness lakes: good intentions, conflicting mandates, and unintended consequences. Ecosystems 4:275–278.
Koth, R. 1995. Game, Fish and Parks streams program. Pages 26–27 *in* C. L. Milewski, C. R. Berry, and S. Wyman, editors. Watershed management workshop for the James, Vermillion, and Big Sioux rivers. South Dakota State University, Agricultural Experiment Station, Research Bulletin 720, Brookings.
Koth, R. 2007. Past and present Black Hills water resources. Pages 135–150 *in* C. R. Berry, Jr., K. F. Higgins, D. W. Willis, and S. R. Chipps,

editors. History of fisheries and fishing in South Dakota. South Dakota Department of Game, Fish and Parks, Pierre.
Langlois, T. H. 1942. Fish-stocking policies and programs. Transactions of the American Fisheries Society 71:343–370.
Lentz, D. C., and M. A. Clifford. 2014. A synopsis of recent history of California's inland trout management programs: litigation and legislation. California Fish and Game 100:727–739.
Lichatowich, J. 1999. Salmon without rivers. Island Press, Washington, D.C.
Longmire, C. L. 2015. Black Hills fishery management: 2014 angler opinion survey results. South Dakota Department of Game, Fish and Parks, Pierre.
Lucas, C. R. 1939. Game fish management. Transactions of the American Fisheries Society 368:67–75.
Ludlow, W. 1875. Reconnaissance of the Black Hills of Dakota, made in the summer of 1874. U.S. Government Printing Office, Washington, D.C.
Lyach, R. 2020. The effects of fisheries management on harvest rates of native and non-native salmonid species. Journal of Applied Ichthyology 36:298–314.
MacArthur, R. H. 1965. Patterns of species diversity. Annual Review of Ecology and Systematics 40:510–533.
Mahon, R., and P. McConney. 2004. Managing the managers: improving the structure and operation of small fisheries departments, especially the SIDS. Ocean and Coastal Management 47:529–535.
Marsh, G. P. 1864. Man and Nature, or physical geography as modified by human action. 1965 reprint. Belknap (Harvard) University Press, Cambridge, Massachusetts.
Marshall, A. G. 2006. Fish, water, and Nez Perce life. Idaho Law Review 42:763–794.
Martling, S., B. Fletcher, and M. E. Barnes. 2020. Economic impact of Cleghorn Springs State Fish Hatchery, Rapid City, South Dakota, USA. Modern Economy 11:1351–1358.
Maxwell, J. M. 1958. Advance in use of pelleted trout food. The Progressive Fish-Culturist 20:182.
May, R. H. 1977. A tribute to Roderick L. Haig-Brown. Pages 3–6 *in* R. A. Barnhart and T. D. Roelofs, editors. Catch-and-release fishing as a management tool: a national sport fishing symposium, September 7–8, 1977. Humboldt State University, Arcata, California.
McAndrews, E. 1969. Custer's engineer—William Ludlow. Society of American Military Engineers 61:200–202.
McDowall, R. M. 1968. Interactions of the native and alien faunas of New Zealand and the problem of fish introductions. Transactions of the American Fisheries Society 97:1–11.
Meehan, W. R. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Special Publication 19, Bethesda, Maryland.
Meyer, K. A., B. High, and S. Elle. 2012. Effects of stocking catchable-sized hatchery Rainbow Trout on wild Rainbow Trout abundance, survival, growth and recruitment. Transactions of the American Fisheries Society 141:224–237.
Moffitt, C. M., G. Whelan, and R. Jackson. 2010. Historical perspectives on inland fisheries management in North America. Pages 1–41 *in* W. A. Hubert and M. C. Quist, editors. Inland fisheries management in North America, 3rd edition. American Fisheries Society, Bethesda, Maryland.
Nakajima, T., M. J. Hudson, J. Uchiyama, K. Makibayashi, and J. Zhang. 2019. Common Carp aquaculture in neolithic China dates back 8,000 years. Nature, Ecology and Evolution 3:1415–1418.
Olson, D. E. 1963. Role of White Sucker in Minnesota waters. Journal of the Minnesota Academy of Science 31:68–73.
Parker, W. 1981. Booming the Black Hills. South Dakota History 11:35–52.
Parris, D. C., G. A. Bishop, and K. F. Higgins. 2007. Prehistoric fishes and fishing in South Dakota. Pages 19–36 *in* C. R. Berry, Jr., K. F. Higgins, D. W. Willis, and S. R. Chipps, editors. History of fisheries and fishing in South Dakota. South Dakota Department of Game, Fish and Parks, Pierre.
Parrish, J. B., D. J. Herman, D. J. Reyher, and F. R. Gartner. 1996. A century of change in the Black Hills and riparian ecosystems. South Dakota State University, Agricultural Experiment Station, Research Bulletin 722, Brookings.
Pister, E. P. 1995. Ethics of native species restoration: the Great Lakes. Journal of Great Lakes Research 21(Supplement 1):10–16.
Pope, K. L. 2008. Assessing changes in amphibian population dynamics following experimental manipulations of introduced fish. Conservation Biology 22:1572–1581.
Radonski, G. C. 2000. History of the Federal Aid in Sport Fish Restoration Program. Special Supplement to Fisheries 25:S37–S45.
Raglon, R. n.d. The trout steel koan: Richard Brautigan's *Trout Fishing in America*. Department of English/Foundations Program, University of British Columbia, Vancouver.
Rahel, F. J. 2016. Changing philosophies of fisheries management as illustrated by the history of fishing regulations in Wyoming. Fisheries 41:38–48.
Rau, C. 1884. Prehistoric fishing in Europe and North America. Smithsonian Institution, Washington, D.C.
Rehm, T. R., S. R. Chipps, and J. L. Davis. 2020. Effects of density reduction on age-specific growth of stream-dwelling Brown Trout. North American Journal of Fisheries Management 40:1355–1366.
Rostlund, E. 1952. Freshwater fish and fishing in native North America. University of California, Publications on Geography 9, Berkeley.
Rypel, A. L., P. Saffarinia, C. C. Vaughn, L. Nesper, K. O'Reilly, C. A. Parisek, M. L. Miller, P. B. Moyle, N. A. Fangue, M. Bell-Tilcock, D. Ayers, and S. R. David. 2021. Goodbye to "rough fish": paradigm shift in the conservation of native fishes. Fisheries 46:605–616.
Scarnecchia, D. L. 1988. Salmon management and the search for values. Canadian Journal of Fisheries and Aquatic Sciences 45:2042–2050.
Scarnecchia, D. L., J. D. Schooley, A. R. Lackmann, S. J. Rider, D. K. Riecke, J. McMullen, J. E. Ganus, K. D. Steffensen, N. W. Kramer, and Z. R. Shattuck. 2021. The Sport Fish Restoration Program as a funding source to manage and monitor bowfishing and monitor inland commercial fisheries. Fisheries 46:595–604.
Schultz, L. D., and K. N. Bertrand. 2012. Long term trends and outlook for Mountain Sucker in the Black Hills of South Dakota. American Midland Naturalist 167:96–110.
Schultz, L. D., K. N. Bertrand, and B. D. S. Graeb. 2016. Factors from multiple scales influence the distribution and abundance of an imperiled fish – Mountain Sucker in the Black Hills of North Dakota. Environmental Biology of Fish 99:3–14.
Schultz, L. D., S. J. Lewis, and K. N. Bertrand. 2012. Fish assemblage structure in Black Hills, South Dakota streams. Prairie Naturalist 44:98–104.
Schumacher, R. E. 1958. Experimental feeding of a pelleted trout food to large fingerling and yearling Brook, Brown, and Rainbow trout, 1955–1956. The Progressive Fish-Culturist 20:51–57.
Shetter, D. S. 1947. Further results from spring and fall plantings of legal-sized, hatchery-reared trout in streams and lakes of Michigan. Transactions of the American Fisheries Society 74:35–58.
Shetter, D. S., and A. S. Hazzard. 1940. Results from plantings of marked trout of legal size in streams and lakes of Michigan. Transactions of the American Fisheries Society 70:446–468.
Shetter, D. S., and A. S. Hazzard. 1942. Planting "keeper trout". Michigan Conservation 11:3.
Simpson, G., B. Miller, M. Bucholz, D. Jones, G. Adams, G. Galinat, J. Davis, J. Carreiro, J. Lott, and M. Barnes. 2015. Fisheries management plan for Black Hills reservoirs, 2015–2019. South Dakota Department of Game, Fish and Parks, Pierre.
Smith, H. E. 1997. Collector's guide to Creek Chub: lures and collectibles. Collector Books, Paducah, Kentucky.
SDGFP (South Dakota Department of Game, Fish and Parks). 1959. Looking back over the past 50 years: annual report for 1959. SDGFP, Pierre.
SDGFP (South Dakota Department of Game, Fish and Parks). 2014. Fisheries and aquatic resources adaptive management system 2014–2018: Black Hills fisheries management area strategic plan. SDGFP, Wildlife Division, Pierre.
SDGFP (South Dakota Department of Game, Fish and Parks). 2015. Fisheries management plan for Black Hills streams. SDGFP, Pierre.
SDGFP (South Dakota Department of Game, Fish and Parks). 2020. Fisheries and aquatic resources adaptive management system. SDGFP, Pierre.
Stewart, R. K., and C. A. Thilenius. 1964. Stream and lake inventory and classification in the Black Hills of South Dakota. South Dakota Department of Game, Fish and Parks, Dingell–Johnson Project F-1-R-13, Jobs 14 and 15, Pierre.
Sugai, D. 2017. Pastoral as commodity: Brautigan's reinscription of Hemingway's trout fishing. Hemingway Review 36:112–123.
Sundstrom, L. 1997. The sacred Black Hills: an ethnohistorical review. Great Plains Quarterly 17:185–212.
Taylor, E. B., C.-A. Darveau, and P. M. Schulte. 2013. Setting conservation priorities in a widespread species: phylogeographic and

physiological variation in the Lake Chub, *Couesius plumbeus* (Pisces: Cyprinidae). Diversity 5:149–165.
Trushenski, J., T. Flagg, and C. H. Kohler. 2010. Use of hatchery fish for conservation, restoration, and enhancement of fisheries. Pages 261–293 *in* W. A. Hubert and M. C. Quist, editors. Inland fisheries management in North America, 3rd edition. American Fisheries Society, Bethesda, Maryland.
Tunison, A. V. 1957. Methods for determining the efficiency of production in the trout hatchery. The Progressive Fish-Culturist 19:51–57.
U.S. Fish and Wildlife Service. 1979. The fish car era of the National Fish Hatchery system. U.S. Government Printing Office, Washington, D.C.
USGS (U.S. Geological Survey). 1909. Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming. USGS Professional Paper 65. U.S. Government Printing Office, Washington, D.C.
Whelan, G. E. 2004. A historical perspective on the philosophy behind the use of propagated fish in fisheries management: Michigan's 130-year experience. Pages 307–315 *in* M. J. Nickum, P. M. Mazik, J. G. Nickum, and D. D. MacKinlay, editors. Propagated fish in resource management. American Fisheries Society, Symposium 44, Bethesda, Maryland.
White, R. 1991. "It's your misfortune and none of my own": a new history of the American West. University of Oklahoma Press, Norman.
Wiley, R. W., R. A. Whaley, J. B. Satake, and M. Fowden. 1993. Assessment of stocking hatchery trout: a Wyoming perspective. North American Journal of Fisheries Management 13:160–170.
Willoughby, H. 1953. Use of pellets as trout food. The Progressive Fish-Culturist 15:127–128.
Wood, E. M. 1953. A century of American fish culture, 1853–1953. The Progressive Fish-Culturist 15:147–162.

SUPPORTING INFORMATION

Additional supplemental material may be found online in the Supporting Information section at the end of the article.

Data S1. AFS