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Evaluation Of Trout Population Trends And Fisheries Management In The Bear Creek Watershed, Vernon And Monroe Counties, WI

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ABSTRACT

The Bear Creek Watershed in Monroe and Vernon Counties includes 178.9 miles of classified trout water. Substantial improvements in trout populations have occurred in these waters over the past three decades, the result of 75 years of land conservation work that has improved watershed hydrology (i.e., increased baseflow and decreased peak flow) and more recent efforts to improve in-stream and riparian stream habitat and stock wild strain trout.

In 2021, the Wisconsin Department of Natural Resources (DNR) Bureau of Fisheries Management sampled 58 sites on 35 streams in the watershed to evaluate the current status of trout populations. Naturally reproduced Brown Trout *Salmo trutta* were captured in all but three sites and at a mean catch rate that was in the top 25th percentile for the region.

Stocked and wild origin Brook Trout *Salvelinus fontinalis* were captured in 33 sites at densities below the median for the region and at one site in the absence of Brown Trout. We documented a significant increase in Brook and Brown Trout in the watershed between 1990 and 2021. However, Brook Trout densities have appeared to decline over the past decade. Brook Trout were generally more abundant in headwater reaches in the watershed and stocked fish contributed little to their overall relative abundance.

Brown Trout were prevalent throughout the watershed, but most abundant in mid-watershed sites. Larger Brown Trout were present in mid-watershed sites where habitat work had been completed and in the mainstem of the Kickapoo River. Catchable Brown Trout densities increased substantially in Weister Creek, relative to a nearby reference site, following habitat restoration work that was completed by the DNR in collaboration with the Kickapoo Valley Reserve (KVR), in 2019.

Though trout populations in the watershed are likely better now than they have been in at least a century, several major challenges exist, including more frequent flooding and warmer air temperatures due to climate change, changes in land use and expansion of high-density Brown Trout populations that limit Brook Trout.

Fisheries management recommendations for the watershed include:

1) focus trout habitat restoration on approaches that will increase stream resiliency to more frequent flooding and warmer air temperatures
2) avoid standard high-gradient (i.e., Hunt 1993) habitat restoration projects where naturally reproducing Brook Trout are present
3) avoid complete tree removal on stream reaches where thermal conditions are marginal and consider riparian tree planting where shade is lacking
4) continue to collaborate with and support internal and external partners involved in upland conservation practices that increase rainwater infiltration and continue to assist with internal fish kill evaluations
5) continue to assist with the evaluation of waterway permits, with a focus on projects that have the potential to impact downstream thermal conditions
6) maintain current angling regulations which provide a variety of trout fishing opportunities
7) adjust Brook Trout stocking to areas where fish will have a higher likelihood of contributing to the fishery or re-establishing a naturally reproducing population
8) identify suitable stream reaches for Brook Trout restoration by Brown Trout removal and fish passage barrier construction
9) continue to pursue streambank easements and propose South Bear Creek, Middle Bear Creek and North Bear Creek as additions to the list of streams eligible for streambank easement purchase
10) monitor and maintain existing easements and habitat projects,

11) classify the 12 streams identified in this report as trout water and update classifications on all Class III waters to Class I or II
12) gauge angler pressure in the watershed with non-traditional, low-cost methods (e.g. trail cameras, angler kiosks, opening day car counts) to determine if a full season creel is warranted on any portion of the watershed
13) re-evaluate these recommendations in eight years, 2029, when the next comprehensive watershed sampling will be completed

INTRODUCTION

The Bear Creek Watershed (10-digit HUC: 0707000603) drains 200.5 mi^2 of primarily forested and agricultural lands in Monroe and Vernon counties. A portion of the watershed (23%, 46 mi^2) lies within Richland County, but is not considered in this report, as it falls outside the La Crosse Inland Fisheries Management boundary. The watershed, like all in the Driftless Area, contains few lakes and a well-developed valley and stream network (Fig. 1). The area's permeable bedrock and relatively widespread land conservation practices allow high rates of groundwater recharge (Trimble 2013). Groundwater captured in the watershed eventually emerges in valley bottoms, resulting in streams with stable flows and temperatures that are well suited to trout (Potter 2019). Currently, the Bear Creek Watershed supports 178.9 miles of classified trout water within Monroe and Vernon counties.

Improvements in agricultural practices over the past 75 years have decreased surface water runoff, increased groundwater recharge, and resulted in substantial improvements in cold-water fish habitat throughout the region (e.g., Trimble 2013). Considerable increases in baseflow have been documented over the past 75 years in the Bear Creek Watershed as the result of improved land use and increased precipitation (Juckem et al. 2008). Though delayed relative to improvements in stream hydrology, naturally reproducing populations of Brown Trout and, to a lesser extent, Brook Trout have expanded in recent decades.

Early DNR Fisheries Management investigations in the watershed, beginning in the 1940s, revealed poor stream habitat conditions, limited natural reproduction of trout, and an abundance of warm-water fish species. On many streams, excessive grazing, stream ditching and poor riparian land use limited adult trout habitat (DNR Fisheries Management files). Despite improvements in stream hydrology from 1970 to present (Juckem et al. 2008, Fig. 2, 3), Brown and Brook Trout densities remained low and were supported by stocking until the early 2000s, when rapid recovery of naturally reproducing trout populations began. In-stream habitat restoration, recovery of habitat following reductions in agricultural land-use (e.g., riparian grazing; Rhemtulla et al. 2007), and stocking of feral strain Brown and Brook Trout likely facilitated the rapid recovery of trout populations in the 2000s.

Trout habitat has substantially improved in the watershed over the past several decades as a result of both active and passive habitat improvement. Passive improvement in habitat conditions have occurred along the Kickapoo River and its tributaries within Wildcat Mountain State Park and the Kickapoo Valley Reserve, which were established in 1948 and 1969, respectively. These two state-managed properties currently include 12,243 acres, which, based on historic aerial photos and reports, were over grazed. Cessation of riparian grazing has allowed vegetation to re-establish and, presumably, trout habitat to improve.

Active in-stream habitat restoration began in the early 1990s, with projects completed by the DNR on Billings and Cheyenne Valley Creek using standard DNR methods for high-gradient trout streams (Hunt 1993). Since then, many stream habitat projects in the watershed have been completed by county conservation departments and the Natural Resources Conservation Service (NRCS) in cooperation with private landowners. In the past decade, collaborative efforts between the DNR,

Vernon County Conservation Department, the Trout Unlimited Driftless Area Restoration Effort (TU DARE), and the Kickapoo Valley Reserve (KVR) have resulted in new easement purchases and 3.4 miles of trout habitat restoration being completed on Weister, Billings and Warner creeks.

Similar to other portions of the Driftless Area, trout stocking has been widespread in the Bear Creek Watershed. Though complete stocking records are only available after 1972, stocking was likely occurring in the watershed as early as the late 1800s (Thorn et al. 1997). Domestic Brown Trout were the primary species stocked in the watershed between 1972 and 1997 and were stocked at an average rate of 14,268 fingerling, yearling or adult per year (Fig. 4). In 1998, DNR stocking transitioned from domestic to feral (i.e., Timber Coulee strain) Brown Trout *Salmo Trutta*. In 2010, feral Brown Trout were phased out and replaced with WI native strain Brook Trout. Currently, around 13,000 yearling Brook Trout *Salvelinus fontinalis* are stocked annually into 12 streams in the watershed (Fig. 5).

Since 1935, trout fishing in the watershed has largely been regulated through state, county or region-wide harvest rules and seasons (Appendix 1). From 1990 to 2016, all streams in Vernon County were managed with a nine-inch minimum length limit (MLL) and a three fish bag limit, while all streams in Monroe County were managed with a seven-inch MLL and a five fish bag limit. In 2016, nearly all streams in the watershed were changed to a five fish bag limit with no MLL. In addition, the start of the early catch and release season was extended from the first Saturday in March to the first Saturday in January, and the end of the harvest season from Sept. 30 to Oct. 15.

These changes were enacted to increase regulation simplicity and provide additional angling and harvest opportunities. The change to more liberal harvest regulations was supported by the evidence of limited angler harvest (e.g., Mitro and Olson in prep.) and presence of moderate to high-density Brown Trout populations in many of the region's Coldwater streams. In the same year (2016), special regulations were enacted on Tenny Springs Creek to protect Brook Trout and encourage harvest of Brown Trout and on Elk Creek to improve Brown Trout size structure (see Appendix 1 for details).

Recently, Brook Trout populations in the watershed appear to be limited by high-density, naturally reproduced Brown Trout populations, which are expanding. In 2007, a Brook Trout restoration project was initiated on Tenny Springs Creek. This project included the construction of a trout passage barrier near the stream's confluence with Elk Creek (Mitro and Kanehl 2016) and removal of Brown Trout upstream of the barrier by electrofishing (Fig. 6). Brook Trout initially responded positively to the removal, but the barrier was not completely effective, and Brown Trout have since re-colonized the reach, resulting in the near collapse of the Brook Trout population.

Though trout populations in the Bear Creek Watershed have increased in recent decades, the watershed faces several challenges that threaten the persistence of the quality fishery that currently exists. Some of the primary challenges currently facing trout streams in the watershed include more frequent flooding and warmer air temperatures due to climate change (WICCI 2018), changes in land use and agricultural practices and expanding Brown Trout populations limiting Brook Trout.

A comprehensive evaluation of trout fisheries management has not been completed in the watershed for several decades. In 2021, 58 sites located on 35 streams in the watershed were sampled as part of a comprehensive watershed evaluation. This report summarizes findings from this effort and evaluates current fisheries management based on these and previously collected fisheries data. The objectives of this report are to:

1) summarize current and past fisheries data from the watershed
2) evaluate current fisheries management activities using this information
3) make recommendations for future fisheries management in the watershed

METHODS

STUDY AREA

The Bear Creek Watershed drains 246.5 mi^2 of Vernon, Monroe and Richland counties. The largest portion of the watershed (200.5 mi^2) is located within Monroe and Vernon counties and includes 178.9 miles of classified trout water. The watershed is located entirely within the Driftless Region, a landscape largely unshaped by the glacial activity and described by flat ridge tops, steep hillsides, and valleys up to 450 feet deep. Underlying bedrock is composed of a mix of limestone, dolomite and sandstone (Fig. 1). Groundwater infiltration is greatest on ungrazed hillslopes (Trimble 2013), where the ground surface is close to porous limestone and dolomite bedrock. Groundwater captured upslope often emerges in valleys as springs where certain non-porous sandstone layers cause lateral movement of groundwater to the surface (Potter 2019).

Land cover in the Bear Creek Watershed (including lands in Richland County) is composed primarily of deciduous forest (56.3%), row crop (16.5%) and pasture lands (16.1%; Fig. 7). A small portion of the watershed is composed of low and high-density development (0.9%), much of which is located in the towns of La Farge, WI (2010 population = 746) and Viola, WI (2010 population = 699).

Public property composes a significant portion of the watershed in Monroe and Vernon Counties. Two state-managed properties, Wildcat Mountain State Park, and the Kickapoo Valley Reserve, cover 12,243 acres of the watershed (Fig. 8). DNR-managed streambank easements have also been purchased along 6.3 miles of classified trout water, and county managed fishing easements are present along 9.8 miles of stream.

FISH SAMPLING

Electrofishing surveys were completed on 58 sites located on 35 streams in the watershed in 2021. Most sites (n = 48) were sampled between June and September. The remaining sites (n = 10) were located on unclassified trout waters and were sampled between late February and early March. Depending on stream size, electrofishing was completed using a pulsed DC backpack electrofisher, DC stream barge or DC mini-boom electrofishing boat. All wadable stream sampling was conducted following standardized single-pass electrofishing protocols utilized statewide (e.g., Lyons and Wang 1996). Following these protocols, sampled reaches were at least 35 times the mean stream width and electrofishing was completed in an upstream direction, with all species being collected. Non-wadable sites were sampled in a downstream direction using a mini-boom electrofishing boat. All species were collected within the first 400 meters and gamefish were collected in the remainder of the station. Station lengths ranged from 35 to 1,094 meters, with only three stations measuring less than 100 meters due to accessibility issues. All gamefish collected were measured to the nearest 0.1 inch and weighed to the nearest gram. All Brook Trout were inspected for adipose fin clips, which were given to yearling fish stocked in spring 2020.

ANALYSIS

Relative density (catch per effort) was estimated by dividing total catch by distance of stream surveyed. Young of year (YOY) and age one and older catches were determined based on length frequency distributions, which indicated that YOY trout were five inches and smaller. Relative densities were compared to the Wisconsin Driftless Region median based on DNR stream surveys completed between 2007 and 2014. Overall patterns in Brook and Brown Trout relative densities were evaluated from 1990 to 2021 visually, with the aid of locally weighted regression lines (loess fit) and 95% confidence bands using the R package ggplot2 (Wickham 2016).

Overall patterns in mean Brown and Brook Trout relative densities were evaluated on the Kickapoo River and six of the most popular tributaries in the watershed, designated based on personal

experience and conversations with local staff. Linear regression models were fit to mean age one and older Brook and Brown Trout densities over time. Mean relative densities were square root transformed prior to analysis to improve normality of residuals and homoscedasticity. ANOVA and post-hoc Tukey's HSD were used to compare Brown Trout catch rates on the Kickapoo River between Ontario and La Farge WI in 1999, 2008 and 2021 (years where at least five sites were sampled).

To evaluate the impact of recent habitat restoration on Brown Trout populations in Weister Creek, we compared relative density and size structure changes following completion of work in 2019 to a nearby reference stream (i.e., Little La Crosse River; WBIC: 1655900). The reference stream was sampled annually (excluding 2020 due to COVID limitations) between 2008 and 2021 at five to six sites using the same methods. Changes in age one and older densities were compared before and after the habitat restoration on the reference reach and on the improved portion of Weister Creek. We compared age one and older density as this represent the portion of the population recruited to angling gear (i.e., five inches and larger). Changes in size structure were evaluated using non-parametric Kruskal-Wallis test.

Fish density, size structure and species composition were mapped using ArcGIS Pro 2.6.0, allowing visual evaluation of spatial patterns. To evaluate spatial patterns in trout size structure, we estimated and mapped mean maximum length (i.e., the mean length of the five largest individuals in the sample) of Brook and Brown Trout. Spatial patterns in thermal conditions were evaluated by mapping maximum mean daily temperature (MMDT), based on hourly water temperature data from eight sites, and proportion of cool and cold-water stenotherm species in each electrofishing sample (Lyons and Wang 1996).

Adipose fins were removed from yearling Brook Trout (mean size = 6.5 in.) stocked into South, North, and Middle Bear, Twenty-Four Valley, Cheyenne Valley, Otter and Jug creeks in the spring of 2020. Yearling Brook Trout stocked into Billings, Brush, Weister and Warner creeks were not marked. The latter group of streams also received large fingerling stocking of Brook Trout in the fall of 2020. Contribution of stocked Brook Trout to populations was evaluated on streams where adipose clipped brook trout were stocked in 2020.

All statistical tests were completed in Program R (ver. 3.5.0, R Core Team) with $\alpha = 0.05$.

RESULTS

Mean Brown and Brook Trout relative densities increased considerably from 1990 to 2021 (Fig. 9). From 1990 to 1999, Brook Trout catch rates were zero and Brown Trout Catch rates averaged 12 fish per mile (n = 17, 1 S.D. = 13). Brown Trout were captured in 55 of the 58 sites sampled in 2021. Mean Brown Trout catch rate in 2021 was 803 fish/mile, in the top 25th percentile of trout streams in Wisconsin's Driftless Region. Brown Trout catch rates exceeded the Driftless median at 39 of 58 sites sampled in 2021. Brook Trout were captured in 33 of the 58 sites sampled in 2021 and in the absence of Brown Trout at one site. Brook Trout catch rates averaged 60 fish per mile in 2021, which was well below the median for trout streams in Wisconsin's Driftless Region (123 Brook Trout/mile). Brook Trout catch rates exceeded the Driftless median at three of the 58 sites sampled in 2021.

Mean relative densities of Brook and Brown Trout exhibited positive trends on the six most popular trout streams in the watershed from 1990 to 2022 (Fig. 10, Fig. 11). Relative density of age one and older Brown Trout increased significantly (R^2 =0.42, $F_{1,38}$ = 27.5, P < 0.0001) as did catch rate of Brown Trout exceeding 12 inches (R^2 =0.24, $F_{1,38}$ = 11.9, P = 0.001). Age one and older Brook Trout catch rate increased significantly (R^2 =0.14, $F_{1,38}$ = 6.3, P = 0.016), while eight inch and larger Brook Trout catch rate did not exhibit a statistically significant linear trend (R^2 =0.075, $F_{1,38}$ = 3.1, P =

0.086). Though Brook Trout exhibited a positive trend over the entire period, declines appear to have occurred on several streams in at least the past six years (Fig. 1, 11.). Young of the year Brook and Brown Trout did not appear in surveys until 2000, after which, catches were highly variable and did not exhibit significant trends.

Brown Trout relative densities were greatest in mid-watershed sites (e.g., Cheyenne Valley Creek, Fig. 12). Young of the year relative densities generally increased from the mainstem Kickapoo River to headwater sites, where the highest relative densities occurred. In contrast, all size classes of Brook Trout had their greatest relative densities in headwaters (Fig. 13) and were lower in relative abundance or absent in mid and lower watershed sites. Mean maximum length of Brown Trout was greatest in the mainstem Kickapoo River and in a few mid- and upper-watershed sites where habitat restoration work had been completed (Fig. 14., e.g., Cheyenne Valley Creek, Upper Brush Creek, South Fork Bear Creek). Mean maximum length of Brook Trout was generally greatest in headwater sites (Fig. 15).

Thermal conditions varied across the watershed based on fish community assemblage and water temperature monitoring (Fig. 16). Generally, temperatures and proportions of warmwater fish species increased from upstream to downstream (e.g., Brush Creek, Fig. 16), but we also observed exceptions to this pattern (e.g., Weister Creek) and variation in thermal conditions among the primary tributaries. Of the tributaries to the Kickapoo River that we evaluated, Elk Creek and Billings Creek had the coldest maximum mean and maximum daily temperatures near their confluences with the Kickapoo River (20.3 and 22.1 °C, respectively), while Brush Creek and Bear Creek had the warmest (23.9 and 25 °C, respectively). Proportion of cool-cold water stenotherms increased subtly from upstream to downstream sites on the mainstem Kickapoo (6% increase from the upstream-most site to the downstream-most site), and MMDT decreased (25.3 to 25.2°F).

Total Brown Trout catch rate on the mainstem Kickapoo between Ontario and La Farge, WI did not significantly increase between 1999 and 2006, but did increase significantly between 2006 to 2022 (Fig. 17., Tukey's HSD, $P < 0.05$). Mean catch rates increased from 18 fish per mile (1S.D. = 11) in 1999 to 127 fish per mile (1S.D. = 51) in 2022.

Brown Trout age one and older relative densities increased following habitat restoration that was completed in 2019 on Weister Creek (Fig. 18). Age one and older relative densities also increased in the reference stream (i.e., Little La Crosse River), however, the increase on Weister Creek was 323 fish per mile greater than that observed on the Little La Crosse. We did not observe a significant change in age one and older Brown Trout length distribution after habitat restoration (Fig. 19, K-W test, Chi-squared = 0.06, d.f. = 1, $P = 0.80$).

Stocked Brook Trout were captured at four of 14 sites where Brook Trout stocking was evaluated (see methods). Where present, relative densities of stocked Brook Trout ranged from 15 to 19 fish per mile. Naturally reproduced Brook Trout were captured at 9 of the 14 sites and, where present, at a mean relative density of 88 fish/mile (range = 15 – 215). Naturally reproduced Brown Trout were present in all 14 stocked sites at a mean relative density of 1,322 fish/mile (range = 336 - 2,334).

Discussion

TROUT POPULATION CHANGES

Significant improvements in land use and hydrology have occurred over the past 75 years on the Bear Creek Watershed, similar to other watersheds in the region (e.g., West Fork Kickapoo River; Olson et al. 2021). Recovery of coldwater fish populations have taken place more recently, with the greatest increases occurring in the past 30 years. From 1990 to 2021, Brown Trout populations have shifted from low density stocked fish, to moderate and high-density populations sustained by

natural reproduction. Naturally reproduced Brook Trout populations have also become established, though at much lower densities. The establishment of Brook and Brown Trout populations was likely facilitated by improvements in hydrology and baseflow (Juckem et al. 2008), in-stream habitat restoration, cessation of heavy grazing along stream corridors, and wild-strain trout stocking. The improvements in trout populations that we documented are not unique to this watershed, but are similar to those described in other parts of the Driftless Region (Thorn et al. 1997, Hoxmeier and Dieterman 2019, Vetrano 2019, Olson et al. 2021).

Our results also indicate that naturally reproducing trout populations have extended both up and downstream in the watershed over the past several decades, similar to what has been observed in the West Fork Kickapoo River (Olson et al. 2021). For example, Brown Trout densities increased substantially between 2008 and 2021 on the Mainstem Kickapoo River, and sampling in unclassified headwater sites and previously Class III streams revealed widespread natural reproduction of Brown Trout and, to a lesser extent, Brook Trout. Improvements in baseflow in the watershed have likely increased the amount of suitable trout habitat in headwaters, which were previously too small or warm, and likely extended cooler temperatures downstream in the mainstem Kickapoo as well. Decreases in summer stream temperatures due to increased baseflows have been documented in other parts of the Driftless, despite increases in air temperature during the same timeframe (Hoxmeier and Dieterman 2019).

CURRENT STATUS OF THE TROUT FISHERY

Naturally reproduced Brown Trout were widespread and captured in all but three of the 58 sites sampled in 2021. Relative densities of Brown Trout were high and, on average, in the top 25th percentile of trout streams in Wisconsin's portion of the Driftless Region. Relative densities were greatest in mid-watershed reaches, similar to the West Fork Kickapoo Watershed (Olson et al. 2021). Headwater and mid-watershed reaches appeared to be important for sustaining lower watershed Brown Trout populations as the greatest young of the year relative densities were present there, while few young of year were captured in lower reaches (Fig. 12). Large Brown Trout (≥14 inches) were typically found in lower and mid-watershed reaches, often where habitat restoration work had been completed. For example, habitat work had been completed at three of the four mid-watershed sites where mean maximum length exceeded 14.3 inches (Fig 14). Evaluations completed across the state have shown that Brown Trout population density and size structure responds positively to Wisconsin style habitat restoration projects (Avery 2004), as these projects typically aim to increase the amount of adult trout habitat by increasing depth and overhead cover. Larger sizes of Brown Trout in the Mainstem Kickapoo River may be attributed to the increased availability of high-quality prey (e.g., cyprinids) and reduced intraspecific competition there.

Brook Trout were less common and were captured in 33 of 58 sites sampled in the watershed and only once in allopatry. Brook Trout relative densities were low in the watershed and only three sites exceeded the Driftless Area median for Wisconsin. Brook Trout populations are likely limited by Brown Trout, which have been shown to displace Brook Trout in Driftless Area streams (Hoxmeier and Dieterman 2016) and are abundant in the watershed. Some have suggested that warmer summer water temperatures in the lower portion of the watershed limit Brook Trout, while colder temperatures in headwaters favor Brook Trout. However, thermal limits of Brook Trout appear to be nearly identical to Brown Trout (Wehrly et al. 2007) and we saw that Brown Trout were numerically dominant even in sites with the most stable thermal conditions in the watershed (e.g., Tenny Springs Creek, Cheyenne Valley Creek).

CLIMATE CHANGE AND HABITAT MANAGEMENT

Thermal conditions on the mainstem of the Kickapoo River were near or at the maximum mean daily temperature tolerance limit for Brook and Brown Trout in Wisconsin (25.3°C; Wehrly et al. 2007). However, the stream is currently supporting a strong population of brown trout that have increased

in abundance over the past several decades. Thermal refuge near confluences of coldwater tributaries are likely critical for maintaining trout populations in the Kickapoo River proper. Trout populations are predicted to retract to colder headwaters as climate change progresses (Mitro et al. 2019), and the FishVis model predicts that the likelihood of Brown Trout persisting in the future on the mainstem Kickapoo River is low. It will be important to maintain stream connectivity, and protection of coldwater refugia. Doing so may allow a seasonal trout fishery to persist in the river, similar to those in other thermally marginal streams in northern Wisconsin (e.g., the Namekagon or Wolf rivers). Considerations should also be given to land use activities upstream as well. Protecting critical sites of groundwater infiltration (i.e., forested hillslopes, Juckem et al. 2006) and maintain shade on upstream waters, may help buffer against warming air temperatures (Feiner et al. 2022).

The watershed has also been impacted by the more frequent, intense flooding that the region has experienced, and which is predicted to increase (WICCI 2018). Anecdotally, DNR Fisheries Management staff have noted significant changes in stream channel course and dimensions in mid- and upper-watershed sites that are moderately or heavily grazed. For example, in portions of upper Otter Creek and Brush Creek that are heavily grazed, we saw widespread stream channel migration and widening following the 2018 flood event, which appeared to reduce adult trout habitat (Fig. 20). More stable stream habitat conditions were noted in throughout the watershed in areas that were not grazed. Maintaining dense riparian vegetation through passive management, low intensity grazing, managed burning or periodic brushing, may be one way to increase resilience of trout habitat to increasing flood events due to climate change. Future habitat projects in the watershed should also consider partial removal of post-settlement alluvium to increase floodway volume and decrease the force of water on stream channel features during flood events.

High-gradient trout stream habitat restoration (Hunt 1993) has been completed throughout the watershed, beginning in the 1990s. No direct evaluations of these projects have been completed. We evaluated the success of one project on Weister Creek that was completed in 2019 and found a substantial increase in Brown Trout from less than 500 age one and older Brown Trout to more than 1,000 per mile. Future projects should focus on similar areas, where Brown Trout densities are not already exceptionally high (i.e., < 500 fish per mile) and stream gradients are moderate. The impact of such projects will be low in streams where Brown Trout densities are already high and habitat presumably good. Projects using standard high-gradient trout habitat restoration methods (Hunt 1993) should also be avoided in headwater sites with naturally reproducing Brook Trout. There is both anecdotal and documented evidence that these practices favor Brown Trout over Brook Trout (Avery 2004, Yallaly personal communication, 2022). In addition, many projects using standard high-gradient trout habitat techniques have failed in steeper stream reaches following floods (Fig. 21), which are predicted to increase in intensity and frequency in coming decades (WICCI 2018).

Riparian vegetation management will also be important to maintain trout habitat into the future. Grazed stream reaches (e.g., upper Otter Creek, Brush Creek), have experienced substantial stream widening, erosion and loss of trout habitat following flooding in recent years (Fig. 21). Reducing grazing intensity near the stream corridor should be encouraged. Though debate persists over whether trees or grass are better for stream habitat in the Driftless Region, shading from trees and taller vegetation reduces stream warming (Cross et al. 2013, Simmons et al. 2015), and maintaining suitable thermal conditions will be critical in areas where temperatures are already near the thermal limits for Brook and Brown Trout (Fig. 16).

Given the thermally marginal conditions in several portions of the watershed, permits requesting private pond construction on springs and small non-navigable headwaters should be thoroughly evaluated for thermal impacts. Pond construction has been widespread in the watershed, and several have been shown to increase downstream summer waters temperatures (Berger et al. 1979a, 1979b, 1979c). In addition, structures that limit trout passage, including poorly designed

road crossings, may reduce resilience of trout populations to warming conditions by limiting access to coldwater refugia or spawning habitat. The Monroe County Conservation Department, in collaboration with the DNR, has recently evaluated road crossings in the Monroe County portion of the watershed. This effort has identified four stream crossings in the Bear Creek Watershed which may be acting as barriers (MI Stream Crossing Dashboard 2022). Of these, one road crossing over a coldwater tributary to Brush Creek on Nevada Road, is of concern to DNR Fisheries Management staff, as it may be preventing trout from the thermally marginal Brush Creek access to at least 1.5 miles of potential cold-water refuge and spawning habitat.

BROOK TROUT MANAGEMENT

Brook Trout management in the watershed has previously focused on Tenny Springs Creek, where DNR Fisheries Management and Research attempted to remove Brown Trout and prevent re-colonization through the construction of a fish passage barrier in 2007 (Mitro 2016, Fig. 6). Unfortunately, this effort was unsuccessful due to the failure of the barrier to prevent upstream passage of Brown Trout. Since then, the Brook Trout population has substantially declined (2021 CPE = 31 fish/mile) and been displaced by Brown Trout (2021 CPE = 1,593 fish/mile).

Given that nearly all suitable trout habitat in the watershed has been colonized by Brown Trout, future efforts to support Brook Trout will require the removal of Brown Trout, which have been shown to displace Brook Trout in Driftless Area streams (Hoxmeier and Dietermann 2016, Olson et al. 2021). Brown Trout removals should not be conducted in the absence of a fish passage barrier as rapid recolonization is almost certain. Future barrier designs should consider elements of effective barriers constructed on high-gradient western streams (e.g., Endicott 2015) or unintentional fish passage barriers that are present in the Driftless region (e.g., NRCS flood control structures). Following construction, barriers should be evaluated by mark-displacement evaluations (e.g., Burford et al. 2009) to ensure no passage occurs before removal efforts begin. In addition, streams in the watershed selected for Brook Trout management need to be evaluated for thermal conditions and likelihood that suitable thermal conditions will persist using the FishVis model (Mitro et al. 2019) and stream temperature monitoring data. Finally, sites should be prioritized based on DNR management authority (e.g., presence or absence of state managed property), and availability of habitat upstream of proposed barrier sites.

STOCKING

Despite the stocking of more than 10,000 yearling Brook Trout annually, Brook Trout populations appear to be limited to headwater reaches, where natural reproduction is occurring. On streams where marked yearling Brook Trout were stocked in spring 2020, we captured marked Brook Trout in only four of 14 sites in summer 2021. In addition, Brown Trout densities were very high on stocked streams, with mean relative density exceeding 1,000 fish per mile. Though it's possible that targeted angling and harvest of stocked Brook Trout may have occurred, resulting in the lower stocked fish densities observed, this explanation seems unlikely given the low rates of angler harvest documented on nearby streams (Mitro and Olson in prep.). It is unsurprising that Brook Trout stocking success is limited in waters where naturally reproduced Brown Trout densities are high given the competitive superiority of the species (Fausch and White 1981, Hitt et al. 2016). In addition, statewide trout stocking guidance recommends against such stocking (WDNR Trout Team 2017). Changes to improve use of stocked fish are already underway in the watershed and future recommendations outlined at the end of this document.

TROUT FISHING REGULATIONS

Trout fishing in the watershed (within Vernon and Monroe counties) has been largely managed using base county or statewide trout fishing regulations. At present, only two special regulations are in place in the Monroe and Vernon County portion of the watershed. A special harvest regulation on

Tenny Springs Creek requires the release of all Brook Trout. Given the potential for additional Brook Trout restoration efforts on Tenny Springs Creek, and limited opportunity for Brook Trout harvest at present, this continues to be a reasonable regulation. A special harvest regulation on Elk Creek allows harvest of five trout under 12 inches. This regulation was enacted to make regulations consistent with those in Richland County. All remaining waters are managed with a five fish bag limit and no minimum length limit. Currently there is limited evidence to indicate that these relatively liberal harvest regulations are influencing trout numbers or size. Recent creel surveys (Mitro and Olson in prep.) indicate limited harvest of trout, even when harvest regulations are very liberal (i.e., 10 bag, no minimum length limit). If evidence emerges of harvest limiting Brown Trout size structure in the region, more restrictive regulations may be considered on the mainstem Kickapoo River, Cheyenne Valley Creek and South Fork Bear Creek, streams with the potential to support large Brown Trout (Fig. 12, 14).

PROPERTY MANAGEMENT

Within the watershed, DNR Fisheries staff directly manage only a handful of streambank easements. There are no immediate plans for habitat work or streambank brushing on existing easements. DNR Fisheries Management maintains an active easement purchasing program in the watershed funded through the Knowles-Nelson Stewardship Fund. Much of the classified trout water in the watershed is eligible for easement purchasing. However, Bear Creek and its tributaries are not, and interested landowners have recently reached out to fisheries staff. Given the high-quality fishing opportunities on Bear Creek and its tributaries, we recommend including this stream on the eligible stream list for future easement purchasing. Easement purchasing should remain a high priority in the watershed, as it has been identified as a high priority statewide (WDNR Trout Team 2019).

FISH KILLS

In 2017 and 2019, significant fish kills occurred on Otter Creek due to manure spills from agricultural operations. These kills impacted roughly three miles of stream and killed over 1,800 trout in total. In the headwaters of Otter Creek, where a complete fish kill occurred in 2017, densities of Brown Trout appear to have rebounded in 2021 (CPE; Brown Trout = 2,334 fish per mile). The recovery of this segment can likely be attributed to the persistence of moderate density trout populations downstream of the impacted area, which were able to re-colonize the reach. Though trout populations in upper Otter Creek have demonstrated resilience to these fish kills, we should not expect this level of resilience in future as stressors on the population are predicted to increase (e.g., Mitro et al. 2019).

Management Recommendations

HABITAT

1) Continue restoration efforts in mid and lower watershed sites, where riparian grazing is limited, and trout numbers do not already exceed 500 fish per mile. We documented that habitat restoration on lower Weister Creek, where Brown Trout densities were lower, resulted in a substantial increase in catchable Brown Trout. Trout habitat restoration in these areas will likely have the greatest impact on trout numbers and the highest likelihood of persisting in the face of more frequent flooding due to climate change. Future projects should also incorporate elements that increase stream channel resiliency to flood, such as removing a portion of post-settlement alluvium and maintaining riparian vegetation.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 1.1, Action 1.1.A.5

2) Avoid standard high-gradient Wisconsin style habitat restoration projects in areas where naturally reproducing Brook Trout are present. These projects often favor Brown Trout when the two occur together.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 1.1, Action 1.1.A.5, Objective 2.1, Action 2.1.B.3

3) In stream reaches where thermal conditions are marginal, avoid complete riparian tree removal and consider planting trees in areas lacking shade. Tree species should be selected which have the least impact on angling accessibility.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 1.1, Action 1.1.A.8

4) Continue to collaborate with internal (e.g., Watershed Management Bureau) and external partners (e.g., Kickapoo Valley Reserve) involved in upland management to promote land use practices that will benefit trout habitat. Continue to assist in fish kill evaluations if they occur.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 1.1, Strategy 1.1.F

5) Continue to assist with evaluation of waterway permits, with particular focus on projects with potential thermal impacts in areas where thermal conditions are already marginal.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 1.3

TROUT FISHING REGULATIONS

6) Maintain current angling regulations in the watershed.

Current angling regulations are straightforward and provide catch and release (i.e., catch and release early season) and harvest opportunities. The history of angling regulations and limitations to our current data did not allow us to evaluate whether angler harvest was limiting trout size or number of trout, but evidence from recent creel surveys suggest limited effect of harvest.

Though Tenny Springs Creek has been re-colonized by Brown Trout, we recommend maintaining the current regulation, which prohibits harvest of Brook Trout, as the stream may be the site of future Brook Trout restoration projects.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 2.1, Action 2.1.B.3, Objective 2.3

TROUT STOCKING

7) Continue effort to stock trout in areas where they will meaningfully contribute to the fishery or where Brook Trout stocking is part of a restoration effort.

An effort to make better use of stocked fish in the watershed was initiated in 2021. Through this effort, we identified sites where angler use was limited based on opening day creel survey. Using this information, in combination with trout population data, we identified that eight of the 15 Brook Trout quotas were being stocked in locations with little angler use and/or extensive naturally reproducing populations of Brown Trout. These quotas were eliminated for the 2023-2024 rearing cycle. We

recommend that existing quotas be evaluated again in the next watershed assessment cycle (2029), unless information emerges that require changes to quotas prior to 2029.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 2.3, Strategy 2.3.B

BROOK TROUT RESTORATION

8) Identify suitable stream reaches for Brown Trout removal and fish passage barrier construction.

In this report we identified several candidate headwater streams reaches which are thermally stable and may be suitable for Brook Trout Management. Brown Trout removal has proven one of our most effective tools for restoring Brook Trout populations (e.g., Avery 1999). A thorough evaluation of potential sites identified in this report should be completed if a Brown Trout removal effort is considered. In addition to thermal habitat considerations, Brook Trout genetic lineage, public accessibility and riparian habitat management authority should be evaluated.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 2.1, Action 2.1.B.3

ACCESS

9) Continue to pursue streambank easements in the watershed on streams that are currently eligible. Propose South Bear Creek, Middle Bear Creek and North Bear Creek as additions to the list of streams eligible for easement purchase.

An internal DNR Fisheries Management survey identified streambank easement purchasing as one of the top activities that should be expanded. At present, the DNR Burearu of Fisheries Management lacks authority to purchase easements on the three branches of Bear Creek and surveys indicate that high-quality Brown Trout populations are present there.

10) Monitor and maintain existing 6.3 miles of streambank easement in the watershed.
With more land being purchased for recreational use, existing easements will need to be monitored to ensure land use activities are consistent with easement agreements and that landowners are aware of the existence of streambank easements. Occasional monitoring of stream habitat restoration projects on easements should also be completed at least once every eight years (in line with current watershed rotation schedule). If required, maintenance of habitat projects will be completed based on fisheries management priorities and resource availability.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 2.2, Strategy 2.2.B, Action 2.2.C.2

TROUT STREAM CLASSIFICATION

11) Update out of date trout stream classification in the watershed.

During the 2021 watershed survey, we sampled 12 streams which were previously unclassified but supported naturally reproducing Brook and/or Brown Trout. In addition, all of the current Class III waters should be updated to Class I or II as they all support naturally reproducing trout. A proposal to update these classifications will be submitted in fall 2022.

Supporting DNR Guidance:
Objective 3.3, Strategy 3.3.A

MONITORING

12) Continue evaluation of angler use, employing non-traditional, low-cost and effort techniques.

Prior to an opening day creel survey, completed in 2021, no evaluation of angler pressure or harvest has been completed on any stream in the watershed. Though a full-season standard creel would likely be cost and effort prohibitive, alternative creel options should be considered to gauge angler pressure and whether a full creel is warranted on any particular stream or set of streams. Angler pressure information from opening day car counts, trail cameras, or angler kiosks will provide, at minimum, a baseline of angler use, which would be valuable in gauging the level of angler use, relative to other streams in the region and state.

Supporting DNR Guidance:
Strategy 3.1.C

13) Complete comprehensive watershed survey and update watershed report in eight years (2029).

Based on our current eight year watershed rotation schedule, the next comprehensive survey of the watershed will occur in 2029. At that time, management recommendations outlined in this plan will be evaluated.

Supporting DNR Guidance:
2020 DNR Trout Management Plan: Objective 3.1, Action 3.1.A.1

Acknowledgements

My sincere gratitude to the DNR La Crosse Inland Fisheries Management Crew (Kevin Mauel, Kristina Pechacek and Ryan Olson) for their efforts collecting the fisheries data that was used in this report. Thanks to David Winston for his assistance with ArcGIS. I thank Heath Benike for his thorough review of the report. Thanks to Weston Matthews for compiling trout habitat restoration permits from the watershed. My deepest gratitude to current and past conservation professionals who have greatly improved conditions for trout and trout anglers in the Driftless Region.

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Tables and Figures

Table 1. Area of land cover types and percentage of total land cover type within the Bear Creek Watershed, including the portion within Richland County. Land cover data from Wiscland 2.0.

Land Cover Type	Area (acres)	% Total
Broad-leaved Deciduous Forest	24455	56.3
Crop Rotation	7164	16.5
Forage Grassland	7005	16.1
Emergent/Wet Meadow	1928	4.4
Idle Grassland	1638	3.8
Forested Wetland	516	1.2
Developed, Low Intensity	356	0.8
Coniferous Forest	169	0.4
Lowland Scrub/Shrub	107	0.2
Shrubland	32	0.1
Developed, High Intensity	24	0.1
Barren	14	0.0
Open Water	10	0.0

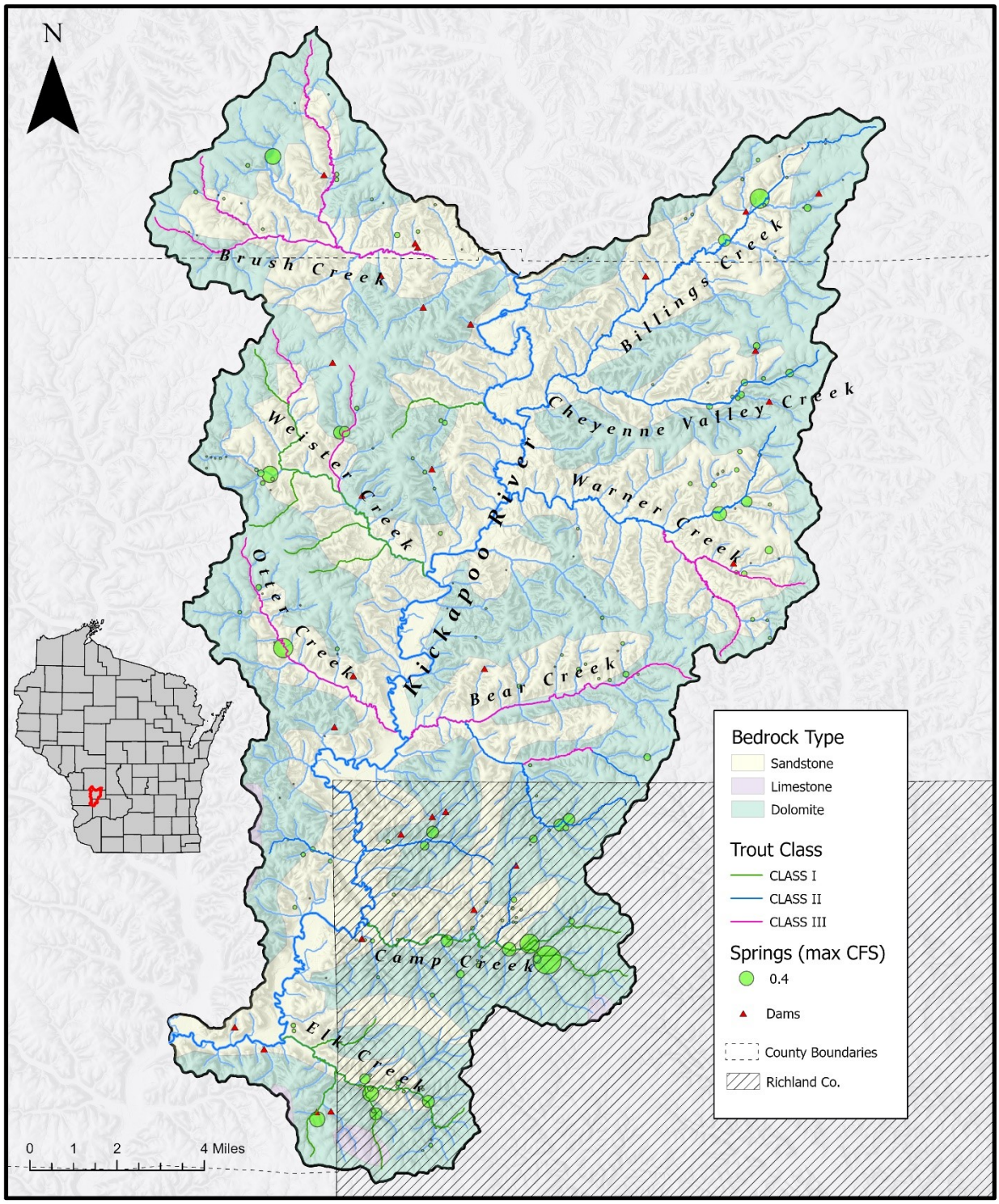

Figure 1. Bedrock geology, springs and dams in the Bear Creek Watershed. Richland County, outside the La Crosse Fisheries Management area, is signified with crosshatching.

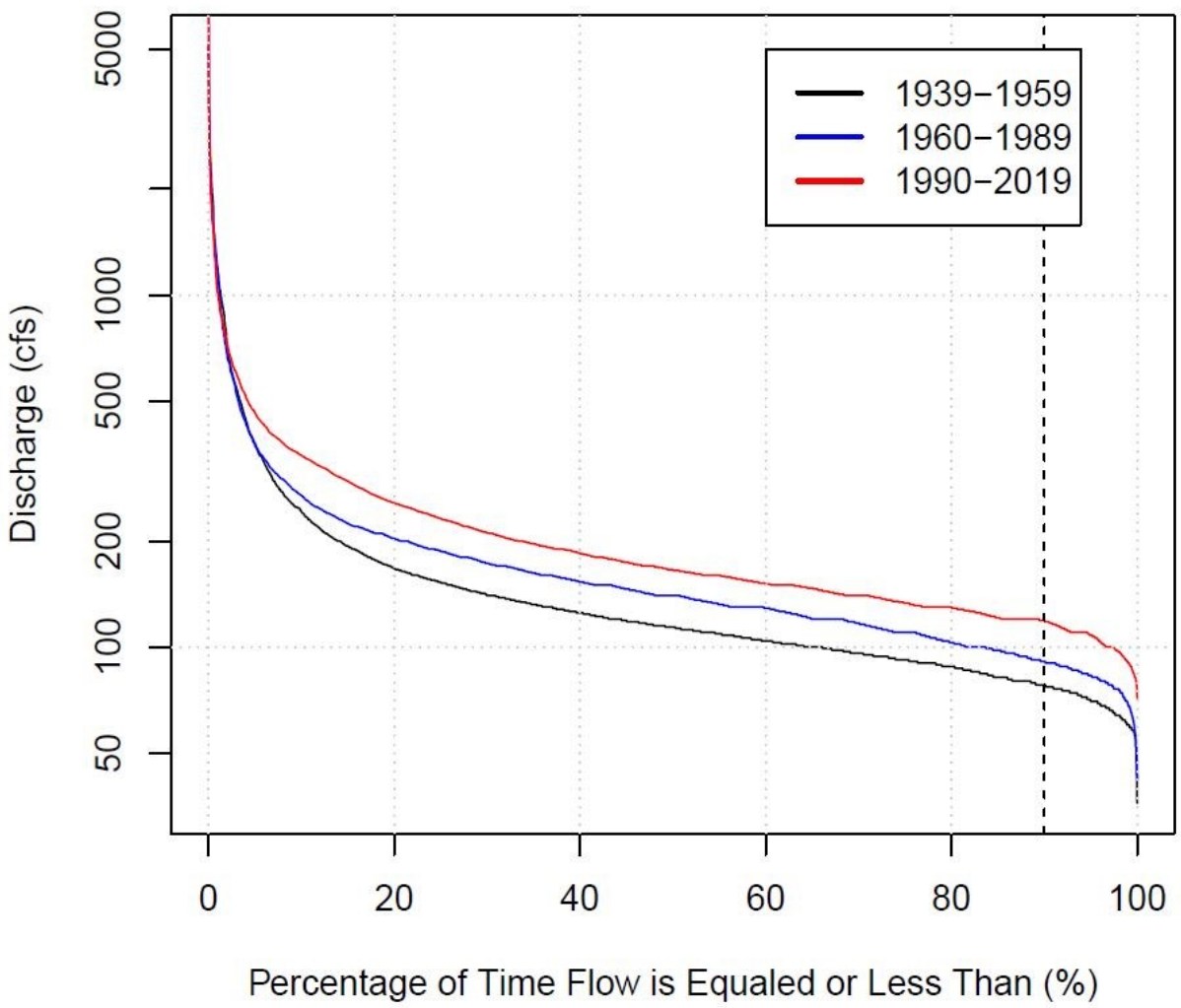

Figure 2. Discharge frequency curves from the Kickapoo River at La Farge, WI by three time periods. Dashed line represents Q_{90}.

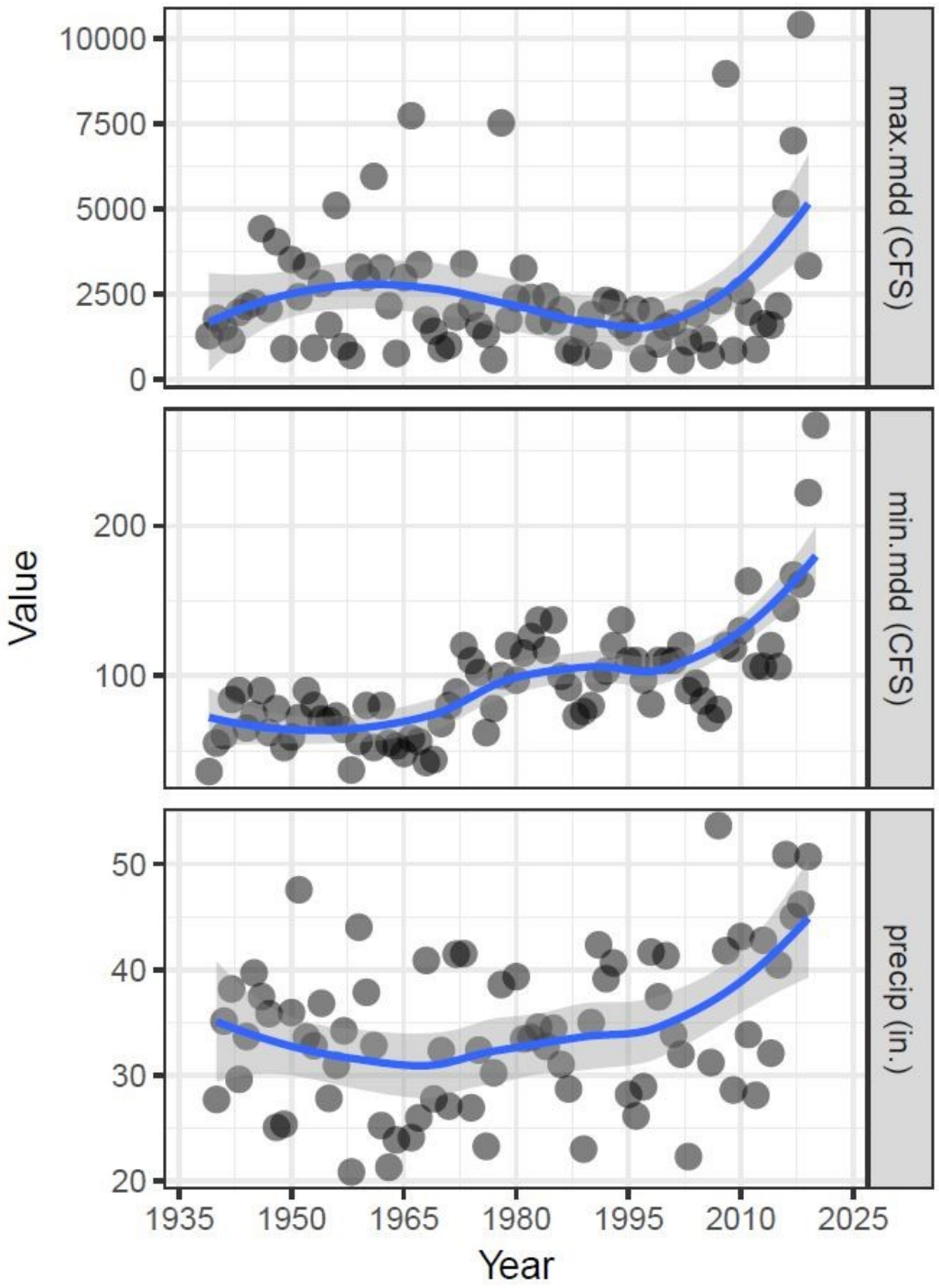

Figure 3. Maximum and minimum mean daily discharge by year from the Kickapoo River at La Farge, WI (top and middle panel, respectively) and annual precipitation measured at Viroqua, WI (bottom panel) from 1940 to 2019.

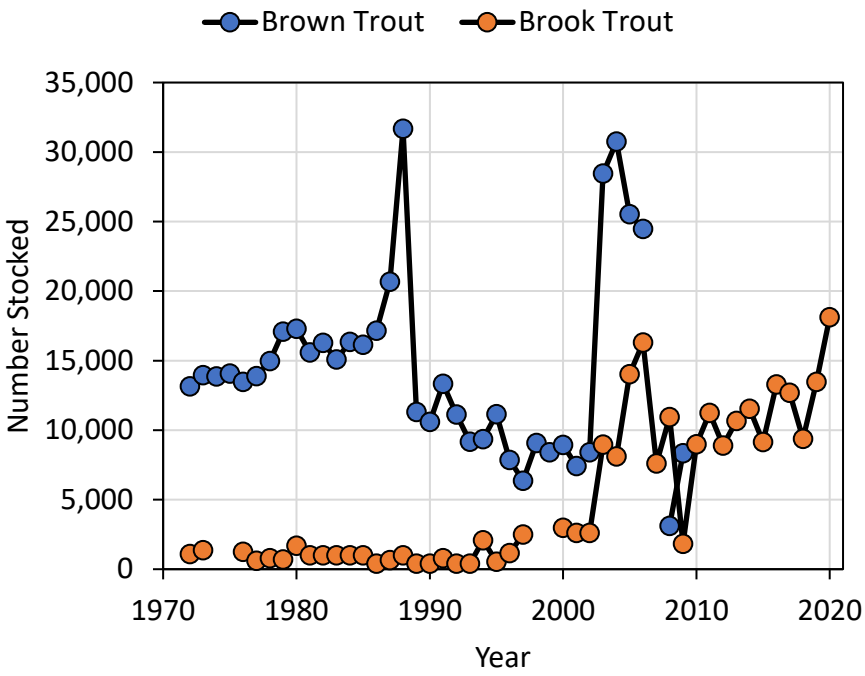

Figure 4. Number of Brook and Brown Trout stocked in the Bear Creek Watershed between 1972 and 2020, excluding fry stocking. Feral trout stocking began in 1998. Brown Trout stocking ceased in 2010.

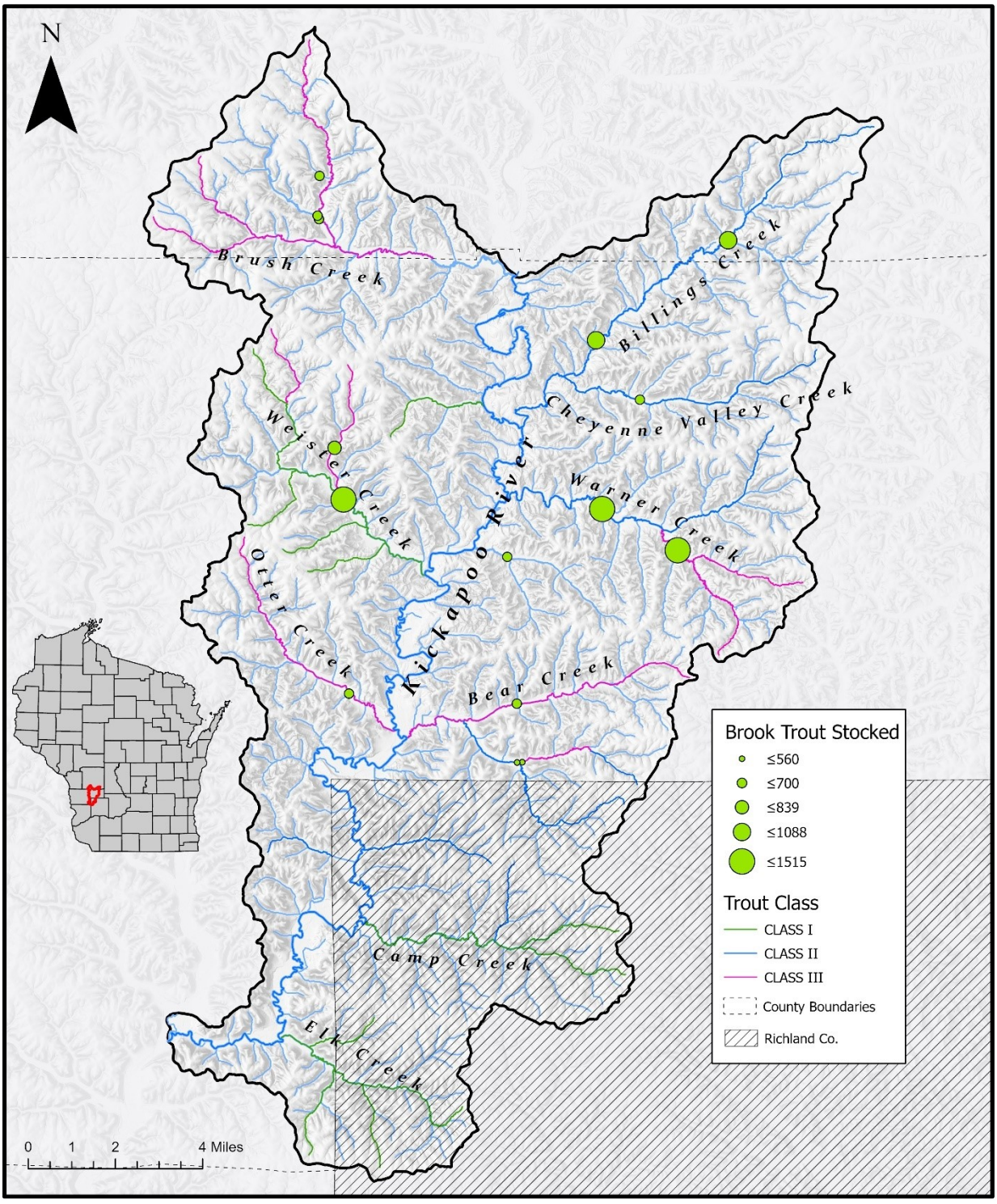

Figure 5. Stocking locations and number of yearling Brook Trout stocked in 2019, which is representative of annual stocking in most years since 2011 in the Bear Creek Watershed.

Fig. 6. Intentional trout passage barrier installed on Tenny Springs Creek in 2007. This structure was determined to be a partial barrier to Brown Trout, which re-colonized the reach in the years following installation and Brown Trout removal. Photo Credit: Matt Mitro.

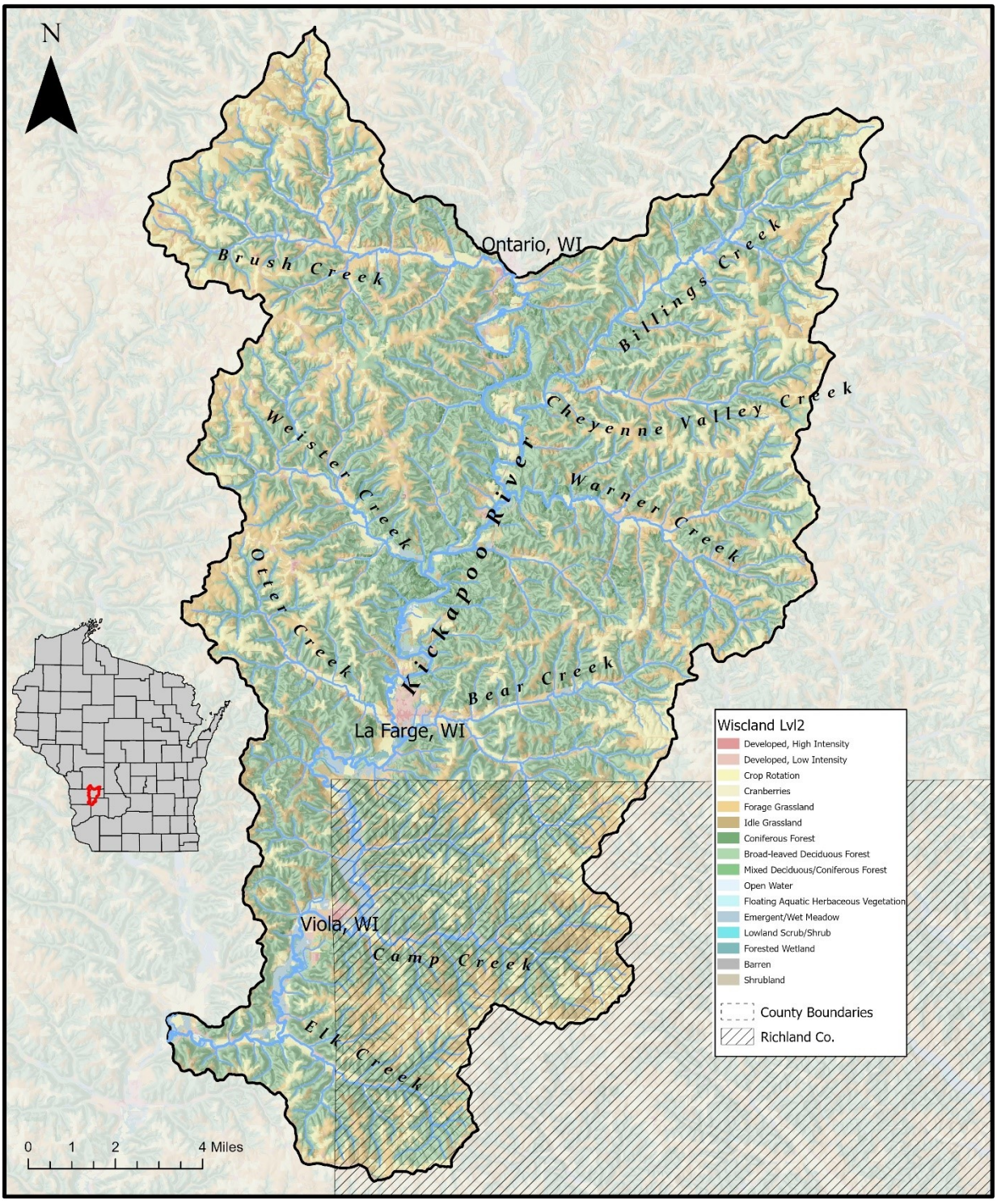

Figure 7. Land cover in the Bear Creek Watershed. Land cover based on level 2 Wiscland classifications, updated in 2016.

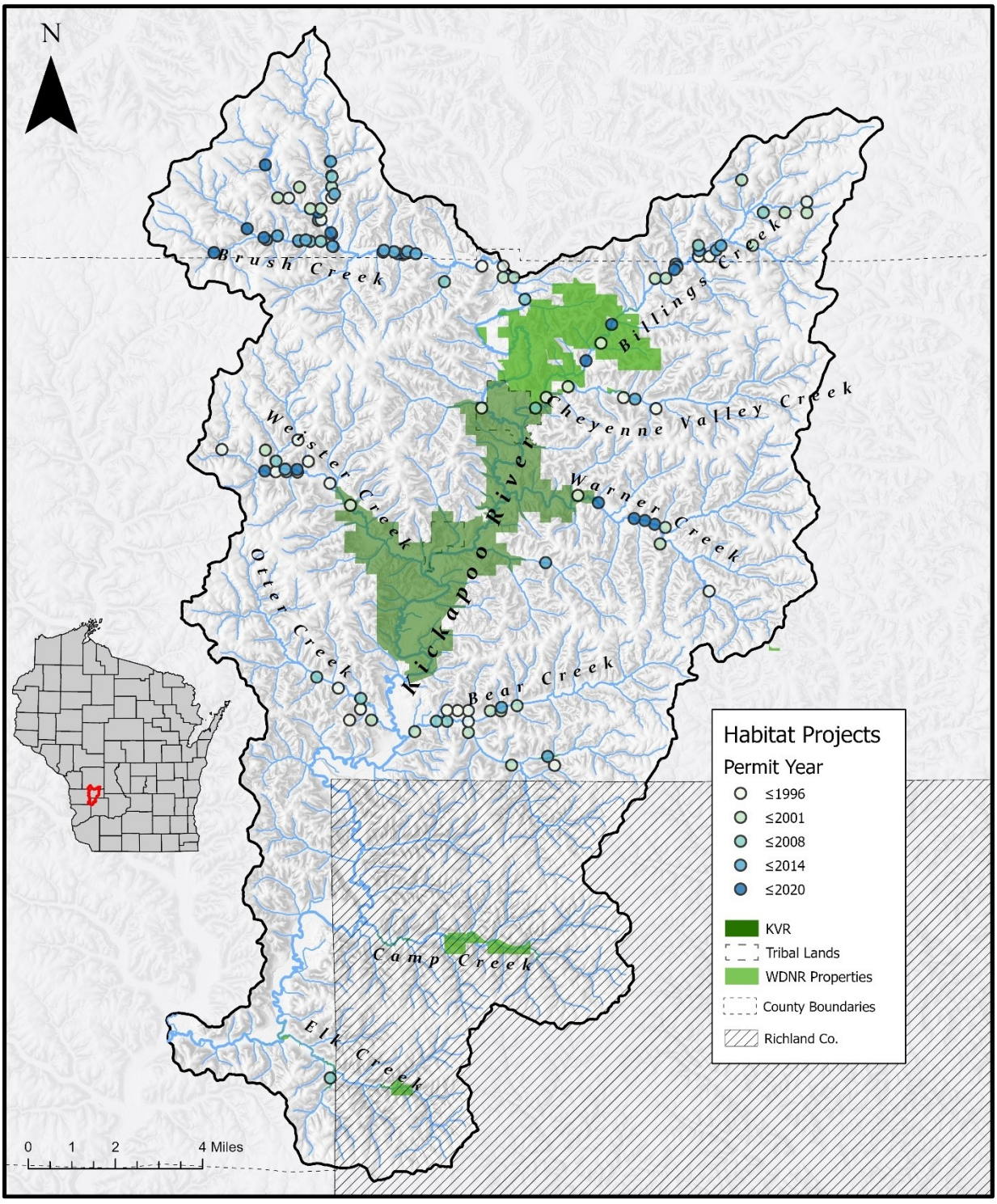

Figure 8. Map of trout habitat restoration permits granted in the Bear Creek Watershed from 1985 to present. Trout habitat restoration permits were granted for projects completed by state, county and/or private landowners.

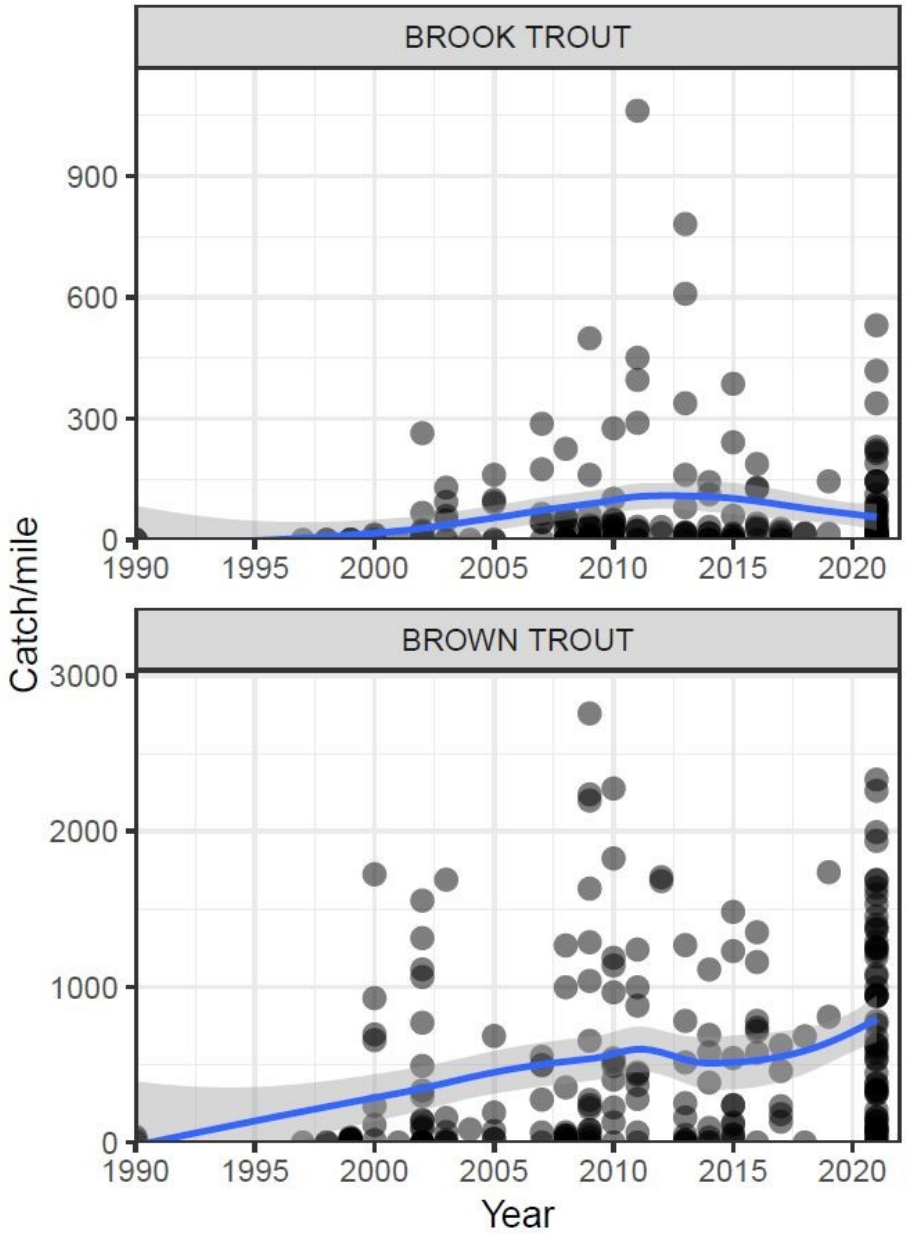

Figure 9. Total catch per mile of Brook Trout (top panel) and Brown Trout (bottom panel) on sites located in the Bear Creek Watershed between 1990 and 2021.

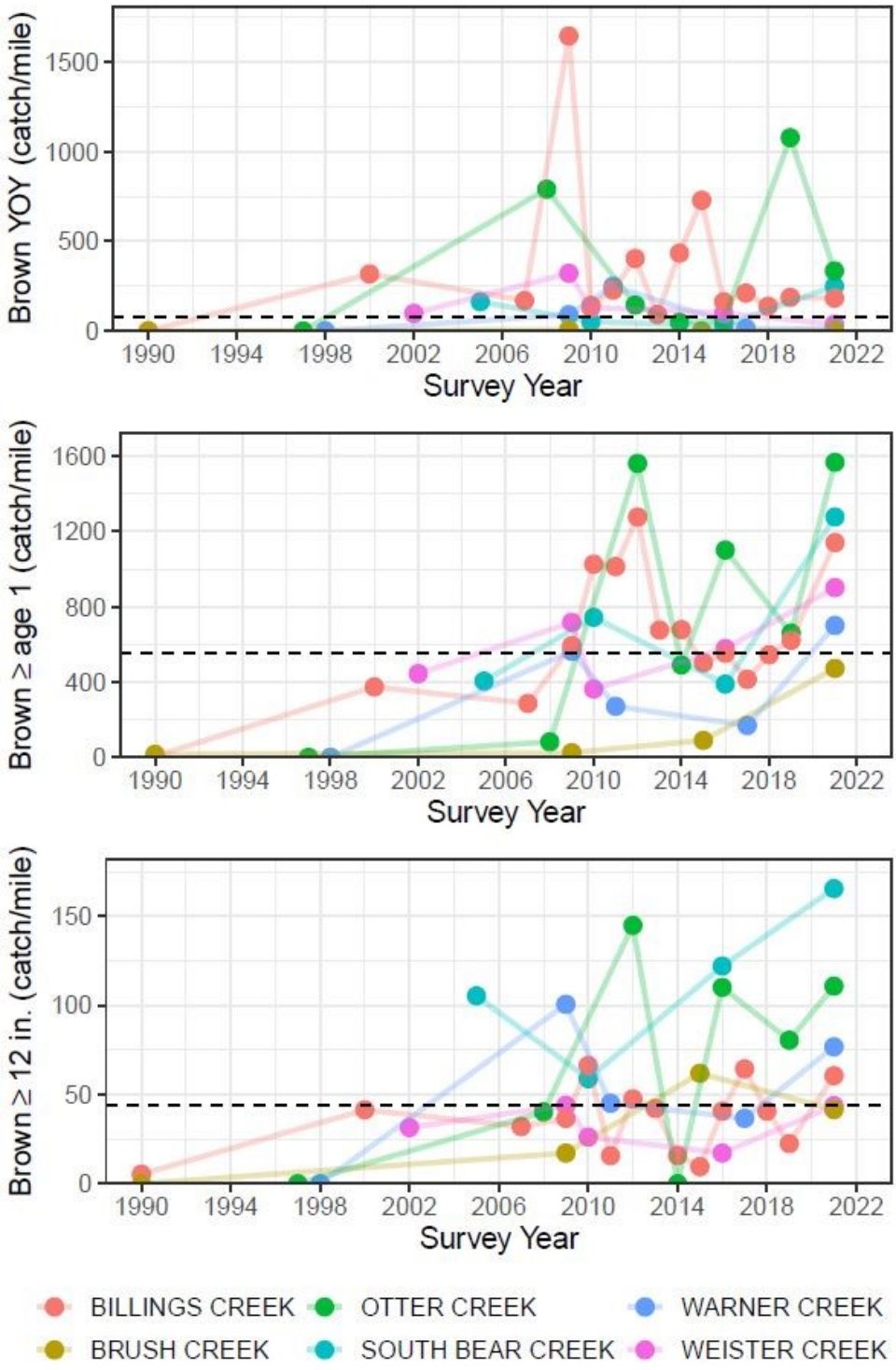

Figure 10. Mean catch per mile of Brown Trout in six select trout streams in the Bear Creek Watershed. Dashed lines represent median catch rates for Driftless Area streams in Wisconsin.

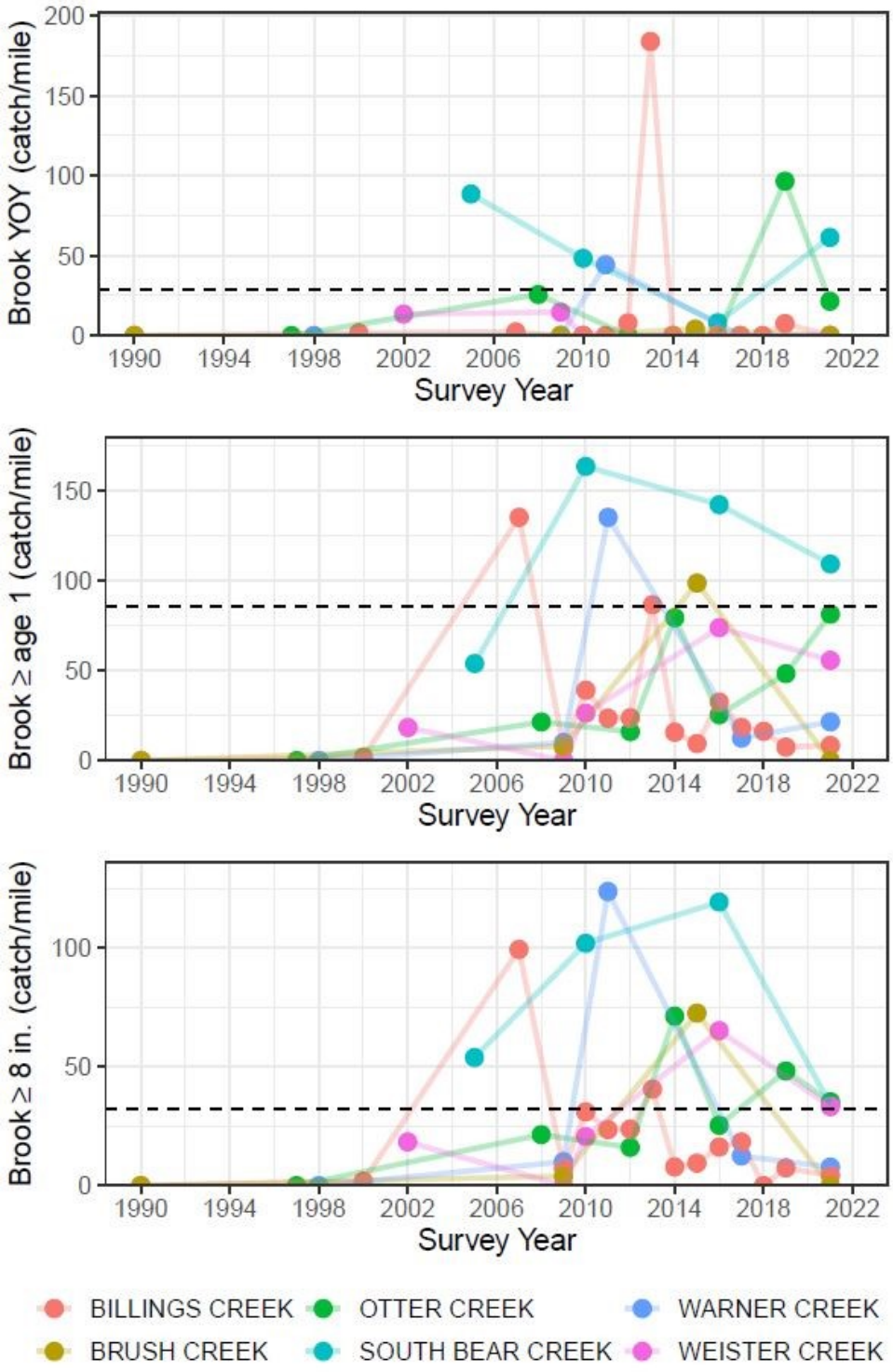

Figure 11. Mean catch per mile of Brook Trout in six select trout streams in the Bear Creek Watershed. Dashed lines represent median catch rates for Driftless Area streams in Wisconsin.

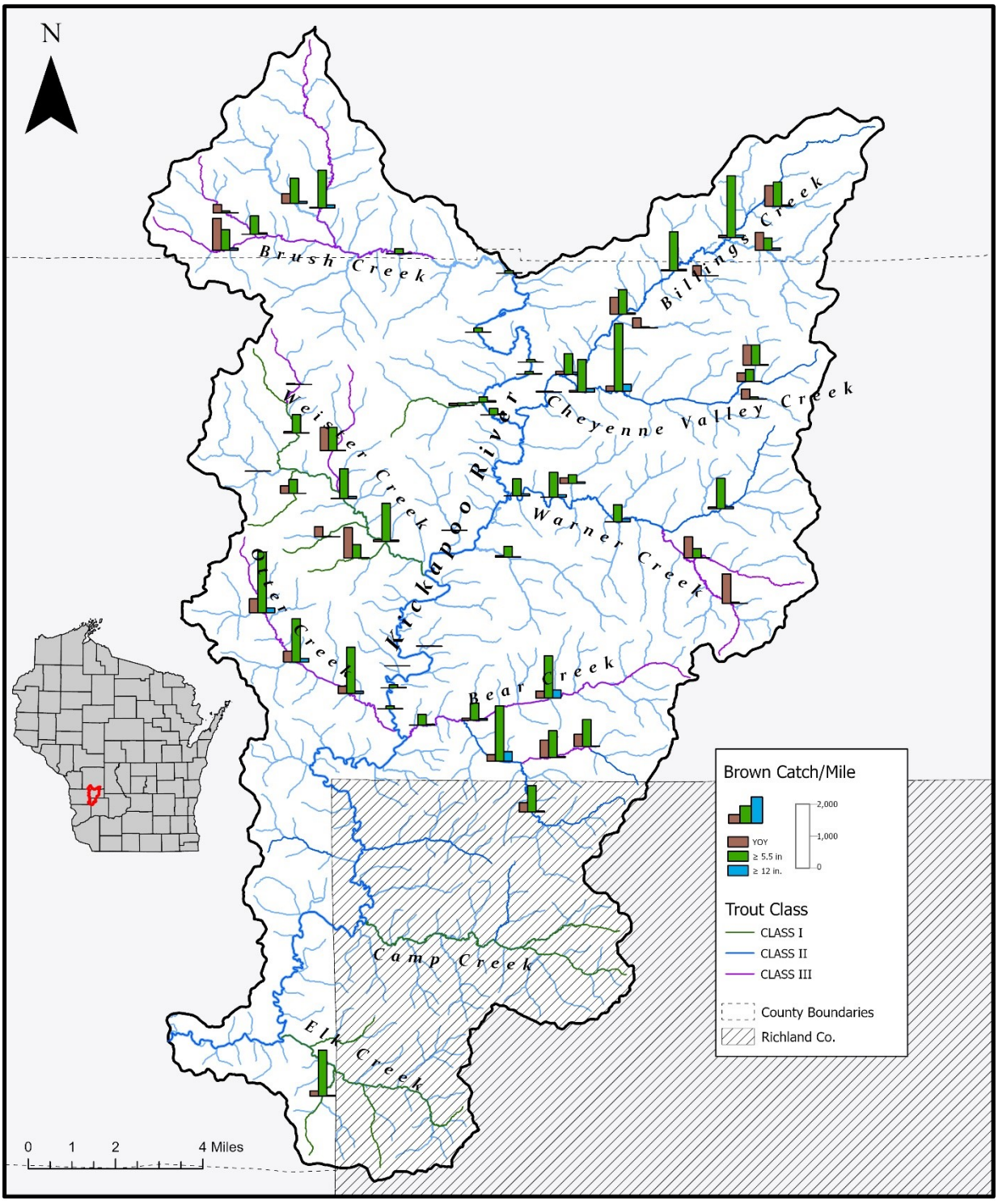

Figure 12. Catch per mile of Brown Trout by size class at each site sampled in 2021.

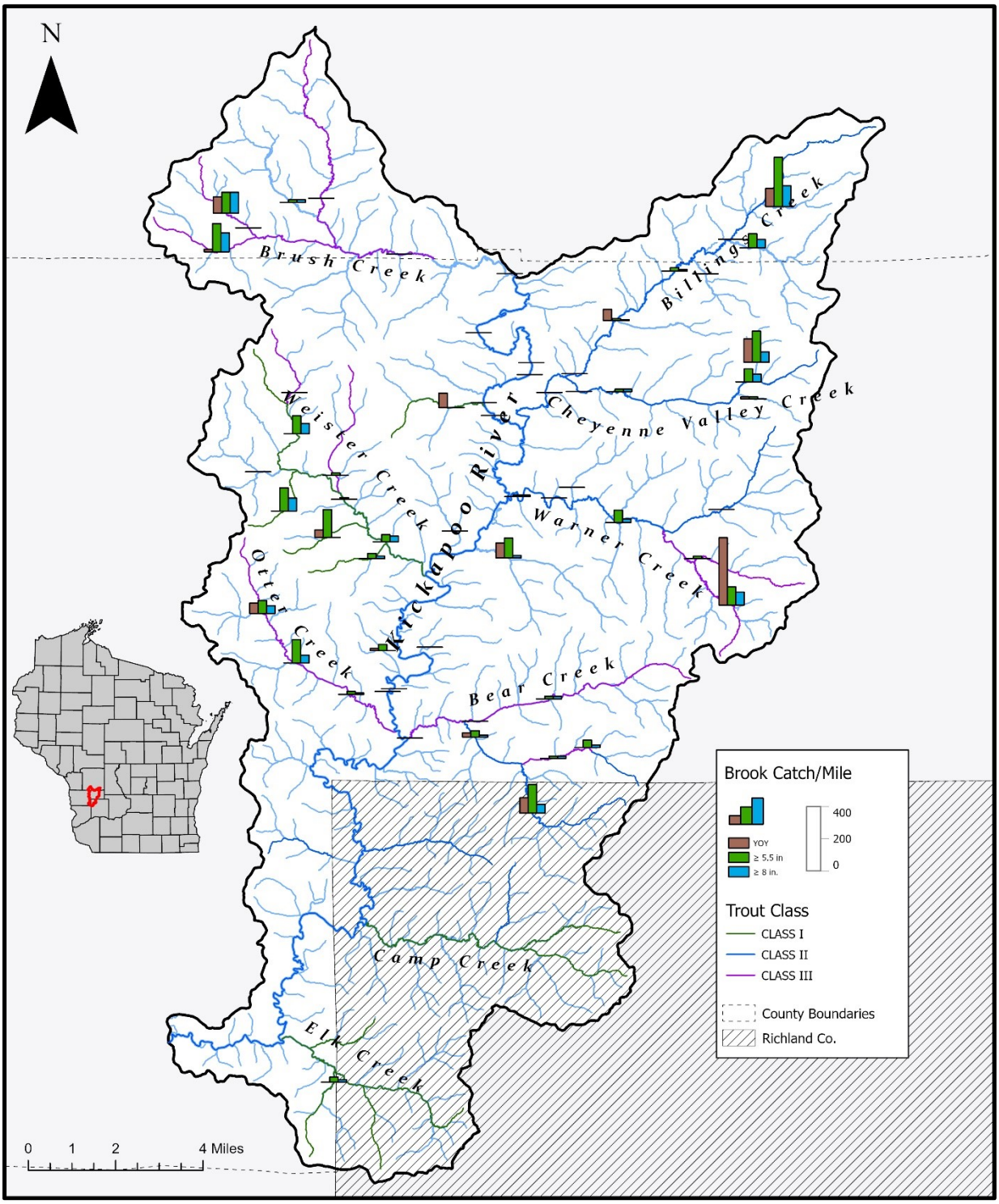

Figure 13. Catch per mile of Brook Trout by size class at each site sampled in 2021. YOY = Young of the Year.

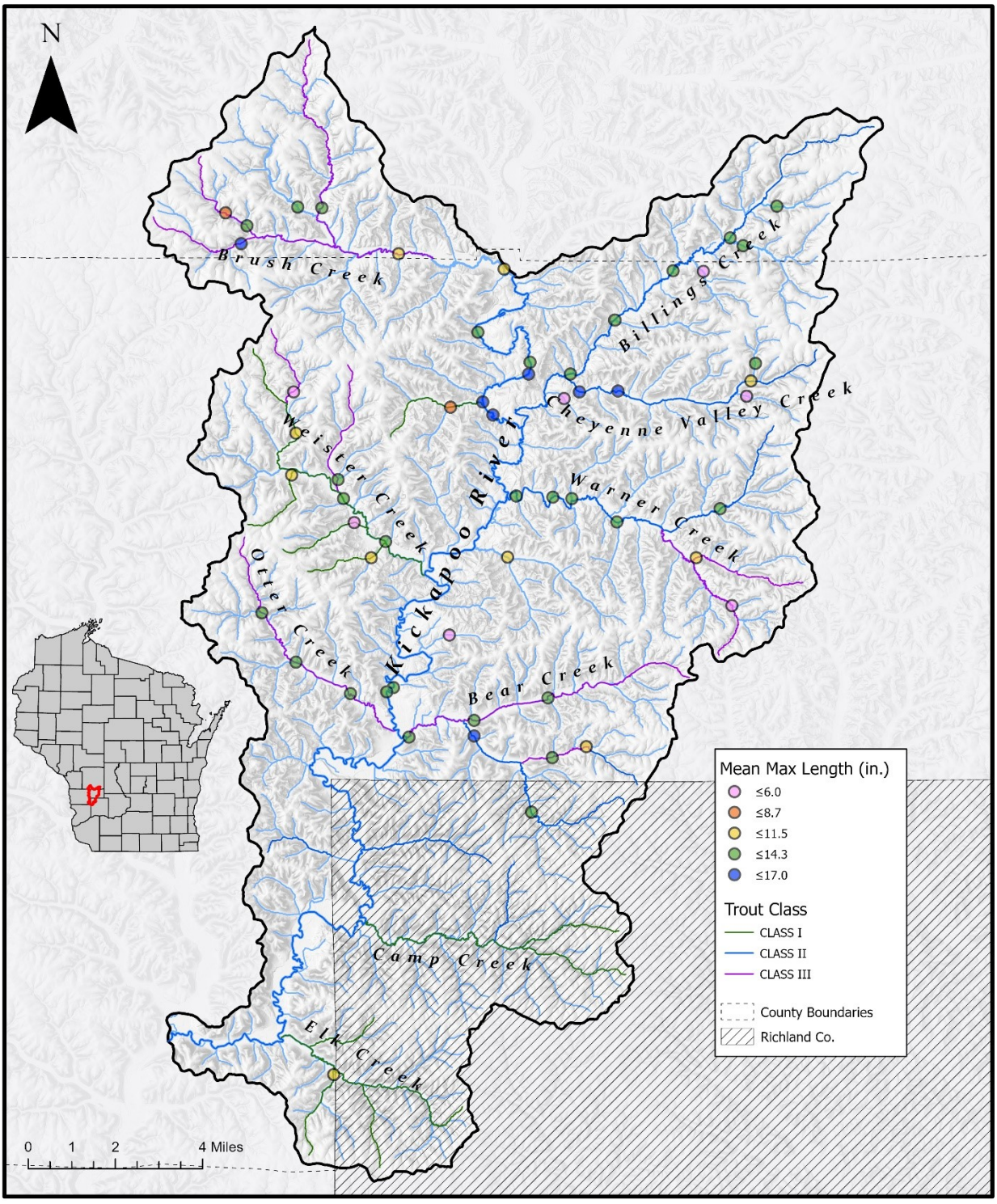

Figure 14. Mean maximum length of the five largest Brown Trout sampled at each station. Cooler colors represent larger sizes.

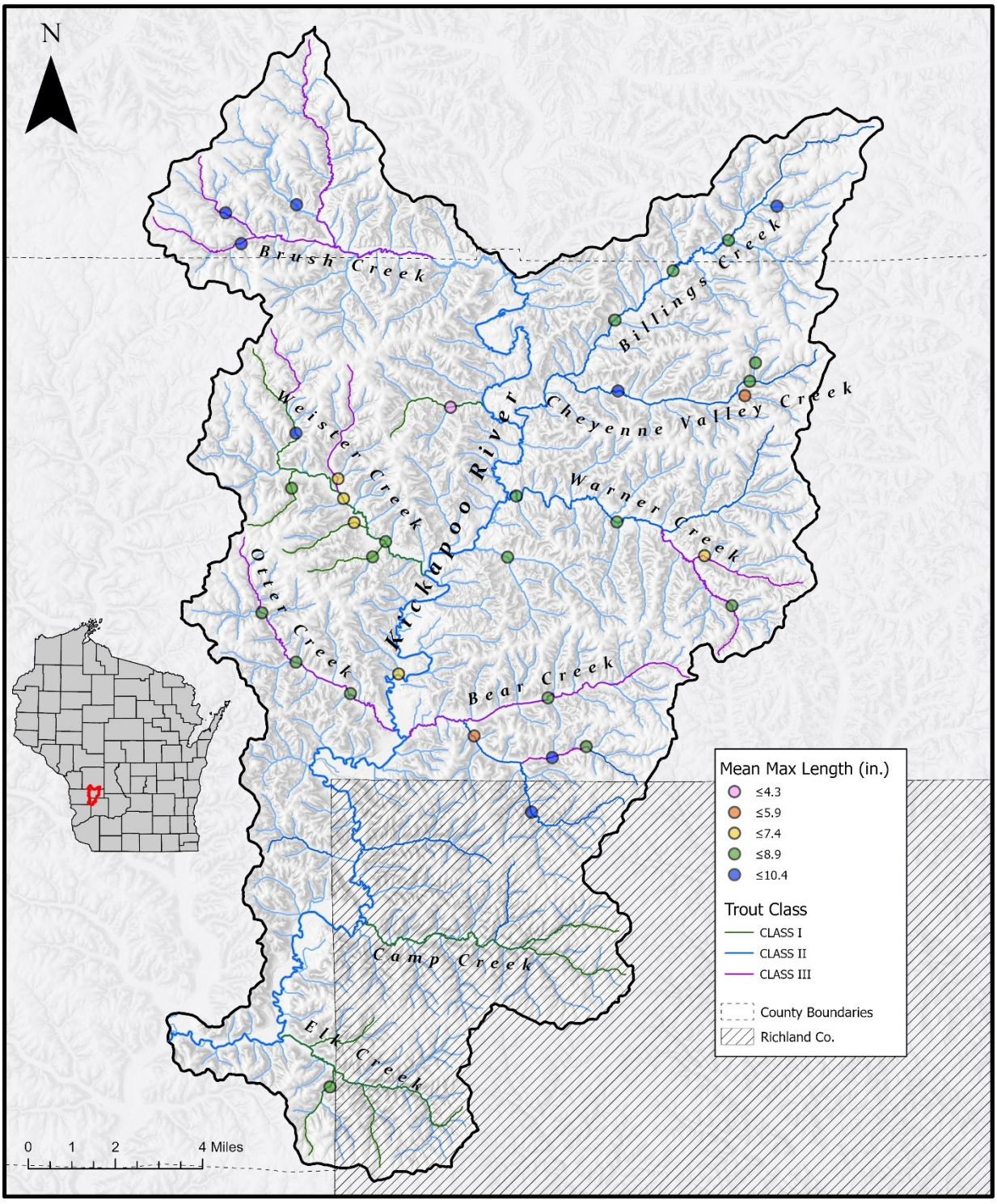

Figure 15. Mean maximum length of the five largest Brook Trout sampled at each station. Cooler colors represent larger sizes.

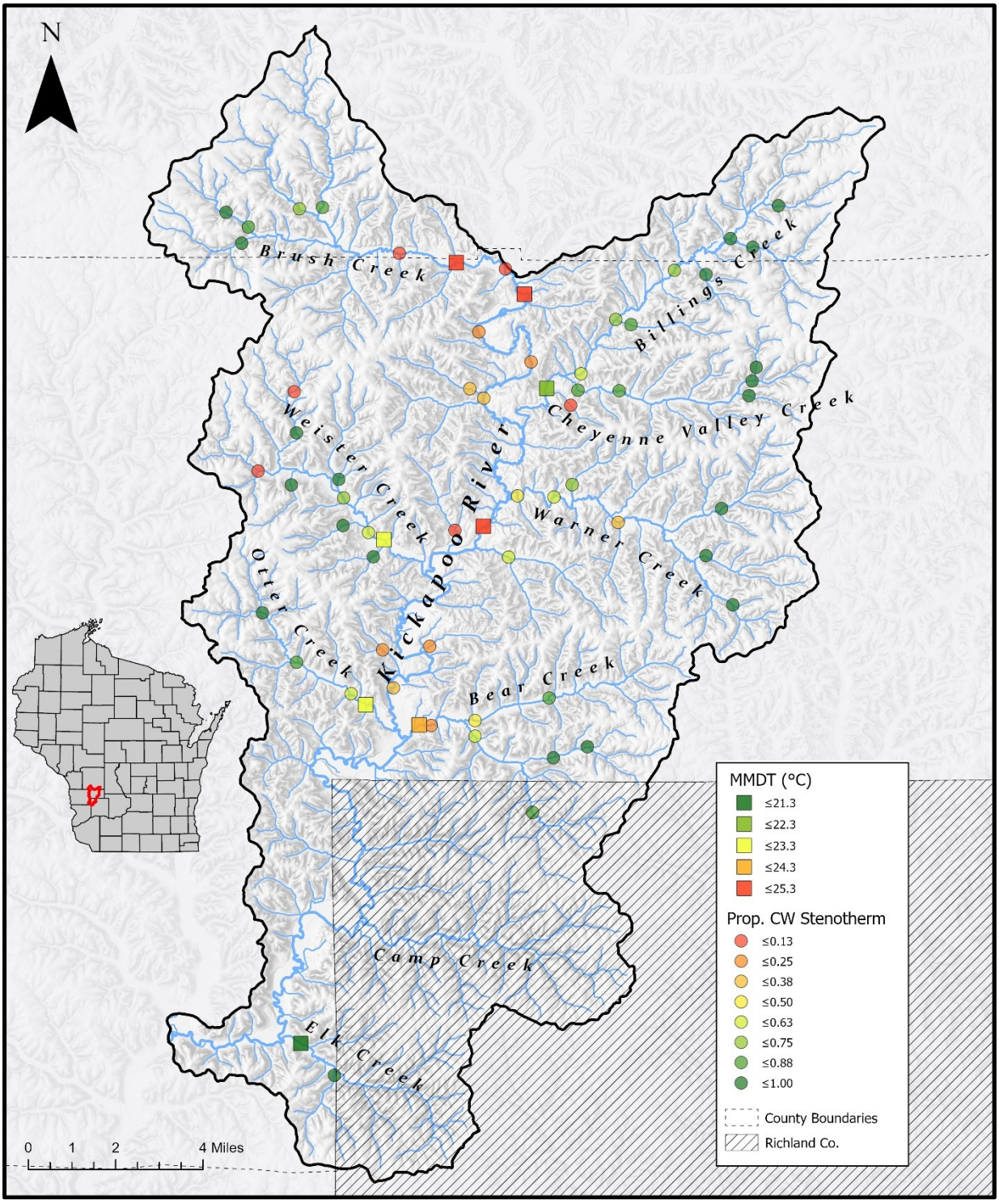

Figure 16. Stream thermal conditions based on summer mean maximum daily water temperatures (MMDT °C) and proportion of cool/cold water stenotherm species captured in electrofishing surveys. Darker green colors reflect colder summer stream temperatures.

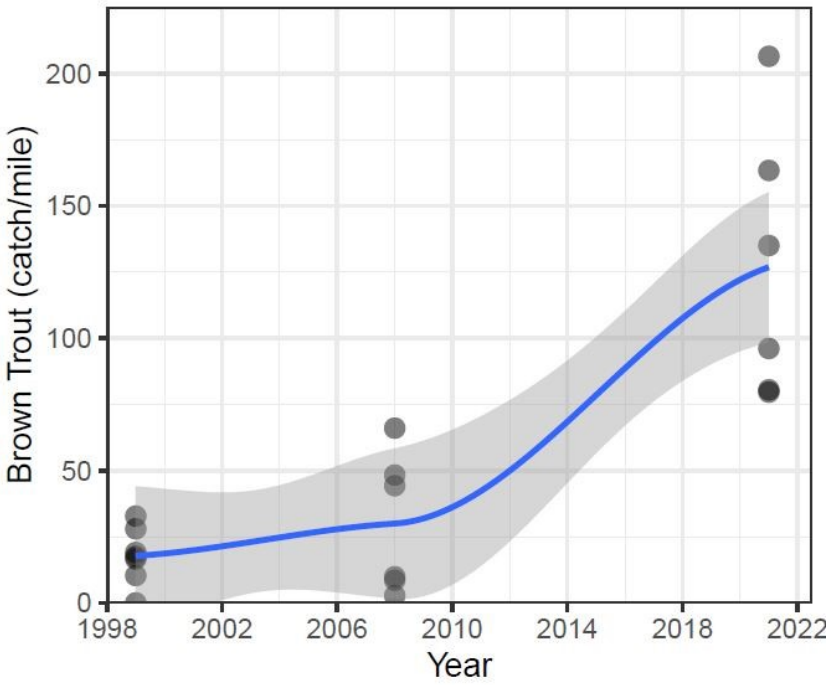

Figure 17. Relative density of Brown Trout sampled on the mainstem Kickapoo River between Ontario and La Farge, WI in 1999, 2008 and 2021 (years when more than six sites where sampled).

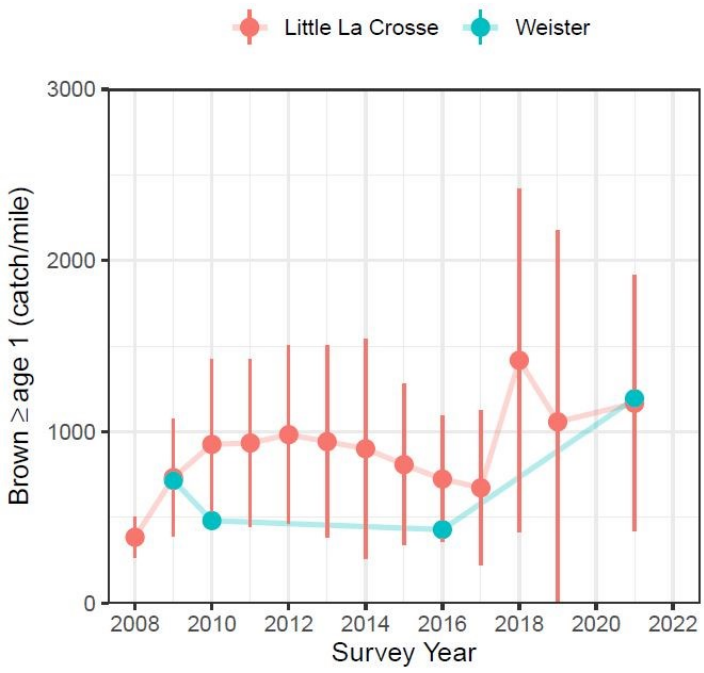

Figure 18. Relative density of Brown Trout sampled on Weister Creek near Wolfe Valley Road, where habitat work was completd in 2019, compared to the Little La Crosse River. Bars represent ±1 Standard Deviation.

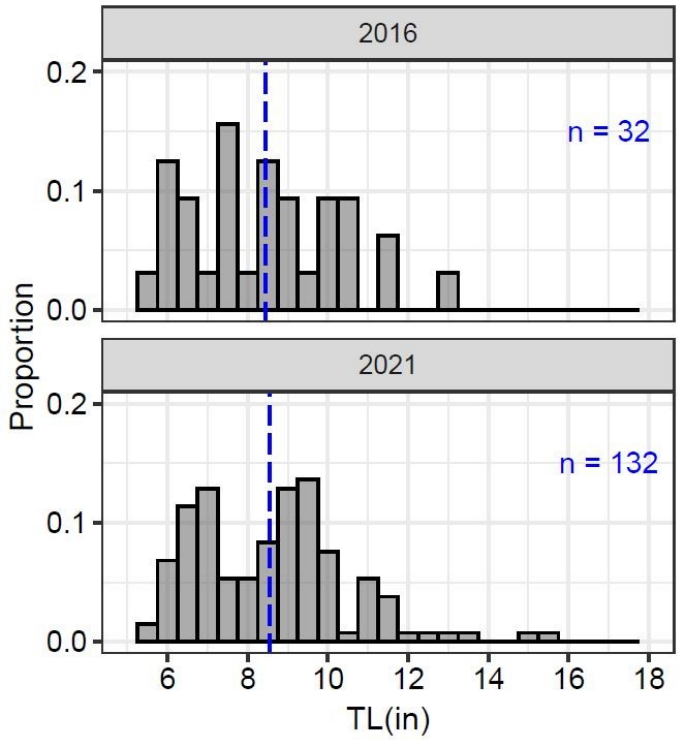

Figure 19. Length frequency distribution of age one and older Brown Trout captured on Weister Creek upstream of County Highway P, before and after habitat restoration was completed in 2019.

Figure 20. Heavily grazed riparian habitat along Otter Creek near County Highway D, Vernon County. Note stream widening and evidence of substantial erosion and deposition following a significant flood event in August 2018.

Figure 21. Failed LUNKER structure pinned against the HWY 82 Bridge over Otter Creek. Photo: Kirk Olson.

Appendix

Appendix 1. Fishing regulations in the Bear Creek Watershed between 1935 and 2019. MLL = Minimum length limit, BL = bag limit.

Year	Waterbody(s)	Section	Species	MLL (in.)	Bag Limit (#/day)	Start Season	End Season
1935	all	all	trout (all)	7	15	Late April-Mid May	Early September
1949	all	all	trout (all)	7	10	Late April-Mid May	Early September
1950	all	all	trout (all)	6	10	Late April-Mid May	Early September
1957	all	all	trout (all)	6	10	Late April-Mid May	August - Early September
1961	all	all	trout (all)	6;13	10; 5	Late April-Mid May	Early September
1963	all	all	trout (all)	6	10	Late April-Mid May	Early September
1972	all	all	trout (all)	6	5	Early May	End of May
1972	all	all	trout (all)	6	10	June	Mid-September
1977-1980*	Vernon County Waterbodies	all	trout (all)	6	5	January	End September
1979	all	all	Brown and Rainbow	6	5	Early May	End of May
1979	all	all	Brook	6	10	Early May	End of May
1979	all	all	trout (all)	6	10	June	Mid-September
1981-1985*	Vernon County Waterbodies	all	trout (all)	6	2	January	Early May
1990	Vernon County Waterbodies	all	trout (all)	7	5	Early May	End September
1990	Monroe County Waterbodies	all	trout (all)	9	3	Early May	End September
1990	South Bear Creek	all	Brown and Rainbow	Protected slot 14-18	3 (combined)	Early May	End September
1990	South Bear Creek	all	Brook Trout	Protected slot 10-14	3 (combined)	Early May	End September
2000	all	all	trout (all)	NA	0	Early March	Early May
2003	South Bear Creek	all	trout (all)	9	3	Early May	End September
2016	all	all	trout (all)	NA	0	Early January	Early May
2016	base¥	all	trout (all)	0	5	Early May	Mid October
2016	Tenny Springs Creek	all	Brown and Rainbow	0	5	Early May	Mid October
2016	Tenny Springs Creek	all	Brook	NA	0	Early May	Mid October
2016	Elk Creek	all	trout (all)	Maximum LL 12	3	Early May	Mid October

* Extended early harvest seasons

¥all streams without regulations listed