WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Trout Population Trends and Fisheries Management in Southern Crawford County

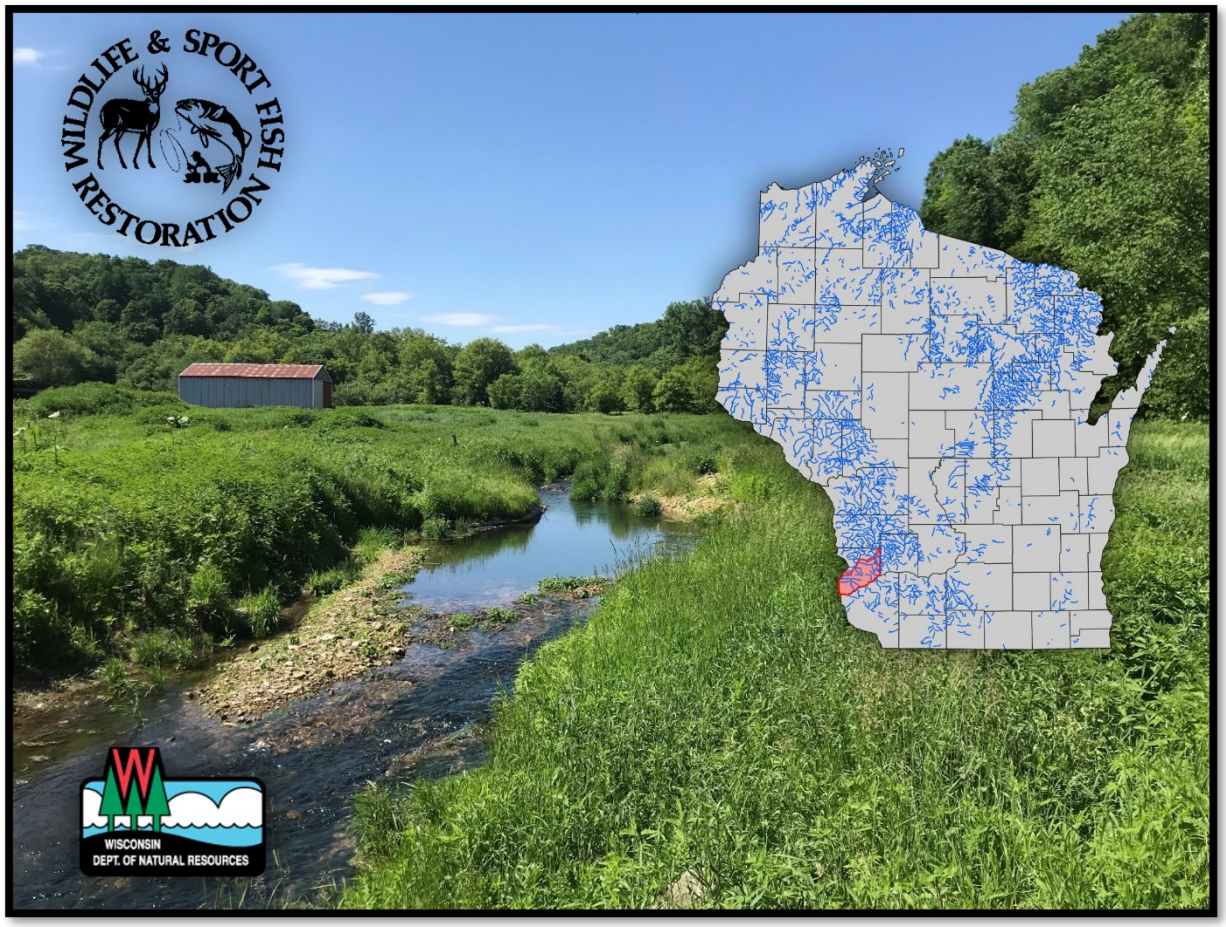

Photo Credit: Kirk Olson

Kirk Olson
Wisconsin DNR
Bureau of Fisheries Management
La Crosse, WI
March 2023

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Executive Summary

Southern Crawford County is comprised of five Watersheds (i.e., Hydrologic Unit Code 10) that drain 379 square miles of forested and agricultural lands into the Wisconsin and Mississippi rivers. The area includes 30 trout streams totaling 146.4 miles of classified trout water, all of which are supported by natural reproduction. In 2022, the Wisconsin Department of Natural Resources (DNR) Bureau of Fisheries Management sampled 45 sites on 28 streams and deployed nine stream temperature loggers to evaluate the current status of trout populations. Naturally reproduced brown trout *Salmo trutta* were captured in 38 sites, with a mean relative density that was in the top 35th percentile of streams region wide. The greatest adult brown trout densities were documented in the middle portions of classified trout water. Larger brown trout were generally associated with sites having deep pools and cover. Young of the year brown trout were most abundant in headwater sites where adult brown trout densities were lower. Brook trout were captured in 27 sites with a mean relative density in the bottom 40th percentile of trout streams in the region. Adult, quality size and young of the year brook trout were all most abundant in sites where brown trout were absent or present in low numbers. Evaluation of long-term trends in trout abundance indicates that brown trout have increased over the past decade on most streams, while brook trout have declined. Thermal conditions on nearly all classified trout streams were well within the range suitable for trout, based on July mean water temperature. Trout habitat projects on Plum and West Fork Knapp creeks resulted in increases in both brook and brown trout densities. However, 15 years of post-monitoring data on Plum Creek revealed that the brook trout population has collapsed in the past decade as brown trout numbers have continued to increase. Brook trout re-introduction stocking, occurring in the late 1990s and early 2000s, was successful in many streams in the first decade after re-introduction, but brook trout populations on several streams have since declined to the point of collapse as brown trout populations have expanded. Halls Branch Creek is currently the only stream stocked with trout in southern Crawford County, receiving feral brook trout annually. Stocking is likely no longer warranted there as naturally reproducing brook and brown trout populations have become well-established, and angler use is limited. Creel surveys have not been completed in southern Crawford County to evaluate angler harvest and pressure on area trout streams. Though trout are now more abundant and widespread in southern Crawford County streams than they've been in at least a century, several challenges face trout fisheries in the area. Current challenges include increased flooding and air temperatures due to climate change, changes in land use and displacement of brook trout by brown trout.

MANAGEMENT RECOMMENDATIONS

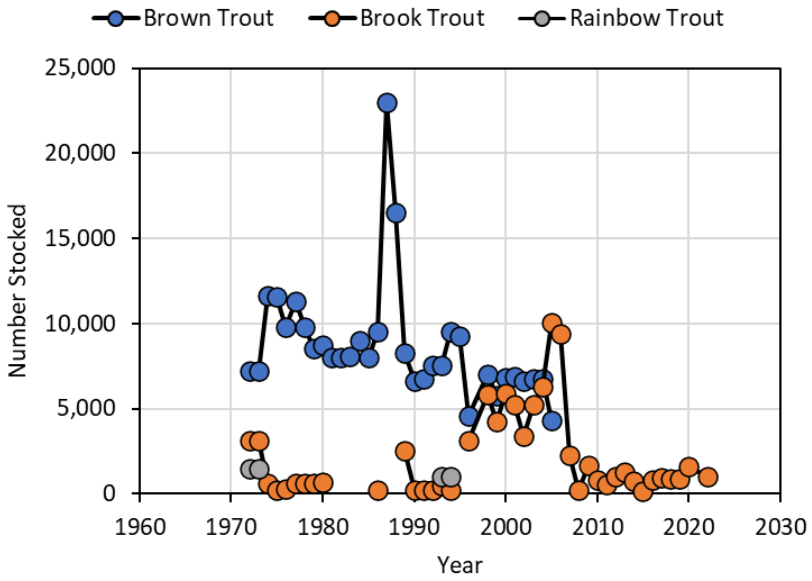
- Focus trout habitat restoration in areas where stream power and trout densities are lower and utilize approaches that will increase stream resiliency to more frequent flooding.

- Avoid standard high-gradient (i.e., Hunt 1993) habitat restoration methods where naturally reproducing brook and brown trout occur together.
- Avoid complete riparian tree removal and consider planting trees where shade is lacking, and downstream thermal conditions are a concern.
- Continue to assist in evaluation of waterway permits, with particular interest in those that may impact trout habitat.
- Stock feral, Wisconsin strain, brook trout in streams with known domestic lineage brook trout (e.g., Picatee Creek).
- Propose a brook trout specific catch and release regulation on Du Charme, Gran Grae, Little Kickapoo, Pine and West Fork Knapp creeks.
- Complete an opening weekend vehicle count to gauge angler pressure on area trout streams.
- Complete a brown trout removal on Du Charme Creek to support the declining brook trout population there.
- Re-introduce native Slimy Sculpin in seven streams where habitat conditions are suitable.
- Monitor and maintain existing property, streambank easements and habitat projects.
- Continue to pursue streambank easements on eligible streams.
- Update trout stream classifications based on results from this report.
- Re-evaluate these recommendations in 2030, when the next comprehensive evaluation is scheduled.

Introduction

Southern Crawford County is comprised of five HUC 10 Watersheds that drain 379 square miles of forested and agricultural lands into the Wisconsin and Mississippi rivers (Fig. 1A, Appendix). Similar to the rest of the Driftless Area, the five watersheds contain few lakes and a well-developed valley and stream network. The area's permeable bedrock and relatively widespread 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, southern Crawford County supports 30 trout streams totaling 146.4 miles of classified trout water, all of which are supported by natural reproduction.

Figure 1 Number of brook, brown and rainbow trout stocked in south Crawford County between 1972 and 2022. Feral trout stocking began in 1998. Brown trout stocking ceased in 2005.



Early DNR Fisheries Management investigations in southern Crawford County, beginning in the 1940s, revealed poor stream habitat conditions, limited natural reproduction of trout and an abundance of fish species adapted to warm summer stream temperatures. Excessive grazing, frequent flooding and poor riparian land use limited adult trout habitat on many streams (DNR Fisheries Management files). Despite improvements in stream hydrology, beginning as early as 1970 (Juckem et al. 2008), brown and brook trout densities remained low and were supported by stocking in all but four streams until the late 1990s, when rapid recovery of naturally reproducing trout populations began. Recovery of trout habitat due to reductions in riparian grazing (Rhemtulla et al. 2007), trout habitat improvement projects and stocking of feral strain brown and brook trout likely facilitated the rapid recovery of trout populations.

Habitat conditions for trout have greatly improved in southern Crawford County over the past several decades due to intensive in-stream trout habitat restoration and passive improvements to riparian vegetation resulting in-stream habitat. Passive improvements in trout habitat have occurred as livestock grazing has decreased along stream corridors, allowing more dense riparian vegetation to become established (Vondracek 2019). Active trout habitat improvements have involved direct manipulation of in-stream habitat features and riparian areas with heavy equipment (e.g., Hunt 1993). Eight trout habitat projects have been completed in southern Crawford County, all following standard methods for high-gradient Wisconsin trout streams. The first trout habitat projects were completed on DNR streambank easements on Richland and Plum creeks in 1997. Since then, six projects have been completed by the DNR and two by private landowners (Fig. 2A, Appendix). All DNR habitat work has been completed on publicly accessible lands. In total, trout habitat improvement work has been completed on 4.7 stream miles, or 3% of the classified trout water in southern Crawford County.

Table 1 Brook trout strain stocked by year and stream. Bold text signifies first known re-introduction stocking.

Stream	Year	Strain
Citron Creek	**1998-2000**	**Melanchthon and Mill Creek**
Citron Creek	2001-2007,2013	Ash Creek
Du Charme Creek	**2000**	**Duncan Creek (Field Transfer)**
Du Charme Creek	2003-2006, 2013	Ash Creek
English Run	**1998-2000**	**Melanchthon and Mill Creek**
English Run	2001-2004	Ash Creek
Gran Grae	**2000**	**Duncan Creek (Field Transfer)**
Halls Branch	**1998**	**Melanchthon and Mill Creek**
Halls Branch	2003-2017	Ash Creek
Halls Branch	2018-Present	WI Feral (Rotating Stream)
Hoover Hollow	2009	Ash Creek
Little Kickapoo	**2001**	**Duncan Creek (Field Transfer)**
Mill Coulee	**2001**	**Duncan Creek (Field Transfer)**
Picatee Creek	**2001**	**Duncan Creek (Field Transfer)**
Pine Creek	2005	Ash Creek
Plum Creek	1996-2000	Melanchthon and Mill Creek
Plum Creek	2001	Ash Creek
Richland Creek	2005-2006	Ash Creek
Trib to Sand Creek	2005	Ash Creek
West Fork Knapp	2005-2006	Ash Creek

Similar to the rest of the Driftless Area, trout stocking has been widespread in the streams of southern Crawford County. Though complete stocking records are only available after 1972, stocking likely occurred as early as the 1880s (Thorn et al. 1997). Between 1972 and 1997, domestic brown trout made up most of the trout stocked in area streams, with an average annual stocking rate of 9,648 fingerlings, yearlings and/or adults per year (Fig. 1). In 1998, stocking transitioned from domestic to feral brown trout *Salmo Trutta* (i.e., brown trout one or two generations removed from wild

parents). In 2005, the DNR ceased brown trout stocking and transitioned to stocking only feral brook trout. Currently, Halls Branch Creek is the only stream stocked in southern Crawford County and it receives 1,500 yearling brook trout annually.

Figure 2 Backpack electrofishing on West Fork Knapp Creek. Photo Credit: Kirk Olson.

Since 1935, trout fishing in southern Crawford County has largely been regulated through region-wide harvest rules and seasons (Table 1A, Appendix). From 1990 to 2016, all trout streams in the area were managed with a nine-inch minimum length limit and a three fish bag limit. In 2016, part of the statewide trout regulation overhaul, several changes to trout regulations occurred. The county base regulation was changed to a five fish bag limit and no minimum length limit, 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. 30th to Oct. 15th. In addition, special regulations, requiring the release of brook trout on Plum Creek and Halls Branch were enacted. These changes were enacted to increase regulation simplicity, provide additional angling opportunities and protect Brook Trout populations on two streams where declines were noted. The more liberal base harvest regulation was supported by the evidence of limited angler harvest in area trout streams (e.g., Mitro and Olson in prep.) and the presence of moderate to high-density brown trout populations in many of the region's cold-water streams.

Re-introductory stocking has been a major component of native brook trout management in southern Crawford County. Between 1996 and 2009, feral and wild (originating from Duncan Creek, Chippewa County) were stocked into 14 streams

where suitable habitat was identified (Table 1). In some locations brook trout populations expanded rapidly after introductions (e.g., Plum Creek, Picatee Creek).

Though trout populations in southern Crawford County have greatly improved over the past several decades, the area still faces challenges that threaten the persistence of the current fishery. Some of the greatest challenges include more frequent flooding and warmer air temperatures due to climate change (WICCI 2018), changes in land use and agricultural practices that negatively impact stream hydrology and habitat and expanding brown trout populations limiting brook trout.

A comprehensive evaluation of trout fisheries management has not been completed in any of the watersheds located in southern Crawford County. In 2022, 45 sites on 28 streams were sampled as part of a comprehensive watershed-based fisheries evaluation. In this report, we 1) summarize current and past fisheries data, 2) evaluate current fisheries management activities including: stocking, habitat restoration fishing regulations and DNR Fisheries property management, and 3) set objectives for future fisheries management.

Methods

STUDY AREA

Southern Crawford County contains four partial watersheds (i.e., Wisconsin River, City of Boscobel – Wisconsin River, Knapp Creek and Bloody Run – Mississippi River) and one complete watershed (i.e., Kickapoo River), which drains 379 square miles. This area includes 146.4 miles of classified trout water located entirely within the Driftless Area, a landscape largely unshaped by the glacial activity and described by flat ridge tops, steep hillsides and valleys up to 450 feet deep. The underlying bedrock of the region is composed of a mix of limestone, dolomite and sandstone (Fig. 1A, Appendix). Groundwater infiltration is greatest on ungrazed forested hillslopes (Trimble 2013), where the ground surface is close to porous limestone and dolomite bedrock. Groundwater captured in these, and other upslope areas, emerges in valleys as seeps and springs where non-porous sandstone layers cause lateral movement of groundwater to the surface (Potter 2019).

Land cover in southern Crawford County is composed primarily of deciduous forest (50.5%), pasture lands (17.8%) and row crops (15.8%; Table 2; Fig. 3A, Appendix). A small portion of the area is composed of low and high-density development (2.9%), much of which is located in the city of Prairie Du Chien (2021 population = 5,487) and less in the smaller towns of Gays Mills (2021 population = 521), and Wauzeka (2021 population = 628). Both Wauzeka and Prairie Du Chien are located at the downstream ends of their respective watersheds (i.e., near the Wisconsin and Mississippi Rivers, respectively).

Wisconsin DNR property comprises a significant portion of the watershed, though much of this land is located along the Kickapoo and Wisconsin river bottoms, where

the management of these lands has limited impact on classified trout water. Wisconsin DNR properties and easements total 16,714 acres in southern Crawford County (7% of land, Fig 2A, Appendix) and include 16.4 miles of classified trout water (11% of all classified trout stream miles).

Table 2 Land cover in the Southern Crawford County Watersheds based on Wiscland 2.0.

Land Cover Type	Area (acres)	% Total
Broad-leaved Deciduous Forest	122375	50.50
Forage Grassland	43105	17.80
Crop Rotation	38375	15.80
Forested Wetland	10948	4.50
Open Water	7265	3.00
Idle Grassland	6233	2.57
Developed, Low Intensity	5429	2.24
Emergent/Wet Meadow	5307	2.20
Developed, High intensity	1616	0.66
Coniferous Forest	882	0.36
Floating Aquatic Herbaceous	669	0.28
Shrubland	81	0.03
Barren	52	0.02
Lowland Scrub	35	0.01

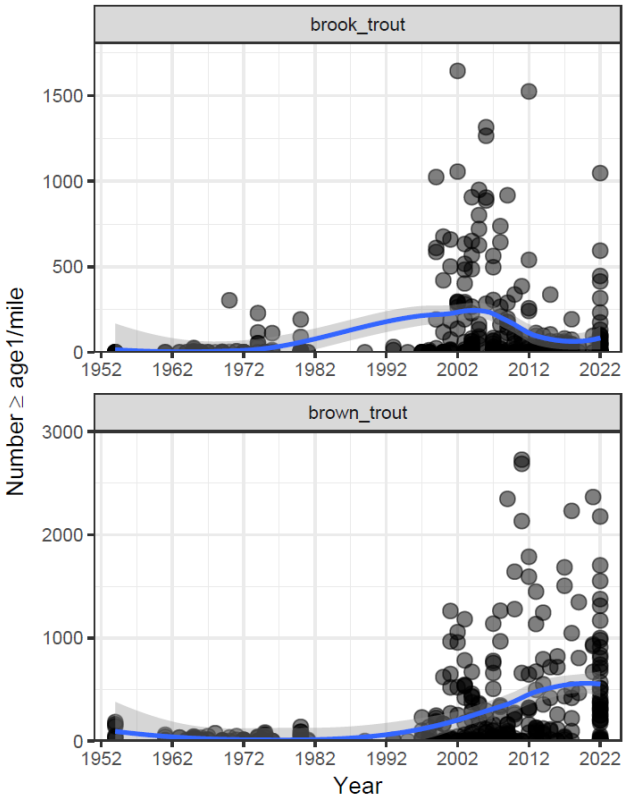
FISH SAMPLING AND ANALYSIS

Electrofishing surveys were completed on 45 sites located on 28 streams sampled between May 24 and Sept. 6. Depending on stream size, electrofishing was completed using a pulsed DC backpack electrofishing unit (e.g., Fig 2) or DC stream barge. 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. Station lengths ranged from 84 to 317 meters, with only one station measuring less than 100 meters due to limited accessibility. All gamefish collected were measured to the nearest 0.1 inch and weighed to the nearest gram.

Relative density (catch per effort) was estimated by dividing the total catch by the distance (in miles) of stream surveyed. Length cutoffs for young of year (YOY) and adult (i.e., age one and older) trout were determined based on length frequency distributions, which indicated that YOY trout were five inches in length and shorter. The relative density of preferred size brook and brown trout (Neumann et al. 2012, brook trout = 9 inches, brown trout = 12 inches) was also estimated. Relative densities were compared to the Wisconsin Driftless Area median based on DNR stream surveys completed between 2007 and 2014. Relative densities were also compared among the

nine most well-known streams (defined based on DNR staff observations) in southern Crawford County.

Figure 3 Catch per mile of adult brook trout (top panel) and brown trout (bottom panel) from electrofishing surveys.

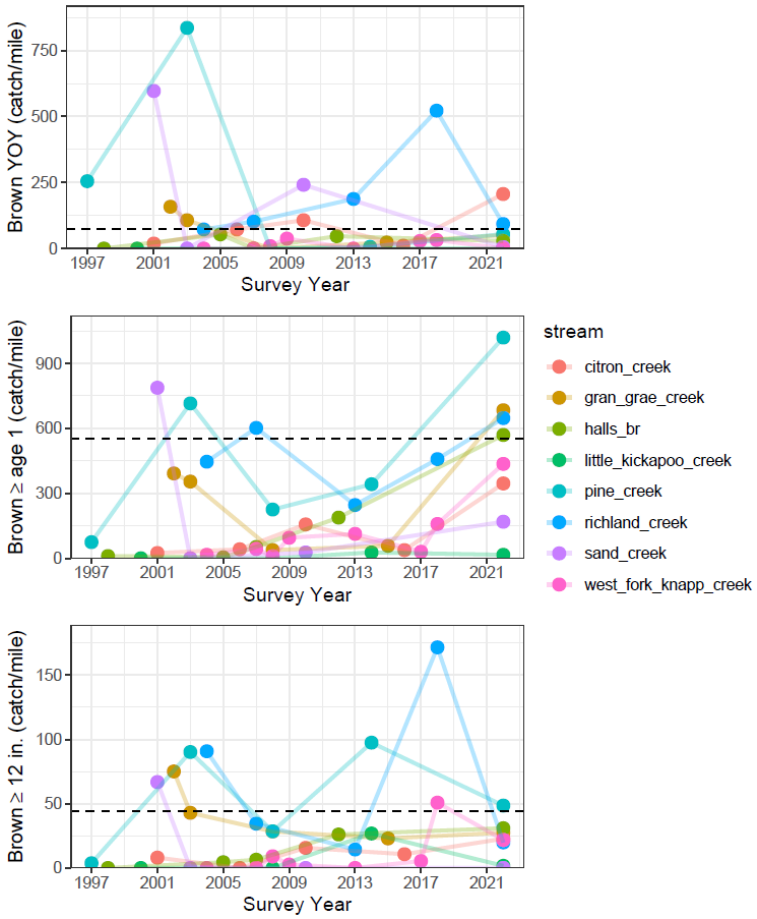


Linear regression was used to evaluate whether density was associated with brown trout size. The mean maximum length (i.e., the mean length of the top five largest individuals at a site) and relative density of 12-inch and larger brown trout were regressed against adult relative density. In order to better fit the assumptions of linear regression, adult relative density was log transformed when regressed against mean maximum length

Patterns in brook and brown trout relative densities were visually evaluated from 1997 to 2022 using locally weighted regression (loess fit) and statistically using linear regression. Years prior to 1997 were excluded from this analysis as earlier electrofishing surveys were not always consistent with current standardized methods. Prior to linear regression, mean catch per effort of adult brook and brown trout were estimated for each stream and year combination. These values were log(x+1) transformed to improve normality and homoscedasticity of residuals, and the resulting values were regressed against year. Non-linear patterns were visually evaluated based on loess fit lines and 95% confidence bands using the program R package ggplot2 (Wickham 2016).

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 the 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 July mean temperature based on hourly water temperature data from 10 sites and the proportion of cool and cold-water stenotherm species in each electrofishing sample (Lyons and Wang 1996).

Figure 4 Relative density of brown trout by size class in eight well known southern Crawford County streams. Plum Creek is excluded from this plot, see Fig. 5. Dashed lines represent median relative abundance for Wisconsin Driftless Area trout streams.



All statistical tests were completed in Program R (ver. 3.5.0, R Core Team) with an α of 0.05.

BROOK TROUT STOCKING EVALUATION

In order to evaluate the efficacy of brook trout stocking in Halls Branch Creek, we examined angler use based on opening day vehicle counts and the abundance of brook trout in electrofishing surveys. Relative abundance of YOY (i.e., wild origin) and adult brook trout were estimated and compared to stocking rate in five years where electrofishing surveys were completed (1998, 2005, 2007, 2012 and 2022) using linear regression. Opening day vehicle counts were made at four road crossings on Halls Branch Creek between 14:31 and 14:49 in 2021 as part of a region-wide evaluation of

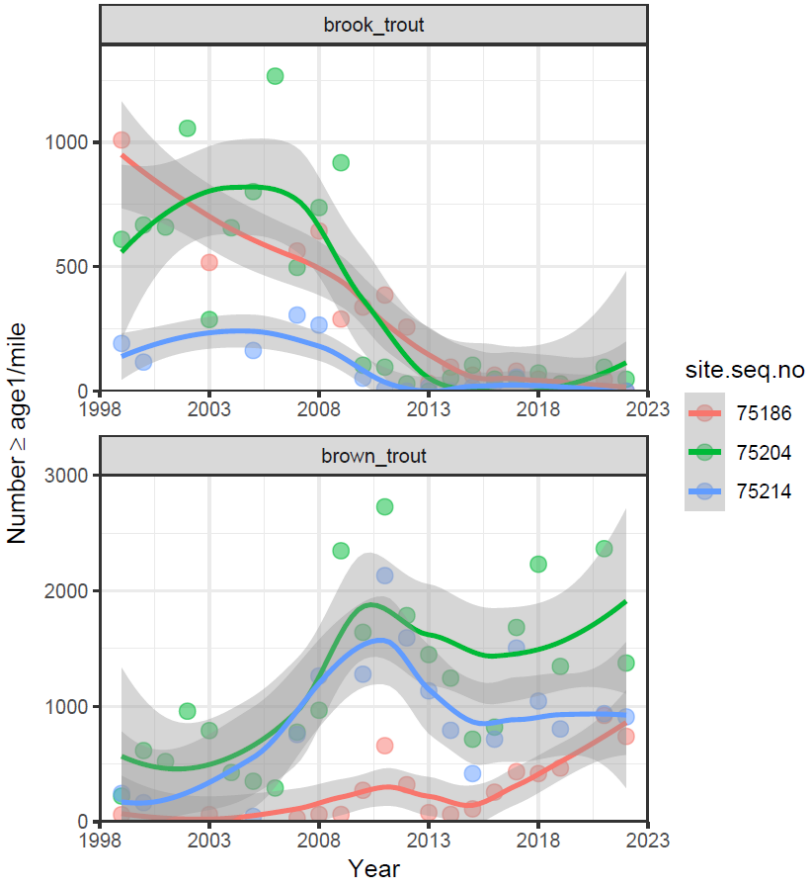
angler pressure at stocked sites. The number of angler vehicles at each access point was counted and recorded.

TROUT HABITAT IMPROVEMENT EVALUATION

Electrofishing data collected before and after the completion of trout habitat restoration projects allowed us to evaluate the impact of habitat projects on Plum Creek and the West Fork Knapp Creek.

Trout habitat improvement projects were completed on Plum Creek in 1998 and 2006 (Fig 2A, Appendix). To evaluate the impact of these projects on trout populations, we examined changes in catch per effort of brook and brown trout collected via electrofishing in the project areas. Both data sets included at least one year before trout habitat work was completed and more than 15 years after.

Figure 5 Relative density of brown (bottom panel) and brook trout (top panel) on three sites sampled on Plum Creek between 1999 and 2022.



Bank stabilization and trout habitat improvement were completed on private land in 2017 on the West Fork Knapp Creek upstream of South Sleepy Hollow Road. We surveyed the stream reach in 2017, prior to the completion of work, and again in 2021,

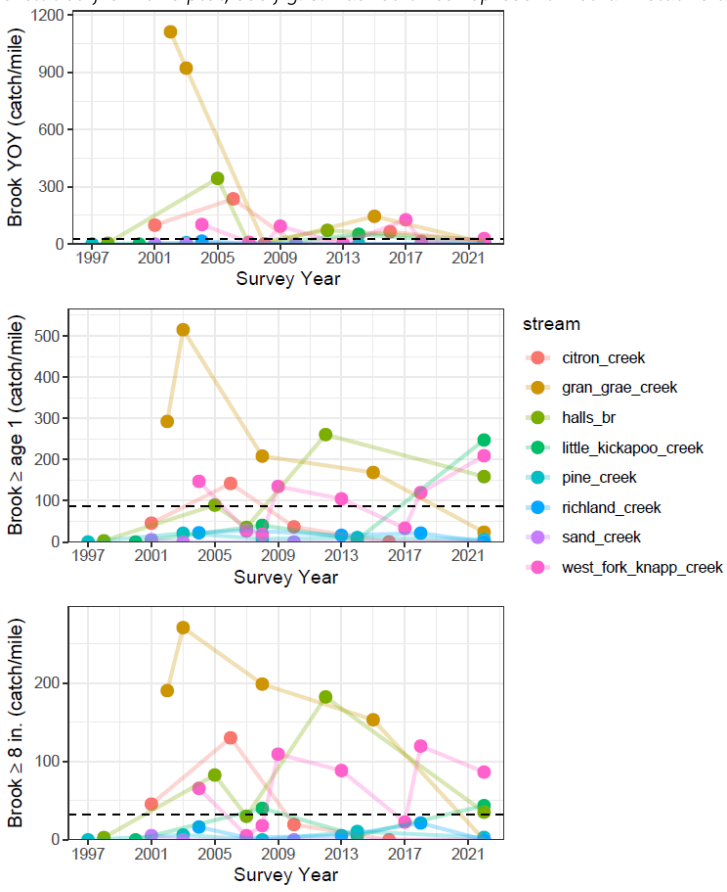
four years after the work was completed. Catch per effort and length distributions of brook and brown trout were compared before and after the work was completed.

Results

BROWN TROUT

Brown trout were present in 38 of 45 sites sampled and at a mean relative density of 601 fish per mile (range = 0-2,239; Fig. 4A, Appendix). This mean relative abundance was in the top 35th percentile of Wisconsin Driftless Area trout streams. In 11 sites, brown trout relative density exceeded the 20th percentile for Wisconsin Driftless Area trout streams (>950 fish/mile).

Figure 6 Relative density of brook trout by size class in eight well known southern Crawford County streams. Plum Creek is excluded from this plot, see fig. 5. Dashed lines represent median relative abundance for Wisconsin Driftless Area streams.



Mean adult brown trout relative density increased from 1997 to 2022 (linear regression, R^2 =0.07, P = 0.002) when evaluated across all streams sampled. In 2022, the mean adult brown trout relative density was 494 fish per mile, in the top 35th percentile of Wisconsin Driftless Area trout streams. Brown trout adult relative densities were greater than all previous surveys on seven of the nine most popular trout waters in 2022 (Fig. 4 and 5). On the remaining two streams (i.e., Plum Creek and Little Kickapoo Creek), densities declined slightly or were similar to previous surveys.

Brown trout densities were exceptionally high (>1,500 fish per mile) in lower Richland, Plum, middle Pine, and Du Charme creeks (Fig. 4A, Appendix).

Larger brown trout (≥12 in.) were present at low densities across southern Crawford County. The greatest densities of large brown trout were observed on Plum, Pine and Richland creeks. The mean relative density of 12-inch and larger fish was 17 fish per mile, which was near the median of Wisconsin Driftless Area trout streams. Sites with the greatest mean maximum brown trout length were located on Plum, Pine and Gran Grae creeks (Fig 5A, Appendix).

Table 2. Nongame species captured in electrofishing surveys in 2022. Cool/cold represents whether the species is classified as cool or coldwater stenotherm species in Lyons and Wang (1996). Mean CPE represents mean catch per mile for each species in sites where the species was captured (i.e., excluding zeros).

Common Name	Scientific Name	Sites	Mean CPE	Cool/Cold?
American Brook Lamprey	Lethenteron appendix	1	31	X
Bluntnose Minnow	Pimephales notatus	1	22	
Brook Stickleback	Culaea inconstans	7	47	X
Burbot	Lota lota	4	13	X
Central Mudminnow	Umbra limi	2	12	
Creek Chub	Semotilus atromaculatus	5	318	
Fantail Darter	Etheostoma flabellare	6	47	
Golden Redhorse	Moxostoma erythrurum	1	57	
Grass Pickerel	Esox americanus	1	13	
Green Sunfish	Lepomis cyanellus	1	32	
Johny Darter	Etheostoma nigrum	4	51	
Longnose Dace	Rhinichthys cataractae	1	134	
Northern Hog Sucker	Hypentelium nigricans	1	11	
Shorthead Redhorse	Moxostoma macrolepidotum	1	10	
Slimy Sculpin	Cottus cognatus	2	18	X
Western Blacknose Dace	Rhinichthys obtusus	9	259	
White Sucker	Catostomus commersonii	18	270	

Mean YOY brown trout relative density was 107 fish per mile (range = 0 – 1,110), in the top 35th percentile of Wisconsin Driftless Area trout streams. YOY relative densities were typically greatest in headwater sites, with the exception of lower Plum Creek, where YOY densities were also high.

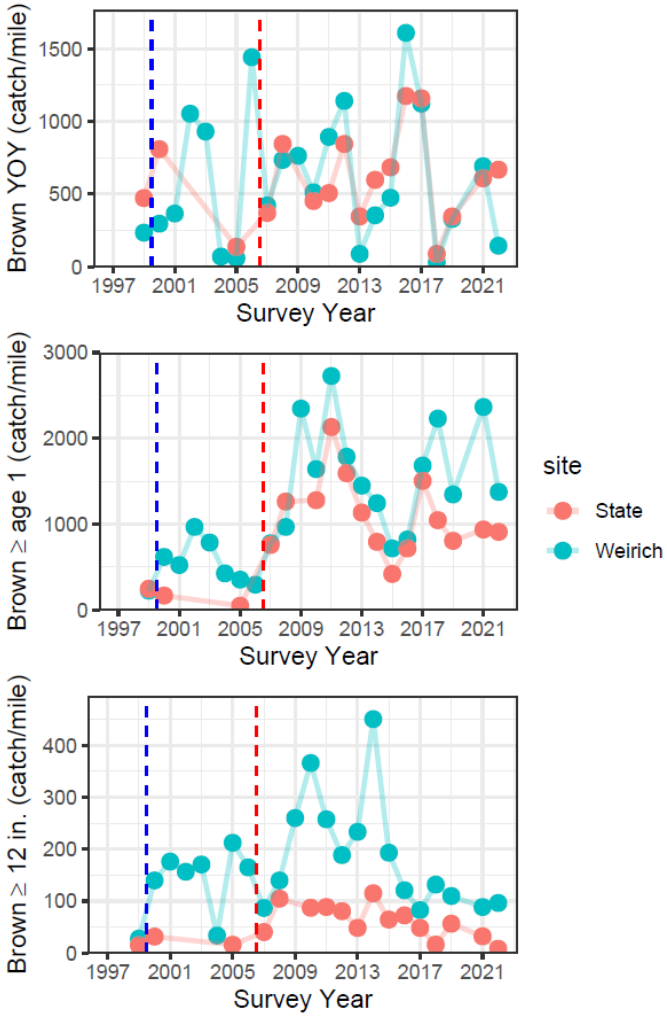
Mean maximum length of brown trout was positively correlated to adult relative density (R^2 = 0.63, P < 0.0001). Similarly, relative density of preferred (i.e., ≥ 12 in.) size brown trout was positively correlated with adult relative density (R^2 = 0.45, P < 0.0001).

BROOK TROUT

Brook Trout were captured in 27 of 45 sites sampled and at a mean relative density of 118 fish per mile (range = 0-1,078, Fig. 6A, Appendix). This relative density was in the bottom 40th percentile, compared to other Wisconsin Driftless Area trout streams. In

three sites, relative density of brook trout exceeded the top 20th percentile for Wisconsin Driftless Area streams (>433 fish/mile).

Figure 7. Catch per effort of brown trout by size class. Blue dashed line indicates when trout habitat work was completed on the Weirich Easement. Red dashed line indicates when habitat work was completed on state property.



Mean adult brook trout relative density was 92 fish per mile in 2022, near the median for Wisconsin Driftless Area streams. Adult relative density did not exhibit a significant linear trend between 1997 and 2022 (linear regression, R^2 =0.002, P = 0.27), but visual evaluation of the smoothed loess fit indicates an increase in density from 1997 to 2005 and a decrease from 2005 to 2013 (Fig. 3). Brook trout relative density declined substantially between the early 2000s and 2022 on Gran Grae and Plum creeks, two popular area streams (Fig. 5 and 6). Considering all area trout streams, recent brook trout declines were steepest on Du Charme, Mill, Gran Grae, Plum creeks and the East Fork of Richland Creek (Fig. 7A, Appendix).

The greatest brook trout relative densities occurred at sites where brown trout were absent (Fig, 6A, Appendix). Larger brook trout (≥8 in.) relative density was 23 fish per

mile in 2022 (45th percentile for Wisconsin Driftless streams) and was greatest on Picatee and West Fork Knapp creeks. Mean maximum sizes were greatest in Picatee, West Fork Knapp, Du Charme and Little Kickapoo creeks (Fig 8A, Appendix).

YOY brook trout relative densities averaged 26 fish per mile (45th percentile for Wisconsin Driftless streams). The greatest YOY relative densities were observed in the headwaters of West Fork Knapp Creek, an unnamed tributary to the Kickapoo River and the headwaters of Richland Creek (Figure 8A, Appendix).

NON-GAME SPECIES

In total, 17 non-game species were captured in 2022 (Table 2). None of the species captured were state or federally listed as threatened or endangered. The three most frequently captured non-game species were white sucker, western blacknose dace and fantail darter, which were found in 18, 9 and 6 of the 45 sites surveyed, respectively. Four cool or cold-water stenotherm species were captured, including American brook lamprey, brook stickleback, burbot, and slimy sculpin. Slimy sculpin were only captured in Citron and Pine creeks in 2022.

STREAM THERMAL CONDITIONS

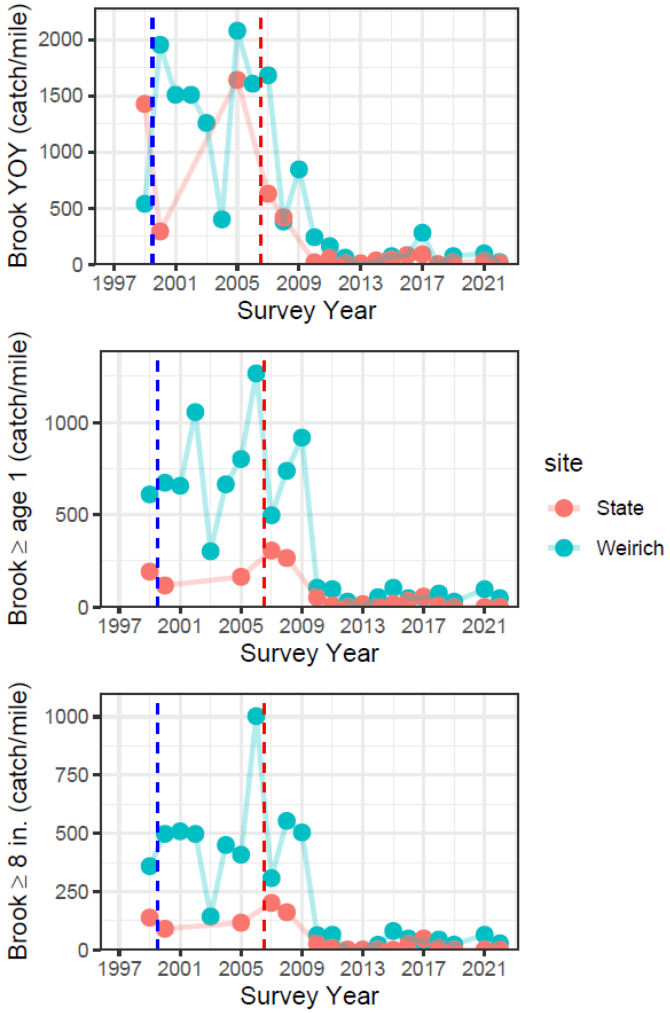
Stream thermal conditions varied across the watershed based on fish community assemblage and water temperature monitoring (Fig. 9A, Appendix). Generally, temperatures and proportions of warmwater fish species increased from upstream to downstream (e.g., Otter Creek, Halls Branch Creek), but we also observed exceptions to this pattern (e.g., English Run, Richland Creek, Citron Creek). Based on water temperature and thermal fish guild classifications from Lyons et al. (2009), Gran Grae, Clear, Citron, Sand, upper West Fork Knapp and Little Kickapoo creeks were coldwater (i.e., July mean <17.5°C), lower West Fork Knapp and Otter creeks were cold-transition coolwater (i.e., July mean 17.5-19.5°C) and Mill Coulee and Halls Branch were warm-transition coolwater (i.e., July mean 19.5-21.0°C). Cool and coldwater stenotherms made up more than 50% of the fish community at 36 sites sampled and were 100% of the fish community at 18 sites.

BROOK TROUT STOCKING EVALUATION

Mean adult brook trout relative abundance on Halls Branch Creek was low and increased from three fish/mile in 1998 to more than 100 fish per mile in 2012 and 2022. Adult brook trout relative abundance was not positively associated with yearling stocking rate (range of stocking rate = 320-1330 fish/year; linear regression, R^2 =0.002, P = 0.94). YOY brook trout were captured in every year except 2005. YOY catch rates averaged 88 fish/mile (range = 0-344 fish/mile). In 2022, YOY brook trout were captured at 20 fish/mile.

In the 2021 opening day angler vehicle survey of four angler access points, one angler vehicle was counted at Halls Branch Creek.

Figure 8. Catch per effort of brook trout by size class (YOY = young of the year). Blue dashed line indicates when trout habitat work was completed on the Weirich Easement. Red dashed line indicates when habitat work was completed on state property.



TROUT HABITAT IMPROVEMENT EVALUATION

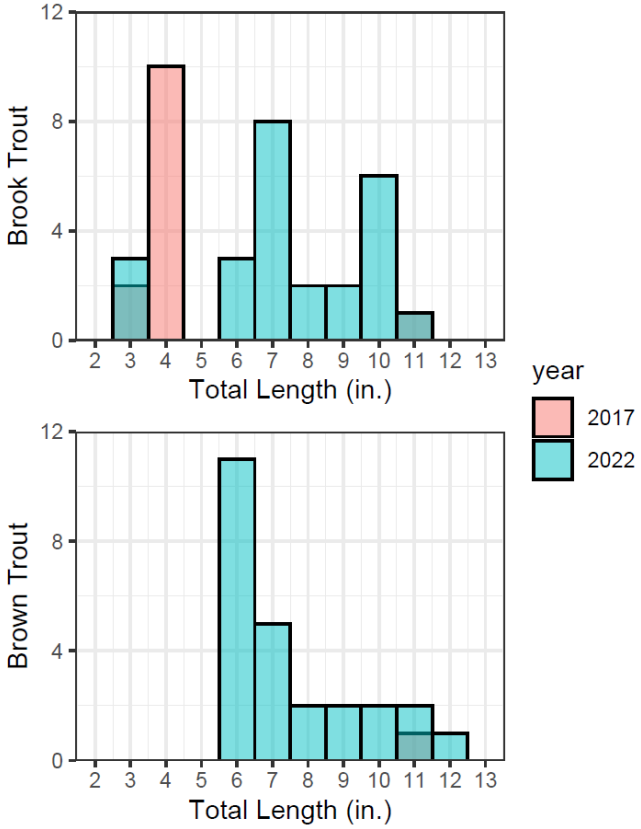
We observed increases in the relative density of both brook and brown trout in the year following habitat restoration on the Weirich DNR easement on Plum Creek. This increase occurred across all size classes (Fig. 7). However, between 2005 and 2010 a more substantial change in both brook and brown trout densities occurred on the site. During this time frame, adult brown trout densities more than doubled, while adult brook trout relative densities sharply declined.

Similarly, relative densities of all brown trout size classes increased on the portion of Plum Creek on state property following a trout habitat project. Brook trout relative densities increased for adult size classes but decreased for YOY. In the following years, brook and brown trout density changes mirrored those noted upstream on the Weirich DNR easement (Fig. 8).

On the West Fork Knapp Creek, brown trout relative density increased from 14 to 359 fish per mile, and brook trout relative density increased from 187 to 359 fish per mile

from 2017 to 2022. Brook trout size structure shifted toward larger individuals, with most fish measuring less than 5 inches in 2017 and between 6 and 11 inches in 2022 (Fig. 9).

Figure 9. Length frequency of brook (top) and brown (bottom) Trout from West Fork Knapp Creek captured in 2017, prior to habitat work being completed, and in 2022, five years after habitat work was completed.



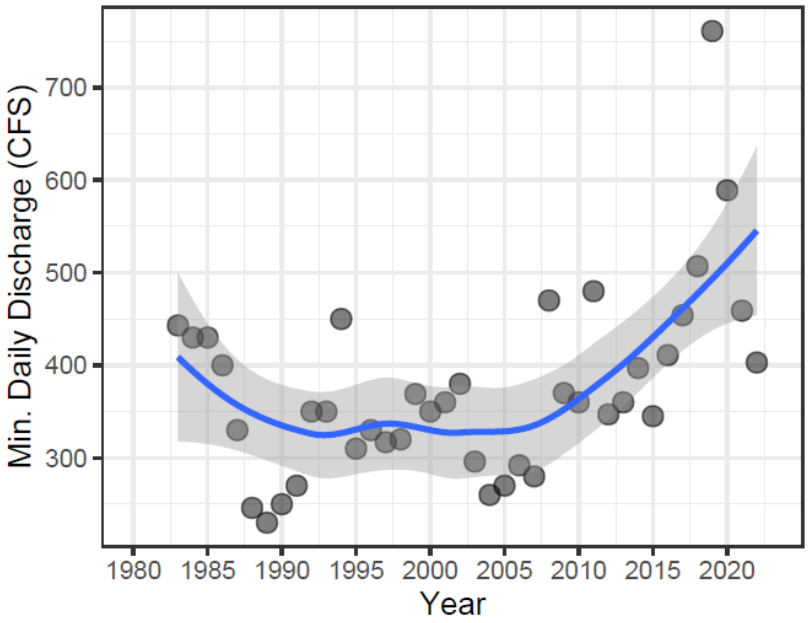
Discussion

BROWN AND BROOK TROUT POPULATION TRENDS

Our evaluation of trout relative densities found that brown trout populations were extremely limited or absent in most streams until the late 1990s when populations began to increase. DNR correspondence and reports dating back to the 1940s support this conclusion. Based on these files, many streams that now support naturally reproducing brown trout populations were non-trout water with poor habitat conditions not suitable for supporting even stocked trout fisheries. As recently as 1972, brown trout natural reproduction was only confirmed in three isolated reaches on Pine, Halls Branch and Steuben Springs creeks (DNR Fisheries Management files). Since that time, brown trout populations have transitioned from primarily low-density populations supported by stocking to moderate and high-density populations that are completely supported by natural reproduction. These changes are similar to those described in other parts of the Driftless Area (Thorn et al. 1997, Hoxmeier and Dieterman 2019, Vetrano 2019, Olson et al. 2021) and were likely facilitated by improvements in baseflow (Juckem et al. 2008), in-stream habitat improvement and stocking of feral trout.

Naturally reproduced brown trout populations were present in more than 80% of sites sampled in southern Crawford County in 2022. The relative density of adult (i.e., age 1 and older) brown trout at these sites was moderately high when compared to other Wisconsin Driftless Area trout streams. On many streams, brown trout relative densities had increased to their highest level in 2022. These results are similar to observations from nearby watersheds, where brown trout populations have grown in the past decade (e.g., Olson et al. 2021, Olson 2022). This increase appears to be associated with continued increases in baseflows (Fig. 10), which increase available habitat area and improve thermal conditions for trout. Adult brown trout relative densities were generally greatest in the middle portions of classified trout water, likely reflecting the combination of ideal thermal conditions and the amount of adult trout in these reaches.

Figure 10. Minimum daily discharge (CFS) of the Kickapoo River at the USGS Gauge in Stueben, WI.



Quality size (i.e., 12 inches and larger, Neumann et al. 2012) brown trout were less common in southern Crawford County streams and present at a level near the median for Wisconsin Driftless Area trout streams. Streams with the greatest number of quality size brown trout included Pine, Plum and Du Charme creeks. Larger brown trout were associated with middle and lower stream reaches that had deep pools and cover. For example, a segment of Plum Creek where trout habitat work was completed in 1999 had the greatest density of 12-inch and larger brown trout in 2022. The habitat work created an abundance of deep pools and adult trout cover based on quantitative habitat surveys completed in the early 2000s (DNR unpublished data 1999-2006). Adult density was positively associated with larger brown trout. This positive association may reflect that those sites with an abundance of adult trout

habitat also had suitable habitat for larger adult brown trout. Based on this analysis, adult densities did not appear to be limiting numbers of larger brown trout in southern Crawford County streams.

YOY brown trout densities were moderately high and highly variable, similar to most trout waters in Wisconsin. We observed that, like nearby watersheds (e.g., Olson et al. 2021, Olson 2022), YOY densities were typically greatest in headwater reaches. Headwater reaches were generally shallower and supported lower adult trout densities relative to downstream sites. In addition, it's likely that the abundance of coarse substrate and groundwater upwelling make these locations ideal spawning habitats. Spawning in smaller upstream reaches is typical for brown trout and has been noted in several movement studies (Myers et al. 1992, Ovidio et al. 1998, Burrell et al. 2000). Our results highlight the importance of small headwater reaches in sustaining brown trout populations in southern Crawford County trout streams.

Similar to brown trout, brook trout populations were limited or absent on many streams until the late 1990s. As recently as 1970, only one isolated reach of Boydtown Creek supported naturally reproducing brook trout. From the late 1990s until around 2010, brook trout populations increased rapidly in southern Crawford County. This increase likely reflects the establishment of populations following their re-introduction into habitats that, in the preceding decade, became suitable for brook trout due to increased base flow and in-stream habitat improvements. In the past decade brook trout populations have sharply declined on many streams in southern Crawford County. This decrease is likely associated with the continued expansion of brown trout. For example, brook trout populations on Plum, Gran Grae and Du Charme creeks have collapsed as brown trout have become very abundant. This finding is not unique, as brown trout have been shown to suppress brook trout in other Driftless streams (Hoxmeier and Dieterman 2016, Olson in prep.). Multiple interacting mechanisms are likely involved in the asymmetric competition between the two species. Lab and field studies indicate that brown trout may displace brook trout from preferred resting positions and thermal habitats (Fausch and White 1981, Hitt et al. 2016) and interfere with reproduction (Essington et al. 1998).

In 2022, brook trout were captured in 27 of the 45 sites sampled. The mean adult density of brook trout was near the median for Wisconsin Driftless Area streams (85 brook trout per mile). The greatest densities and sizes of brook trout were documented in streams where brook trout occurred in allopatry (i.e., in the absence of brown trout). In addition, trends in brook trout abundance were positive at all sites where brook trout occurred in allopatry, while substantial declines were noted on four streams where brown trout were also increasing in abundance. These results likely reflect the negative impact of brown trout on brook trout populations in Driftless Area streams.

Of the streams sampled in 2022, Plum, Citron, Grane Grae, Mill and East Branch Richland creeks experienced the steepest brook trout declines. Decreases on Plum,

Citron, Gran Grae and East Branch Richland creeks occurred at the same time brown trout populations expanded. The decrease on Mill Creek is unknown as no fish were captured in a more than 170-meter stretch of stream that was surveyed in 2022. The complete absence of fish in this reach may indicate that some catastrophic event occurred in recent years, such as the stream running dry.

Substantial brook trout declines occurred on three streams identified as potential Brook Trout Reserves by DNR Fisheries Management in 2017. Brook Trout Reserve streams were selected based on FishVis (Stewart et al. 2016) predicted future stream temperature, suitable brook trout habitat, riparian and watershed conditions and amount of public land in the watershed. These metrics do not account for potential declines in brook trout as a result of brown trout population expansion.

HABITAT MANAGEMENT

Only 3% (4.7 miles) of all classified trout stream miles in southern Crawford County have received in-stream habitat restoration. Initial work, beginning in the late 1990s, was completed by the DNR on fisheries lands and easements on Plum and Richland creeks. Since then, work has been completed by the DNR and private landowners in cooperation with Trout Unlimited, the Crawford County Conservation Department and USDA – NRCS (Appendix 1, Fig. 2A). 16.4 miles of classified trout streams run through DNR managed lands or easements, making it possible for trout stamp funds to be used to improve trout habitat on another 11.7 miles of stream in the future. However, many of these stream reaches already support moderate or high-density brown trout populations. The greatest potential for trout habitat improvement appears to be in lower 3rd to 5th order stream reaches (e.g., lower Pine Creek), where vertical accretion of post-settlement alluvium has resulted in an incised stream channel, often with fine substrate bottom and limited trout habitat and densities. These sites are also lower in gradient and stream power, increasing the likelihood that improved stream habitat features will persist in future floods.

Our evaluation of trout habitat improvement work on West Fork Knapp Creek and Plum Creek found an initial positive response of both brook and brown trout populations. In the following 23 years on Plum Creek, the brown trout population continued to expand, while the brook trout population declined and eventually collapsed. Five years after the 2017 habitat restoration project on the West Fork Knapp Creek, brown trout relative densities have increased substantially and to a greater extent than brook trout. Standard high-gradient trout habitat improvement methods employed on Driftless Area streams (e.g., Hunt 1993) appear to favor brown trout (Avery 2004, Yallaly Pers. Comm.), often to the detriment of brook trout. Future habitat improvement projects in the area should avoid employing standard Wisconsin high-gradient habitat methods where brook and brown trout occur in sympatry.

Future habitat restoration in southern Crawford County should also consider the current and predicted increases in air temperature and frequency and intensity of flood events (WICCI 2018; Fig. 10A). Habitat projects should incorporate partial removal of post-settlement alluvium to increase floodplain volume and decrease the power of stream water on stream banks during flood events. Riparian management such as burning, brushing and intermittent grazing should be used to encourage a well-vegetated riparian buffer to maintain stream bank stability during flood events. Moderate to heavy grazing in the riparian zone should be discouraged. Though riparian vegetation conditions created by moderate grazing may create enough bank stability for most floods, the significant floods that have occurred in recent years (e.g., Coon Valley in 2018) have revealed that moderately grazed stream banks are much less resilient than more heavily vegetated banks (Olson et al. 2019). Consideration should also be given to the thermal impacts of riparian vegetation where thermal conditions are marginal. Shading created by trees and taller vegetation has been shown to reduce stream warming (Cross et al. 2013, Simmons et al. 2015).

BROOK TROUT MANAGEMENT

Re-introductory stocking has been the primary tool used to restore brook trout populations in southern Crawford County. In the late 1990s and early 2000s, brook trout were re-introduced into eight streams. Brook trout used in this effort originated from Wisconsin's feral trout stocking program (Table 1) or were field transferred from Duncan Creek (Chippewa County, WI). Naturally reproducing populations were established on all eight streams in the initial years after re-introduction, but substantial declines have since occurred on all but three streams. Declines on four streams corresponded with increases in brown trout, and the cause of complete extirpation from one stream is unknown. Of the three streams where moderate or high-density brook trout populations persist, one is supported by annual stocking of yearling brook trout (Halls Branch) and two (Little Kickapoo Creek and Picatee Creek) occur in the absence of brown trout.

Recent genetic evaluation of Wisconsin brook trout has revealed that Duncan Creek (Chippewa County) brook trout are of domestic hatchery origin (Erdman et al. 2022). As a result, streams where Duncan Creek brook trout were used for re-establishment have also been classified as domestic and closely related to their source population (e.g., Gran Grae Creek, Maple Dale Creek, Seas Branch Creek). Since Duncan Creek brook trout were used to establish populations on Picatee, Little Kickapoo and Du Charme creeks, it is reasonable to assume that these fish are also of domestic lineage. Stocking of feral and wild strain brook trout in Picatee and the Little Kickapoo creeks, two streams where high-density brook trout persist in allopatry, should be given priority to introduce both diversity and native Wisconsin genetics into these isolated populations.

Brown trout removal has been shown to be a useful tool for supporting brook trout populations where the two species exist and barriers to brown trout recolonization are present (Avery 1999, Hoxmeier and Dietermann 2016, Olson in prep.). Though no passage barriers exist in the trout streams in southern Crawford County, several stream segments are isolated by large warmwater rivers. For example, Picatee Creek, which is a direct tributary to the Mississippi River, has not been colonized by brown trout in the 22 years since brook trout were re-established there. Du Charme Creek, another direct tributary to the Mississippi River, supported naturally reproduced brown trout prior to brook trout re-introductions. Unfortunately, the limited brown trout population there has expanded greatly in recent years, displacing brook trout. Du Charme has also been identified as a Brook Trout Reserves, where conditions are expected to remain suitable for brook trout into at least the late century, making it an ideal candidate for future brown trout removal efforts.

Based on our evaluation of thermal conditions in southern Crawford County streams (Appendix 1, Fig. 9A) and predictions of future (late century) water temperatures from the FishVis model (Appendix 1, Fig. 10A), stream temperatures in most area streams are and will continue to be thermally suitable for brook trout into the future. This thermal resilience is, in part, why Du Charm, Picatee, Gran Grae, West Fork Knapp and Mill Coulee creeks were identified as potential Brook Trout Reserves by DNR Fisheries Management in 2017.

FISHING REGULATIONS

Trout fishing in the watershed has primarily been managed with county base regulations. Excluding a few opening day creel surveys on select streams, little information is available on angler pressure or harvest on southern Crawford County trout streams. Among local fisheries staff, it is assumed that angler use in the area is lower than other more well-known parts of the Driftless Area, like those near Viroqua and Coon Valley, WI. Recent creel surveys from nearby streams (i.e., Bohemian Valley Creek in 2016 and the West Fork Kickapoo River in 2022) indicate that harvest is often low despite high catches, the result of widespread voluntary catch and release. Based on these results, it seems unlikely that angler harvest could be responsible for widespread impacts to overall trout abundance in the area, though a creel survey would ultimately be required to verify this.

Our finding that brown trout sizes were positively correlated with density in streams in the area may indicate that densities are not limiting growth or, since relative density per mile was compared among streams, it may reflect that trout densities are high where quality large trout habitat also exists. If densities are not limiting growth, then regulations that encourage harvest with the goal of improving size structure may not be effective in area streams. Ongoing tagging and growth evaluation on Plum Creek will help better answer this question in the near future.

STOCKING

Currently stocking occurs in only in Halls Branch Creek, which receives 600 yearling brook trout annually. Angler use appears to be limited, with only one angler vehicle documented during an opening day angler vehicle count. It does appear that stocking has buoyed the brook trout population there, which has persisted in the presence of a moderate density brown trout population.

PROPERTY MANAGMENT

Within the watershed, the DNR Fisheries Management program manages 7.2 miles of streambank easements located on Plum, Pine, Otter and Richland creeks and 89 acres of DNR-owned land along Richland Creek. There are no immediate plans for habitat work or streambank brushing on existing easements or land. Maintenance of angler access paths on Plum Creek and signage on all easements and lands will continue. 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. Easement purchasing should remain a high priority in the watershed, as it has been identified as a high priority statewide (WDNR Trout Team 2019).

NON-GAME SPECIES

We captured relatively few non-game species in our surveys, which is typical for Wisconsin's coldwater streams that support only a few non-salmonid species (Lyons and Wang 1996). Slimy sculpin *Cottus cognatus*, a coldwater stenotherm species that was likely extirpated from most of the Driftless Area in the early to mid-1900s (Mundahl et al. 2012), was only found on Citron and Pine creeks in 2022. Based on our fish community and stream temperature results, it is likely that many more streams could support slimy sculpin. Re-colonization of the species has likely been slow due to its sedentary nature, with home ranges typically including less than 12 meters of stream (Hill and Grossman 1987). In addition, human-assisted transfers have not taken place in southern Crawford County to re-establish the species. Like salmonids, the species requires relatively stable stream temperatures associated with significant groundwater inputs. Based on observations from the field and our evaluation of stream temperature and fish community composition in 2022, slimy sculpin could likely survive in every stream surveyed except Mill Creek. Sculpin spp. are widespread in trout streams throughout North America and, where found, are an important prey item of trout and component of the stream food webs (Adams and Schmetterling 2007).

Management Recommendations

HABITAT

1. Future restoration efforts should focus on mid-watershed sites, where riparian grazing is limited and trout numbers do not already exceed 500 fish per mile.

Trout habitat restoration in these areas will likely have the greatest impact on trout density 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 encouraging only light livestock grazing along the stream corridor.

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

2. Avoid standard (i.e., Hunt 1993) habitat restoration methods where brook and brown trout occur together. We saw brown trout increase from nearly zero to moderated densities on a section of West Fork Knapp Creek five years after habitat work was completed. Other evaluations of habitat work in Wisconsin have similarly found that standard habitat methods favor brown trout (e.g., Avery 2004).

   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 areas where downstream warming is a concern, avoid complete riparian tree removal and consider planting trees in areas lacking shade to increase the thermal resilience of streams. Tree species, spacing and location of trees should be selected to have the least possible impact on angling accessibility. Shading from trees has been shown to slow the warming of streams in other parts of the state (Simmon et al. 2015).

   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., Crawford County Land and Water Conservation) involved in upland management to promote land use practices that will benefit trout habitat.

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

5. Continue to assist with the evaluation of waterway permits, with particular consideration given to projects that have the potential to impact trout habitat. For example, the construction of recreational ponds on headwaters have been shown to warm downstream waters in multiple area streams (e.g., Berger et al. 1979).

   Supporting DNR Guidance:

2020 DNR Trout Management Plan: Objective 1.3

6. Trout stream habitat projects completed by the DNR should be inspected at least once every eight years (i.e., in line with current rotation sampling 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 1.1, Action 1.1.A.3

TROUT STOCKING

1. Transfer the brook trout quota from Halls Branch Creek to each of the following streams, in rotation, with stocking occurring for three consecutive years on each stream: Picatee, Little Kickapoo, Gran Grae and Du Charme creeks.

   Currently, the stocking on Halls Branch Creek is supporting a limited fishery, only one angler vehicle was counted on opening day in 2021, and naturally reproducing brook trout are already established. The four streams listed above were established with Duncan Creek (Chippewa County) brook trout, which later were determined to be of domestic origin (Erdman et al. 2022). The goal of stocking feral brook trout in these streams will be to introduce wild Wisconsin strain genetics and increase overall diversity. Presumably, this will also increase the stability of receiving populations.

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

FISHING REGULATIONS

1. Complete opening weekend angler creel survey to evaluate level of angler use on area streams.

   No quantitative information is available on contemporary angler use or harvest on area streams. Opening weekend creel surveys require limited resources and provide a snapshot of angler use during the two most popular trout fishing days of the year. This information will be valuable in gauging angler use of area streams and whether more involved creel surveys are warranted to evaluate angler harvest.

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

2. Propose changing angling regulations on Du Charme, Gran Grae, Little Kickapoo, Pine and West Fork Knapp creeks from the county base regulation (i.e., five trout in total bag limit, no minimum length limit) to five trout in total bag limit, no

minimum length limit of brown and rainbow trout and mandatory release of brook trout. In addition, anglers should be encouraged to harvest brown trout on these systems.

All five streams support naturally reproducing brown trout at different levels of density and, presumably, stages of colonization. Brown trout have been shown to displace brook trout, and we have documented significant brook trout declines in area streams following brown trout population increases. The goal of this regulation is to slow the transition of streams from brook trout to brown trout (e.g., the Little Kickapoo) or encourage harvest of brown trout and release of brook trout, where brook trout populations are already limited. In addition, Du Charme, Gran Grae and West Fork Knapp creeks have been identified as Brook Trout Reserves, where the thermal conditions suitable for brook trout are expected to persist into at least the end of the century. If brook trout populations rebound to previous levels on streams where declines have occurred, or if brown trout are extirpated from streams where brown trout are currently present in lower numbers, the regulations should be returned to the county base regulation to allow brook trout harvest.

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

BROOK TROUT RESTORATION

3. Complete brown trout removal on Du Charme Creek.

   Du Charme Creek is an ideal candidate for brown trout removal. brook trout were established in the stream within two years after introductory stocking in 2000. Between 2003 and 2022, the brook trout population collapsed while the existing brown trout population increased sharply. Similar to nearby Picatee Creek, where brown trout have not colonized in the 22 years after brook trout re-introduction, Du Charme Creek is a direct tributary to the Mississippi River, which appears to limit brown trout colonization.

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

NON-GAME SPECIES

1. Re-introduce slimy sculpin into Little Kickapoo, Gran Grae, Plum, Picatee, Du Charme, Richland and West Fork Knapp creeks.

   All of the listed streams appear to have suitable thermal conditions presently and are predicted to remain suitable into the future (Appendix 1 Fig 10A).

   Supporting DNR Guidance: NR 1.01

PROPERTY MANAGEMENT

1. Continue to pursue streambank easements in southern Crawford County on streams that are currently eligible.

   Supporting DNR Guidance:
   2020 DNR Trout Management Plan: Strategy 1.2.B

2. Monitor and maintain the existing 7.2 miles of streambank easement in the watershed.

   With changes in ownership on multiple parcels, 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.

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

TROUT STREAM CLASSIFICATION

1. Update out of date trout stream classifications in the watershed.
   During the 2022 watershed survey, we sampled 3 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 the fall of 2024.

   Supporting DNR Guidance:
   2020 Trout Management Plan: Objective 3.3, Strategy 3.3.A

MONITORING

1. Complete an opening weekend angler vehicle count to gauge and compare angler access among streams prior to the next comprehensive report.

   Little information is available on angler use and harvest in southern Crawford County. Given that opening weekend is the period of greatest angler use on trout streams in Wisconsin, vehicle counts will at least provide DNR Fisheries Management with a general idea of angler use and how it varies among streams and in association with different fisheries management in the area.

   Supporting DNR Guidance:
   2020 DNR Trout Management Plan: Strategy 3.1.C

2. Complete a comprehensive watershed survey and updated watershed report in eight years (i.e., 2030).

   Based on our current eight-year watershed rotation schedule, the next comprehensive survey of the south Crawford County watersheds will occur in 2030. At that time, management recommendations outlined in this plan will be evaluated and revised if necessary.

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

Acknowledgements

My sincere gratitude to Kevin Mauel, Ryan Olson and Kristina Rands for their efforts collecting the fisheries data that was used in this report. Thanks to Bryce Linden for his assistance estimating land cover percentages. Thanks to Weston Matthews for compiling historical trout habitat restoration permits. I thank Heath Benike, Bob Hujik and Claire Gaber for their reviews of this report. 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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Appendix 1

Table 1A Fishing regulations for southern Crawford County streams since 1935. MLL = Minimum length limit, BL = bag limit, C&R = spring catch and release season.

YEAR	SPECIES	MLL (IN.)	BAG LIMIT (#/DAY)	START SEASON	END SEASON
1935	trout spp.	7	15	Late April- Mid May	Early September
1949	trout spp.	7	10	Late April- Mid May	Early September
1950	trout spp.	6	10	Late April- Mid May	Early September
1957	trout spp.	6	10	Late April- Mid May	August - Early September
1961	trout spp.	6;13	10; 5	Late April- Mid May	Early September
1963	trout spp.	6	10	Late April- Mid May	Early September
1972	trout spp.	6	5	Early May	End of May
1972	trout spp.	6	10	June	Mid-September
1977-1980	trout spp.	6	5	January	End September
1979	Brown and Rainbow	6	5	Early May	End of May
1979	Brook	6	10	Early May	End of May
1979	trout spp.	6	10	June	Mid-September
1981-1985	trout spp.	6	2	January	Early May
1990	trout spp.	9	3	Early May	End September
2000	trout spp.	NA	C&R	Early March	Early May
2016*	trout spp.	NA	C&R	Early January	Early May
2016*	trout spp.	0	5	Early May	Mid October

**In 2016, special regulations requiring the mandatory release of Brook Trout were enacted on Halls Branch and Plum Creek.*

Figure 1A. Bedrock geology, springs, dams and classified trout water in the five southern Crawford County watersheds included in this report. Thick black lines represent HUC 10 watershed boundaries.

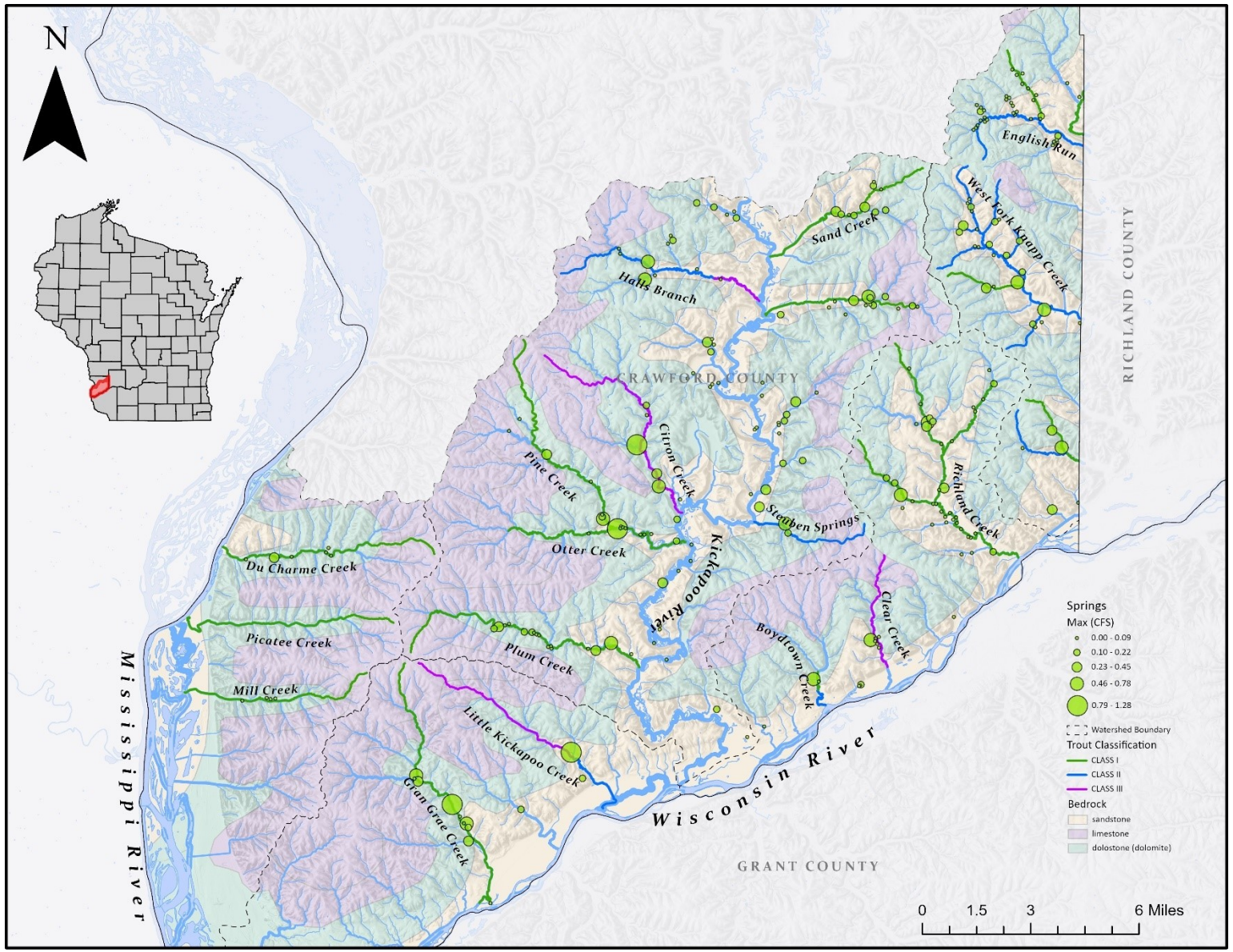

Figure 2A Location and date of trout habitat projects completed in southern Crawford County.

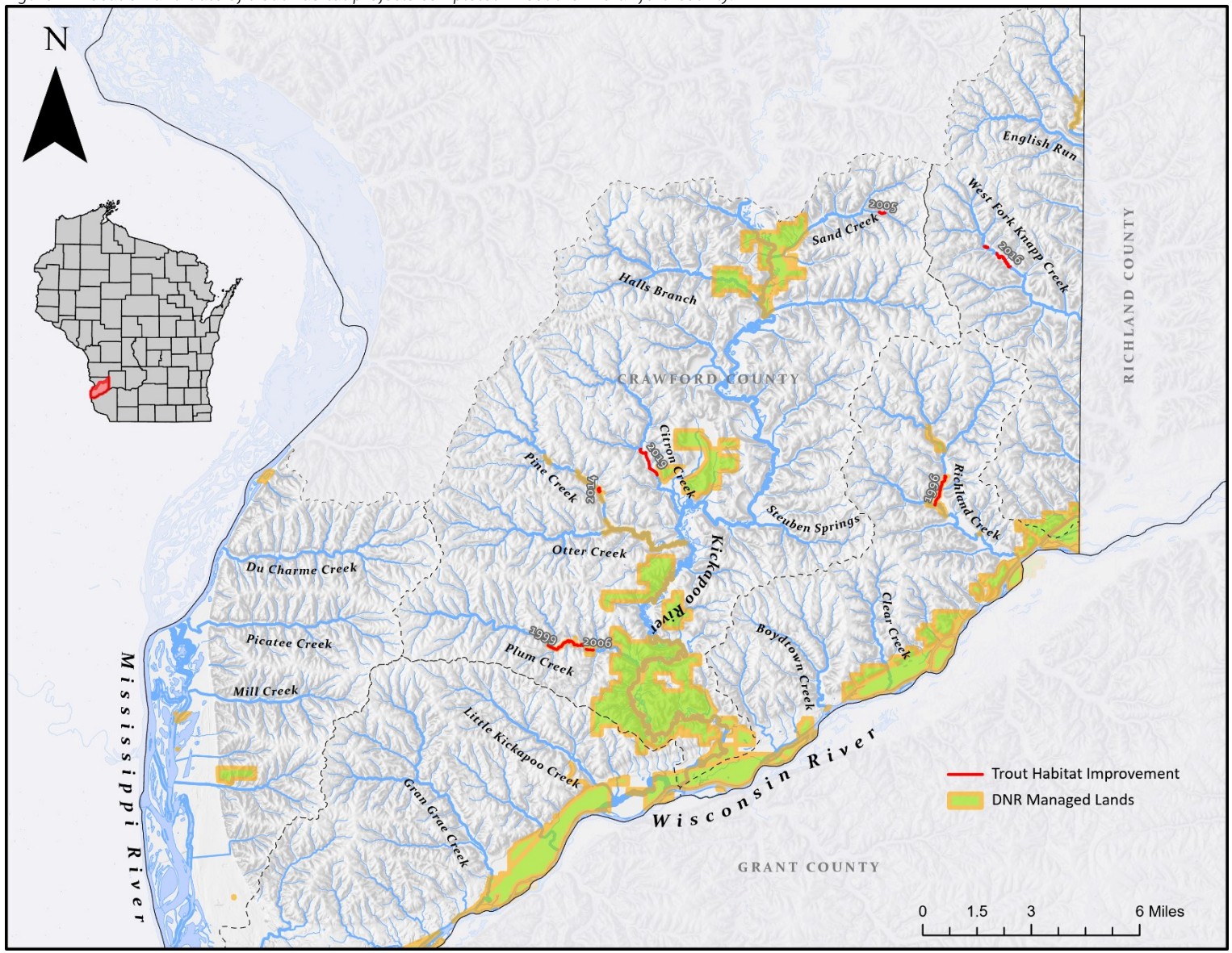

Figure 3A Land cover of the five southern Crawford County watersheds included in this report. Land cover based on level 2 Wiscland classifications, updated in 2016.

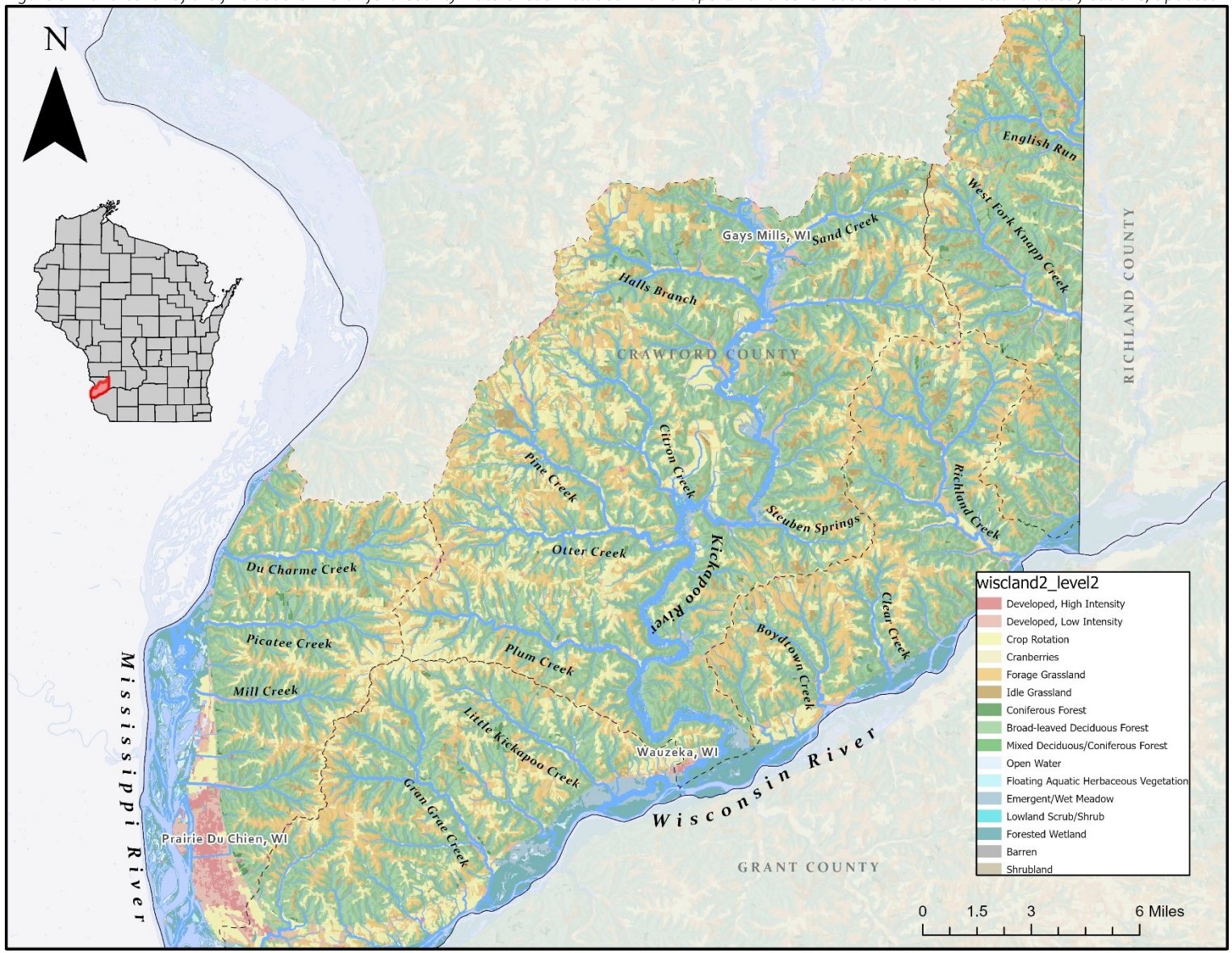

Figure 4A Electrofishing catch per mile of brown trout in 45 sites surveyed in 2022.

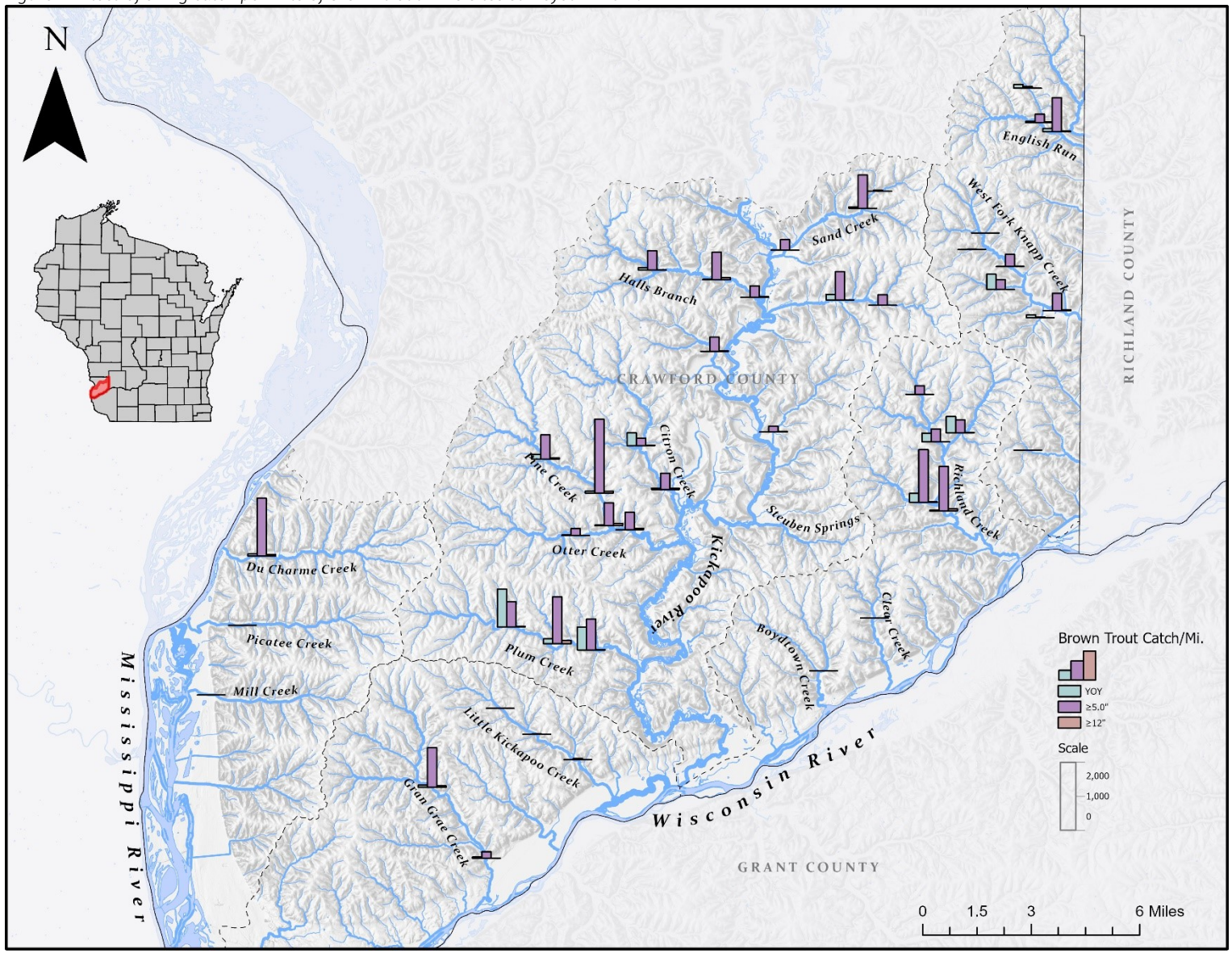

Figure 5A Brown trout mean maximum length (i.e., mean of the five largest individuals), in sites where at least five brook trout were captured.

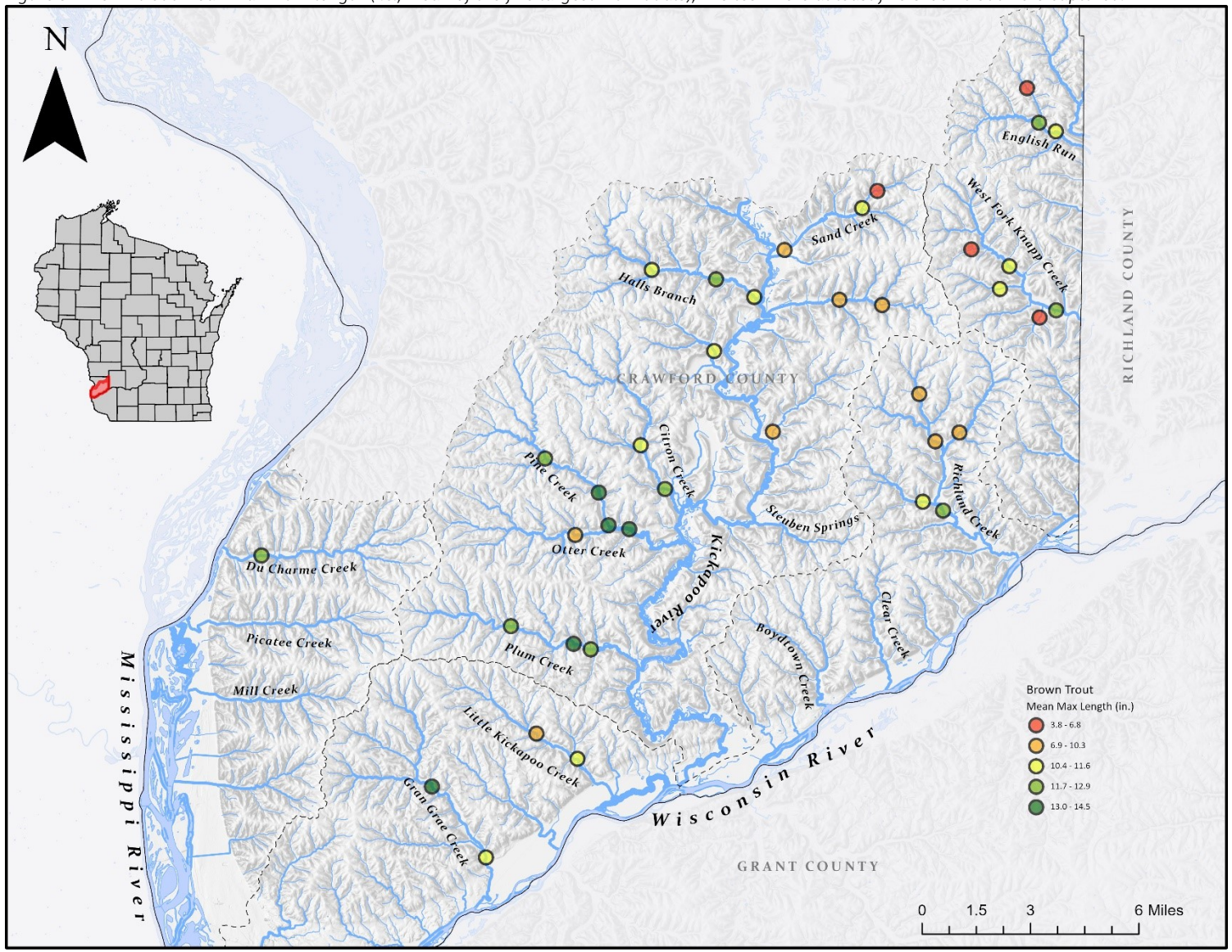

Figure 6A Electrofishing catch per mile of brook trout in 45 sites surveyed in 2022. Green asterisks indicate sites where brook trout occur in the absence of brown trout.

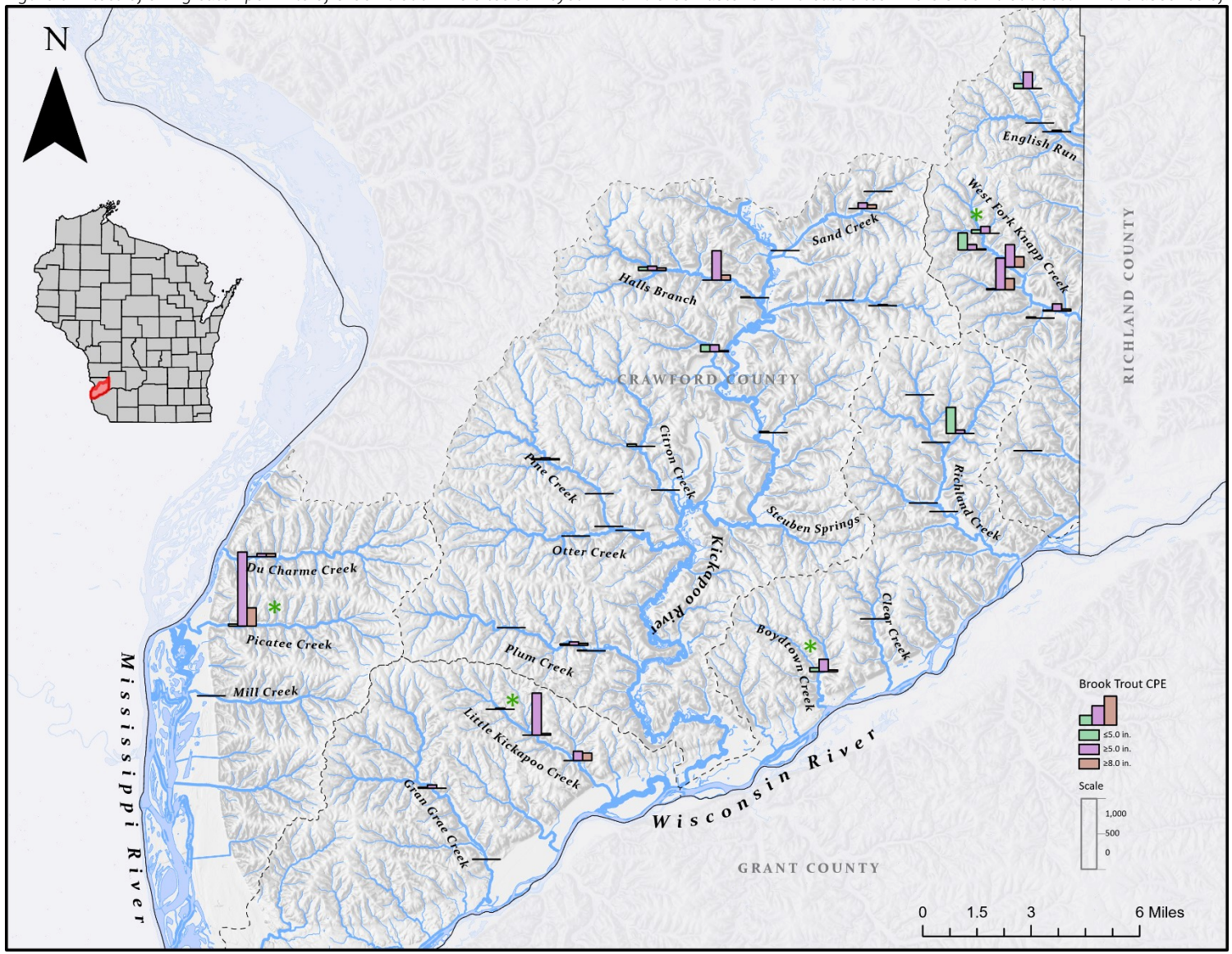

Figure 7A Slopes of brook trout relative abundance by stream between 1997 and 2021. Open circles indicate absence of brook trout in all years sampled. Green asterisks indicate sites where brook trout occur in absence of brown trout.

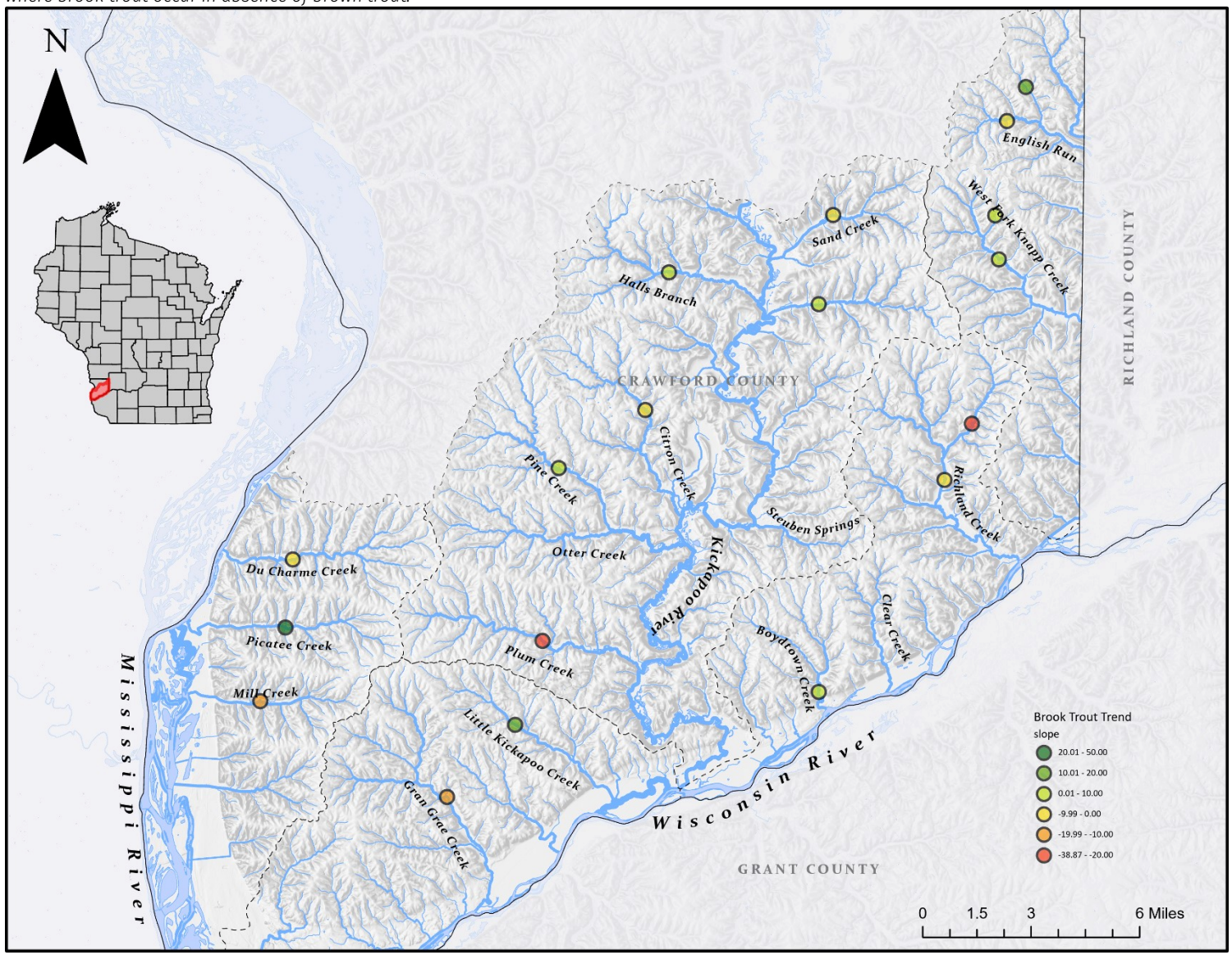

Figure 8A Brook trout mean maximum length (i.e., mean of the five largest individuals), in sites where at least five brook trout were captured.

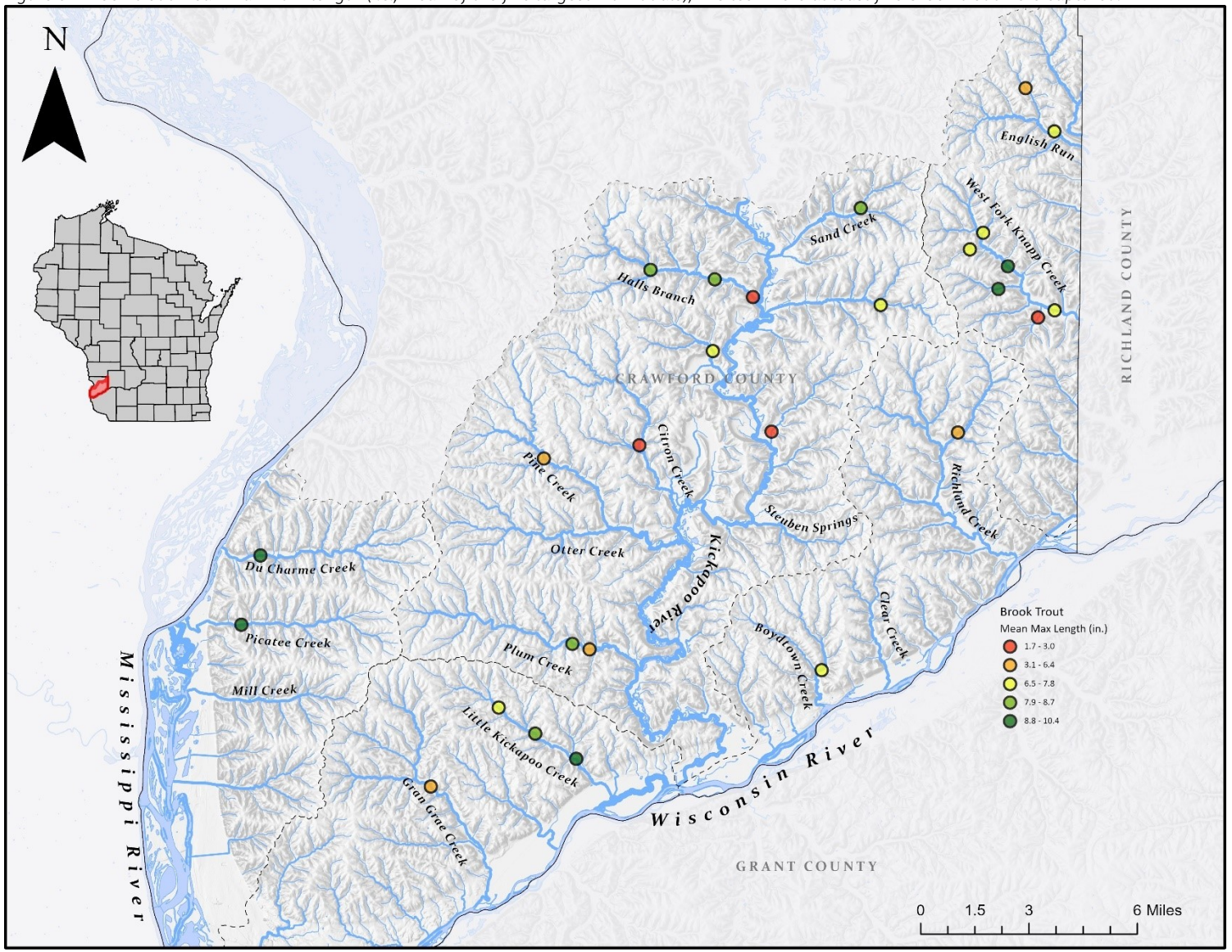

Figure 9A Stream thermal conditions based on July mean water temperature and proportion of cool/cold water stenotherm species captured in electrofishing surveys. Darker green colors reflect colder summer stream temperatures.

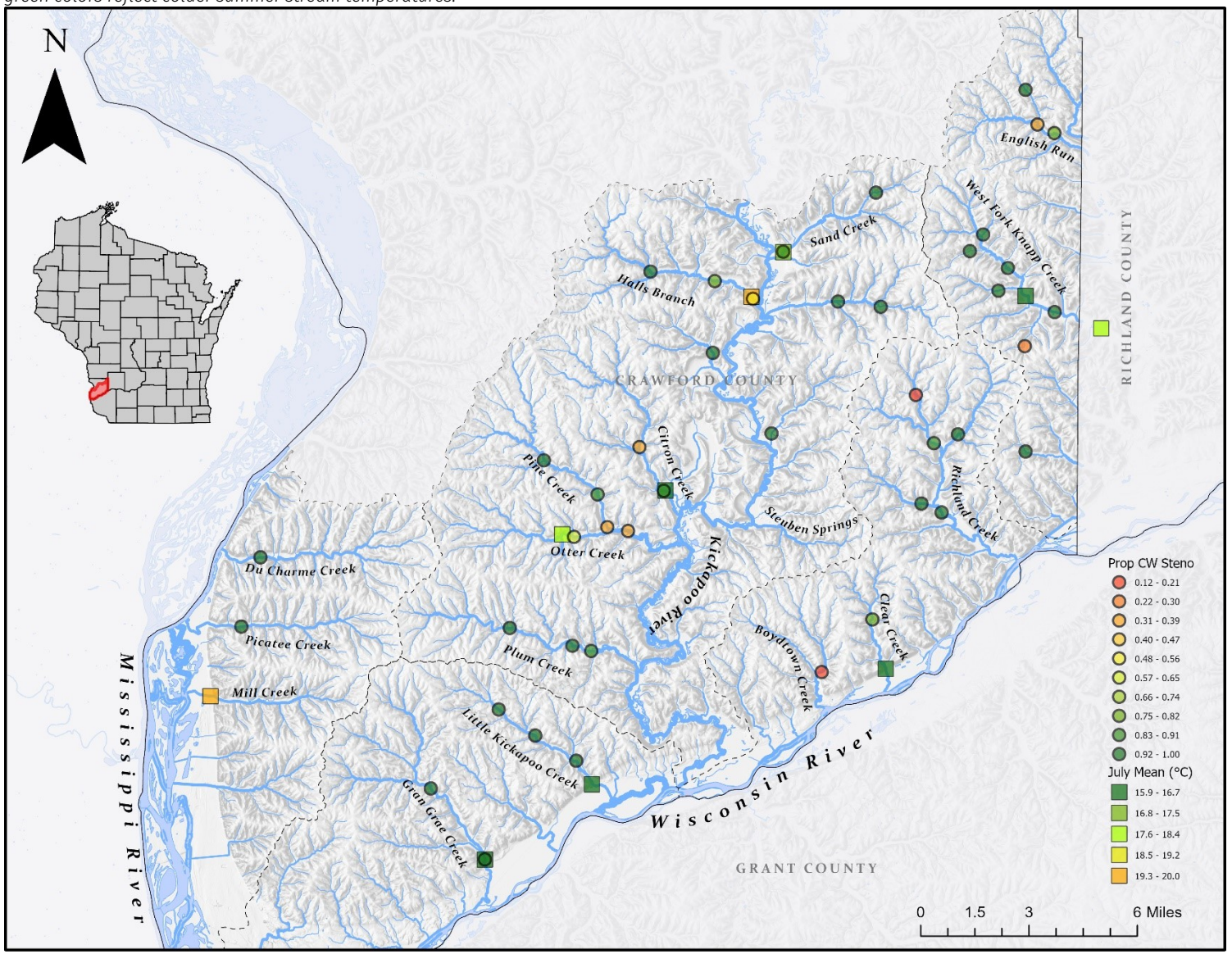

Figure 10A Predicted (2081-2100) July mean stream temperatures from the FishVis (Stewart et al. 2016).