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Maine's Brook Trout Stream Monitoring Project: Trends in Abundance and Size Quality of Stream-Dwelling Brook Trout, 1990-2014

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ABSTRACT

A long-term brook trout (*Salvelinus fontinalis*) stream monitoring (TSM) project was initiated in 1990 in order to assess brook trout populations in select Maine streams and to determine the effects of a change in the general law bag limit. Seven long-term index sites were chosen for the TSM and many additional streams were also chosen for shorter-term monitoring throughout the project's duration (1990-2014). For 29 study stream trout populations, 11 trended upwards, 16 trended downwards, two had no trend, and only 3 exhibited significant trends (Big Brook and North Branch Fox Brook in Region G – upward trend; Rome Trout Brook in Region B – downward trend). Study streams that exhibited significant trends were impacted by several different environmental, social, and/or cultural variables. The overall lack of broad significant trends based on monitoring data indicate that most of Maine's stream trout populations are likely more heavily influenced by environmental variables than changes in fishing regulations. Future TSM efforts should continue at established index sites, but at less frequent survey intervals. Effort previously spent on other TSM sites should be redirected at collecting less intensive data, but on a broader scale among more reaches of individual streams.

SUMMARY

In 1990, the Maine Department of Inland Fisheries and Wildlife (MDIFW) began a statewide, long-term brook trout (*Salvelinus fontinalis*) stream monitoring (TSM) project in order to assess brook trout populations in select sample streams. This effort aimed to help the Department better understand stream brook trout populations, assist in species planning, and analyze the potential impacts of more restrictive fishing regulations implemented in 1992.

Originally, seven long-term index sites were chosen for the TSM based on select criteria, but many additional streams were also chosen for shorter-term monitoring throughout the project's duration (1990-2014). Index sites averaged 370 ft. in length, 16.7 ft. in wetted width, and were electrofished annually using 3-pass depletion sampling with backpack electrofishers to estimate brook trout abundance and size quality.

For 29 study streams, the Mann-Kendall (M-K) trend analysis determined that while 11 trout populations trended upwards, 16 trended downwards, and two had no trend, only three streams exhibited statistically significant trends (Big Brook and North Branch Fox Brook in Region G – upward trend; Rome Trout Brook in Region B – downward trend). The M-K analysis for the percent of legal brook trout (≥ 6") determined that while 15 sites trended upwards, 12 trended downwards, and two had no trend, only one stream exhibited a statistically significant trend (Branch Brook in Region A – upward trend).

Study streams that exhibited significant trends were impacted by several different environmental, social, and/or cultural variables. The overall lack of significant trends based on monitoring data indicate that most of Maine's stream trout populations are likely more heavily governed by environmental factors than changes in fishing regulations. The findings from this long-term dataset will help guide brook trout management in streams and allow MDIFW biologists to focus limited resources on stream monitoring efforts likely to provide data most useful for research and management applications.

We recommend a shift in the focus of MDIFW's trout stream monitoring moving forward. Monitoring should continue similar to past efforts in only the longest-term (10^{+} year) brook trout monitoring sites, and at less frequent intervals – perhaps once every third year. Effort previously spent on other TSM

sites should be used to collect less intensive data, but on a broader scale, with a focus on characterizing brook trout distribution and abundance in more streams, and among more reaches of individual streams. Additional data such as presence/absence of fish species, species distribution, and rudimentary habitat and road crossing characteristics should be included in future trout stream monitoring efforts. New stream survey methodologies could be developed regionally based on data needs and program objectives.

KEYWORDS: BROOK TROUT, POPULATION ESTIMATES, STREAM MONITORING, TREND ANALYSIS.

INTRODUCTION

During its 1986 - 1990 planning period, the Maine Department of Inland Fisheries and Wildlife (MDIFW) Fisheries Division (Division) recognized the need to develop a systematic means of assessing stream-dwelling brook trout (*Salvelinus fontinalis*) populations. Goals set forth in species planning documents included specific brook trout abundance objectives, but brook trout population estimates were available for only a few streams statewide. In addition, the statewide general law regulations would soon change to restrict harvest of brook trout in Maine's brooks, rivers and streams. In 1990, the Division developed a brook trout stream monitoring (TSM) project to assist with updating the brook trout species plan. The primary objectives of the TSM project, defined at a December 1989 Fisheries Division Meeting, were:

1. To monitor brook trout populations in a sample of streams across the state.
2. To gather growth, standing crop, and population size distributions for species planning.
3. To monitor the effects of changes in general law regulations on brook trout populations[1].

The Division also discussed criteria to guide each of the seven Fisheries Management Regions and the research office in selecting streams to include in the project. These criteria were, in order of importance:

1. Naturally reproducing brook trout populations are present in the stream and brook trout have never been stocked.
2. There are historic data on the population for at least one year.
3. The stream section has water quality and physical habitat characteristics that are representative of good brook trout streams in the Region.
4. The stream is open to fishing, regulated under general law, and is of Regional importance.
5. The selection of streams provides good geographic coverage of state, and includes streams within the major drainage basins.

Each Region selected at least three candidate streams for brook trout population and habitat surveys. All candidate streams met the first and third criteria. Previous Interim Summary Reports (ISR) documented

[1] In the third year of the project (1992), the general law creel limit on brook trout in streams had dropped from 10 to 5 fish daily for most of the state.

the stream selection protocol, population assessment methodology and preliminary data analysis (Trial 1993 [ISR 1]; Trial 1996 [ISR 2]; Gallagher 2004 [ISR 3]). Brook trout populations in candidate streams were assessed for a minimum of three years. In addition, each Fisheries Management Region dedicated a long-term index site for annual brook trout assessment (Figure 1). Trial (1993 and 1996) described age and growth of stream brook trout, presented standing stock estimates, and summarized the 1992 general law regulation change. Gallagher (2004) presented standing stock and biomass estimates of stream brook trout from 1990 to 2003, characterized statewide trout populations for seven long-term index sites, and reported the fish community composition for each stream. ISR 3 did not address the third goal (to monitor the effects of changes in general law regulations on brook trout populations) of the TSM project outlined in 1989. This report provides an update to previous reports describing brook trout population characteristics in study streams, while also evaluating the impact of fishing regulation changes and the overall usefulness of the trout stream monitoring project.

METHODS

The stream selection methodology and survey protocols are outlined thoroughly in prior ISR's (Trial 1993; Trial 1996; Gallagher 2004). Following the selection of streams, reaches averaging 370 ft. in length and 16.7 ft. in width were selected for annual 3-pass depletion sampling with backpack electro-fishers (Zippin 1958; Beland et al. 2004). Each sampling reach was isolated with blocking seines and all collected fish were identified to species, measured for total length and wet mass, and released back into the reach after sampling was completed. These data were used to calculate total annual brook trout population estimates, along with abundance estimates for three specific brook trout size/age groupings including small/young of year (YOY; < 88 mm TL), mid-size/juvenile (88 – 150 mm TL), and legal/adult (> 150 mm TL) for streams reaches between 1990 and 2014.

To determine population trends and the potential impact of fishing regulation changes, total brook trout population estimates, and the percent of legal trout for each stream reach were estimated and plotted over time. Those sites with the most robust datasets (≥ four years) were analyzed using a Mann-Kendall (M-K) time series trend analysis to show trends in response variables over time. The M-K is a non-parametric test that assesses whether a time-ordered data set exhibits an upward or downward trend, with a predetermined level of significance ($\alpha = 0.05$). Ideally, the M-K test requires ≥ eight years of data to produce meaningful results. The brook trout monitoring dataset included seventeen sites (45.9%) with four to seven years of brook trout data. The relevance of those results should be considered less robust than the results of those streams with more years of data (12 sites, 32.5% of the total sites), which should possess more statistical and biological validity. Those streams with three or fewer years of data (n = 8, 21.6% of all study streams) were excluded from the M-K trend analysis due to deficient sample sizes. All statistical analyses were completed using R (v.3.1.2; 2014-10-31).

RESULTS

Trends in BKT population and percent legal brook trout were evaluated using M-K for the 6 longest-term TSM index streams. Brook trout population and percent legal brook trout estimates are presented in Figures 2 and 3, respectively, for the six longest-term brook trout monitoring streams (Branch Brook - Region A, Rome Trout Brook – Region B, Indian River – Region C, Alder Brook – Region D, Lord Brook – Region F, and Clark Brook – Region G).

Trends in Brook Trout Population Estimates

The majority of stream reaches were studied for three or more years, while six streams were studied for 16 or more years (Table 1). The M-K time series analysis for 29 brook trout population estimates indicated two streams with significant upward trends (i.e. Big Brook and North Branch Fox Brook – Region G), while one stream exhibited a significant downward trend (Rome Trout Brook – Region B; Table 2). Most of the detected trends (n = 26, 89.6%) were statistically insignificant; 11 streams (37.9%) with an upward trend, 16 streams (55.2%) with a downward trend, and two streams (6.9%) showed no trend (Table 2, Table 3). The M-K trend analysis verified that while brook trout population estimates were inconsistent in their trend directions (Table 3), only a few (n = 3; ~10%) showed significant trends over time.

Trends in Brook Trout Size Quality

Estimates of the percentage of legal brook trout (≥ 150 mm) for 29 TSM streams also indicated both upward and downward trends, but only 1 of the Branch Brook (3.4%) was statistically significant. While not statistically significant, 14 streams (48.3%) showed an upward trend, 12 streams (41.4%) showed a downward trend, and two streams (6.9%) exhibited no trend (Table 4, Table 5).

DISCUSSION

Brook trout population trends

Despite a long-term TSM dataset, few significant trends in brook trout abundance or size quality were observed. The daily bag limit for brook trout in Maine streams was reduced from 10 to 5 fish (≥ 6" length limit) statewide in 1992. In doing so, the Division hoped that this would reduce the sensitivity of stream-dwelling trout populations to overharvest, and protect the legal-size, spawning-age component of wild trout populations. TSM data indicated that significant changes to Maine's brook trout populations were an exception, rather than the rule, suggesting that previous stream fishing regulations (angler harvest) were having little impact on most of these trout populations. Environmental variables may be more influential on stream dwelling brook trout populations than bag limit regulations.

Floods, droughts, land use practices, altered temperature regimes, availability of over-wintering habitat, invasive species, and other environmental factors can shape both the abundance and dynamics of trout populations (Hunt 1969; Carline and McCullough 2003; Hakala and Hartman 2004; Vincenzi et al. 2012). Consequently, stream-dwelling trout experience inherent fluctuations in population size both spatially and temporally (Platts and Nelson 1988). The results from this study corroborate these findings. The environmental and physical habitat variables noted above were not sufficiently studied throughout the duration of the TSM project to determine their role in affecting trout population trends.

The lone stream with a significantly declining brook trout population (1990 – 2012) was Rome Trout Brook in central Maine. Rome Trout Brook is a tributary to Great Pond, part of the Belgrade Lakes chain. The Belgrade Lakes host robust populations of exotic/invasive species, most notably northern pike (*Esox lucius*). Northern pike are voracious predators of salmonines, particularly in fluvial habitats, and have been shown to be exemplary consumers of juvenile trout (Hyvarinen and Vehanen 2004). The abrupt decline in the wild brook trout population was likely a result of the northern pike population in Rome Trout Brook over the course of this study. As of 2012, brook trout estimates were only about a third of what they were in the early 1990's. It is important to note, however, pike have been present in this watershed since the 1970's, yet wild trout continue to persist in Rome Trout Brook.

There were two streams that showed significant upward trends in brook trout population estimates from 1990 to the present: Big Brook and North Branch Fox Brook, both located in northern Maine. In addition to environmental conditions, empirical evidence suggests that anthropogenically induced changes via fishing regulations may impact stream-dwelling trout populations (Almodovar and Nicola 2004). According to regional fisheries biologists, the increase in the Big Brook trout population was almost fully attributable to the change in general law in 1992 that decreased the daily bag limit from 10 to 5 fish. Big Brook was overfished and following the regulation change, harvest declined to the point that the brook trout population rebounded and has since stabilized (Frost 2002). The habitat and fishing pressure at North Branch Fox Brook are very different than Big Brook; fishing access is difficult and harvest is considerably less. Therefore, we suspect that the upward trending brook trout population estimate was not a result of the regulation change, but merely a natural population swing (J. Wood, personal communication).

Branch Brook (Region A) was the only stream showing a significant increase in brook trout size quality over time (1990 – 2014, n = 25 years), but this increase is not likely due to the regulation change. Unlike most state counties, the minimum daily bag limit for Branch Brook was not reduced in 1992 but in 1985, and most benefits to its trout population were likely gained prior to the inception of this TSM project. Regional fisheries biologists suggested a number of factors that may have contributed to the higher percentage of larger brook trout in Branch Brook including: 1) the prevalence of catch-and-release angling (particularly in southern Maine), 2) a decrease in the number of anglers visiting smaller streams due to concerns over Lyme disease, and 3) an increase in agricultural and urban inputs that have likely increased overall stream productivity. Conversely, regional fisheries biologists also documented a substantial decline in habitat since 2008 after a large precipitation event widened the wetted channel, increased silt substrates, decreased pool depths, and reduced coarse wood. Despite recent habitat degradation, high release rates by anglers and declining angler use probably had a greater impact to adult brook trout abundance, allowing older, larger trout to persist in less suitable habitat (F. Brautigam and J. Pellerin, personal communication). Since Branch Brook is located in a more populated region of Maine, the dynamics governing its wild brook trout population are likely more complex than in northern streams. It is these sensitive brook trout populations, located in more urbanized watersheds, that are most susceptible to extirpation, and therefore deserve the closest monitoring (Stranko et al. 2008, DeWeber and Wagner 2015).

The TSM project has provided Division fisheries biologists with 20-plus years of insight into the dynamics governing wild, stream-dwelling brook trout populations throughout Maine. These data strongly indicate that while brook trout populations fluctuate annually in terms of overall abundance and age structure, few populations trended significantly, and even fewer were impacted by changes in fishing regulations. Empirical evidence suggests that trout populations in small streams are generally not impacted by angler harvest or fishing regulations (Hunt 1966; Schill et al. 2007). Instead, natural mortality as a result of instream environmental variables plays a much bigger role in regulating trout populations (Hunt 1966). Therefore, the Division should consider restructuring the stream monitoring program to measure and evaluate stream habitat, rather than continuing to quantify the impacts on trout populations due to fishing regulations.

TSM Project Recommendations

Wild, stream-dwelling brook trout populations are an important resource in Maine and their status should continue to be monitored. However, the current brook trout stream monitoring project, a nearly three decade-long endeavor, while invaluable, is time-consuming, laborious, and probably unwarranted under its current methodology. The TSM project has provided fisheries managers with insight into statewide brook trout trends, and those environmental stressors that have the potential to impact trout populations. The findings from this project demonstrate that stream-dwelling brook trout are governed by unstable environments, and their population numbers are therefore inherently stochastic. There are occasional circumstances when extraordinary biotic, physical, or anthropogenic factors can override natural stream processes and affect brook trout populations. In this project, we have documented three brook trout streams that have all been significantly impacted by different factors (i.e. Branch Brook – cultural/social/habitat modifications, Rome Trout Brook – invasive species introduction, Big Brook – harvest regulation change), and these case studies will be invaluable to our understanding and management of stream-dwelling brook trout populations moving forward. We recommend that our six long-term brook trout monitoring index sites be monitored as they have in the past, but on a less frequent basis. Less frequent data collections will still provide sufficient monitoring of brook trout populations, but be less taxing on the labor, time, and funding of MDIFW staff, and should allow these limited resources to be better allocated elsewhere.

Along with reduced monitoring of the six long-term index sites, we recommend that the Fisheries Division monitor fish assemblages, water quality, and habitat changes in a greater number of waters using less intensive methods. For instance, monitoring could include a greater effort on sampling in accessible areas such as road crossings, using fewer electrofishing passes and shorter reaches. Simple data collections such as presence/absence of fish species in a greater number of waters may be more valuable than a single, intensive 3-pass depletion estimate at one long term site. Biologists could also collect more data on rudimentary habitat characteristics (e.g. wetted width, substrate type, riparian composition, temperature spot-checks, degree of habitat degradation), and road-crossing dimensions (e.g., diameter, length, type, perch distance, fish passage potential, etc.).

Monitoring of trout streams will continue to be an integral part of fisheries management in Maine. Results from the long term TSM project, combined with changes in technology, monitoring methods and regional data needs will provide fisheries biologists with a more efficient and effective trout stream monitoring program in the future.

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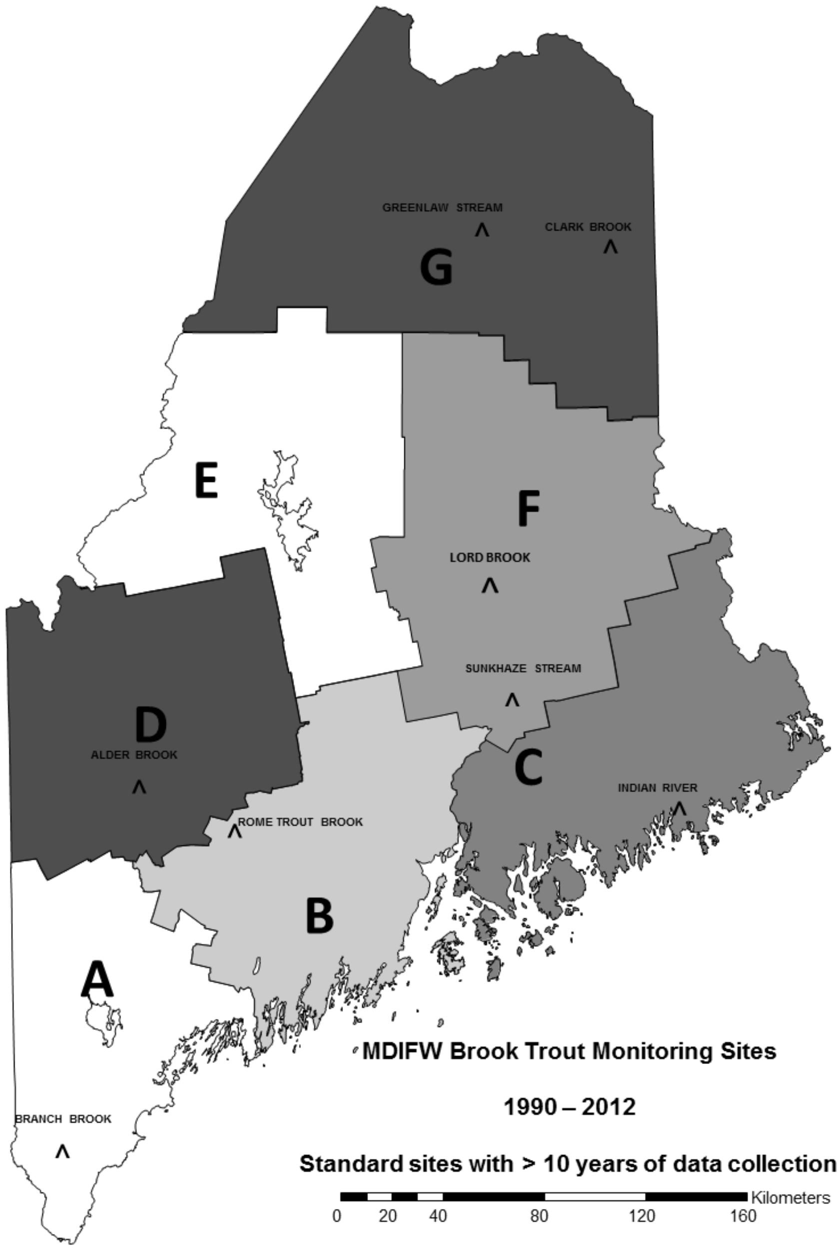

Figure 1. Brook trout stream monitoring index sites.

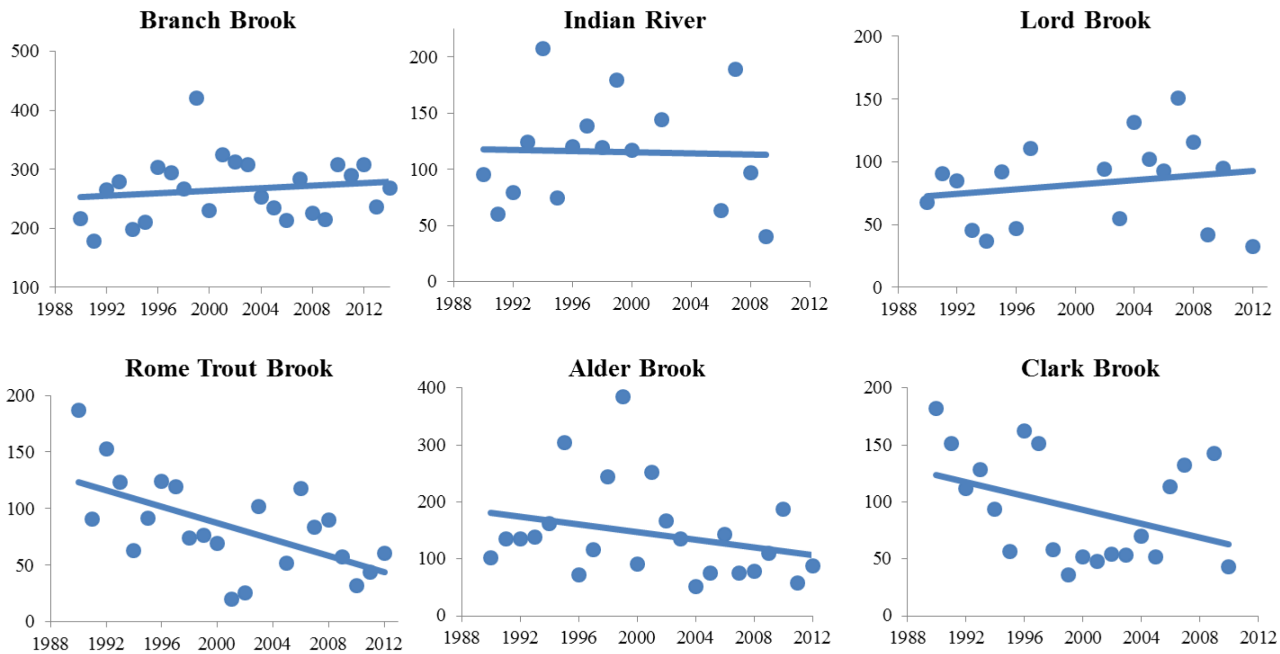

Figure 2. Brook trout population abundance estimates based on 3-pass depletion backpack electrofishing for 6 long-term brook trout monitoring stream reaches by year.

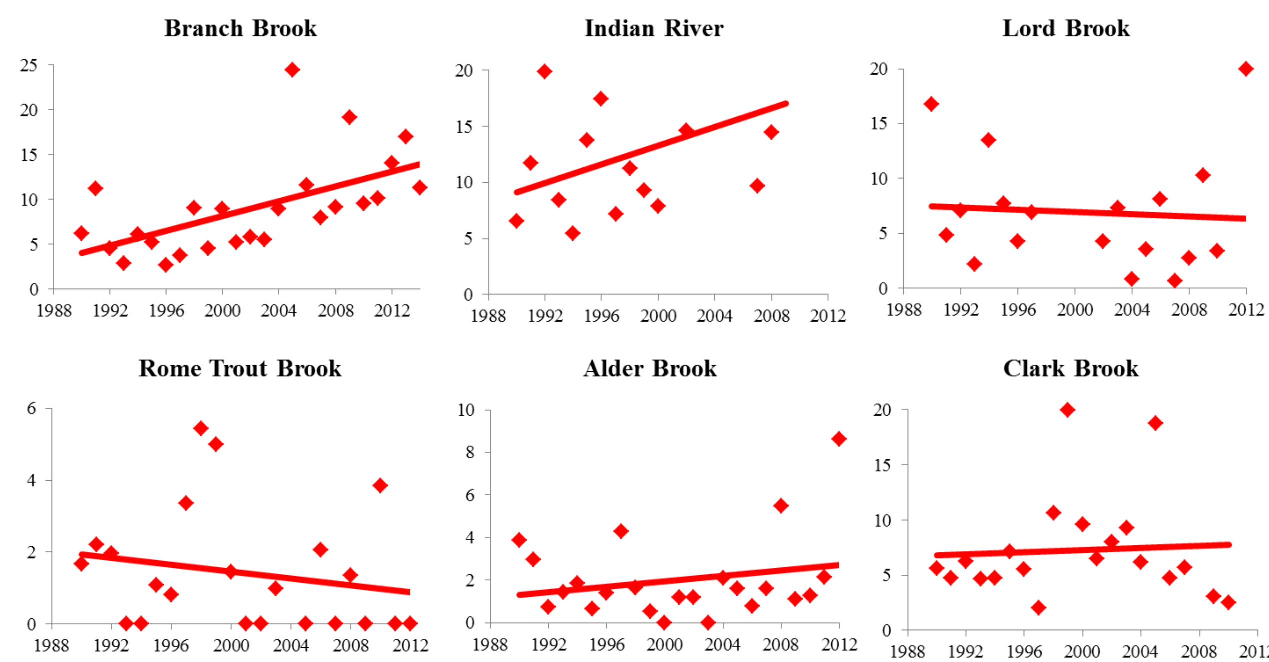

Figure 3. Legal brook trout (≥ 150 mm) abundance percentage estimates based on 3-pass depletion backpack electrofishing for 6 long-term brook trout monitoring stream reaches by year.

Table 1. Regional brook trout monitoring streams with watcode, years sampled, and number of years surveyed.

STREAM	REGION	WATCODE	YEARS SAMPLED	NO. OF YEARS
Branch Brook	A	022002	1990-2014	25
W. Branch Tenmile River	A	03204101	1990-93, 2000-04	9
Worthley Brook	A	08602304	2005-12	9
Back Brook	A	032027	1990-93, 2000	5
Shepards River	A	032045	1999-2000, 2002-04	5
Emerson Brook	A	0320301503	1995-98	4
W. Branch Nezinscot River	A	08603415	-	1
Rome Trout Brook	B	093038071103	1990-2003, 2005-12	22
Hope Brook	B	139008	1990-93	4
Martin Stream	B	08603410	1990-92	3
Indian River	C	356004	1990-2000, 2002, 2006-09	16
Little Mopang Stream	C	37302202	1990-94	5
Haynes Brook	C	2610180403	1990-93	4
Mill Stream	C	418003	1991-93	3
Alder Brook	D	0860722302	1990-2012	23
Bigelow Brook	D	2100534107	1990-95, 1997-99	9
Lemon Stream	D	0930403101	1990-93	4
South Bog Stream	D	086175101301	1990-93	4
Fillibrown Brook	D	09306911	1990-93	4
Abbott Brook	D	08616808	2006-07	2
Cold Stream	D	093108	2004-05	2
Chandler Mill Stream	D	09306958	2008-09	2
Michael Stream	D	093077050503	2010-11	2
Phelps Brook	D	086089140101	2012	1
Squaw Brook	E	093129	1990-93, 1995, 1997, 2002	7
North Brook	E	210053202221	1990-93, 1998	5
Lord Brook	F	21005018	1990-97, 2002-10, 2012	18
Sunkhaze Stream	F	210038	1990-95, 1997-98, 2000	9
Salmon Stream	F	210068	1990-93	4
Clark Brook	G	42711118	1990-2007, 2009-10	20
Greenlaw Stream	G	4271354902	1990-2001	12
Big Brook	G	42709607	1991-96, 1999, 2000, 2009	9
Hockenhull Brook	G	42713506	1991-1995, 1999, 2001	7
McConnell Brook	G	4271354904	1991-96, 2003	7
B Stream	G	42709615	1991-93, 1997-98, 2009	6
West Hastings Brook	G	2100724014	1990-93, 1995	5
North Branch Fox Brook	G	4272165301	1990-93, 2002	5

Table 2. Regional brook trout monitoring streams with number of years sampled, and Mann-Kendall results including tau coefficient (τ), trend direction, p-value, and test significance determination (alpha, $p < 0.05$) for brook trout population estimates over time. Those streams that were sampled for ≤ three years were excluded from the M-Ktime series analysis for study stream brook trout population estimates.

STREAM	REGION	NO. OF YEARS	TAU COEF (τ)	TREND DIRECTION	P-VALUE	SIGNIFICANT
Branch Brook	A	25	0.137	Upward	0.350	No
W. Br. Tenmile River	A	9	-0.467	Downward	0.260	No
Worthley Brook	A	8	-0.500	Downward	0.108	No
Back Brook	A	5	-0.400	Downward	0.086	No
Shepards River	A	5	-0.467	Downward	0.300	No
Emerson Brook	A	4	0.333	Upward	0.734	No
Rome Trout Brook	***B***	***22***	***-0.437***	***Downward***	***0.005***	***Yes***
Hope Brook	B	4	-0.333	Downward	0.734	No
Indian River	C	16	0.033	Upward	0.893	No
Little Mopang Stream	C	5	-0.400	Downward	0.462	No
Haynes Brook	C	4	0.000	No Trend	1.000	No
Alder Brook	D	23	-0.182	Downward	0.234	No
Bigelow Brook	D	9	-0.222	Downward	0.466	No
Lemon Stream	D	4	0.333	Upward	0.734	No
South Bog Stream	D	4	-0.333	Downward	0.734	No
Fillibrown Brook	D	4	0.000	No Trend	1.000	No
Squaw Brook	E	7	0.048	Upward	1.000	No
North Brook	E	5	-0.600	Downward	0.221	No
Lord Brook	F	18	0.176	Upward	0.325	No
Sunkhaze Stream	F	9	0.278	Upward	0.348	No
Salmon Stream	F	4	-0.333	Downward	0.734	No
Clark Brook	G	20	-0.284	Downward	0.086	No
Greenlaw Stream	G	12	0.273	Upward	0.244	No
Big Brook	***G***	***9***	***0.556***	***Upward***	***0.048***	***Yes***
Hockenhull Brook	G	7	-0.524	Downward	0.133	No
McConnell Brook	G	7	-0.143	Downward	0.764	No
B Stream	G	6	0.400	Upward	0.462	No
West Hastings Brook	G	5	-0.600	Downward	0.221	No
N. Branch Fox Brook	***G***	***5***	***1.000***	***Upward***	***0.027***	***Yes***

Table 3. Summary of Mann-Kendall time series data for brook trout population estimates in brook trout monitoring study streams with ≥ 4 years of fish collection data.

TREND DIRECTION	TOTAL	PERCENT of STUDY STREAMS	# SIGNIFICANT
Upward	11	37.9	2
Downward	16	55.2	1
No Trend	2	6.9	-

Table 4. Regional brook trout monitoring streams with number of years sampled, and Mann-Kendall results including tau coefficient (τ), trend direction, p-value, and test significance determination (alpha, $p < 0.05$) for the percet of legal brook trout (≥ 6") estimates over time. Those streams that were sampled for ≤ three years were excluded from the M-K time series analysis on the percent of legal brook trout collected.

STREAM	REGION	NO. OF YEARS	TAU COEF (τ)	TREND DIRECTION	P-VALUE	SIGNIFICANT
Branch Brook	***A***	***25***	***0.491***	***Upward***	***0.001***	***Yes***
W. Br. Tenmile River	A	9	0.067	Upward	1.000	No
Worthley Brook	A	8	0.143	Upward	0.711	No
Back Brook	A	5	0.800	Upward	0.086	No
Shepards River	A	5	0.467	Upward	0.260	No
Emerson Brook	A	4	0.333	Upward	0.734	No
Rome Trout Brook	B	22	-0.212	Downward	0.197	No
Hope Brook	B	4	0.000	No Trend	1.000	No
Indian River	C	16	0.300	Upward	0.115	No
Little Mopang Stream	C	5	0.800	Upward	0.086	No
Haynes Brook	C	4	-0.183	Downward	1.000	No
Alder Brook	D	23	0.052	Upward	0.751	No
Bigelow Brook	D	9	-0.028	Downward	1.000	No
Lemon Stream	D	4	-0.667	Downward	0.308	No
South Bog Stream	D	4	-0.333	Downward	0.734	No
Fillibrown Brook	D	4	0.183	Upward	1.000	No
Squaw Brook	E	7	-0.480	Downward	1.000	No
North Brook	E	5	0.200	Upward	0.807	No
Lord Brook	F	18	-0.124	Downward	0.495	No
Sunkhaze Stream	F	9	-0.028	Downward	1.000	No
Salmon Stream	F	4	0.333	Upward	0.734	No
Clark Brook	G	20	0.000	No Trend	1.000	No
Greenlaw Stream	G	12	0.030	Upward	0.945	No
Big Brook	G	9	0.167	Upward	0.602	No
Hockenhull Brook	G	7	0.048	Upward	1.000	No
McConnell Brook	G	7	-0.238	Downward	0.548	No
B Stream	G	6	-0.200	Downward	0.807	No
West Hastings Brook	G	5	-0.200	Downward	0.807	No
N. Branch Fox Brook	G	5	-0.400	Downward	0.462	No

Table 5. Summary of Mann-Kendall time series data for the percent of legal brook trout (≥ 6") estimates for brook trout monitoring index sites with ≥ 4 years of fish collection data.

TREND DIRECTION	TOTAL	PERCENT of STUDY STREAMS	# SIGNIFICANT
Upward	15	51.7	1
Downward	12	41.4	0
No Trend	2	6.9	-