Evaluation of Wild Brook Trout Populations in Vermont Streams

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SUMMARY

Wild brook trout populations in Vermont streams appeared to be relatively stable over a period of five decades as evidenced in this evaluation of 150 sites. Present-day brook trout populations sampled in 138 streams within 17 watersheds were characterized by abundant natural reproduction and multiple age-classes, including the contribution of older, larger fish. While most population measures were consistent between the two time periods, significantly higher densities of young-of-year brook trout were observed in current populations which may reflect improved environmental protections initiated since the 1950s. A decline in sympatric brown trout and rainbow trout sites also suggest that non-native trout populations have not appreciably expanded over the past 50 years.

INTRODUCTION

Brook trout *Salvelinus fontinalis* are native to Vermont and are widely distributed throughout the state (VDFW 1993, EBTJV). It is the fish species most likely to be encountered in small upland streams, particularly at higher elevations where it is often the only fish species inhabiting these waters. In addition to being an indicator of high quality aquatic habitat, brook trout are also a favorite of Vermont anglers. Statewide angler surveys conducted in 1991, 2000 and 2010, revealed it was the fish species most preferred by Vermont resident anglers (Claussen et al. 1992, Kuentzel 2001, Connelly and Knuth 2010).

Increased attention has been focused on the brook trout which has experienced significant declines across its historic range due to habitat degradation and fragmentation, elevated water temperatures, genetic introgression and the expansion of non-native species (EBTJV, Hudy et.al. 2008). Consistent with these observations, the Vermont Brook Trout Conservation Strategy (Kirn 2007) emphasizes attention on the protection and enhancement of riparian and aquatic habitat and water quality as well as the control of harmful aquatic species and pathogens.

While the ecological and recreational importance of these wild trout resources is clear, a systematic effort to monitor the status of these populations on a statewide scale has not been developed. This is in part due to the widespread distribution of these resources and the limited potential for active management within individual stream populations (VDFW 1993, Kirn 1994).

A statewide inventory of stream fish populations was conducted between 1952 and 1960 by former Department fisheries biologist James MacMartin, providing an invaluable quantitative baseline of Vermont's trout stream resources (MacMartin 1962, Kirn 1996). At this time MacMartin (1962) reported that Vermont's brook trout resource had substantially recovered as "significant numbers of brook trout were taken from all watersheds," and "a striking amount of natural reproduction" was observed. While physical habitat conditions were improving from the onset of reforestation, pollution from dairies, canneries, tanneries, paper mills, sawmills, granite sheds and slaughterhouses were still noted as significant threats. Although self-sustaining wild brown trout and rainbow trout populations were well established, it was primarily temperature that was believed to limit the distribution of brook trout at this time.

A subset of 35 MacMartin stream surveys comprising eight watersheds were resampled between 1978 and 1980 by Claussen (1980) to evaluate the effect of the 1974 removal of the six inch size limit on stream brook trout populations. Claussen (1980) concluded that, in addition to the regulation change having no effect on population size structure, brook trout populations had exhibited little change over the 20+ year period between the 1950s and 1979-1980. Similar results were found by Kirn (2001) who compared 62 stream survey sites, representing 53 streams and 12 watersheds over a 40 year period. The current evaluation further expands the Kirn (2001) study by comparing 150 sites representing 138 streams and 17 watersheds. The objective of this study is to document the current status of Vermont wild brook trout stream populations and to determine if substantial changes have occurred over the past half century.

METHODS

Brook trout population densities from 150 survey sites within 138 Vermont streams and 17 watersheds were compared between two time periods, generally comprised of the "1950s" (1952-1960) and "2000s" (2005-2016). The 1950s surveys were the result of a statewide inventory of stream fish populations conducted between 1952 and 1960 (MacMartin 1962). Survey sites ranged between 323 and 2024 feet in elevation, with over 86% of the sites above elevations of 750 feet, and 58% exceeding 1000 feet in elevation. Only three survey sites were below 500 feet in elevation.

Electrofishing Surveys:

Trout population surveys consisted of single or multiple run electrofishing sampling with a DC stream-side generator (250-500 volt) or battery powered backpack electrofisher. Captured brook trout, brown trout *Salmo trutta*, rainbow trout *Oncorhynchus mykiss* and Atlantic salmon *Salmo salar* were measured to the nearest mm (2000s) or 0.1 inch (1950s, total length) and released. In the 2000s surveys all trout and salmon were also weighed to the nearest gram, except YOY which were group weighed. Nongame fish species were identified and enumerated (1950s) or documented (2000s).

If encountered, stocked trout distinguished by fin condition and/or size were not included in population estimates. As discussed later, the confidence that surveys represented wild trout stocks was much higher in the 2000s than in earlier years.

MacMartin (1962) conducted single run electrofishing surveys, while more recent surveys generally consisted of multiple run depletion estimates. For consistency with the MacMartin surveys, brook trout population estimates for both time periods are presented as one-run minimum estimates, i.e. representing the number of trout captured on the first electrofishing run only. Trout population estimates are partitioned into three age/size classes: young-of-year (YOY); yearling and older <6 inches; yearling and older ≥6 inches and are presented as number of brook trout per mile. The mean brook trout estimates for YOY, <6 inches, ≥6 inches and total brook trout were each statistically compared between the two time periods with t-tests in Microsoft Excel.

Survey Site Selection:
A total of 205 stream survey sites sampled by MacMartin were subsequently sampled by Vermont Department of Fish and Wildlife staff between 2005-2016. Efforts were made to sample within a reasonable proximity of the original MacMartin sites which were identified by elevation, location descriptions and maps. Posting of private property, road realignments or other complications required deviation from MacMartin sites in some instances. To ensure that streams reaches were capable of supporting at least moderate brook trout densities, only surveys which resulted in minimum estimates of ≥500 brook trout/mile in at least one of the two time periods evaluated were included for analysis. In addition, only surveys conducted after mid-June were selected to insure brook trout YOY were large enough to be vulnerable to electrofishing gear. These criteria resulted in a total of 150 survey sites representing 138 streams and 17 watersheds for comparison (Table 1).

Several sites comprised multiple surveys (2-11) within the time period of interest. In these cases, the mean values of the surveys conducted within the time period were used for comparison. This occurred in 25 (17%) of the 150 site comparisons.

Table 1. Number of brook trout sampling sites per Vermont watershed.

Watershed	Sites
Batten Kill	3
Black River	3
Connecticut (direct tributaries)	11
Deerfield River	2
Lamoille	16
Memphremagog	13
Missisquoi	17
Nulhegan	1
Opmompanoosuc	1
Ottauquechee	10
Otter Creek	9
Passumpsic	7
Poultney	2
Waits	14
Wells	4
White	15
Winooski	22

RESULTS

With the exception of YOY brook trout, average population levels were very consistent between the two time periods. YOY brook trout densities were significantly higher in the 2000s (mean = 703/mile, SE = 44.0; $p<0.01$), reflecting a >300% increase over average densities observed in the 1950s (203/mile, SE = 22.2; Figure 1). Brook trout <6 inches were somewhat lower in the 2000s (mean = 342/mile, SE = 26.9) vs. 1950s (mean = 425/mile, SE = 40.0; $p<0.10$), reflecting a decrease of 20%. Average densities of brook trout ≥6 inches were essentially the same between the two time periods (1950s = 82/mile, SE = 8.9; 2000s = 76/mile. SE = 7.9; $p = 0.647$). Total brook trout/mile estimates, largely reflecting differences in YOY densities, were also significantly higher in the 2000s (mean = 1121/mile. SE = 58.6 vs. 710/mile, SE = 50.4; $p<0.01$).

The large disparity in the distribution of YOY densities between the two time periods further illustrates the differences observed. The peak of the distribution of YOY densities during the 1950s occurred between 0-250 trout/mile and quickly tailed off (Figure 2). This contrasts with that of the 2000s where YOY densities were well represented between 500-2000 trout per mile. During the 1950s only 14 (9%) survey sites supported >500 YOY/mile compared with 89 (59%) in the 2000s.

For yearling and older brook trout <6 inches, the most pronounced difference between time periods was observed in sites which supported ≤250/mile (Figure 3). In the 1950s, 35% of the surveys fell into this range of densities compared with 45% of the 2000s surveys. The distribution of yearling and older brook trout ≥6 inches, however, was very similar for the two time periods (Figure 4).

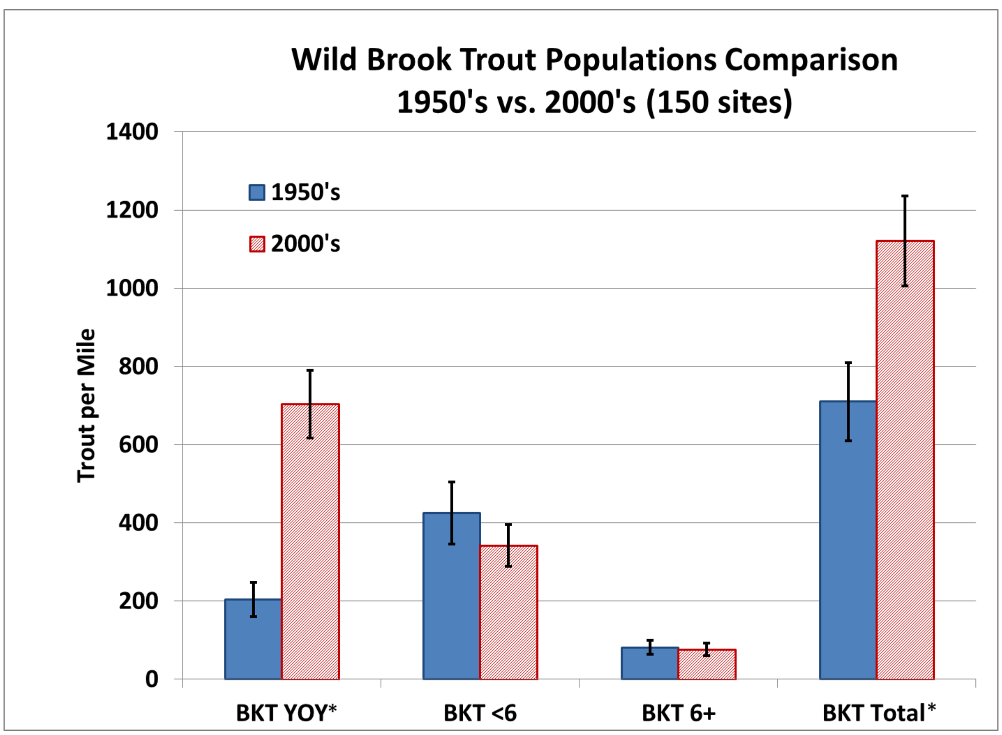

Figure 1. Mean wild brook trout densities and 95% confidence interval bars from 150 sites sampled during the 1950s and 2000s. (* denotes significant differences between time periods $p<0.05$; t-test).

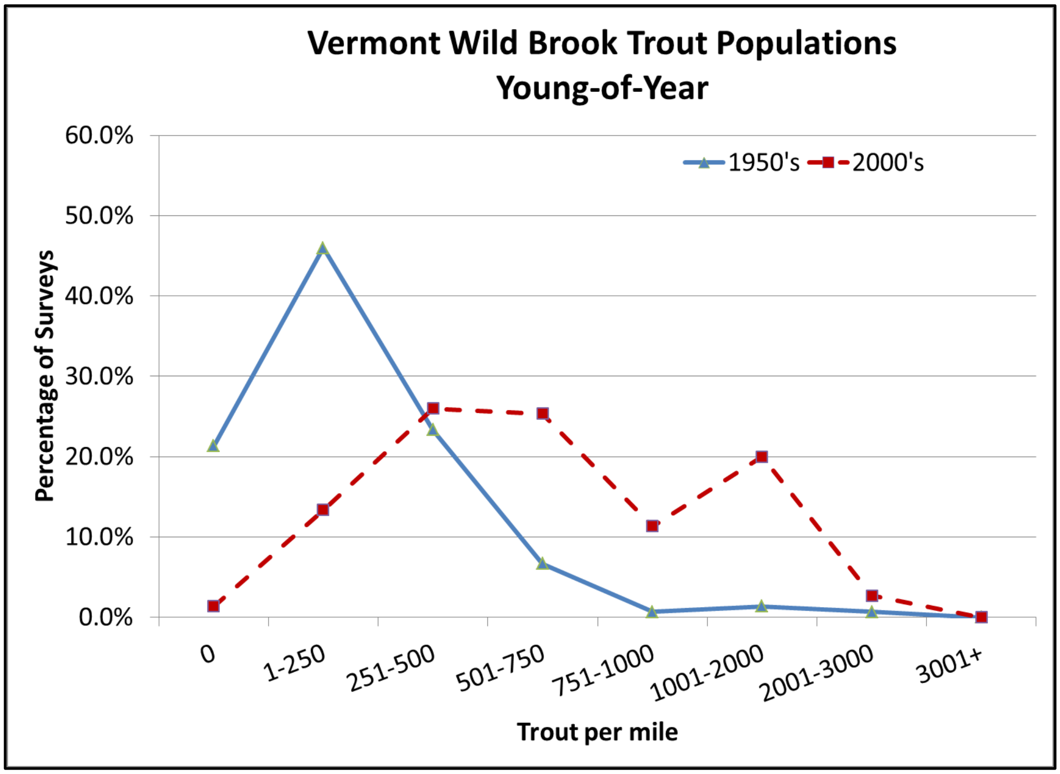

Figure 2. Distribution of wild brook trout young-of-year (YOY) densities sampled during the 1950s and 2000s in 150 sites.

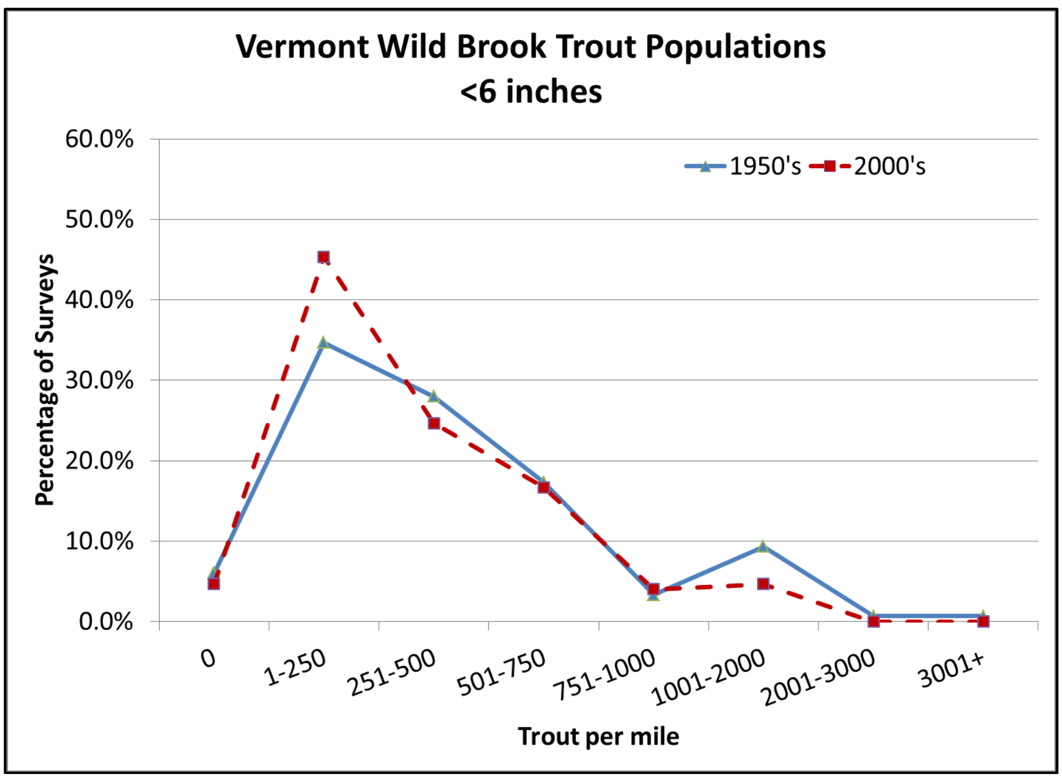

Figure 3. Distribution of wild brook trout yearling and older < 6 inches densities sampled during the 1950s and 2000s in 150 sites.

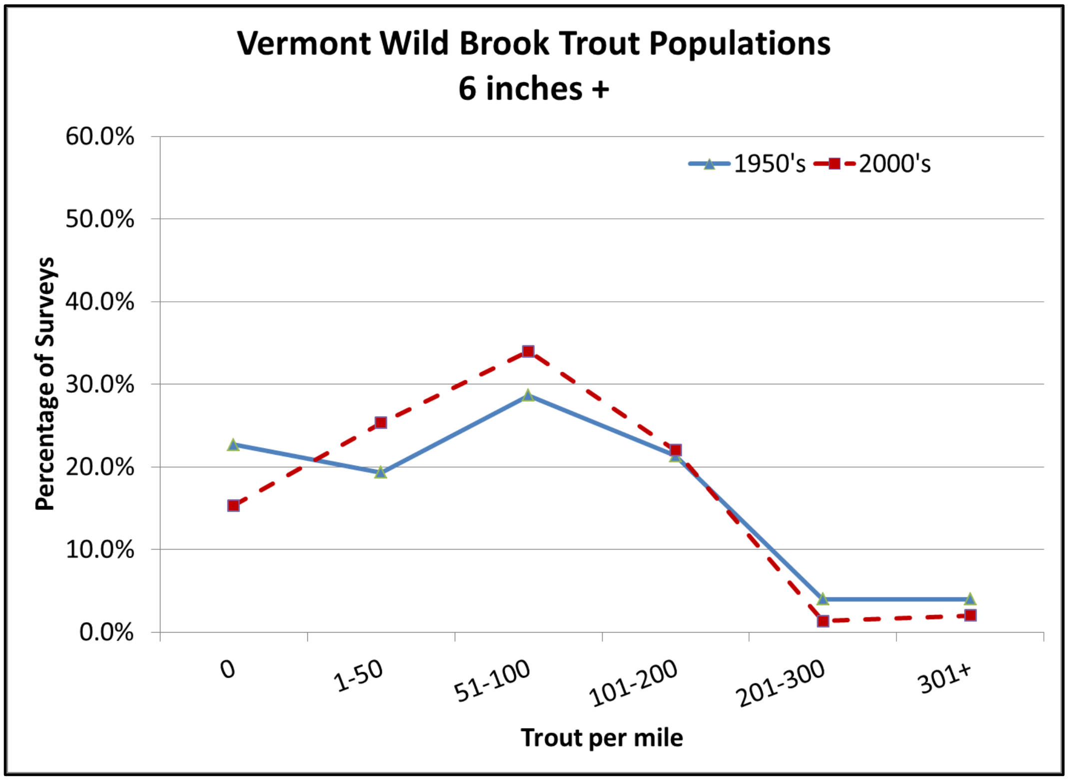

Figure 4. Distribution of wild brook trout yearling and older ≥6 inches densities sampled during the 1950s and 2000s in 150 sites.

Of the 150 sites surveyed between the two time periods, 40 (27%) showed a decline in total population density while 109 (73%) increased (Figure 5). Half of the sites showing declines were reduced by less than 500 trout per mile, while 66% of the sites displaying higher densities increased by more than 500 trout per mile.

The proportion of allopatric (brook trout only) sites increased from 69% to 80% between the 1950s and 2000s (Figure 6). The number of sites with brook trout and brown trout declined from 17 % to 13% while the number of sites with brook trout and rainbow trout declined from 19 % to 10% over the evaluation period. Current day sympatric (brook trout with brown and/or rainbow trout) sites generally supported very good, although somewhat lower densities of brook trout across all size/age classes, and higher combined trout densities (Table 2).

Table 2. Mean wild trout densities (#/mile) from 150 sites sampled from 2005-2016.

Population Composition	# Surveys	Period	Brook Trout YOY	Brook Trout <6	Brook Trout 6+	Brook Trout Total	Brown Trout Total	Rainbow Trout Total	Total Trout
Allopatric	120	2000's	728	360	79	1166	0	0	1166
Sympatric	30	2000's	604	268	66	939	222	242	1403

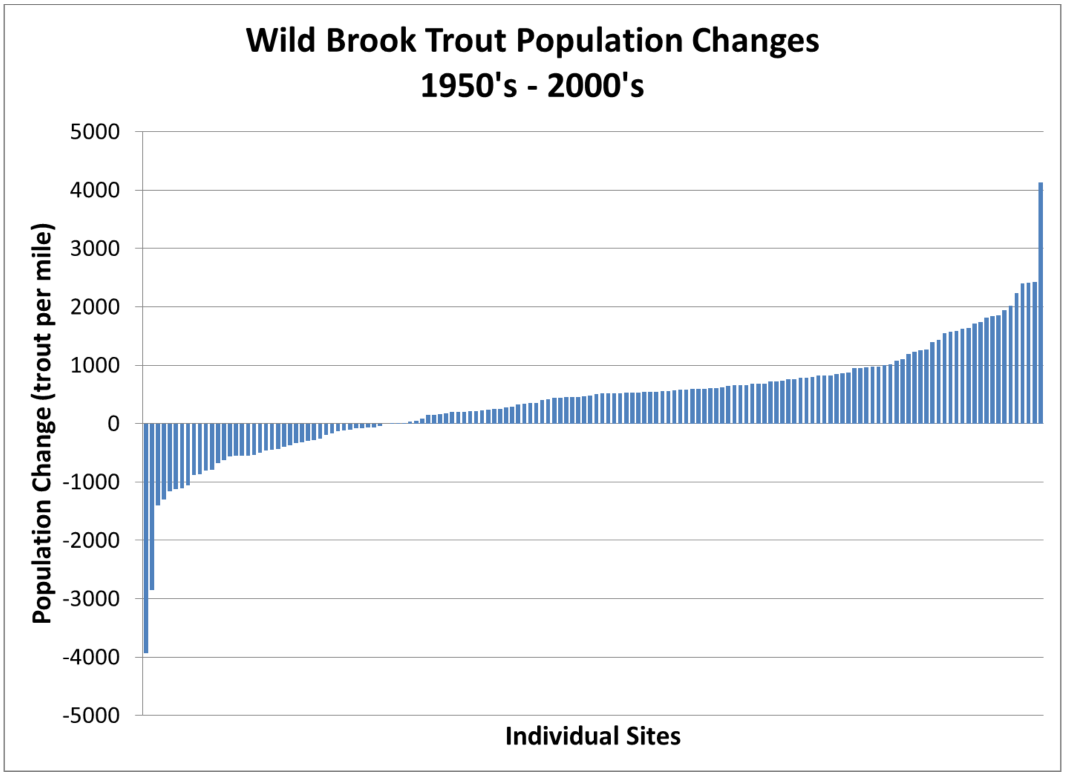

Figure 5. Distribution of the difference in total wild brook trout densities (#/mile) for 150 individual sites sampled in the 1950s and 2000s.

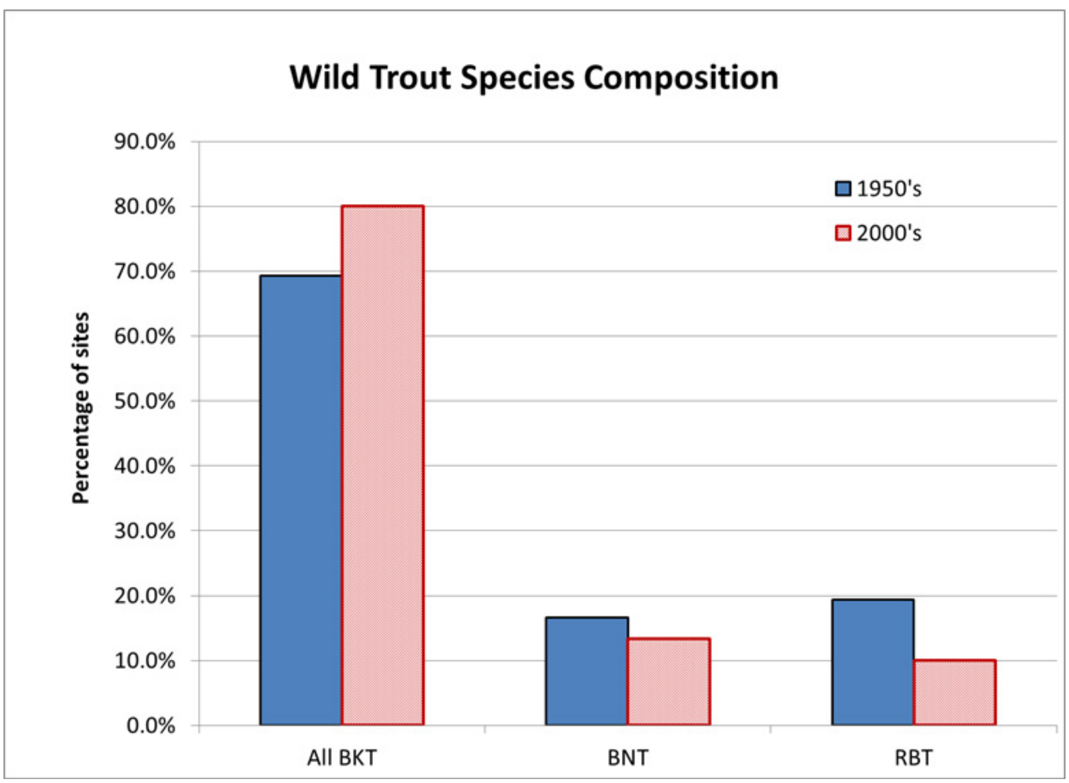

Figure 6. Percentage of sites with allopatric and sympatric brook trout populations surveyed during the 1950s and 2000s in 150 sites.

DISCUSSION
The most striking difference observed in this study was a >300% increase in mean YOY densities of from the 1950s to the 2000s. Improvements in brook trout YOY production may possibly reflect water quality and aquatic habitat improvements since the 1950s. Significant state and federal environmental legislation, which provide increased protection of water quality and aquatic habitat, have been in place since the early 1970s (VDFW 1993). Thorn (et al. 1997) described improvements in Minnesota's salmonid stream populations with a progression of habitat recovery over a 50 year period. This recovery was primarily the result of changes in land use which promoted the restoration of streamside vegetation, increased shading and reduced streambank erosion, in addition to active stream restoration activities.

It is important to understand the natural variability of wild brook trout populations when conducting a long-term evaluation. In a study of wild brook trout populations in Vermont streams, YOY densities were the most variable population parameter measured (Kirn 1997). Wild book trout population estimates of YOY and yearlings and older (1++) age classes from Clay Brook in the Mad River watershed demonstrate wide fluctuations in these population variables (Figure 7). Two large flood events in 1998 and 2011 had significant effects on YOY and 1++ age classes for several years. Broad environmental variables can also drive YOY densities as evident in the West Branch of the Little River watershed where clear peak (1999, 2005, 2012) and low densities (1997, 2000, 2006) were observed across sites in specific years (Figure 8). By comparing brook trout populations over several years within each time period, the influence of annual variability and severe environmental events should be moderated.

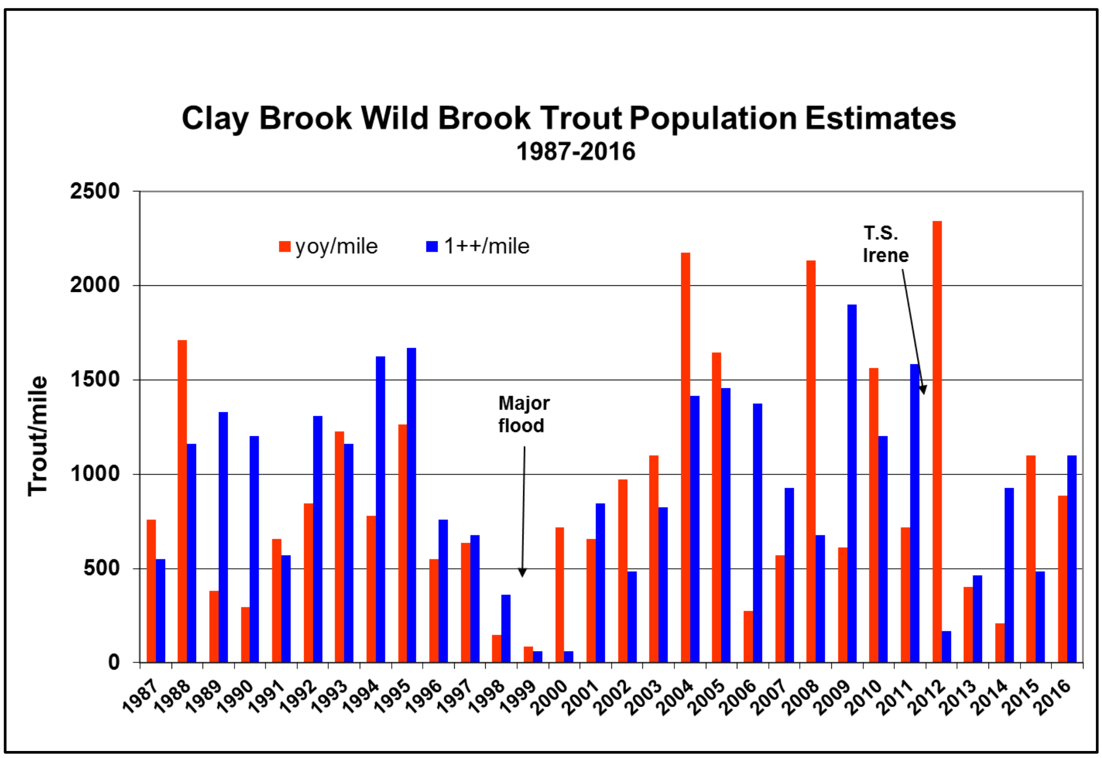

Figure 7. Wild brook trout young-of year (YOY) and yearling and older (1++) population estimates from Clay Brook; 1987-2016.

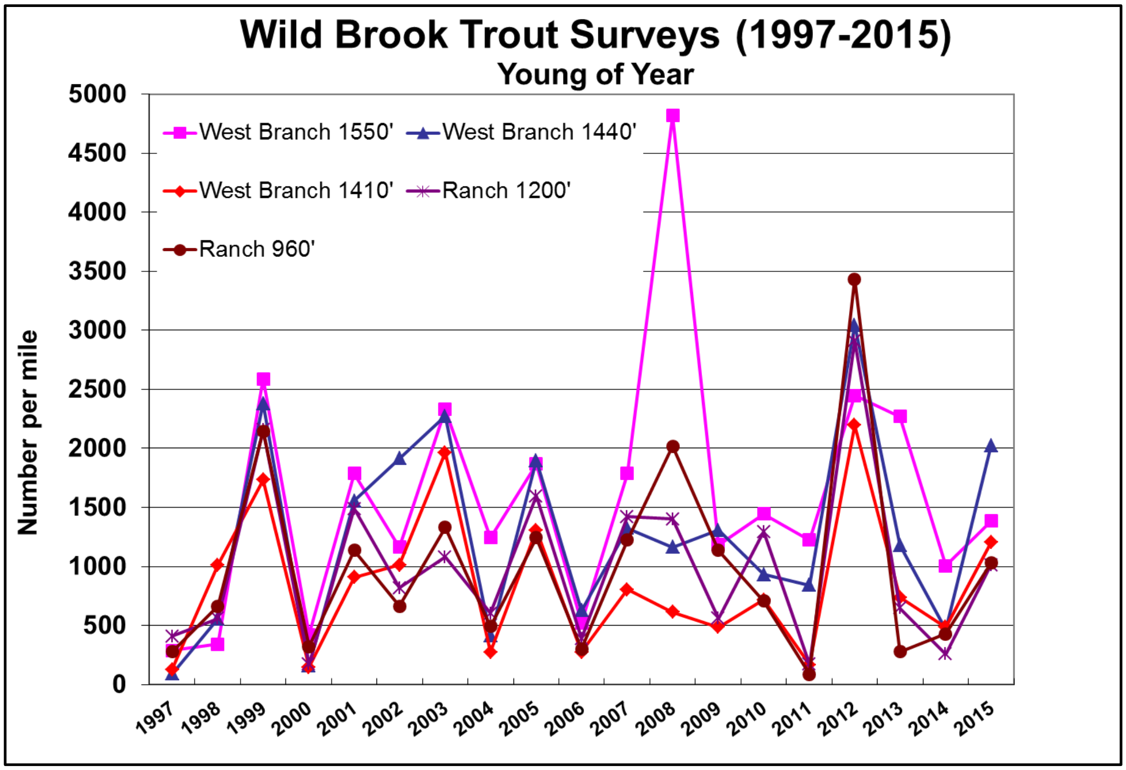

Figure 8. Wild brook trout young-of year (YOY) population estimates from Ranch Brook and the West Branch of the Little River; 1997-2015.

Changes in sampling efficiency do not appear to be a reasonable explanation for the large differences observed in brook trout YOY densities over the two time periods. While some changes in DC electrofishing gear has occurred since the 1950s, Claussen (1980) did not observe substantial differences in the 1-3 inch size class (primarily YOY) of brook trout among 35 stream populations compared from the 1950s to 1979 and 1980. Electrofishing gear used for the surveys conducted in the 2000s is comparable, and in most cases identical, to that used by Claussen (1980). Maximum observed brook trout densities were also similar in both time periods (1950s = 4541; 2000s = 4733) suggesting comparable catch efficiencies.

Discrepancies observed in densities of older age classes of brook trout were not as substantial. This is consistent with conclusions of a ten-year evaluation of wild brook trout streams in Vermont (Kirn 1997), where yearling and older brook trout population levels were one of the most stable population parameters observed. In this evaluation of 150 sites, mean densities of brook trout <6 inches were somewhat lower in the 2000s, representing an average decline of 20% from the 1950s. Densities of brook trout ≥6 inches, which are usually 2 years and older in Vermont (Claussen 1980), did not change over the 50+ year period evaluated in this study.

The stocking of cultured brook trout could have influenced the results of this study, as considerably more brook trout were stocked in the 1950s than the 2000s (Table 3). State stocking of brook trout averaged 1,701,499 from 1953-1960 compared to 243,435 from 2005-2016. In addition, fry and fingerling stocking was widely used in the 1950s averaging 1,439,518 brook trout 1-5 inches in length. Smaller stocked trout would be harder to distinguish from wild stocks as fin and overall condition differences are not as obvious. Trout stocking during this time was widespread with very little direction, consistency or evaluation.

In contrast, stocking in the 2000s was directed by the *Vermont Management Plan for Brook, Brown and Rainbow Trout* (VDFW 1993) which discourages the stocking of trout in wild brook trout waters as well as the use of fry and fingerling stocking, with very limited exceptions. In addition, stream stocking is more targeted, focused on larger waters with habitat limitations, requires a formal request and is well documented. Fry and fingerling stocking is generally reserved for remote ponds where transport of yearling trout is not feasible. One possible exception is a cooperative stocking program at the Morgan Hatchery which produces brook trout fry for distribution into beaver ponds in the Northeast Kingdom. These fish are stocked by volunteers with only broad direction from the Department and averaged 77,000 fry per year during the 2000s.

Considering that brook trout stocking in the 2000s averaged less than 15% of the 1950s, focused on larger trout and were more targeted in location, it is highly unlikely that higher YOY densities observed in the 2000s can be attributed to stocking efforts. It is conceivable, however, that the differences in wild brook trout population densities observed in the 2000s may have been further moderated by widespread stocking in the 1950s.

Table 3. Average brook trout stocking during the 1950s and 2000s.

Age	1950s Average	2000s Average
Fry (1-2")	1,170,222	93,343
Fingerling (3-5")	269,296	53,057
Yearling (6-10")	260,304	94,095
2 year and older (11"+)	1,677	2,940
Total	1,701,499	243,435

Naturalized non-native trout populations have also been implicated in the decline of native brook trout population abundance and distribution throughout their range (Waters 1983, Larson and Moore 1985, EBTJV, Kanno et. at. 2016). In this study, the number of sympatric sites supporting naturalized rainbow trout and brown trout actually decreased since the 1950s. This observation is consistent with other reports of the loss of naturalized rainbow trout populations within several Vermont watersheds (Claussen 1999, Kirn 2016). Even where these populations co-existed, very good brook trout densities were generally observed and total combined wild trout production was higher than in allopatric brook trout sites. These observations indicate that the threat of non-native naturalized trout on wild brook trout populations in Vermont may have stabilized or declined. More judicious use of cultured trout (McKenna et. al. 2013) and the development of sterile triploid trout for stream stocking will further minimize the potential for expansion of these populations (Kirn 2011).

Management Strategies for Wild Brook Trout Streams:

Although small wild brook trout streams represent important ecological and recreational resources in Vermont, effective strategies for managing these populations are somewhat limited. The potential benefits of cultured trout stocking, regulation of angler harvest, and management of aquatic habitat are discussed below:

Stocking of Cultured Trout - Stocking artificially reared trout may be effective in maintaining recreational fisheries where adequate wild populations cannot be sustained due to physical or environmental habitat limitations. Although the stocking of hatchery reared trout is an important trout management tool, this practice may pose some risks to wild trout populations. Specific areas of concern include: potential genetic alteration of wild stocks due to interbreeding or altered selection pressures (Hindar et al. 1991, Krueger and May 1991, Kirn 2003, Habera and Moore 2005); displacement of native species by hatchery-reared trout (Waters 1983, Larson and Moore 1985, Hindar et al. 1991); direct mortality on wild trout due to behavioral interactions with stocked trout (Bachman 1984, Vincent 1987); and contamination of wild trout through introduction of disease (Goede 1986, Hindar et al. 1991, Krueger and May 1991, Stewart 1991).

The Vermont Management Plan for Brook, Brown and Rainbow Trout (VDFW 1993) specifically recommends managing for wild brook trout without stocking in *"Small upland streams which maintain dense populations (≥20lbs/acre and ≥1000 trout/mile) of brook trout through natural reproduction."* Nearly half of the streams evaluated from the 2000s in this study supported wild brook trout population densities above this threshold despite the use of single run, minimum population estimates. Standard multiple run estimates would increase the proportion of brook trout populations above this threshold. As discussed earlier, temporal variability must also be considered as annual wild brook trout population estimates in a given year may vary widely from their long-term average.

Stream stocking criteria used in Vermont include the consideration of wild trout populations as well as fishing pressure (VDFW 1993). Wild brook trout streams are widely distributed throughout Vermont and receive light and diffuse fishing effort, rarely high enough to warrant stocking.

Stream stocking in Vermont is primarily conducted with yearlings to provide put-and-take fisheries as overwinter survival of stocked trout is not expected and rarely observed (Kirn 1999). The stocking of younger age classes (fry, fingerlings) in streams is not recommended for several reasons (VDFW 1993):

> *"Streams/rivers designated for wild trout management should be avoided as reproduction is not normally a limiting factor in these populations. Fall fingerling stocking may in fact be detrimental in these waters as wild trout biomass is at its peak while habitat often becomes limiting in winter months."*
>
> *"Newly hatched trout, or fry, provide limited management potential for establishing recreational fisheries (Everhart and Youngs 1981) primarily due to high mortality of these fish from predation, competition and environmental pressures following stocking. Best results can be expected in barren waters such as reclaimed ponds or newly formed beaver ponds."*
>
> *"The stocking of fingerling trout (2-5 inches) in streams was identified as an ineffective management technique for providing recreational fisheries by the 1940's (Surber 1940, Shetter 1950, Needham 1959). The percentage of these fish which were eventually creeled by anglers was usually less than 3% of the total stocked, effectively raising the total cost per fish more than 30-fold (Needham 1959, Burns and Calhoun 1966, Cresswell 1981)."*

While the stocking of small wild brook trout streams is largely unwarranted due to adequate wild trout population levels and low fishing effort, it is recognized that stocked trout could move into these areas when environmental conditions (e.g. temperature) of larger stocked waters decline. In Vermont, brook trout are the species most at risk from genetic interaction with hatchery-reared trout as stocked trout need only survive to the first fall after stocking (about four months) to spawn with wild stocks. Genetic testing of five brook trout populations from geographically distinct Vermont watersheds conducted in 2006 indicates that Vermont maintains genetically diverse, highly differentiated wild brook trout populations with no evidence of influence from past stocking (Kirn 2007). The existence of genetically distinct wild brook trout populations reinforces the need for a prudent approach to trout stocking in and near these populations. To address this concern Vermont produces sterile triploid brook trout for stream stocking as a fisheries management strategy for conserving native stocks while meeting the public demand for recreational angling opportunities (Kozfkay et. al. 2006, Kirn 2011).

Management of Angler Harvest - The Vermont Management Plan for Brook, Brown and Rainbow Trout (VDFW 1993) specifically addresses the potential for managing wild brook trout streams with restrictive harvest regulations:

> *"However, further restricting the harvest in Vermont's upland brook trout streams would appear undesirable. These streams generally contain dense populations of slow-growing, short-lived wild brook trout which rarely exceed six inches in length. These populations do not normally require restrictive harvest regulations because of their inherent high natural mortality (Habera and Strange 1993)."*
>
> *"In Vermont, a statewide six-inch minimum length limit provided very little protection for wild brook trout populations (Claussen 1980). The slow growth and high natural mortality characteristic of these populations, not angler harvest, apparently precluded fish from attaining large sizes. Hunt's (1970) evaluation of a six-inch limit on brook trout in Michigan resulted in similar conclusions."*

In a recent study of catch-and-release regulations on Pennsylvania headwater streams, Detar (et. al. 2014) found no improvement of adult or large brook trout, citing slow growth and low angler use as likely causes. The current study in Vermont further supports these conclusions as densities of brook trout ≥6 inches surveyed in the 2000s have remained essentially identical to the 1950s, when these populations were protected under a statewide 6-inch minimum size limit.

Management of Trout Habitat – Hudy (2008) reported brook trout populations to have been extirpated or reduced in >70% of the subwatersheds in their original range due to a variety of human activities. Consistent with these observations, the Vermont Brook Trout Conservation Strategy (Kirn 2007) places a high priority on the protection and enhancement of riparian and aquatic habitats and water quality in the management of wild brook trout populations.

Stream temperature has a profound effect on the distribution and abundance of aquatic populations. (Poole and Berman 2001, DeWeber and Wagner 2014, Hitt et. al. 2015). Global climate change predictions suggest further losses of brook trout populations throughout their range due to increases in temperature and flood frequency (Wegner et al. 2011). In Vermont, Kratzer and Warren (2013) found brook trout abundance to be negatively correlated with the duration of temperatures exceeding 20°C (68°F). Maximizing cold water in smaller tributary streams is also extremely important for moderating temperatures and providing thermal refuges in the larger streams, rivers and lakes which they feed (Baird and Kruger 2003). The preservation and restoration of streamside vegetation has been long recognized as extremely important for controlling temperatures by shading stream channels (ANR 2015). Undisturbed, naturally vegetated riparian zones also promote stable streambanks, filter pollutants and provide food and shelter for fish and other aquatic organisms through the natural recruitment of fine organic material and large wood. These benefits are realized not only within the protected stream reach, but also in its downstream receiving waters.

The alteration of natural flow regimes through damming and diversion can also greatly effect aquatic populations by modifying physical and chemical processes, reducing abundance and diversity, shifts in species composition, reducing habitat diversity and affecting natural behavioral cues (Novak et. al. 2016). The damming of streams often promotes increased temperatures as the wider, slower impoundment is exposed to increased solar radiation and heating. Maxted et al. (2008) and Lessard and Hayes (2003) reported degraded aquatic habitat from increased temperatures and reduced dissolved oxygen resulting in significant impacts to macroinvertebrate communities and coldwater fish populations. Lessard and Hayes (2003) concluded that increased temperatures were maintained 2-3 km below small dams and resulted in shifts in macroinvertebrate communities, increased fish species richness and reductions in brook trout, brown trout and slimy sculpin densities. Larger hydroelectric dam operations can also result in extreme fluctuations of flow and temperature which can be detrimental to brook trout populations (Kirn 2016b).

Wild brook trout rely on regular seasonal movements to maintain viable populations (Letcher et. al. 2007) which can be greatly affected by the presence of dams and culverts. Barriers to movement can isolate populations, impact genetic diversity and increase the risk of extirpation (Letcher et al. 2007, Whiteley et al. 2013). Gowan and Fausch (1996) documented brook trout summer seasonal movements of over a mile and shorter distances traveled regularly by resident brook trout. Movement occurs even in high gradient streams, as evidenced by Adams et al. (2000) who observed upstream movement of brook trout in slopes as high as 22%. In addition to moving during higher flows to access suitable spawning habitat in spring and fall, brook trout also move during summer low flows and in anticipation of winter low flows. Peterson and Fausch (2003) observed peak movement of brook trout in the summer and fall, with nearly 80% of recaptured fish moving upstream and up to 2 km away within a summer. Likewise, Kanno et al. (2013) observed distinct peak movements in June and September-October of wild brook trout in a Massachusetts stream.

In addition to thermal impacts, sedimentation and habitat alterations are among the most serious threats facing Vermont's wild brook trout stream populations. The loss of habitat diversity and complexity has been well studied and is directly linked to decreased diversity and abundance of macroinvertebrate and fish populations (Lau et. al 2006, Carline and Klosiewski 1985, Edwards, et. al 1984, Chapman and Knudsen 1980, Groen and Schmulbach 1978). These conditions can be associated with instream impoundments, loss of functioning riparian habitats and direct instream mining and channelization. Legacy logging practices in the Northeast Kingdom of

Vermont have resulted in reduced habitat diversity, including the lack of large wood complexes which have been correlated with wild brook trout abundance (Kratzer and Warren 2013, Kratzer 2014.) While detrimental instream activities tend to be less common due to more stringent environmental regulation, post flood alterations recently resulted in the homogenization of over 75 miles of stream following Tropical Storm Irene in 2011 (Kirn 2012).

CONCLUSIONS

Wild brook trout populations in Vermont streams appeared to be relatively stable over a period of five decades as evidenced in this evaluation of 150 sites. Present-day brook trout populations sampled in 138 streams within 17 watersheds were characterized by abundant natural reproduction and multiple age-classes, including the contribution of older, larger fish. While most population measures were consistent between the two time periods, significantly higher densities of YOY brook trout were observed in current populations, possibly reflecting improved environmental protections initiated since the 1950s. A decline in sympatric brown trout and rainbow trout sites also suggests that non-native trout populations have not appreciably expanded over the past 50 years.

The long-term viability of Vermont's wild brook trout stream populations will require the protection and enhancement of forested riparian areas, diverse, complex and connected aquatic habitats and the protection and improvement of suitable water temperatures, water quality and natural hydrology. The Department of Fish and Wildlife can positively affect the conservation and enhancement of critical habitat requirements of this important ecological fisheries resource through the influence of state and federal environmental regulatory procedures, policies and practices. In addition, education, outreach and technical assistance to private landowners and municipalities will be essential.

RECOMMENDATIONS

1. Develop and implement effective wild brook trout habitat protection and enhancement strategies with other state, federal and non-governmental agencies, watershed and angler organizations and private landowners.

2. Consistently and effectively participate in environmental regulatory proceedings and the development of environmental regulations, policies and procedures to protect and enhance wild brook trout habitats in Vermont.

3. Manage small upland streams supporting naturally reproducing populations of brook trout as wild trout waters without stocking. These waters will often support moderate to dense populations of wild brook trout and are unlikely to attract high enough fishing pressure to warrant stocking. Where the stocking of cultured trout is justified, utilize sterile triploid brook trout to minimize the potential interaction with wild stocks.

4. Protect wild brook trout populations from the introduction of aquatic species and diseases that may adversely impact brook trout populations or their habitat.

5. Continue to monitor wild brook trout streams across Vermont to understand long term population trends and inform fisheries management priorities.

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Prepared by: ____
Rich Kirn, Fisheries Program Manager

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