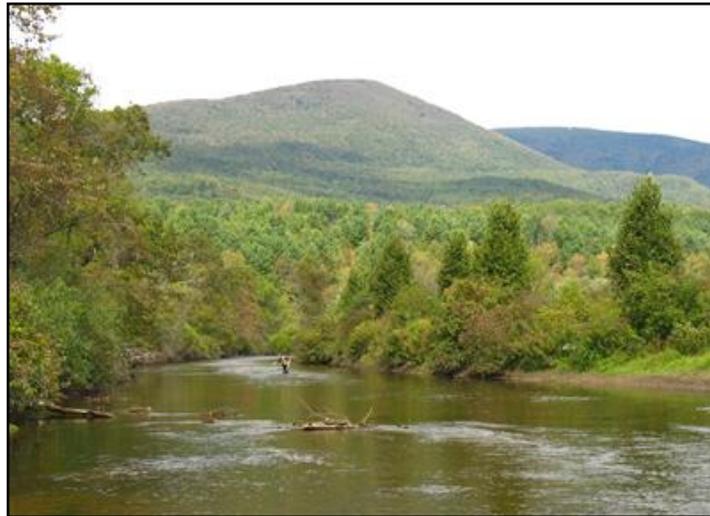


State of Vermont
Agency of Natural Resources
Fish & Wildlife Department

**BATTEN KILL TROUT MANAGEMENT PLAN
2007-2012**



Prepared by: Kenneth M. Cox, Fisheries Biologist

January 8, 2006



Approved: Wayne A. Laroche
Wayne Laroche, Commissioner, VFWD

Date: 1/16/07

Table of Contents

Executive Summary	1
Introduction.....	2
Purpose.....	3
Scope.....	3
Trout Management History.....	3
Stocking.....	3
Regulations.....	5
Habitat	6
Fishery Assessments.....	8
Current Resource Assessment.....	9
Goals and Actions	15
Public Input.....	19
Literature Cited	19
APPENDIX 1. Fisheries and habitat assessments of the Batten Kill, 1934-2006	22
APPENDIX 2. Summaries of special studies and assessment activities, 2000-2006.....	23
APPENDIX 3. Goals and strategies.....	28

BATTEN KILL TROUT MANAGEMENT PLAN 2007-2012

Executive Summary

The Vermont Fish and Wildlife Department (VFWD), in June 2006, released for public review and comment a draft trout management plan for the Batten Kill. The plan emphasized: (1) continued protection of lower main stem wild trout populations from angler harvest; (2) restoration and protection of in-stream and riparian habitats; and (3) low density stocking of yearling triploid rainbow trout on an interim basis to improve angling quality until such time that wild populations are restored to a level supportive of limited angling harvest. Based on extensive public input, the first two elements of the proposed plan have broad public support. On the other hand, stocking the Batten Kill is opposed at this time by a resounding segment of the angling community. The public also raised several issues or concerns that they urged the VFWD to address: (1) the high incidence of hooking mortality anticipated to result from increased fishing pressure and bait use following stocking; (2) the potential for stocked fish to compete with wild trout for limited cover habitat; and (3) the potential for stocked rainbow trout to aggravate the incidence of whirling disease in the Batten Kill including spreading the pathogen into uninfected waters within and beyond the limits of the watershed.

After considering public input, the VFWD has decided not to stock the Batten Kill at this time. The Batten Kill main stem and its tributaries with the exception of the Roaring Branch and Dufresne Pond will continue to be managed exclusively as wild trout fisheries without stocking for the term of this six-year plan. The "test waters" regulation that has been in place, closing the main stem from the base of Dufresne Pond dam down to the New York state line to the harvest of brown and brook trout since 2000, will be extended through December 31, 2012. The regulation will also be expanded to include the Green River and Roaring Branch/Warm Brook, where trout harvest will be prohibited October 1-31 to protect Batten Kill trout entering these tributaries during the fall spawning season. Other than these exceptions, the remaining main stem and tributaries will continue to be managed under Vermont general fishing regulations for rivers and streams.

For the time period of this Management Plan, trout management in the Batten Kill will concentrate on wild trout population and habitat restoration and protection. The VFWD and its other partners will work cooperatively with a wide range of stakeholders to address habitat deficiencies that negatively affect the capacity of the river to support a productive wild trout fishery.

Introduction

Vermont has many notable trout streams; for example, the White, Willoughby and Mettawee rivers. The Batten Kill, however, prominently stands out as the State's most famous trout stream and is considered by many anglers to be one of the most technically challenging streams to fish. Extending back to at least the 1850s when Manchester emerged as a resort center, the Batten Kill began attracting anglers from distant locations. Over the next 100 years its reputation of being one of the United States' premier trout streams continued to build as it was written about in numerous outdoor journals and continued to attract fly fishing luminaries. The Batten Kill was named one of the 100 best trout streams in the United States in 1989 (Trout Unlimited 1989). It was voted the tenth best stream in the country in a 1998 poll of Trout Unlimited members (Ross 1998). However, as with any trout stream of note, the Batten Kill has been a lightning rod for critical opinions regarding perceived and real changes in fishing quality as well as how the fishery is being managed. A 1934 Vermont Fish and Game Service report documents that, even then, any discussion of the Batten Kill and its trout fishing was often qualified with "it isn't what it used to be." This is no less true today.

Most of the Batten Kill main stem and its tributaries have been managed almost exclusively for wild brook and brown trout (i.e., without stocking) since the mid 1970s. Over the next two decades these populations sustained themselves and a quality sport fishery under high levels of fishing pressure and harvest. However, between 1994 and 1996, catchable-size (total length ≥ 6 inches) brown trout abundance declined precipitously despite continued evidence of abundant reproduction. Since then, the population of catchable brown trout has not recovered and has stabilized at a level substantially below that which occurred prior to the decline. Consequently, catch rates have declined as have angler satisfaction and fishing pressure.

In 2000 the VFWD placed the lower 20 miles of river main stem from the New York State line upstream to Dufresne Pond dam in Manchester, under a "test waters" regulation (#1028) in response to the unexplained decline of the brown trout population. The regulation restricted the fishery to catch-and-release (no-harvest) angling and was in effect from April 8, 2000 through December 31, 2005. The no-harvest regulation was subsequently extended to cover the 2006 fishing season. The regulation had two purposes: (1) protect the remaining wild brown trout population from angling mortality and possible further decline as might occur should harvest be allowed to continue; and (2) establish a period of six years during which investigative studies of the river's trout populations and habitats could be conducted to identify the likely cause(s) for the brown trout population decline. The test water regulation essentially eliminated harvest as a factor affecting the trout populations during the assessment period.

Purpose

The purpose of this plan is to identify key issues relative to the current status of the trout resources and fisheries in the Batten Kill main stem and selected tributaries, and to develop goals and strategies that will address these issues during the next six years (2007-2012). Even though the plan gives much attention to the current condition of the brown trout population and lays out a course of action intended to restore the species to its former prominence, the plan will also benefit wild populations of the native brook trout. Management of the sport fishery and habitat cannot be pursued independent of the other fish species inhabiting the river.

Scope

The focus of the plan is limited to the Batten Kill main stem in Vermont from the New York State line upstream to Dufresne Pond dam and two particularly important tributaries which feed into this reach: the Green River at river-mile 34.4 and the Roaring Branch at river-mile 39.1 (Figure 1). Unless specifically identified, it is not within the scope of this plan to discuss or propose major changes in the management of the trout fisheries of other tributaries and waters within the Batten Kill watershed.

Trout Management History

Stocking

Before the introduction of brown trout into the Batten Kill, sometime between 1892 and 1910, angling was essentially limited to the native brook trout, the only salmonid species indigenous to the watershed within Vermont. The earliest brown trout releases appear to have been experimental and may have involved relatively small numbers of fish. The 26th (1922) Biennial Report of the Vermont Department of Fish and Game mentions a plan to develop a cooperative brown trout milt and egg stripping operation on the Batten Kill which suggests the wild population by that time had become established. The same report also states that the Department had acquired brown trout fingerlings from which a brood line would be developed. Beginning about 1926 brown trout stocking became a regularly occurring management activity within the Batten Kill basin.

Early stocking records do not provide definitive information on the strain or origin of the brown trout released into Vermont waters. However, brown trout stocked in 1896 by the State were apparently of the Von Behr, or German, strain (14th (1898) Biennial Report of the Vermont Commissioners of Fisheries and Game). It is not until 1927 that the Loch Leven, or Scottish, strain of brown trout appears in the biennial reports. From these documents it is surmised that the first brown trout introductions to the Batten Kill may have originated from Von Behr stock and in later years were supplemented with or replaced by Loch Leven strain fish. Whether or not the plan to strip Batten Kill brown trout of eggs and milt ever occurred and contributed to the population in the river cannot be confirmed via the biennial reports.

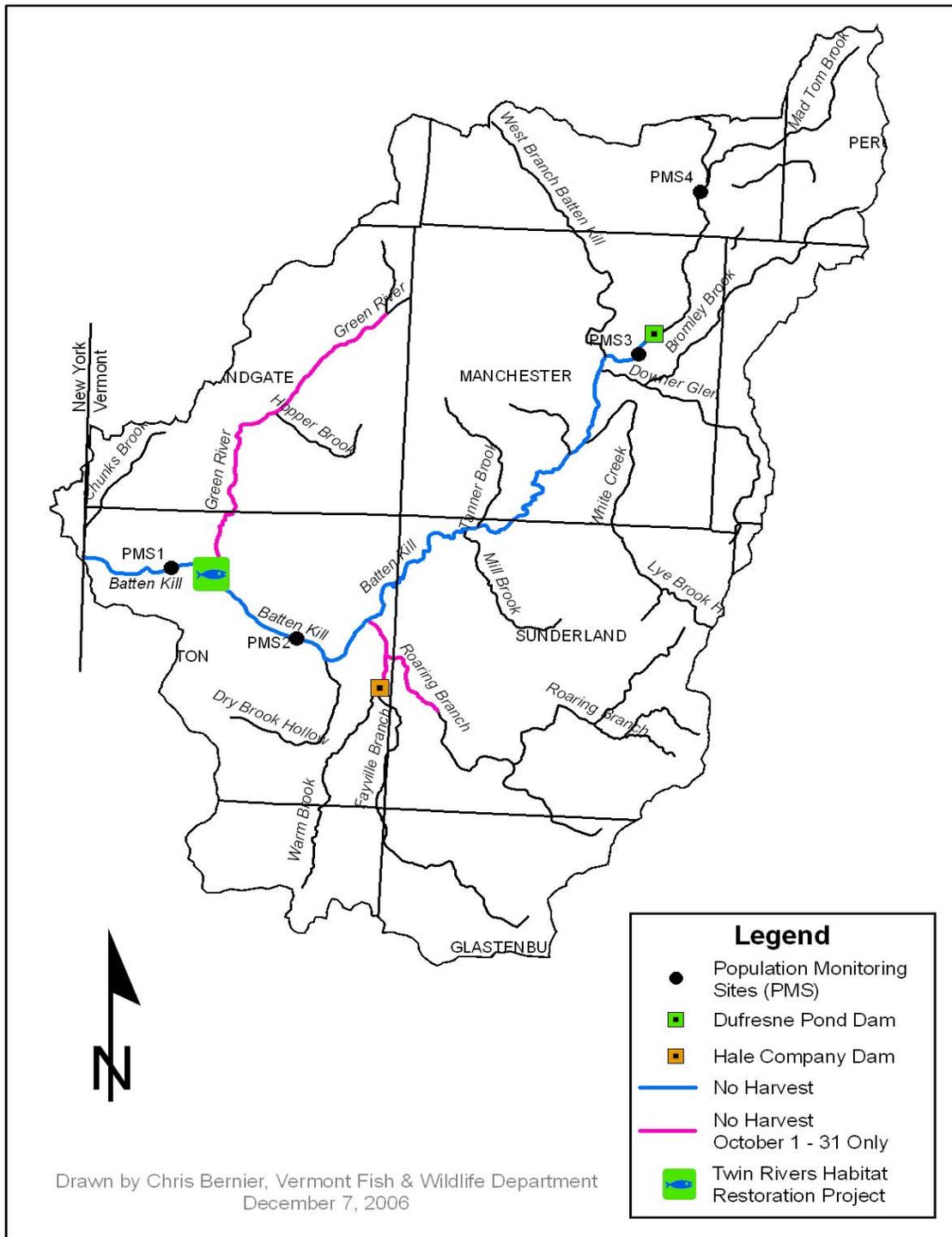


Figure 1. Vermont portion of Batten Kill main stem drainage basin.

In 1941 rainbow trout, native to western North America, were added to the mix of fish stocked into the Batten Kill. That year the Department released the results of the first biological survey of the watershed (Otis 1941) which included stocking recommendations for brook and brown trout only. Numbers of fish to be released were derived from a formula developed by Embury (1927), one of the earliest biologically based systems for arriving at stocking numbers based on stream size, pool quality and frequency, and relative abundance of food organisms. What rationale resulted in rainbow trout being introduced into the Batten Kill fishery is unclear. Nonetheless, rainbow trout continued to be stocked until the mid 1950s. However, rainbow trout stocking failed to establish a naturally reproducing population in the Batten Kill. Management of the Batten Kill fishery continued to stock hatchery brook and brown trout to supplement wild populations through the next 25 years.

The VFWD considered plans to end stocking of the Batten Kill and to manage the fishery for wild trout as early as 1968 in that portion of the main stem situated in the town of Arlington, hereafter referred to as the lower river. This decision was based on trout population surveys and “test waters” studies which indicated the fishery was capable of sustaining itself by natural reproduction. Brown trout were last stocked in the lower river in 1970. By 1972 all brown trout stocking was terminated in the Batten Kill watershed. The last year of main stem brook trout stocking with the exception of Dufresne Pond was 1975. In 1993 the VFWD adopted *The Vermont Management Plan for Brook, Brown and Rainbow Trout*. The fishery characteristics of most waters in the Batten Kill watershed were consistent with guidelines established for wild trout management and for this reason most stream trout stocking was terminated by 1995. Several lakes and ponds and one stream continue to be stocked annually with brook trout: Beebe Pond, Branch Pond, Dufresne Pond, Lake Shaftsbury, and Roaring Branch.

Regulations

A chronology of Vermont trout management milestones since 1866, including fishing regulations, is summarized in the 1993 State trout management plan. Over the past 30 years numerous other regulatory changes have occurred affecting trout fisheries at a statewide level and in a few cases have been specific to the Batten Kill.

The Vermont legislature passed an omnibus bill in 1961 that made sweeping changes to the state’s fishing laws. It streamlined many regulations and abolished numerous exceptions to general regulations. For example, a prohibition on the use of baitfish in the Batten Kill was repealed.

In 1974 a six-inch minimum size limit on brook, brown and rainbow trout was removed from the general fishing regulations. This regulation had been in place since 1888, including a creel limit was based on weight (daily harvest of all trout species in aggregate not to exceed six pounds). Sometime during the early 1900s a 20 fish limit was enacted which remained in effect until 1957 when the daily limit was lowered to 12 trout. The creel limit was reduced to six fish (brown and/or rainbow trout) in 1993, except brook trout in streams remained at 12 per day. These limits applied to the Batten Kill main stem and its tributaries through 1999 with the exception of 2.1 miles of the

lower river which had a three fish limit during the 1994-1999 fishing seasons. As of 2000 the entire Batten Kill main stem from the Dufresne Pond dam to the New York State line has been under a no-harvest “test waters” regulation.

The application of special regulations designed to achieve specific fisheries management outcomes from the Batten Kill is a relatively recent development, albeit angler interest and debate on the subject has existed for some time. As mentioned previously, at least as far back as the 1940s the use of fish as bait in the Batten Kill was prohibited. Lord (1946) offers some discussion of the speculated pros and cons of the “no baitfish” regulation, but he states the rationale for its adoption was unclear.

Subsequent to the VFWD eliminating stocking in the early 1970s in favor of wild trout management, a segment of the angling community advocated for special regulations on the lower river based on their belief that general regulations were not restrictive enough to maintain quality fishing (Biggins 1972). After assessing the fishery in the lower river, the VFWD decided to continue managing the river for wild trout and the harvest of fish under the general regulations. However, the door was left open to future consideration of special regulations subsequent to additional evaluation of the wild trout populations’ response to that management.

The wild trout fishery in the lower river under general regulations was assessed between 1988 and 1993 (Cox 2000). It was determined that the catch and harvest of quality size brown trout (total length ≥ 10 inches) was heavily concentrated during the first two months of the fishing season (April-May) thus not maintaining fishing quality over the remaining season (June-October). The mean exploitation rate, brown and brook trout combined, for the years 1988-1992 was 41% of the pre-season catchable-size population. Brown trout comprised 81-89% of the total harvest. Over the same time-period fishing effort and trout catch decreased by 37% and 55%, respectively, and trout catch-per-unit-effort declined from 0.69 trout/angler-hour in 1988 to 0.49 trout/angler-hour in 1992. With support from the angling community, the VFWD established in 1994 a “test waters” regulation for a 2.1 mile long special regulation section on the river. From 1994 to 1999 the regulation established a protected slot length limit of 10-14 inches, a reduced creel limit of three fish per day, and angling by artificial lures and flies only. The goal of the special regulation was to improve the quality of the brown trout fishery within the 2.1 mile long river section. However, it was not apparent at the time that the brown trout population throughout the Batten Kill main stem was declining. During the special regulation evaluation period the abundance of catchable-size brown trout declined by 54% and quality size fish by 77%. It seemed that any positive effects that the special regulation was intended to produce were negated by factors causing the brown trout population decline. This decline led to the VFWD designating the lower 20 miles of the Batten Kill as a no-harvest zone in 2000 which remained in effect through 2006.

Habitat

The importance of habitat to sustaining healthy, abundant fish populations has long been recognized and studied. Consequently fisheries managers are concerned about activities that affect the habitats required to support trout and other fish populations.

Trout habitat suitability is defined by physical, chemical and biological parameters, including but not limited to water temperature, depth and velocity, substrate composition, in-stream and riparian cover, water chemistry (e.g., dissolved oxygen, pH, alkalinity), abundance of food organisms, and the presence of predatory and competing species. Natural events, such as floods and droughts, can alter and degrade habitats, but the duration of their effects on aquatic communities is generally short term. In contrast, anthropogenic, or human-induced, changes to the landscape affect aquatic and riparian environments and all too often have long term and even permanent negative consequences for trout. Land development can impact streams whether these activities occur at a watershed scale or are specific to a particular stream. Increased sedimentation from accelerated rates of soil erosion, stream channel alteration, flow regulation and diversion, thermal regime modification, loss of in-stream structural diversity, as well as chemical and nutrient pollution all degrade habitat and water quality at the expense of trout populations and fishing opportunities.

Albers (2000) gives a comprehensive historical perspective of the changing Vermont landscape. Massive conversion of the Vermont landscape began about 225 years ago with the clearing of its virgin forests by European colonists for small family farms. The Valley of Vermont, encompassing the Batten Kill valley, was one of the first regions of the state to be settled. From that time forward the Batten Kill watershed has undergone several phases of land use which have changed not only the social and economic character of the region but also profoundly altered its natural resources. By 1830 much of the valley had been converted from a land dominated by forests to one primarily of extensive fields and pastures associated with scattered farmsteads and small villages. The energy of streams was captured by numerous small dams to power saw and grist mills. Through much of the first half of the 19th century sheep grazing maintained an open landscape. However, the collapse of Vermont sheep boom led to the abandonment of high elevation pastures which gradually reverted to forests. Bottomlands transitioned into a new agricultural enterprise, dairy farming. At the same time village centers expanded and became the focal points for industrial and commercial activities. The dairy industry continued to be a prominent feature of the Vermont landscape through the 1950s. During the 1960s and continuing to the present, family farms have either gone out of business or have become consolidated into larger, more modern operations. Open and forested lands have been converted to residential and commercial development throughout many parts of the state including the Batten Kill valley.

It cannot be disputed that the history of land development and use in Vermont has had a profound impact on natural resources including aquatic habitat and fisheries. As early as 1892, the Vermont Fish Commissioners stated in their 11th Biennial Report: “[t]he preservation of our streams would be materially assisted if land owners would be careful to protect all trees growing along their banks. Even the alders and other shrubbery along the banks of a brook are a protection...[to] insure greater volume and purity of water for fish.” This is a not so subtle acknowledgement of the impact agriculture and other land uses have had on the Vermont’s streams and fisheries during last century. Additionally, stream channels, including the Batten Kill watershed, have been straightened, dredged, filled, and obstructed. They have also been the recipient of agricultural, domestic and industrial wastes. The first biological survey of the Batten

Kill and its principal tributaries (Lord 1941) identified several activities in widespread practice that were detrimental to water quality and trout habitat including dredging, gravel washing operations, pollution discharges from creameries, raw domestic sewage, sawdust and woodworking waste, and general refuse. A 1961 report of the Vermont Department of Water Resources identified many of the same pollutants, noted above, as continuing to be discharged to streams within the Batten Kill watershed with the addition of municipal pollution from treated and untreated wastes discharged via sewer outfalls.

Significant progress has been made in abating point-sources of water pollution and improving habitat for aquatic biota with enactment of the Federal Water Pollution Control Act of 1972, subsequently amended in 1977, and hence known as the Clean Water Act. Other environmental laws and programs adopted and implemented at state and federal levels of government have also contributed to improving water quality.

Since adoption of Vermont's Land Use and Development Law in 1970 (Title 10, Chapter 151), commonly referred to as Act 250, State resource managers have been active participants in the permit review process involving land subdivisions and residential, commercial, industrial and public facilities developments having potential negative impacts on aquatic habitats and fisheries. Nonetheless, pressures from land development and destruction of physical components of stream habitat (e.g., loss of wooded riparian lands and in-stream fish cover; and habitat fragmentation) continue to threaten the viability of our waters to maintain fish populations and quality trout fisheries.

No quantitative surveys of trout habitat in the Batten Kill have been done until the studies undertaken between 2000 and 2004 (see [Current Resource Assessment](#)). Prior to these recent studies habitat assessments were limited to the general habitat descriptions presented in the 1941 biological survey report and several subsequent water quality assessments.

Fishery Assessments

The Batten Kill is one of the most extensively studied trout fisheries in Vermont (Appendix 1). The first official survey of the river was conducted in 1934 and assessed the general quality of habitat in the main stem and several major tributaries. This was followed by a 1940 biological survey including many of the same streams. The survey was slightly more quantitative in terms of evaluating trout habitat for the primary purpose of developing stocking recommendations. Fish collection methods at that time were much more limited than those now in use. The 1940 survey provides no quantitative information about fish populations in the Batten Kill. The first comprehensive survey of trout in the Batten Kill watershed was conducted in 1956 (MacMartin 1962). The data collected at that time is often used today as the historic reference point to which more current trout populations are compared. Between 1969 and 1974, the VFWD conducted five annual trout population surveys in the Batten Kill main stem. Populations have been monitored nearly every year from 1984 to the present.

The 1935 Vermont legislature created the so-called “test waters” regulation option which allows the Commissioner of VDFW to designate certain waters as “test waters”. The use of test waters has proven to be an invaluable tool for evaluating fishery responses to specific management strategies; for example, regulations and stocking. The first application of the test water regulation on the Batten Kill was in 1941 through 1945. The accompanying study yielded the first quantitative assessment of the Batten Kill fishery including catch and effort data, catch rates, trout species composition of the catch, and stocked fish returns. Since then, the VFWD has conducted 17 similar investigations to assess recreational aspects of the trout fishery (Appendix 1). The most recent angler surveys were done in conjunction with the 1994-1998 special regulation study.

Current Resource Assessment

The Batten Kill continues to be managed as a wild trout fishery as it has been since the mid 1970s. However, the near collapse of the brown trout population during the mid 1990s prompted the VFWD to close the fishery to the harvest of all trout beginning with the 2000 fishing season. The test water regulation was extended through December 31, 2006 restricting the lower 20 miles of the Batten Kill main stem to catch-and-release angling only, i.e. all trout caught must be immediately released. Vermont general regulations for fishing season and fishing tackle apply in this reach. The main stem upstream of Dufresne Pond dam and all Batten Kill tributaries have remained open to the harvest of trout pursuant to the general regulations.

In 2000 the VFWD established an inter-agency Batten Kill Study Team charged with investigating likely causes for the brown trout population decline. Agencies represented on the study team include the U. S. Forest Service, Green Mountain National Forest (USFS); Vermont Department of Environmental Conservation (VDEC); and the VFWD. One of the study team’s first tasks was identification of possible factors that may have caused or contributed to the population decline. Over the next six years (2000-2006), the team, in collaboration with other partners and cooperators, conducted studies investigating factors relevant to habitat suitability, trout survival and behavior. Summaries of these studies are provided in Appendix 2.

- Fluvial geomorphic assessments of the main stem and tributaries and trout habitat surveys including water temperature monitoring, quantification of available trout cover, and effects of sediment transport on spawning substrates.
- Seasonal water quality assessment by analysis of water chemistry (total and dissolved phosphorus; nitrate, ammonia and total nitrogen; chloride; sulfate; potassium, sodium, calcium and magnesium; pH; turbidity; and specific conductance) and aquatic macroinvertebrate communities (biotic index, benthic organism density, relative abundance and composition of taxonomic groups) for sites on the Batten Kill as well as in several other reference wild brown trout streams located in the Mettawee, Poultney, Castleton and Dog River watersheds.

- Relative abundance and diet composition of predators (common mergansers and large brown trout) of midsized trout.
- Identification of disease causing organisms in trout populations residing in the Batten Kill main stem and tributaries, including whirling disease.
- Study of the seasonal movements, behavior and habitat use of wild adult brown trout in the Batten Kill watershed.
- Wild and hatchery brown trout population genetics (study still in progress).

Annual trout population estimates collected since the mid 1980s through 2005 were analyzed to (1) quantify the decline of the brown trout population in the Batten Kill, and (2) identify stages in the brown trout life cycle where excessive mortality or reduced reproductive output seems to have lead to population decline. Population models were used to test several competing hypotheses that might explain the decline.

Four key findings came out of the studies: (1) brown trout recruitment¹ appears to be bottlenecked at the midsize (6-10 inch) class; (2) adult brown trout summer cover in the Batten Kill main stem is significantly below levels reported in the scientific literature as being adequate for predator avoidance and resting; (3) mergansers appear to preferentially feed on trout over other fishes present within the Batten Kill fish community; and (4) there is evidence of extensive channel form and habitat degradation has resulted from past channelization and river bank berming activity. Water quality, temperature, fish health, and spawning success do not appear to be linked to the brown trout decline at this time.

Under the no-harvest regulation, introduced in 2000, the abundance of brown trout in excess of 18 inches in the Batten Kill has increased substantially above that observed during the preceding 20 years. Fish population sampling by electrofishing regularly turns up fish in the 20-23 inch range (Figure 2) and occasionally larger fish are observed where suitable cover habitat exists. The increased representation of large trout in the population appears to be a result of some fish being able to successfully survive the recruitment bottleneck, and then exhibiting enhanced growth under current low trout densities. Furthermore, the no-harvest regulation has reduced fishing mortality on the smaller size classes allowing fish to survive to a larger size. These fish are probably important contributors to the river's current spawning population.

¹ Recruitment is defined as the addition of fish from one size class within a population by growth into a larger size category upon which they then become vulnerable to the sport fishery (Ricker 1975).



Figure 2. Examples of large brown trout collected from the lower Batten Kill on October 12, 2001. Both fish measure in excess of 20 inches.

The foregoing conclusions and the elimination of other investigated factors as possible significant contributors to the brown trout population decline leads to the following hypothesis:

The chronic loss of trout cover in the Batten Kill main stem resulting from past river channel alterations and encroachments, the reduction and loss of forested riparian areas by land use activities, and the removal of newly recruited in-stream large woody debris and other cover structures has degraded habitat in the river at the expense of midsize brown trout. Inadequate cover exposes fish to increased predation and possible environmental stresses, such as winter mortality. Cover within the river had degraded by the 1990s to the point that the habitat was no longer able to support adequate abundance of midsize trout to be recruited into the fishery. At lower population densities fish growth rates have increased allowing survivors to move through the midsize bottleneck more quickly and attain a size less vulnerable to predation. With the absence of angler harvest and reduced predation, large fish have been able to attain sizes rarely observed prior to implementation of the no-harvest regulation.

It must be emphasized that while predation, such as from mergansers, may influence brown trout recruitment, it appears more likely this is a result of there being inadequate in-stream cover for midsize trout to find refuge and evade predation. Therefore the predators are not necessarily the problem; inadequate cover available for trout to avoid predation is.

Binns and Eiserman (1979) defined trout cover as any bank or channel feature “that allows trout to avoid the impact of the elements or enemies.” It is an essential component of trout habitat and takes many forms, such as overhanging bank vegetation, undercut stream banks, large woody debris, boulders, aquatic vegetation, deep pools, and surface turbulence. Cover occurs in streams as a result of fluvial geomorphic processes, interaction with riparian vegetation, and stream flow (Wesche et al. 1987). The interaction between stream and riparian ecosystems should not be undervalued. The presence and composition of vegetation occupying the riparian zone influences channel forming processes, sediment and chemical inputs affecting water quality, and in-stream fish cover, particularly that contributed by large wood resulting from fallen trees or exposed root systems. Therefore, stream habitat management, involving both protection and restoration measures, needs to consider aquatic and riparian environments as a whole unit rather than as separate entities (Orth and White 1993).

Characteristics of brown trout cover have been studied extensively; however, the precise amount of it necessary to support a healthy trout population has not been well documented. Shirvell and Dungely (1983) cite research that indicates stream-residing trout use as little as 15% of the available cover. More specific to brown trout, a value of 35% of the total stream area has been reported as adequate for adult fish (Raleigh et al. 1986).

The 2000-2004 Batten Kill habitat survey measured brown trout cover at 43 pool and riffle habitat units. Estimated available brown trout summer cover was on average 7.2% (range 0-35.2%) of the wetted area. The median value is 4.0%. Based on a cover suitability target range of 15-35% (Raleigh et al. 1986; Shirvell and Dungely 1983), this habitat component in the Batten Kill main stem is deficient by 84% and 98% at the 15% and 35% coverage levels, respectively. Pool habitats contribute most to the available cover in the river. Water depth ≥ 4 feet is the primary cover type at 6.1%. Next in importance are hard structure: large wood and coarse substrate, 1.2%; revetments (stone riprap and bridge abutments), 1.0%; and overhanging bank vegetation, 1%. Cover in riffle sections is generally lacking with each of the identified cover types affecting less than 1% of the total wetted riffle area. These data led to the conclusion that adult brown trout cover in the Batten Kill falls significantly short of the 15-35% desirable target range. Lack of adequate cover increases fish vulnerability to predators, flood events, winter ice formation, and other environmental stresses which in turn can lower survival.

Of all the possible causes for the brown trout population decline investigated by the Batten Kill Study Team the most compelling finding is that of there being inadequate fish cover in the river. Unfortunately, the absence of habitat data prior to the year 2000 does not allow a retrospective analysis of how much cover existed and has changed over the past 100 years or even during the decade leading up to the mid 1990s. It is probably reasonable to speculate that in-stream and riparian cover are one element of habitat that has not improved over time. Nonetheless, the absence of a concrete historical perspective does not diminish the importance of having adequate cover to support an abundant brown trout population and that current cover falls substantially short of that reported to be optimum. Increasing available cover through construction of in-stream structures and reforestation of riparian lands is doable and specifically addresses this habitat deficiency. Moving forward with cover restoration provides an opportunity to test the proposed hypothesis at no risk to the fishery.

Annual trout population monitoring at the four long-term main stem index sites (Site 1 – West Arlington, Site 2 - Arlington, Site 3 - Manchester, Site 4 - East Dorset) continued during the six-year investigative period, 2000-2005 (Figure 3). Of particular note is that the catchable-size component of the brown trout population since the mid 1990s decline has remained relatively flat without any appreciable recovery of fish numbers even in the absence of fishing harvest.

In 2001 the myxosporean parasite *Myxobolus cerebralis*, the causative agent of whirling disease (WD), was detected in brook trout sampled from the New York portion of the Batten Kill. The following year it was found in both brook and brown trout collected from the river in Vermont. This was the first documented occurrence of WD in the state. In 2004 WD was confirmed in brook trout collected from the Green River.

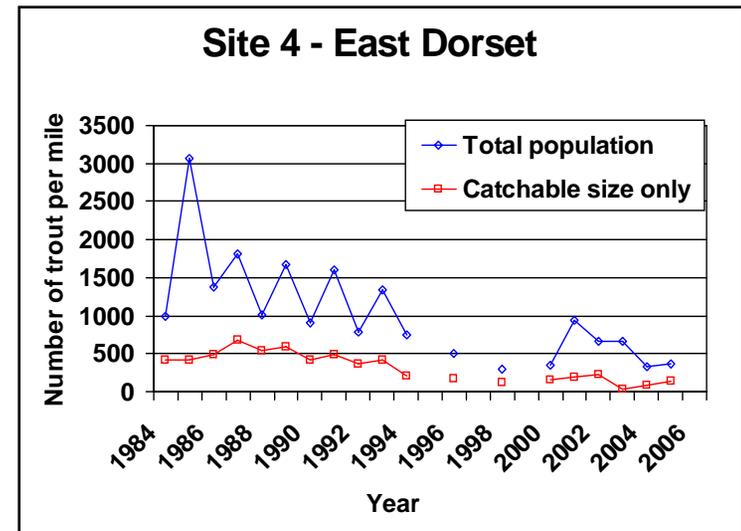
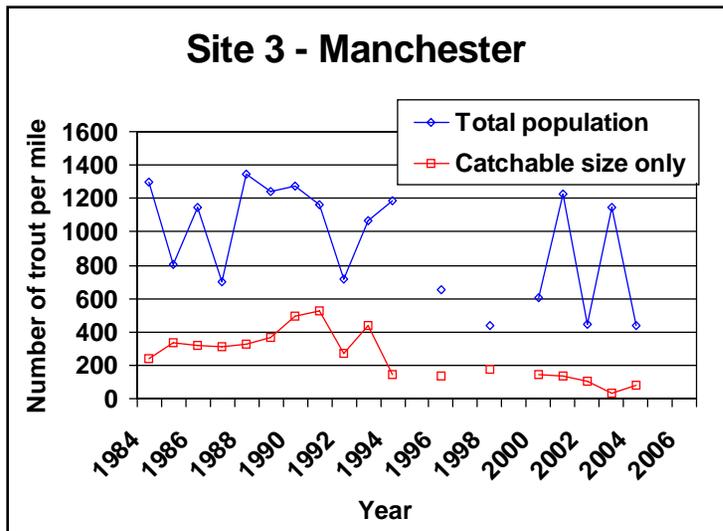
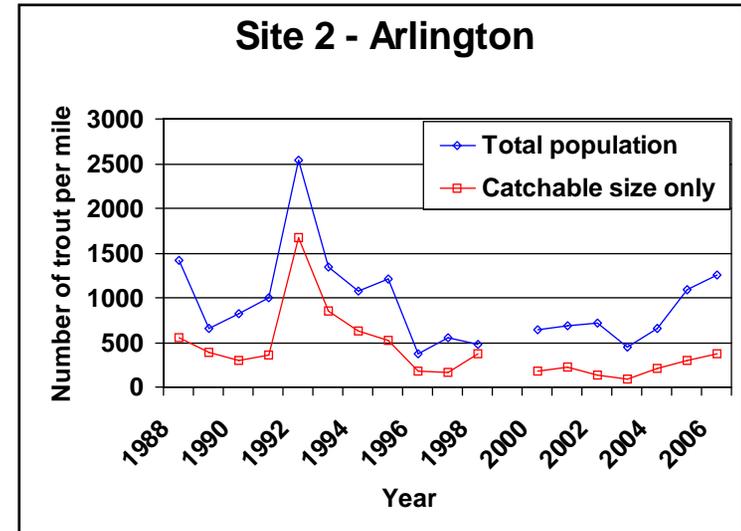
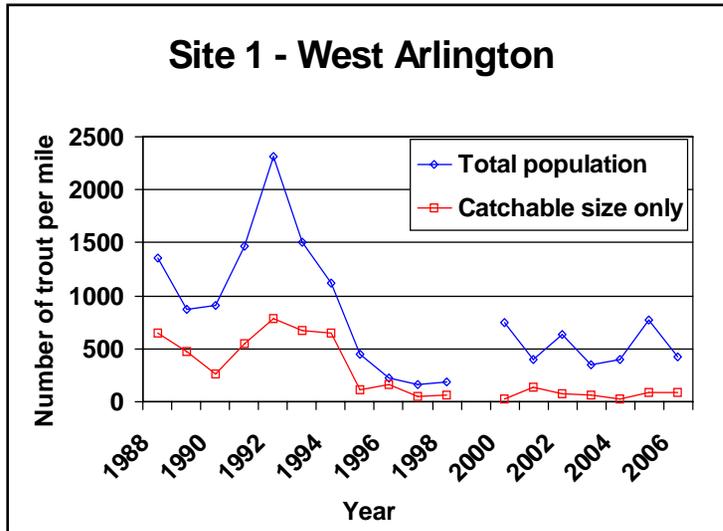


Figure 3. Brown trout abundance trends, 1984-2005, estimated at Batten Kill main stem population index sites. The catchable size class includes fish having a minimum total length of 6 inches.

WD is a debilitating disease causing skeletal deformities and interruption of nerve impulse transmission in infected fish. Several species of salmonids, including brook and rainbow trout, may experience significant mortality when exposed to the triactinomyxon (TAM) stage of the parasite within the first few weeks of life, when the fry are most susceptible to infection (Nehring 2006). In contrast, brown trout have natural resistance to WD but nonetheless may be carriers of the parasite. Nehring (2006) states 10 years of study have failed to show any evidence of WD having a negative impact on brown trout at the population level. Similarly, there is no evidence at this time that WD is the cause of the brown trout population decline in the Batten Kill. On the other hand, several brook trout analyzed from the lower Batten Kill and the Green River yielded “very strong positive” signals based on the polymerase chain reaction testing technique. Considering the high vulnerability of brook trout to WD with reported mortalities approaching 90% (Thompson et al. 1999), the potential for significant impact on wild brook trout in the Batten Kill watershed warrants continued monitoring.

Upon learning of WD in the Batten Kill, the VFWD undertook a public outreach effort to inform anglers and other river users of the potential threat this disease presents to trout fisheries throughout the state should it be transported to other watersheds. Also, the public as well as federal and state natural resource agencies have been instructed how to minimize the risk of spreading WD to other waters. Nehring (2006) states containment and control of myxospores has proven to be extremely difficult, since there are a variety of ways the parasite can be moved. Mechanisms for spreading WD include mammals, birds and other fish that feed on infected trout, natural and people assisted fish movements, and contaminated water craft (e.g., boats and canoes) and fishing waders and boots.

Goals and Actions

This plan is consistent with *The Vermont Management Plan for Brook, Brown and Rainbow Trout* (VDFW 1993) which is a guidance document for VFWD fishery biologists to use in managing trout resources. It also serves as a public education resource explaining biological and social rationales for various management strategies. The goal of the statewide trout management plan is:

“[T]o manage the state’s trout resources to sustain optimal population levels supportive of quality recreational opportunities.”

It is also the policy of the VFWD to:

(1) Place priority on implementing effective harvest regulation and habitat protection, restoration and enhancement measures in managing the state’s wild trout resources.

(2) Utilize cultured trout where management of a recreational trout fishery is justified, but cannot be sustained through wild trout management.

The overall trout management goal for the Batten Kill watershed is:

Sustain wild brook and brown trout population abundance and fish size class structure in the Batten Kill and its tributaries to support quality fishing within the ecological carrying capacity of the system.

The time frame for this plan encompasses a six year period, 2007-2012, during which specific strategies and objectives are defined (Appendix 3). The following actions will be implemented under this plan.

Action 1: Establish and maintain partnerships involving federal and state resource agencies, private conservation organizations and landowners for the purpose of implementing habitat projects designed to protect, restore and/or enhance in-stream trout cover and protect and/or re-establish forested riparian buffers.

Rationale: Restoration and protection of in-stream and riparian habitats are of paramount importance to rebuilding the wild brown trout population in the Batten Kill as well as maintaining the wild brook trout fishery. Habitat management on a large scale will need to be a cooperative undertaking involving multiple partners: state and federal government agencies, towns within the watershed, non-governmental organizations, anglers, local businesses, and most importantly riparian landowners.

A pilot demonstration habitat restoration project got underway in 2006 on the lower Batten Kill. The Twin Rivers Project involves nearly half a mile of river and several landowners. A 2005 pre-treatment survey estimated cover to be 1.5% of the total wetted area. During the first year, habitat restoration focused on a 337 foot long pool and a 315 foot long riffle within the project area. The installation of cover structures comprised of large wood clusters and coarse rock substrate, similar to that shown in Figure 4, is projected to increase cover in the pool from 1.4% to 22.8% and in the riffle from 0.4% to 6.4%. The project includes pre- and post-treatment trout population assessments to measure fish responses to the added cover. Additionally, riparian lands presently lacking woody vegetation because of past and current agricultural practices will be set aside as buffers and replanted with trees and shrubs.

Partners in the Twin Rivers Project are the Batten Kill Watershed Alliance, Bennington County Conservation District, U. S. Forest Service's Green Mountain National Forest, U. S. Department of Agriculture's Natural Resources Conservation Service, The Orvis Company, National Fish and Wildlife Foundation, River Network, Trout Unlimited, Vermont Fish and Wildlife Department, Vermont Department of Environmental Conservation's River Management Program, William Lesko and other private landowners. The partners hope the pilot project will be a springboard to enrolling increasing numbers of landowners in more extensive trout habitat restoration work.



Figure 4. One of 40 artificial structures being constructed in 2006 and 2007 at the Batten Kill Twin Rivers Project in West Arlington, Vermont, designed to create large wood trout cover habitat.

Action 2: Work with other resource agencies and conservation organizations in developing public outreach materials that provide landowners and towns with best management practices for stream and riparian habitats.

Rationale: Long term habitat protection and restoration cannot be realized in the absence of a well-informed public that understands not only the importance of habitat to a healthy aquatic environment and trout fishery, but also that their own values and the manner in which they use the river and adjacent lands can have real consequences. Government agencies and conservation organizations are engaged in various forms of public outreach to deliver habitat information to their respective constituencies; however, key messages often fail to resonate with the public or some critical audiences are missed entirely. More effective techniques for communicating responsible stewardship of rivers and riparian lands to a broader audience are needed. For example, educational opportunities may exist through local public access television, the news media, landowner workshops, and internet websites. The VFWD Land Ethic Team is currently working on a landowner information package to introduce new landowners and others to: the Vermont culture and values; foster good stewardship, management and conservation of private lands, including aquatic and riparian habitats; and maintain and improve access to private lands.

Action 3: Continue managing wild brown and brook trout populations under the current no-harvest regulation through at least the end of the 2012 fishing season.

Rationale: Wild trout populations will continue to receive protection under a six-year (2007-2012) extension of the current test waters regulation. If brown trout recruitment into the catchable-size classes continues to be too low, harvest could further weaken the population. The current no-harvest regulation applies to the Batten Kill main stem from Dufresne Pond dam in Manchester to the New York State line.

Adult brown trout radio-tracking studies determined that fish from the lower Batten Kill main stem population frequently ascend the Green River and Roaring Branch/Warm Brook to spawn in the fall. The spawning season for main stem brown trout typically runs from late September through mid- to late November. Once in the tributaries, spawning fish are especially vulnerable to harvest. Therefore, it seems prudent to afford trout in the Green River and Roaring Branch/Warm Brook a similar level of protection as they receive in the main stem by restricting angling to no-harvest from October 1 to October 31. The fall no-harvest provision applies to the Green River from its mouth on the Batten Kill upstream to the confluence with Moffitt Hollow Brook near Beartown (Sandgate), and the Roaring Branch from the Batten Kill upstream to the bridge in East Kansas (Sunderland) as well as Warm Brook from its confluence with the Roaring Branch upstream to the base of the so-called Hale Company dam (Figure 1). In all other respects angling will continue under Vermont general fishing regulations for rivers and streams.

Action 4: Continue managing the Batten Kill main stem as a wild trout fishery without stocking.

Rationale: An earlier draft version of this plan proposed stocking up to 1,000 yearling triploid (sterile) rainbow trout into the lower Batten Kill starting in 2007. Stocking would have been an interim measure intended to improve angling quality while habitat restoration took place which is envisioned to be a long term commitment. As the abundance of the catchable-size component of the wild trout populations improved, the number of rainbow trout stocked annually would have been proportionally reduced with the objective of returning entirely to wild fish management. The VFWD identified the triploid rainbow trout stocking option as posing the least threat to wild populations. A majority of the anglers, who commented on the draft plan during the public involvement process expressed opposition to stocking the Batten Kill and voiced their desire to see the river continued to be managed as a wild trout fishery and fully supported the habitat restoration actions identified in the plan. This plan responds to the public comment by setting aside the stocking option for the time being.

The VFWD has taken into consideration (1) the unique positive characteristics of the Batten Kill trout fishery at the present and in the more recent past, (2) the potential risks to wild trout fisheries in the Batten Kill watershed as well as other waters around the state presented by stocking, and (3) the low public support for stocking the Batten Kill, in arriving at a decision to continue managing the Batten Kill fishery for wild trout only through the duration of this plan.

Action 5: Trout populations will continue to be monitored for abundance, size structure, and health status; angler surveys will be conducted as needed to measure angler participation and fishing quality.

Rationale: Data derived from trout population and angler surveys is necessary to monitor the fishery and assess its response to management actions implemented over the term of this plan, as well as setting the course for future management of the resource.

Public Input

The public involvement process for the Batten Kill Trout Management Plan officially began in June 2006 with the posting of the draft plan on the VFWD website and issuance of a press release to Vermont media outlets. The public was invited to review the plan and submit comments to the VFWD.

Another opportunity for the public to voice their opinions occurred on September 21, 2006, when an advertised public meeting was held between 7:00 and 9:00 p.m. at Burr and Burton Academy in Manchester. The meeting began with formal presentations by VFWD staff about elements of the plan and the issue relating to the conflict between trout habitat and recreational floating activity. Over 50 people attended the meeting of which 28 spoke and another 14 submitted written comments. A 30-day public comment followed the meeting and closed on October 21, 2006.

In excess of 1,100 responses from the public were received including two petitions representing a combined total of 773 signatures in favor (42%) and opposed (58%) to stocking the Batten Kill. Of the 42 comments made at the public meeting, 88% were opposed to stocking. The remaining balance of submissions comprised letters, post cards, and email with 99% of these weighing in against the stocking proposal.

Literature Cited

- Albers, J. 2000. Hands on the land: a history of the Vermont landscape. The MIT Press, Cambridge, Massachusetts.
- Biggins, R. G. 1972. Batten Kill fish population studies. Vermont Fish and Game Department, Federal Aid in Fish Restoration F-12-R-5, Annual Job Progress Report, Montpelier.
- Binns, N. A., and F. M. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Transactions of the American Fisheries Society 108:215-228.
- Claussen, J. H., R. Kirn, C. MacKenzie, and K. Cox. 1991. Statewide fisheries management planning process. Vermont Fish and Wildlife Department, Federal Aid in Fish Restoration Project F-12, Job Performance Report, Waterbury.

- Cox, K. M. 2000. Evaluation of wild trout populations in the Batten Kill and application of a catch and release regulation. Vermont Department of Fish and Wildlife, Federal Aid in Fish Restoration Final Report F-36-R-2, Waterbury.
- Embrey, G. C. 1927. An outline of stream study and development of a stocking policy. Cornell University Aquaculture Laboratory, Ithaca, New York.
- Gatz Jr., A. J., M. J. Sale, and J. M. Loar. 1987. Habitat shifts in rainbow trout: competitive influences of brown trout. *Oecologia* 74: 7-19.
- Lord, R. F. 1946. The Vermont "test-water" study 1935 to 1945 inclusive. Vermont Fish and Game Service, Fisheries Research Bulletin 2, Montpelier.
- Louv, R. 2005. Last child in the woods: saving our children from nature-deficit disorder. Algonquin Books, Chapel Hill, North Carolina.
- MacMartin, J. M. 1962. Vermont stream survey 1952-1960. Vermont Fish and Game Department, Federal Aid to Fisheries Final Report F-2-R, Montpelier.
- Mongillo, P. E. 1984. A summary of salmonid hooking mortality. Washington Department of Game, Fish Management Division.
- Nehring, R. B. 2006. Colorado's cold water fisheries: whirling disease case histories and insights for risk management. Colorado Division of Wildlife Special Report 79, Fort Collins.
- Orth, D. J., and R. J. White. 1993. Stream habitat management. Pages 205-230 in C. C. Kohler and W. A. Hubert, editors. Inland fisheries management in North America. American Fisheries Society, Bethesda, Maryland.
- Otis, J. C., Jr. 1941. A biological survey of the Battenkill river system in Bennington county Vermont. Vermont Fish and Game Service, Bulletin 27, Montpelier.
- Raleigh, R. F., D. Zuckerman, and P. C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: brown trout, revised. U.S. Fish and Wildlife service, Biological report 82, Washington, D.C.
- Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries research Board of Canada, Bulletin 191, Ottawa.
- Ross, J. 1998. 101 best trout streams. *Trout* 39(3):10-11.
- Shirvell, C. S., and R. G. Dungely. 1983. Microhabitats chosen by brown trout for feeding and spawning in rivers. *Transactions of the American Fisheries Society* 112:355-367.

- Taylor, M. T., and K. R. White. 1992. A meta-analysis of hooking mortality of nonanadromous trout. *North American Journal of Fisheries Management* 12:760-767.
- Thompson, K. G., R. B. Nehring, D. C. Bowden, and T. Wygant. 1999. Field exposure of seven species or subspecies of salmonids to *Myxobolus cerebralis* in the Colorado River, Middle Park, Colorado. *Journal of Aquatic Animal Health* 11:312-329.
- Trout Unlimited. 1989. 100 best trout streams. *Trout* 30(2):12-13.
- VDFW. 1993. The Vermont management plan for brook, brown and rainbow trout. Vermont Department of Fish and Wildlife, Waterbury.
- VDFW. 2001. 2000 Vermont angler survey. Report of University of Vermont, School of Natural Resources to Vermont Fish and Wildlife Department, Waterbury.
- Wesche, T. A., C. M. Goertler, and C. B. Frye. 1987. Contribution of riparian trout cover in small streams. *North American Journal of Fisheries Management* 7:151-153.

APPENDIX 1. Fisheries and habitat assessments of the Batten Kill, 1934-2006.

Year(s)	Activity	Report reference
1934	General biological and habitat assessment of main stem and tributaries	Vermont Fish & Game Dept., undated
1940	Biological survey of main stem and tributaries	Otis 1941
1941-1945	Test water study	Lord 1946
1956	Trout population survey of main stem and tributaries	MacMartin 1962
1956-1957	Angling surveys of main stem	Lord 1956, 1957
1962	Test water study	Vermont Fish & Game Dept., undated
1968	Trout population survey of main stem and tributaries	Biggins 1969
1971-1974	Trout population surveys of main stem	Biggins 1975
1972-1975	Angling surveys of main stem	Biggins 1975, 1976
1984-2005	Trout population surveys of main stem and tributaries	Cox 1991
1985	Angling survey of main stem	Cox 1986
1987-1989	Angling surveys of main stem	McMenemy 1990a, 1990b
1991-1992	Angling surveys of main stem	McMenemy 1992, 1993
1994-1998	Test water study	Cox 2000
1998-2004	Temperature monitoring of main stem and tributaries	Cox, in preparation
1998-2004	Fish pathogen investigation	Jones & Johnston, in preparation
1999	Fish passage survey of main stem and tributaries	Vermont Fish & Wildlife Dept. file data
1999-2003	Fine sediment monitoring in main stem and tributaries	Nislow and Wixsom, in preparation
2000-2003	Habitat survey of main stem	Bernier, in preparation
2000-2004	Phase 1 and 2 geomorphic assessments of main stem and tributaries	Jaquith et al. 2005; Kline & Field 2005
2001-2002	Assessment of water quality and macroinvertebrate assemblage characteristics	Vermont Dept. of Environmental Conservation, 2003
2001-2003	Brown trout cover habitat survey	Cox, in preparation
2001-2003	Mass bank failure monitoring at two sites on main stem	McKinley 2001
2001-2004	Pesticide investigation	Vermont Dept. of Agriculture
2001-2005	Basin hydrologic regimes analysis	Nislow & Magillan, in preparation
2003-2005	Adult brown trout seasonal movements, behavior and habitat use study	Cox, in preparation
2003-2004	Brown and brook trout population modeling	Omland & Parrish, in preparation
2004	Predation study	Omland & Parrish, in preparation
2005-2006	Brown trout genetic assessment	Parrish & Kilpatrick, in progress

APPENDIX 2. Summaries of special studies and assessment activities, 2000-2006.

Batten Kill Habitat Survey: Stream and riparian habitat conditions for the lower Batten Kill main stem from the New York state line upstream to the base of Dufresne Pond dam in Manchester, approximately 20 river-miles, were inventoried and analyzed for baseline data on channel morphology at the river reach and habitat unit (riffle and pool) levels. Habitat metrics included identification and quantification of pool and riffle habitat units and areas; channel geomorphology (width/depth ratios, entrenchment, channel and valley slopes, valley width, channel sinuosity, and substrate composition); riparian and river bank conditions; fish cover (abundance of large wood, pool cover quality), fish passage barriers, and location of tributaries and springs. These data establish baseline reference condition against which future river channel and habitat changes and conditions can be assessed, as well as provide resource managers guidance for determining the need, location and design of future habitat improvements. Principal Investigators: Christopher Bernier and Kenneth Cox, VFWD. Funding Source: VFWD.

Phase 1 Geomorphic Assessment of the Batten Kill Main-stem and Major Tributaries: Past and current fluvial geomorphic characteristics of the Batten Kill main stem and tributaries were described by field surveys and map and orthophoto interpretations. The study utilized Phase 1 and 3 protocols established by the Vermont Agency of Natural Resources Stream Geomorphic Assessment Program. Phase 1 analysis revealed that over half of the Batten Kill and major tributaries experienced in the past varying forms and rates of channel adjustment. The Phase 3 assessment verified that adjustment processes in several reaches is continuing. Channel adjustments appear to be in response to historic channel and floodplain modifications, 19th century deforestation, flood control activities, mill dams, agricultural practices, and transportation projects, and other developments. Principal Investigators: Michael Kline and Shayne Jaquith, VDEC; John Field, Field Geology Service; and James Henderson, Bennington County Regional Commission. Funding Sources: USFS, VDEC and BCRC.

Summer Stream Temperature Monitoring and Assessment for Trout Habitat Suitability in the Batten Kill and Four Reference Streams: Water temperatures were measured hourly at several locations on the Batten Kill main stem and several tributaries, as well as four out-of-basin reference streams supporting wild brown and brook trout populations, i.e. the Mettawee, Poultney, Castleton and Dog rivers. Temperature data were analyzed to determine whether summer temperatures are a significant factor limiting habitat suitability for these species. As would be expected summer water temperatures in the Batten Kill main stem and reference streams warm progressively from the headwaters downstream. No correlation between temperature and brown trout abundance are indicated; however, this is not the case for brook trout, a more temperature sensitive species. With the possible exception of the most downstream monitoring site, the temperature regime of the Batten Kill provides conditions suitable for brown trout. Even though the lowermost river may at times experience high summer water temperatures exceeding levels that can result in physiological stress and even the death of individual fish, it is important to note that over the past 25 years there have been no reports of extensive fish kills coincident with high summer water temperatures. Further, temperature alone does not explain observed trends showing brown trout population

abundance declines throughout the length of the main stem. Principal Investigators: Kenneth Cox, VFWD; and Scott Wixsom, USFS. Funding Sources: VFWD and USFS.

Assessment of Brown Trout Cover in the Batten Kill Main Stem and Four Reference Streams: Habitat features providing refuge cover for adult brown trout were studied in a sample of habitat units previously identified during the Batten Kill habitat survey (see above) and population monitoring sites located on the Batten Kill main stem and the four out-of-basin reference streams. Data were analyzed to determine any relationship between current trout abundances and how available cover matches with a desirable condition, i.e. with the range of 15-35% of the channel wetted area. Measurements of adult brown trout cover indicate that this critical habitat component is significantly below the desire target range. On average about 7% of the wetted area potentially available to trout provides cover; the median value is about 4%. The lack of adequate cover can increase trout vulnerability to environmental and predator stressors. Principal Investigators: Kenneth Cox, VFWD; and Scott Wixsom, USFS. Funding Sources: VFWD and USFS.

A Comparative Assessment of the Chemical Characteristics of the Batten Kill with Other Wild Trout Streams in Vermont: The study involved collecting and analyzing representative macroinvertebrate assemblage and water chemistry samples from trout population monitoring sites on the Batten Kill main stem and the four out-of-basin reference streams. Data were analyzed to determine whether or not there are any differences in secondary productivity and biological integrity variables within and between the streams investigated. None of the chemical or biological factors evaluated account for differences between trout populations. Observed elevated phosphorus and nitrogen levels measured in the Batten Kill downstream of the Manchester wastewater treatment plant and macroinvertebrate community characteristics are more in line with conditions that would benefit trout populations rather than be a detriment to them. Principal Investigators: Douglas Burnham and Steve Fiske, VDEC. Funding Sources: USFS, VDEC and VFWD.

Population Modeling and Predation on Trout of the Batten Kill: Trout population data from Batten Kill main stem index sites spanning 20 years (1984-2004) was analyzed using population models based demographic variables (e.g., fish abundance, size and age classes) to identify stages in the brown trout life cycle where excessive mortality or diminished reproductive output may be leading to the observed population decline. Similar analyses were done for wild trout populations in four out-of-basin wild trout streams for comparison to the Batten Kill. The abundance and diet of common merganser, a trout predator, were also investigated. Early life stage analyses were used to estimate survival rates for mid-sized trout. Modeling data do not indicate a problem with recruitment and survival in the early life stages of the brown trout as might be associated with pollution, siltation, and certain fish pathogens (e.g., whirling disease). Data do indicate a problem with the survival of brown trout through the yearling size class as might be associated with predation and the lack of adequate trout refugia. Principal Investigators: Kristian Omland and Donna Parrish, University of Vermont, Vermont Cooperative Fish and Wildlife Research Unit. Funding Sources: USFS, VCFWRU and VFWD.

Fine Sediment Monitoring in the Batten Kill Basin: Current levels of fine sediment in the Batten Kill, 1999-2002, and the Green River, 2002, were monitored to assess potential impacts on trout spawning and incubation that might translate to negative effects at the population level. Although high levels of fine sediment (>20%) were observed at some locations, many other sites were consistently low indicating substrate conditions compatible with good quality spawning and nursery habitat. Results do not strongly suggest that fine sediment is a significant limiting factor on trout populations in the Batten Kill. Principal Investigators: Keith Nislow, USFS Northeast Research Station; and Scott Wixsom, USFS. Funding Source: USFS.

Analysis of Hydrologic Regimes in the Batten Kill Basin: Long-term river gage data from the Batten Kill and other streams in the region were assessed to determine whether hydrologic regimes have changed over the last century in terms of river flow timing, duration and magnitude, and if any observed changes are coincident with the recent decline of brown trout abundance. No evidence of long-term hydrologic regime change was observed which can be attributed as a major factor responsible for the brown trout population decline in the Batten Kill. Project Leader: Keith Nislow, USFS Northeast Research Station; and Frank Magilligan, Dartmouth College, Department of Geography. Funding Source: USFS.

Seasonal Movements, Behavior and Habitat Use of Adult Brown Trout in the Batten Kill: Seasonal activities and habitat preferences of adult brown trout, captured, radio-tagged and returned to the Batten Kill, were monitored during two consecutive studies done in 2003 and 2004. Tagged fish were observed for their responses to available habitat, changing daily and seasonal environmental conditions, and human activity on the river. Results indicate adult brown trout typically have well defined home ranges that vary in size between individual fish, and their daytime lies are usually associated with some kind of cover structure. Some fish may have more than one established lie within their home range. At dusk, fish may move from the cover to take up evening feeding positions. Beginning as early as late September, fish may leave their home range to undertake spawning migrations which involve moving considerable distances from their home range. The Green River and Roaring Branch were used consistently by multiple fish during the spawning season. The duration of the spawning season for main stem resident trout varies somewhat from fish to fish but typically takes place anytime between late September and middle to late November. The data suggest fish that use a tributary to spawn may be imprinted to its natal stream. Following spawning, adult brown trout generally return to their home range to over-winter. Because most of the adult fish studied occupied cover sites during daylight hours that is removed from water-based recreational activity (e.g., boating and swimming), very little interaction occurred between humans and fish. Principal Investigator: Kenneth Cox, VFWD. Funding Sources: USFS and VFWD.

Fish Pathogen Investigation on the Batten Kill: Brown and brook trout populations in the Batten Kill main stem, Green River and West Branch were sampled multiple years to determine the presence of pathogenic infections of bacterial (3), viral (4), and parasitic (1) origin. Positive results were received for bacterial kidney disease *Renibacterium salmonarum* and whirling disease *Myxobolus cerebralis*; however, at this time there is no

evidence that either disease is negatively affecting trout at the population level. Principal Investigators: Barbara Johnston and Thomas Jones, VFWD. Funding Sources: USFS and VFWD.

Mass Failure of Two Bank Slides on the Batten Kill: Eroding banks on the Batten Kill main stem, one opposite the mouth of the Roaring Branch and the other downstream of the Union Street bridge in Manchester, were surveyed and studied to quantify the amount of sediment each site is contributing to the river and to monitor long term changes in site channel geometry. Measurements suggest that the two sites may have contributed as much as 21.6 cubic yards of sediment to the river during a single high flow event that occurred in 2001. Sediments eroded from within the active channel are being replaced by materials from further up the face of each slide. Until such time that the toe of the banks stabilize the site will continue to be unstable. Large wood revetments were installed at the Manchester site in 2005 to hasten the stabilization process and are currently being monitored. Principal Investigators: Dan McKinley and Scott Wixsom, USFS. Funding Source: USFS.

Trout Population Monitoring at Index Sites on the Batten Kill, Green River and Four Reference Wild trout Streams: Wild trout populations at 15 sites were sampled annually by electrofishing for estimates of fish abundance and size class structure. Population trend data is important to evaluating the changing status of trout populations in the Batten Kill relative to wild populations inhabiting out-of-basin rivers. See Figure 3 for examples. Principal Investigator: Kenneth Cox, VFWD. Funding Sources: VFWD and USFS.

Trout Spawning Survey: The Batten Kill and Green River main stems were surveyed during the fall spawning season to identify the distribution and approximate abundance of trout redds. Observations were recorded and mapped. Data provides some insight into the relative importance of specific locations in these streams as focal points for spawning activity. Surveys were carried out by USFS and VFWD personnel and volunteers of the Southwest Vermont Chapter of Trout Unlimited.

Draft Batten Kill Corridor Protection and Restoration Plan: Following extensive stream geomorphic assessments, using Vermont Agency of Natural Resources protocols, river channel adjustments have been documented. The plan is being developed as an approach to remediating river instability that is largely responsible for erosion conflicts, increased sediment and nutrient loading, and reduction of river habitats. The corridor plan, using assessment information, is intended to develop and appropriately scale projects and strategies to protect and restore river equilibrium. The plan identifies: (1) river science and societal benefits of managing streams toward equilibrium conditions; (2) key assessment results and maps depicting stream geomorphic conditions; (3) priority river corridor protection and restoration projects and strategies; (4) examples of project designs to address and remediate common stressors found to be causing instability in the Batten Kill, including methods to evaluate project feasibility; and (5) information on current programs available to Vermont landowners, towns and other parties interested in implementing river corridor protection and restoration projects. The plan is being drafted

by John Field, Field Geology Services of Farmington, Maine with funds from the USFS and VDEC.

Genetics of Brown Trout in the Batten Kill: brown trout tissue samples have been collected from two Batten Kill populations, an out-of-basin wild trout population (Mettawee River), and the hatchery brown trout line that New York Department of Environmental Conservation stocks into its section of the Batten Kill. DNA was extracted from the samples and will be tested using microsatellite markers to examine genetic differences between populations. This study is still in progress. Principal Investigators: William Kilpatrick, University of Vermont, Department of Biology; and Donna Parrish, University of Vermont, Vermont Cooperative Fish and Wildlife Research Unit. Funding Sources: USFS, VCFWRU and VFWD.

APPENDIX 3. Goals and strategies.

Goal 1: Protect, enhance and restore wild trout populations and the aquatic and riparian habitats on which they depend such that healthy wild brown and brook trout populations are rebuilt and sustained in the Batten Kill and its tributaries.

Strategy 1.1. Work with federal and state resource agencies, town governments, and non-governmental organizations (e.g., Batten Kill Watershed Alliance and trout Unlimited), private landowners, and others toward the protection, enhancement and restoration of in-stream and riparian habitats, ecological functions, and natural fluvial processes.

Strategy 1.2. Assist landowners in their decisions and activities concerning riparian management and trout populations.

Strategy 1.3. Continue VFWD participation in state and federal environmental review processes (e.g., Act 250, stream alterations, wetland conditional use determinations) such that adverse impacts on aquatic and riparian habitats are avoided or mitigated.

Strategy 1.4. Support efforts to protect aquatic and riparian habitats through land acquisition and conservation easements.

Goal 2: Conserve, protect and manage the fishery resources of the Batten Kill and tributaries such that quality and diverse fishing opportunities are maintained or enhanced.

Strategy 2.1. Apply appropriate angling regulations designed to conserve and enhance wild trout populations.

Strategy 2.2. Maintain or improve angler access to the river by fostering greater angler and other river user respect for private lands abutting streams.

Strategy 2.3. Identify and recommend for state acquisition sites that may be developed for public fishing access to waters within the watershed if there is a willing seller.

Strategy 2.4. Continue working with anglers and other stakeholders to help resolve river user conflicts.

Goal 3: Increase and/or improve communication efforts to encourage the public to be better informed about fisheries management issues and VFWD management programs and activities, and to encourage environmental stewardship.

Strategy 3.1. Provide information to anglers and other stakeholders so they are informed about fisheries management and environmental issues.

Strategy 3.2. Engage the public in outreach and educational opportunities that enhance town, private landowner, and other river user understanding of fish habitat requirements and appropriate environmental stewardship supportive of fisheries conservation.

Strategy 3.3. Provide anglers and other stakeholders with opportunities for input into current and proposed fishery resources conservation.

Goal 4: Conduct appropriate scientific investigations, monitoring and evaluations so management decisions are based on good biological and social information.

Strategy 4.1. Conduct fish population, habitat and angler surveys as necessary to maintain up-to-date information on the fishery resource.

Strategy 4.2. Support or conduct research projects designed to increase our understanding of the fish populations, especially trout and their habitats, as well as social and abiotic factors that may be affecting the river environment and the fishery.

Goal 5: Contain and control the spread of whirling disease (WD) and minimize its risk to wild trout populations in the Batten Kill watershed.

Strategy 5.1. Continue assessing the distribution, prevalence and severity of WD and its impacts on fish populations in the Batten Kill watershed.

Strategy 5.2. Provide the public with outreach materials designed to increase their knowledge of WD, the threat it poses to trout fisheries in the Batten Kill and Vermont as a whole, and actions they can take that will help contain and/or limit its spread to other waters.