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Assessing Brook Trout Population Status and Potential for Restoration in the Hudson Highlands

Black Rock Forest Consortium

June 2012

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I. Introduction

In 2008, Black Rock Forest Consortium received a grant from the Sarah K. de Coizart Article TENTH Perpetual Charitable Trust to assess potential for restoration of the Eastern brook trout, *Salvelinus fontinalis,* in the Hudson Highlands. Native brook trout populations in New York are greatly reduced after two centuries of human-induced changes to their habitat. The cold, clear streams that sustain this species were altered by deforestation and resultant stream warming and sedimentation, as well as acid rain and other forms of pollution.[i] Development and dam building fragmented brook trout habitat and increased water temperatures. In the Hudson Highlands, clear cutting for agriculture, tanning, and charcoal and iron production also took a heavy toll on the landscape and aquatic habitats. For decades, streams in this region were stocked by the New York State Department of Environmental Conservation (DEC), the state park system, and other groups to enhance sports fishing.[ii] Some stocked fish, including brown trout and other non-native species, have outcompeted brook trout and are able to thrive in warm waters that brook trout cannot tolerate.

However, conditions for brook trout have slowly improved since the mid-1970s, when conservation of native fish species became a priority in New York State. *Salvelinus fontinalis* was named the state fish in 1975. To prevent the brook trout's extinction, the DEC created a heritage trout program and reclaimed habitat for wild brook trout strains, curtailing stocking of hatchery-raised, domestic brook trout which could reduce survival rates for wild populations. The DEC also improved monitoring to prevent illegal stocking. In the Hudson Highlands, efforts by the DEC, the state park system, the Palisades Interstate Parks Commission, and many private landowners and conservation groups to improve land management policy have resulted in substantial forest re-growth and recovery of riparian habitat.

In the western Hudson Highlands, the prevalence of private and public landowners committed to conservation has made it possible to preserve a 100,000-acre ecosystem management zone, a significant achievement and one that establishes some of the preconditions for native species restoration. Much of the habitat for brook trout is still impaired however, since aggressive, non-native fish populations remain in the larger stream segments that attract sport fishermen, and many streams remain warmer than they were two centuries ago due to reduced tree cover. Water above 24° C does not have high enough dissolved oxygen levels to support brook trout. However, the area's many cold, clear headwater streams offer possibilities for brook trout restoration.

A. Assessment Goal

Black Rock Forest Consortium has worked in coordination with the Eastern Brook Trout Joint Venture (EBTJV) on the project summarized in this report. EBTJV is a 17-state coalition of governmental conservation agencies, research institutions, and nonprofit organizations, federally funded as a Fish Habitat Partnership working under the National Fish Habitat Action

Plan. The EBTJV has defined a process for the restoration of brook trout. Recommended conservation strategy is as follows:

> *Where habitat for brook trout is absent or severely diminished, actions should center around habitat restoration that can be accomplished through the best available scientific knowledge. [...] If brook trout populations have been eliminated as a result of habitat deterioration, they can be restored by transplanting brook trout of the appropriate genetic origin from adjacent streams or watersheds after restoration of the habitat is completed. [...] Restoration efforts must focus on restoring habitats and developing ecosystem conditions and functions that will allow for expanding and maintaining diversity within and among species in order to sustain a system of robust populations in the face of environmental variation.* [iii]

Whether the focus of a particular effort is restoring stream conditions prior to re-introduction of brook trout or enhancement of existing habitat, creating the conditions that will sustain this environmentally sensitive species is a complex challenge. The U.S. Department of the Interior's Fish and Wildlife Service has created a Habitat Suitability Index that describes and weights factors critical to creation or protection of brook trout habitat. The Suitability Index examines the needs for brook trout populations in each of the fish's four life stages, during different seasons, and when spawning.[iv] Despite these guidelines, success in any particular restoration effort can only be determined through site-specific research, in which populations are under close observation and management for a number of years.

One of the biggest challenges of restoration work is addressing how to preserve or ensure genetic diversity. Decades of stocking hatchery brook trout has negatively impacted some wild brook trout strains, decreasing genetic diversity and producing offspring that may not have the adaptations necessary to survive over the long term. For wild strains unaffected by stocking, research indicates that brook trout populations in the same geographic location can differ significantly. Dr. Tim King, a biologist with the U.S. Geological Survey who has researched brook trout genetics throughout the fish's native range, found genetic differences on "scales ranging from local streams to river basins," including differences between "specific locations within streams." Thus brook trout populations can be adversely impacted by human transport of brook trout from one location to another. Dr. King concludes:

> *Recommendations to managers include the need for great caution before moving brook trout between river drainages, and the recommendation that supplemental stocking should proceed conservatively and be based on local broodstock collections. Remaining genetic diversity should be preserved wherever possible.*[v]

Significant investment is required, both to perform the requisite genetic analysis, and to assess and rank the suitability of streams using the Fish and Wildlife Service's index or a similar model. With these conditions in mind, Black Rock Forest Consortium undertook a population assessment in the Hudson Highlands over the course of 2008 to 2010 to provide a baseline for establishing priority zones within the study area, identifying places in which protection and restoration work should be focused. Our assessment goals were to:

- Survey streams and compile and review recent survey data for all streams with self-sustaining brook trout populations in the 100,000-acre study area;
- Identify the streams most likely to contain genetically diverse, heritage strains;
- Survey additional streams to suggest priority areas where stream habitat appears particularly conducive to future restoration work.

It is our hope that, as a result of this assessment, other phases of this project may develop, such as research studies on the reintroduction of brook trout within priority areas.

B. Project Objectives

1. Determine Historic Status of Brook Trout in the Hudson Highlands

According to the Eastern Brook Trout Joint Venture, brook trout populations in New York State are considered "intact" in only 5% of the watersheds historically inhabited. These watersheds are located in the northern part of the state. In the southern part of the state, the Joint Venture has described brook trout populations as "greatly diminished" in most watersheds, meaning that the fish is present in only 1 – 50% of the stream miles inhabited prior to European settlement. The Joint Venture drew on fish survey data records of DEC's Region 3 to make their assessment of brook trout populations in the Hudson Highlands. The Joint Venture determined that the status of "greatly diminished" is accurate for watersheds in this region. [vi]

For a map of the Joint Venture population assessment, please see **Appendix A.**

2. Determine Present Status of Brook Trout in the Highlands

Black Rock Forest Consortium coordinated with DEC Region 3 and contracted with Alan Wells, Ph.D., an aquatic biologist familiar with brook trout populations in the Hudson Highlands, to update and extend the Eastern Brook Trout Joint Venture's prior assessment for this region. Because brook trout have for the most part been relegated to headwaters, the assessment strategy for much of the Highlands involved focus on headwater stream segments where high genetic diversity has been reported or where it is believed wild strains may have been relatively unaffected by stocking. In addition, the assessment identified streams that are not stocked for anglers and that might provide the base flow, cover, and temperature ranges capable of sustaining brook trout populations in the future.

A special effort was made to thoroughly survey Black Rock Forest headwater streams. These streams had not previously been surveyed by the DEC or other groups and had been determined to have no remnant brook trout populations. Since 2001, the Consortium has run an educational "Brookies at Black Rock" program and released brook trout fingerlings into Forest streams as part of that program. To provide education on conservation techniques,

Consortium staff have enhanced Forest streams as brook trout habitat, creating areas suitable for spawning grounds, improving stream flow, and reforesting stream banks.

For the Bear Mountain, Harriman, and Sterling Forest State Parks, the assessment took into account earlier survey work by Dr. Wells. For an overview of Wells' survey work in the Bear Mountain and Harriman State Parks, undertaken in 2001 for the League of Naturalists, please see **Appendix B**. For these parks and Storm King Mountain State Park, a Black Rock Forest assessment team reviewed detailed fish survey records kept by DEC Region 3.

Members of the assessment teams included four Black Rock Forest Consortium staff members; Alan Wells, Ph.D. and Della Wells; Dustin Dominesey from the DEC Region 3 staff; and several college and high school interns working under the direction of William Schuster, Ph.D., the Consortium's Executive Director, and John Brady, the Forest Manager.

3. Determine Current Habitat Availability

In each survey location, assessment teams observed and recorded stream conditions that could help determine likelihood of long-term viability for brook trout. These conditions include water turbidity (brook trout are sight feeders and can only thrive in clear streams); summer stream temperature; riparian vegetation; minimum base flow in late summer; and the presence or absence of cover, non-native fish species, and groundwater upwelling/deep pools suitable for spawning. Teams avoided stream segments stocked by the DEC for sports fishing.

II. Assessment Strategy

A. Partners

Black Rock Forest Consortium consulted with, and received assistance from, a number of public and private landowners in the Hudson Highlands while conducting the brook trout population assessment. Their participation and guidance in this project, together with assistance from the DEC Region 3 staff and representatives of Trout Unlimited, made the assessment possible. Partners included staff from the Bear Mountain, Harriman, and Sterling Forest State Parks; the Environmental Management Bureau of the New York State Office of Parks, Recreation and Historic Preservation; West Point Military Academy; a conservation biologist from Columbia University; and the Consortium's consultant on this project, Dr. Alan Wells.

B. Landowner Perspectives

In July of 2010, the Consortium called a meeting for large landowners in the Hudson Highlands to elicit perspectives on the potential for brook trout restoration in the region. Information gathered at this meeting helped shape strategy for assessment teams that subsequently surveyed streams across these 100,000 acres in August 2010.

Bear Mountain and Harriman State Parks

Both Alan Wells, Ph.D., and Ed McGowan, Ph.D., the Director of Science and Trailside Museums for the Palisades Interstate Park Commission (including Bear Mountain and Harriman State Parks), shared information on prior brook trout assessments in the parks' 71,000 acres. Ancestral strains of brook trout have been identified in adjacent watersheds in New Jersey, in eleven drainages.[vii] For years, the question remained whether they also existed in the Hudson drainage (see **Appendix C** for map of this area), but little genetic testing has been done.

Decades of stocking, both by the DEC and unregulated groups, have made it less likely that heritage strain brook trout are left in the park system. Within the Popolopen watershed, Doodletown Creek and Timp Brook have self-sustaining brook trout populations; there is a possibility that these are heritage strains. Both brooks flow into Doodletown Reservoir, while Doodletown Brook continues to the Hudson River. Prior surveys have also reported brook trout populations in Tiorati and Horse Chock Brook. However, it is likely that these streams were stocked in the past. The DEC established a fish nursery nearby on Arden Brook in the 1920s or 30s; the genetic source for the brook trout the nursery raised is not known to project partners. The park system also maintained a hatchery for years, and has its own stocking records.

Torne Brook, a tributary to the Ramapo River in the southern range of Harriman State Park (near Sloatsburg in Rockland County), has a brook trout population that has drawn interest as potentially ancestral. Further research into stocking records is required; it is possible that stocking occurred here as well.

Water supply is an important factor for brook trout assessment in these parks. Many lakes here were originally created by damming wetland basins. The parks are obligated to honor existing agreements to supply surface water to populated areas; development pressure may increase this demand. The upper parts of the Tiorati Brook and Upper Ramapo River have been known to occasionally run dry. A recommended strategy is to choose headwater areas and work upstream to identify seepages and cool water refugia. Occasionally, headwaters may be dry, but aquatic organisms may persist as a result of hillside seeps.

West Point Military Academy

Many streams in West Point are valued for sports fishing and are stocked with fish from the DEC. Chris Pray, a Natural Resources Specialist with West Point, surveyed 19 streams on the 16,000-acre property, a follow-up to a stream assessment conducted in 2006. Smaller streams, which typically are of less interest to fishermen and thus are less likely to be stocked, were considered as part of Pray's assessment. Cat Hollow Brook has many of the criteria that make for good brook trout habitat, and it is not stocked. No brook trout have been identified in this stream, however. Segments of Cascade Brook have a good gradient and may be conducive to brook trout and other cold-water fish species, though some portions of the brook are impaired due to fertilizer runoff from the Academy's golf course.

Brook trout have been identified in Mineral Springs Brook on West Point property, but are likely there as a result of the Consortium's "Brookies at Black Rock" program, since Mineral Springs Brook originates in Black Rock Forest.

Sterling Forest

Dr. Wells examined twenty survey stations in Sterling Forest, in segments of Jennings Creek, Sterling Brook, Eagle Brook, and Summit Brook, among others. Beaver dams affect habitat in parts of Sterling Forest, as they do in Harriman State Park, inundating areas and often producing water temperatures too warm for brook trout. Sterling Forest was identified as a location to focus further stream assessment work.

Surveys conducted in Sterling Forest during 1983, 1989, and 1992 by LMS Engineers (LMS 1984, 1990, 1994) indicate the following:

- Indian Kill – no trout in 1989
- Warwick Brook – no suitable trout habitat in 1989
- Wanaque River – brown trout in 1983
- Ringwood River – brown trout and rainbow trout in 1989; brown, brook, and rainbow trout in 1992
- Sterling Creek – no trout in the spring of 1989; a pair of ripe adult brown trout and numerous young-of-the-year in addition to one ripe female brook trout in fall 1989
- Sterling Brook - brown and rainbow trout in July 1983; brown and brook trout in 1992; it should be noted that at the time of these surveys, the Sterling Forest Corporation annually stocked approximately 2,000 trout in Sterling Brook. There appears to be little holdover through the summer despite light angling pressure.

C. Field Surveys

Black Rock Forest Consortium's assessment teams conducted fish surveys using a backpack-mounted electrofishing unit in the fall of 2009 and spring of 2010. The fish surveys focused on Black Rock Forest streams, as well as Storm King Clove in Storm King Mountain Park. Some seine netting was done in the spring of 2010, in the attempt to find brook trout fry and thus evidence of reproduction in Forest streams. While the majority of survey information was collected via electrofishing to ensure consistency with DEC data, electrofishing may underestimate the presence of young fish because smaller fish are less likely to be affected by the electrical field. Teams then conducted stream surveys in August 2010, after gathering input from project partners. To ensure consistency with DEC survey records, similar physical and chemical data were recorded, including latitude and longitude of the survey station, air and water temperature, and conductivity and pH levels.

The Consortium had two objectives for the stream surveys conducted in August 2010: investigating whether streams with established brook trout populations might need habitat

enhancement, as some stream segments can dry up in late summer or warm too significantly for cold-water fish; and investigating streams that had not previously been surveyed to make an initial determination on their potential suitability for brook trout. Each stream was sampled at multiple locations across its length in order to ascertain the degree of habitat heterogeneity. The Consortium teams reported the range of values observed across the different locations in order to reflect the variability of each stream.

III. Findings

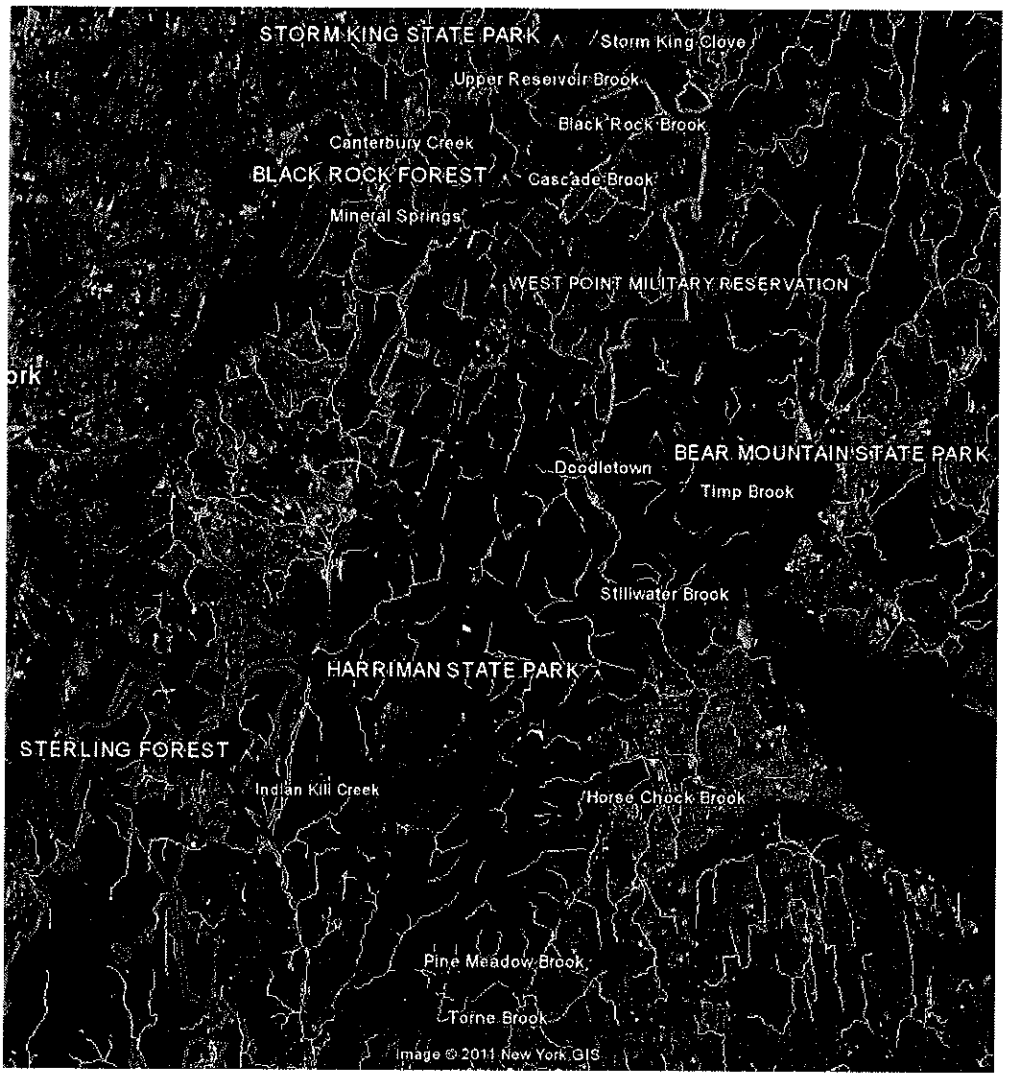

Figure 1 Overview of Study Area

Figure 1 represents the study area for the Consortium's brook trout assessment. Each stream marked by a purple dot was either visited by survey teams (in some cases, a stream was surveyed several times) or a team reviewed the stream's prior survey records and consulted with the DEC, the state park system's Science Director, Dr. Ed McGowan, and/or Dr. Wells

regarding what is known about brook trout and stocking practices. Please refer to **Appendix D** for a Summary Table of physical and chemical data gathered by the Consortium's assessment teams in these study areas.

Below are summaries of the Consortium's findings in each park or private preserve.

A. Black Rock Forest

The four major stream drainages within the Black Rock Forest were surveyed in October of 2009 and April 2008.

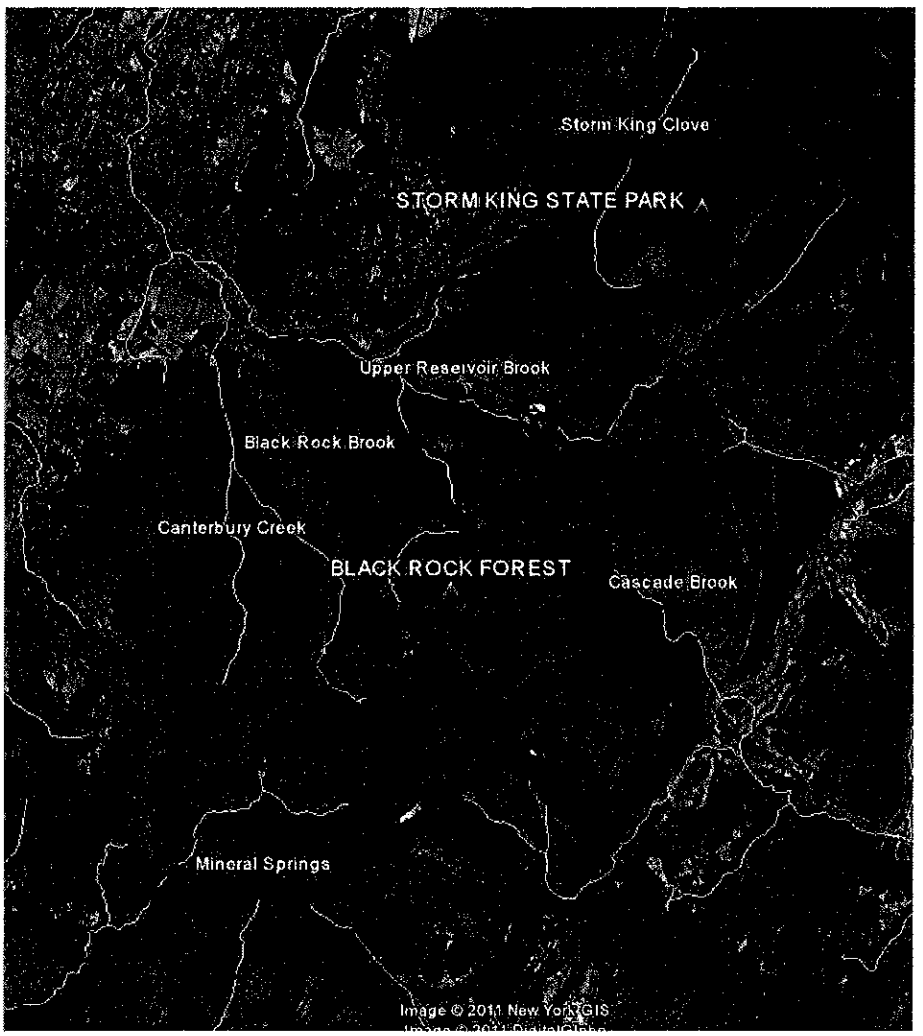

Figure 2 : Black Rock Forest Preserve and Storm King Mountain State Park

Figure 2 provides an overview of the Black Rock Forest property, as well as the adjacent Storm King State Park, where a stream survey was conducted by a Consortium team (as described in the section on Storm King, below).

Black Rock Brook

Black Rock Brook is part of the Moodna Creek drainage into the Hudson River watershed and the majority of its length is within the borders of Black Rock Forest. Black Rock Forest staff along with Dr. Wells performed two surveys (three stations in fall 2009 and three stations in spring 2010) at locations along Black Rock Brook and a tributary, Upper Reservoir Brook. Additionally, Dustin Dominesey from the DEC's Region 3 office helped with the fall 2009 Black Rock Brook fish surveys and provided an electroshocker for the survey work.

General Habitat

The riparian zone along the edges of Black Rock Brook is dominated by mixed deciduous forest. The most abundant tree types are oak (*Quercus spp.*), maple (*Acer spp.*), birch (*Betula spp.*), sycamore (*Platanus occidentalis*), and hemlock (*Tsuga canadensis*). Stream bed composition varies between sites, however, boulder and rubble are the most common cover type with gravel also being present. During both seasons water level was moderate to high with varying pool to riffle ratios.

Water Quality

The water quality of Black Rock Brook was high. Water was clear and cool (10^{o}-11^{o}C) and pH was fairly neutral (pH range: 6.5-7.0). Specific conductivity was moderate (34-76 μScm^{-1}) but relatively high for within Black Rock Forest. Flow was ample at each site (0.418-0.551 m^3s^{-1}) surveyed during both seasons.

Electrofishing results

The electrofishing device borrowed from the DEC did not have a timer and therefore the number of fish caught per second could not be determined for the fall 2009 sample. However, examining abundances alone, more fish (~1200) were caught in Black Rock Brook during the fall 2009 sampling period than anywhere else in the forest (0-75 fish at other sites). Additionally, Black Rock Brook has the highest species diversity, with electrofishing showing seven different species. During the spring 2010 sampling electrofishing in Black Rock Brook produced 0.040 fish per second and 0.001 brook trout per second.

Canterbury Brook

Canterbury brook is part of the Moodna Creek drainage in the Hudson River watershed and is largely within the Black Rock Forest with its lower reaches running through the town of Cornwall and Village of Cornwall-on-Hudson. Black Rock Forest staff and Dr. Wells performed two surveys (four samples in fall 2009 and three samples in spring 2010) at different locations along the brook.

General Habitat

The riparian zone of Canterbury Brook is dominated by mixed deciduous forest with steep slopes and large bedrock outcrops. The most abundant tree types found along the stream bed are oak (*Quercus spp.*) and maple (*Acer spp.*) along with American beech (*Fagus grandifolia*)

and young white pine trees (*Pinus strobus*) planted under direction of the Consortium's Forest Manager, John Brady. Stream bed composition varied from site to site, most commonly boulders and rubble, with gravel and bedrock also present. Water levels were moderate to high during both fall and spring surveys with varying pool to riffle ratios.

Water Quality
The water quality of Canterbury Brook was generally high. Water temperatures were consistently cold (Fall 2009:11°-14°C; Spring 2010: 6°-8°C) and pH was relatively neutral (pH range: 6.5-7.0). Specific conductivity was relatively low and was significantly higher in the fall (54.2-56.2 μScm^{-1}) than in the following spring (25 μScm^{-1}). Flow was relatively high in the spring (0.116-0.419 m^3s^{-1}) but moderate to low the preceding fall (0.059 m^3s^{-1}).

Electrofishing
Electrofishing produced 0.102 total fish per second during fall 2009 and 0.106 fish per second during spring 2010. On the fall 2009 sampling day three species were observed: brook trout, black-nose dace and pumpkinseed sunfish; while the spring 2010 effort produced only two species: brook trout and black-nose dace. Electrofishing caught 0.043 brook trout per second in fall 2009 but only 0.021 in the spring of 2010.

Cascade Brook

Cascade Brook drains directly into the Hudson River watershed with the majority of the brook lying within the boundaries of the Black Rock Forest. Black Rock Forest staff and Dr. Wells performed seven surveys (four in fall 2009 and three in spring 2010) at six different locations.

General Habitat
The dominant vegetation along the riparian zone of Cascade Brook is deciduous forest with an occasional conifer such as hemlock (*Tsuga canadensis*) and white pine. The most common deciduous trees include oaks, maples, birch (*Betula lenta and Betula alleghaniensis*) and American beech. The stream bed composition varied significantly between sites. Boulder, rubble and gravel were the most common cover types with sand, silt and bed rock also being present. Water levels were moderate in both seasons with varying riffle to pool ratios.

Water Quality
The water quality of Cascade Brook was generally high. Water temperatures remained cold (Fall 2009: 7°-11°C; Spring 2010: 11°-16°C) and conductivity remained low (Fall 2009: 16-24 μScm^{-1}; Spring 2010: 15-18 μScm^{-1}) in both seasons. A relatively neutral pH was also observed (pH range: 6-6.5) in spring 2010 and flow was moderate as well (0.056-0.138 m^3s^{-1}).

Electrofishing
Electrofish sampling produced 0.054 total fish per second in fall 2009 and only 0.002 total fish per second in spring 2010. During the fall 2009 sampling period only brook trout and creek chubs were observed, and the number of brook trout far outnumbered the number of chubs. In the spring 2010 sample only one fish was caught and it was a brook trout. However, it must

be noted that brook trout and black nose dace were observed in the stream but were not caught by the electrofishing team.

Mineral Springs Brook

Mineral Springs Brook is part of the Moodna Creek watershed, which eventually drains into the Hudson River. Much of the brook, including the headwaters, lies within the borders of the Black Rock Forest. Black Rock Forest staff and Dr. Wells surveyed five stations (two in fall 2009 and three in spring 2010).

General Habitat

The riparian zone along Mineral Springs Brook is dominated by mixed deciduous forests. The dominant tree types are oaks, birch, and hemlock with beech and maple also present. Stream bed composition varies between sites. The most common stream bed cover types are rubble and boulder with bedrock, silt and gravel present in fairly low amounts. The pool to riffle ratio also varied considerably between sites and the water level was moderate to low during both sampling periods.

Water Quality

The quality of the water in Mineral Springs Brook was generally high. Observed water temperatures were suitably low for cold water species in both seasons (Fall 2009: 9°C; Spring 2010: 8°-9°C) and pH was 6.0. Specific conductivity was very low, but higher in the fall (23 μScm^{-1}) than in the spring (15-16 μScm^{-1}). Fall flow measurements (0.007-0.015 m^3s^{-1}) were lower than spring flow measurements (0.037-0.142 m^3s^{-1}) and were generally low compared with other survey sites.

Electrofishing

Electrofish sampling produced 0.012 total fish per second in fall 2009 representing three species while spring 2010 electrofishing produced 0.007 fish per second with three species present. Combining data from the two surveys increases species richness to five species. Brook trout were the most abundant species captured followed closely by pumpkinseed sunfish. American eel, black-nose dace and brown trout were also present. The number of brook trout caught per second decreased the least in Mineral Springs Brook from fall to the following spring (0.006 fall 2009; 0.005 spring 2010); however, brook trout were in relatively low abundance compared to other nearby streams.

B. Storm King Mountain State Park

Storm King Clove

Storm King Clove is a direct tributary of the Hudson River and is located in Storm King Mountain State Park. The DEC's first survey records for Storm King Clove date from 1936, and note that

this 1.4 mile stream was not stocked. The stream ran "practically dry at Highway 9W," and flow was minimal where measured, at less than five gallons per minute (< 0.0003 m^3s^{-1}).

When the clove was surveyed by the Consortium's team in August 2010, the uppermost portions of the stream were completely dry. These dry sections gave way to intermittent pools, and eventually running water. Seven sites were surveyed; only one 200 meter stretch of stream was a viable location for electroshock sampling.

General habitat
The riparian zone was dominated by mixed deciduous forest. The most abundant woody species along the riparian zone are yellow birch (*Betula alleghaniensis*), witch hazel (*Hamamelis virginiana*), sugar maple (*Acer saccharum*) and striped maple (*Acer pennsylvannicum*). Stream bed composition varied considerably, with boulders, rubble and silt the most common and abundant cover types. Water level was low across all survey locations and the majority of water was found in pools rather than riffles (range: 70-100% pool; 0-30% riffle).

Water Quality
Water quality for Storm King Clove was high with good potential as brook trout habitat. The water remained very cool for late summer (16-19°C) compared to other survey locations. It was also found that pH was relatively neutral along most of the stream (pH range: 6.6-7.4). Specific conductivity was a high (207-850 μScm^{-1}) compared to some other survey locations, but is well within the tolerable range. Flow was moderate (0.016-0.086 m^3s^{-1}) and could only be measured at four of the seven stations.

Electrofishing
At the single sampling location, Storm King Clove produced 0.11 total fish per second. The sample comprised two species, brown trout (*Salmo trutta*), which was the most abundant, and the American eel (*Anguilla rostrata*).

*For a map of this park and stream, please see **Figure 2** in above section.*

C. Harriman and Bear Mountain State Parks

Historically, Harriman and Bear Mountain State Parks have been considered the last remaining refuge for wild brook trout populations in the Hudson Highlands region. Consortium staff visited the DEC Region 3 office to review survey data from these parks dating back to 1936.

File Factory Brook

File Factory Brook is part of the Ramapo River watershed. When the brook was surveyed by our team in August of 2010 the brook was completely dry along its entire length. Therefore, no further measurements were taken.

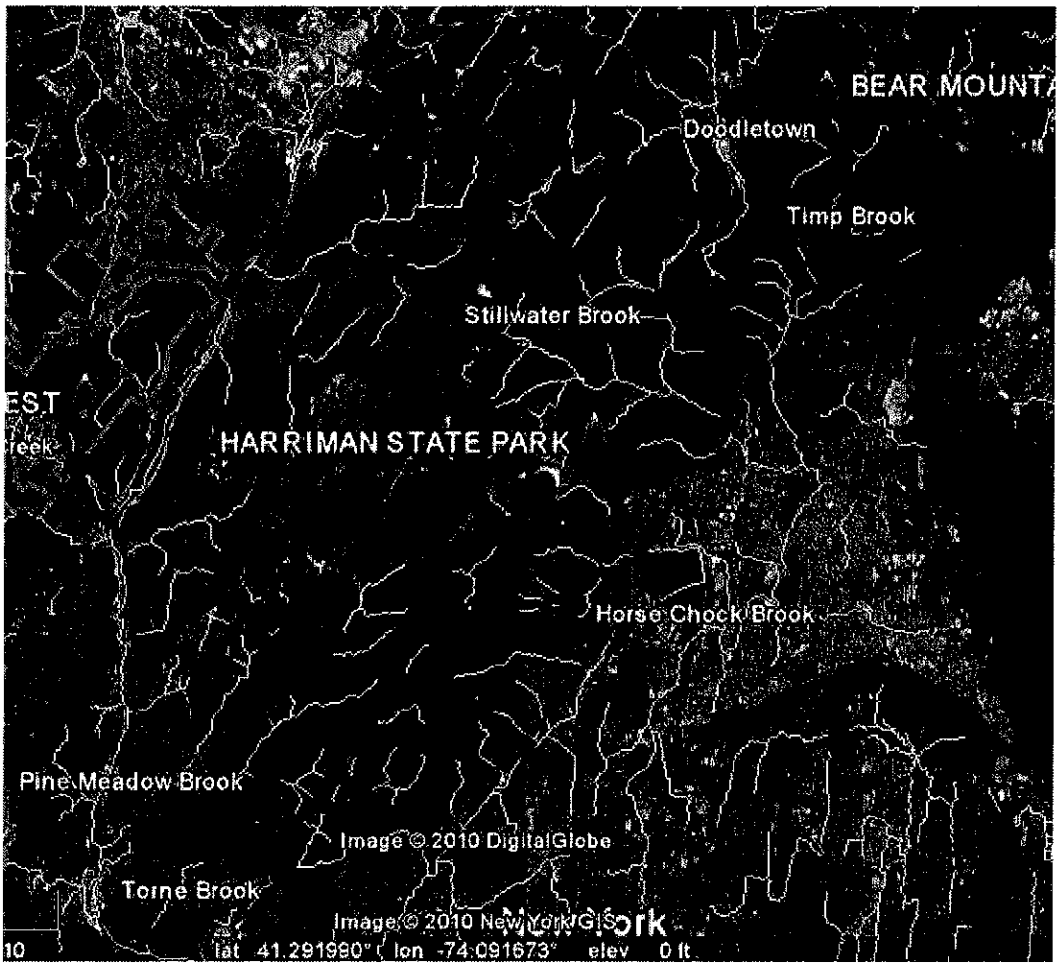

Figure 3: Horse Chock and Stillwater Brooks (Hudson Drainage), Pine Meadow and Torne Brooks (Passaic Drainage)

Horse Chock Brook

Horse Chock Brook is a part of the Hudson River watershed within Harriman State Park. The DEC's Horse Chock Brook survey was conducted in September 1989. Several 6 – 9 inch brook trout were caught using an electrofishing unit in this 2.2 mile stream. The surveyor noted that stream flow was "controlled by flow from an outlet valve."

During the Consortium's August 2010 survey, large portions of the brook were found to be completely or nearly dry. However, there are three substantial reservoirs located along the course of the brook which help feed the stream segment located between the reservoirs. Throughout this section of the brook, substantial, deep pools were located and electrofished. In all, three stream locations were surveyed.

General Habitat

The riparian vegetation consists of mixed deciduous hardwoods with maple (*Acer spp.)*, oak (*Quercus spp.)* and birch (*Betula spp.*) the most common tree types observed. Stream bed

composition varies substantially between each site ranging from 15-70% boulders, 15-50% rubble, 7- 30% gravel, 0-30% sand and 8-15% silt. The ratio of pool to riffle also varies between sites from 100% pool and 0% riffle to 10% pool and 90% riffle.

Water quality
Water temperatures throughout the course of Horse Chock Brook were fairly high, ranging from 20-25°C (with air temperatures ranging from 26-30 °C). The pH levels were relatively neutral with values of 6.6 and 7. Specific conductivity showed great variation, with values between 18 and 109 μScm^{-1}. Stream flow was moderate with a consistent value of 0.293 m^3s^{-1}.

Species Composition
Over the three sampling areas Horse Chock Brook produced 0.02 fish per second and three fish species. The first sampling location returned no fish species while the second and third sampling locations returned two and one species respectively. The most abundant species was the pumpkinseed sunfish (*Lepomis gibbosus)*, indicative of warm water. The brown bullhead catfish (*Ameiurus nebulosus*) and blacknose dace (*Rhinichthys atratulus*) were also present.

Pine Meadow Brook

The Consortium did not visit Pine Meadow Brook, since both the DEC and Dr. Wells had previously surveyed the water body. Both surveys showed the presence of brook trout.

Pine Meadow Brook is a 2-mile stream in Harriman State Park, a tributary to Stony Brook, which has stocked and wild brown trout. The stream was most recently surveyed by the DEC in August 2003. Due to low conductivity, the electrofishing unit did not work well and more fish were observed than caught. Five brook trout approximately 5 to 7 inches in length were caught. The DEC data through scale analyses suggest this may be a wild, reproducing brook trout population. The stream has not been stocked with brook trout by the DEC, at least in recent times.

According to Dr. Wells, the upper reaches of Pine Meadow may be a good stream segment in which to focus a genetic analysis/restoration effort.

Stillwater Brook

Stillwater Brook is a tributary of Tiorati Brook. Upstream, it crosses Palisades Interstate Parkway (PIP). Further upstream are several tributaries and the unfinished Owl Swamp Pond. Dr. Wells surveyed brook trout in Stillwater Brook during September 1996 and April 1997. Brook trout were found upstream of the PIP crossing, while brown trout were found downstream from the PIP crossing and into Tiorati Brook. A naturally produced tiger trout, a hybrid between a brook and brown trout, was found at the PIP station.

Genetic analysis is recommended for this stream. No genetic analysis has been performed, and the DEC confirms that there is no current stocking policy for Stillwater Brook. Brook trout were

observed in the DEC's 1936 survey, but no modern (post-1988) survey has been conducted by their staff. Records indicate that brook trout fingerlings were stocked in Stillwater Brook in 1928, 1930, 1932, and 1933.

Upper Pound Swamp Creek

Upper Pound Swamp Creek is a part of the Hudson River watershed and is located within the boundaries of Harriman State Park. Only two locations were surveyed from the creek draining the swamp due to the general lack of water, minimal flow, and overall poor water quality. No electrofishing was conducted at these sampling locations.

General habitat

The riparian zone along the Upper Pound Swamp Creek consists of deciduous trees and shrubs. The most abundant are oak (*Quercus spp.*), birch (*Betula spp.*), ash (*Fraxinus spp.*), ironwood (*Carpinus spp.*) and the shrub, witch hazel (*Hamamelis virginiana).* Stream bed composition varied some between the two sampling locations. The stream bed of sampling location one consists of 70% boulder, 10% gravel, 10% sand and 10% silt while the stream bed of sampling location two is 15% boulder, 10% sand, 70% silt and 5% clay. Both sampling locations were 100% pool and 0 riffle.

Water Quality

In general the quality of the water at Upper Pound Swamp was relatively poor. In both locations the water appeared very brown. There was also a rusty color at the first location, which may be a product of the growth of red algae. Water temperature was fairly high at 22.5° and 23° C, just slightly cooler than the observed air temperatures of 26° and 28° C. The pH was slightly acidic at 6 and 5.9 for the two sampling locations and conductivity was moderate at 53 and 41 μScm^{-1}. Flow was minimal and undetectable by the flow meter.

Torne Brook

Torne Brook is part of the Ramapo River watershed and is located within Harriman State Park. This brook has been surveyed a number of times in the past several decades by the DEC. In June of 2007, 25 brook trout were caught, in multiple year classes, providing evidence of reproduction. The DEC also performed analyses of the sample scales taken from each fish captured to determine an age distribution. Young of the year, 1, 2 and 3 year old trout were all present in Torne brook suggesting that a wild, reproducing population exists. Dr. Wells also collected young, 55-66 mm TL in August, in Torne Brook during 1997.

The Consortium's survey team also found brook trout of varying sizes in Torne Brook. The team covered the majority of the brook's length in two survey days, with seven sampling locations extending from just above the water treatment plant to a fork which splits the brook into two tributaries. Above the split, the junction of each stream branch was surveyed. Electrofish surveys were conducted at five of the seven stations.

General Habitat

Along the course of the entire brook, the vegetation varied little. The most prevalent woody species along the entire length of the brook are red oak (*Quercus rubra*), hemlock (*Tsuga canadensis*), yellow birch (*Betula alleghaniensis*), American beech (*Fagus grandifolia*) and the shrub mountain laurel (*Kalmia latifolia*). Stream bed composition varied considerably with many combinations of bedrock, boulders, rubble, etc. Similarly the proportion of riffle to pool also varied considerably depending on topography and stream bed composition.

Water Quality

The stream increased in water level when surveyed the second time, due to a large rain event earlier in the week. The team re-measured pH, temperature, and conductivity at the TB05 (Collection # 10082005 and 10082701) and re-measured pH and temperature at TB06 (collection # 10082006 and 10082702). At TB05 pH decreased from 7.1 to 6.5 after the rain event. Water temperature also decreased from 21.5°C to 17° C, however, this decrease partly reflects time of day (afternoon on 20 Aug and morning on 27 Aug). Specific conductivity also decreased after the rain event from 55 before the rain to 49 after.

Across all seven survey sites pH ranged from 4.1 to 6.55 with an average pH of 5.4. Water temperature remained fairly consistent at 21° C on the first survey day (air temperature range: 21°-32° C) and 17° C on the second survey day (air temperature range: 19°-23°C). Specific conductivity across the entire stream ranged from 49 to 773 μScm^{-1} with the headwaters having higher values than the lower waters. Water level was consistently low on the first survey date and higher on the second survey date. Flow readings were only taken on the first survey day and ranged from 0 m^3s^{-1} to 0.924 m^3s^{-1}. Flow increased after the rain event between sampling periods and appeared adequate through most of the stream.

Electrofishing

Over the length of the brook, 0.11 fish were caught per second of fishing effort. The most common species observed in the lower portions of the brook were brown trout (*Salmo trutta*), blacknose dace (*Rhinichthys atratulus*) and creek chub (*Semolitus atromaculatus*). In the upper portions of the stream, only brook trout (*Salvelinus fontnalis*) and blacknose dace were found. Despite the relatively low pH in some portions of Torne Brook, brook trout were observed at four of the five sites that were electrofished, ranging in size from 61mm- 157mm. The lowest pH at which brook trout were observed was 4.4, at the stream junction. This was the location where the smallest fish was found. The location above the junction was the only stream segment where brook trout were not observed.

Genetic Analysis:

Timothy L. King, Ph.D., a fishery biologist with the United States Geological Survey, has performed genetic analysis on hundreds of brook trout collections across the fish's native range. Dr. King has results from microsatellite DNA analysis for two of the streams in the Consortium's study area: Torne Brook in the Passaic Drainage and Timp Brook in the Hudson Drainage. Dr. King's findings indicate that the Timp and Torne strains are genetically distinct;

that they differ significantly from any of the hatchery strains he tested; and that their lines diverged from each other a long time ago, as might be expected from two streams in the same park system but in different watersheds. King saw no strong evidence of hatchery influence and indicated that coalescent analysis would be the next step for genetic analysis of these strains. Coalescent analysis would give the best approximation of how long each strain has persisted in its current habitat; the more generations the greater likelihood of sufficient genetic variation and chances of survivorship long into the future.

With the Timp and Torne strains, King found relatively low allelic diversity (an average of 3.1 – 3.4 alleles per locus compared to other populations which showed as many as 24 alleles per locus). Low allelic diversity sometimes is the result of a population "bottleneck," a stressor or combination of stressors, like disease and drought, which reduces abundance. It can take some time for allelic diversity to recover. This finding does not necessarily indicate that these strains would have trouble re-establishing. According to King, some intact, wild brook trout populations have low allelic diversity, as for example the populations in Great Smoky Mountains National Park where average diversity is below 2 alleles per locus.

Bear Mountain State Park

The Consortium's team did not perform surveys in Bear Mountain State Park, as this area was surveyed extensively by Dr. Wells during the late 1990s and early 2000s. Wells found brook trout populations in the two major drainages within Bear Mountain State Park, Doodletown Creek and Timp Brook.

For a map of this survey area please see **Figure 4** below. Other species found in the area include blacknose dace, tessellated darter (*Etheostoma olmstedi*), American eel (*Anguilla rostrata*), and the white sucker (*Catostomus commersonii*).

Doodletown Creek

Doodletown Creek and Timp Brook both flow into the Doodletown Reservoir. Doodletown Creek continues from the reservoir to the Hudson River. This stream segment includes an approximately 10-to-15-foot waterfall that represents a substantial barrier to fish upstream movement.

Timp Brook

The DEC's last record of stocking in this stream was in 1934. While it is unclear what the practice was between 1934 and 1957, from the DEC's records it appears as if no stocking occurred from at least 1957 to present day. Timp Brook was surveyed in November 2005 to collect brook trout for genetic analysis. A total of 23 brook trout were caught. Both the DEC and Dr. Wells have concluded that Timp Brook has a wild, self-sustaining population of brook trout.

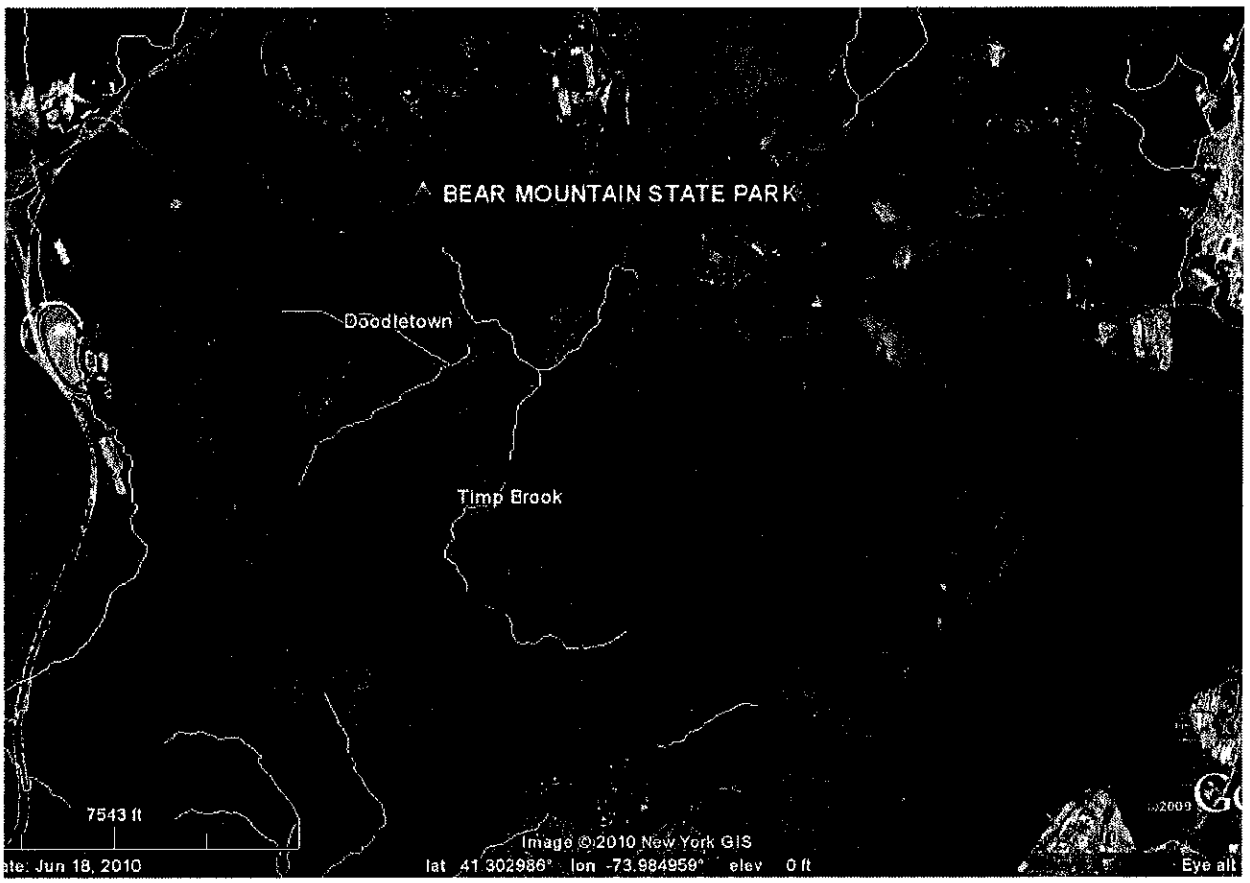

Figure 4: Timp Brook and Doodletown Creek, tributaries of the Hudson River

Genetic Analysis

According to Dr. King, the Timp Brook and Torne Brook strains merit closer study and further genetic analysis to determine their age and history (Please reference the above section on Genetic Analysis for Torne Brook in Harriman State Park).

D. Sterling Forest State Park

Indian Kill Creek

Indian Kill Creek is a part of the Ramapo River watershed and is located within Sterling Forest State Park. Six stations were chosen along the length of the stream and electrofishing was carried out at two of these locations.

General Habitat

The most abundant woody species along the riparian zone of the Indian Kill Creek are red maple (*Acer rubrum*), sugar maple (*Acer saccharum*) and black birch (*Betula lenta*). Stream bed

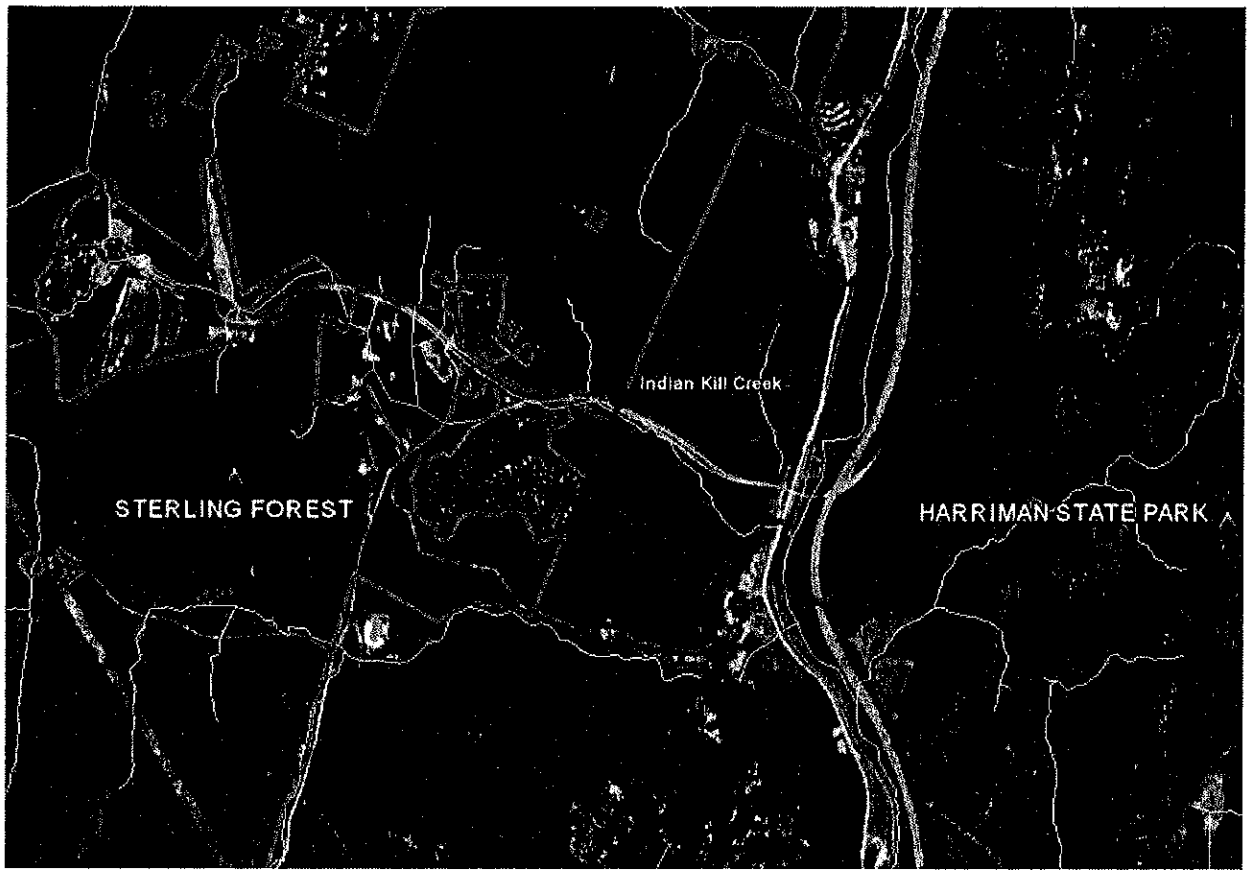

Figure 5: Indian Kill Creek, Sterling Forest State Park (Passaic Drainage)

composition ranged considerably between sites with all but two classes being represented (no streambeds of bedrock or clay). Water level was generally low; however there were still areas of both pool and riffle. Two of the sites surveyed were 100% pool, while the other sites ranged from 20% pool/80% riffle to 70% pool/30% riffle.

Water Quality

The water quality of Indian Kill creek is generally fairly high and favorable to brook trout survival. Water temperatures ranged from 18.5°C to 22.5°C with air temperatures ranging from 24.5°C to 28°C. Additionally, pH was fairly neutral ranging from 6.9 to 7.4. The specific conductivity remained fairly high across the entire length of the stream that was surveyed with a range from 545 Scm^{-1} to 700 Scm^{-1}. Lastly, flow varied somewhat between sites, however at all sites flow was moderate relative to other streams in the region. Observed flows ranged from 0.015 m^3s^{-1} to 0.070 m^3s^{-1}.

Electrofishing

During the electrofishing of the brook, the team caught 0.056 fish per second and three species were observed. The most abundant species was blacknose dace followed by creek chub and a

single bullhead catfish. No brook trout were observed; however, the habitat might be suitable throughout much of the creek if summer temperature regimes were suitable.

Little Cedar Pond and Little Cedar Pond Creek

Little Cedar Pond is part of the Passaic River watershed. Little Cedar Pond plus seven sites along the entire length of the creek tributary were surveyed for a total of eight survey locations. Only one of the eight survey sites had sufficient water for electrofishing.

General Habitat

The riparian zone of Little Cedar Pond Creek is dominated by mixed deciduous forest. The most abundant trees along the creek are yellow birch and sugar maple with an occasional red oak, chestnut oak, American beech or black birch. The stream bed composition varied considerably between sites, with boulders, rubble, or silt the most abundant cover type. Like most of the other sites surveyed by the teams, the water level was generally low and a large portion of the creek was pool as opposed to riffle. Across all the sites the percent area which was considered to be a pool ranged from 30 to 100 with the majority of sites (6) being over 70% pool.

Water Quality

In general the water quality of Little Cedar Pond was fair. Water temperatures were relatively cool (17.5°- 22°C) compared to other streams that were surveyed and specific conductivity was also relatively low (21-73 μScm^{-1}). However, pH was relatively low (as low as 4.2) and the water consistently had a brown or reddish tint. Along the majority of the creek, flow was either non-existent or minimal and only three of the eight sites (sites 1, 7 and 8) had sufficient flow to be measured by flow meter. Where flow was measurable it was moderate (0.016 m^3s^{-1} - 0.033 m^3s^{-1}).

Electrofishing

At the singular location for electrofishing, the team caught 0.26 fish per second comprising four species. The most abundant species was the pumpkinseed sunfish with blacknose dace, creek chub and brown bullhead catfish also present.

Sterling Lake and Creek

Sterling Lake and its associated creek are part of the Passaic watershed and are located within Sterling Forest State Park. The survey team examined both Sterling Lake itself and the small creek which drains it. Sampling was conducted at three locations; one at the lake and two along the creek. Only habitat characteristics and water quality were recorded at these sites (i.e. no electrofishing was performed).

General habitat

Along the edge of the lake numerous oaks (chestnut, red and white) were observed along with hemlock and witch hazel shrubs. However, along the creek the vegetation was dominated by maples (red and sugar) as well as sycamore (*Platanus occidentalis*) and black birch. The

composition of the bottom material also differed between the lake and the creek. Sterling Lake is composed of a mixture of boulders, rubble and silt with some sand and gravel, whereas the stream bed is largely dominated by clay (80-85%) with a little rubble, sand and silt. All three locations which were surveyed were considered 100% pool and had a neutral water level.

Water Quality
The water quality of Sterling Lake and the creek is fair. Water temperatures were moderate to high (19.5-22.5°C) with the lake having the highest temperature. The pH was somewhat acidic (5.4-5.8) with the lake having the lowest pH. Specific conductivity at all three sites was moderate (43-75 μScm^{-1}) with the lake having the lowest conductivity. No flow measurements were taken since all areas surveyed were 100% pool.

Laurel Meadow Pond

The area of Laurel Meadow pond consists of several small ponds, a wetland and a creek which drains the ponds and wetlands. Three locations were surveyed; one at the pond and two along the creek. The two creek locations were also surveyed for fish using electrofishing.

General habitat
The vegetation along the riparian buffer of the lake was significantly different from that along the edges of the creek. Along the bank of the lake were white ash (*Fraxinus americanus*) and black birch while within the edges of the pond there were water lilies (*Nymphaeaceae*), goldenrods (*Solidago spp.*), rushes (*Juncaceae*) and the invasive purple loosestrife (*Lythrum salicaria*). The banks along the creek were dominated by maples (red and sugar), red oak, yellow birch and the invasive shrub barberry (*Berberis thunbergii*). Bottom material varied; however, silt was the most abundant material present at all three locations followed by clay and gravel. Two of the locations were considered 100% pool and the third was 90% pool.

Water Quality
In general the quality of the water at Laurel Meadow Pond is high. Water temperatures were moderate (18-20°C; air temperatures: 22-28.5°C) with the pond itself having the highest temperature. The pH was relatively acidic (5.9-6.4) with the pond being slightly more acidic than the creek. Specific conductivity was moderate to high (79-175 μScm^{-1}) compared to other sites surveyed. However, flow was minimal, as most of the water was confined to relatively large pools.

Electrofishing
Across both sites 0.12 total fish were caught per second comprising four species. The most abundant fish was the white sucker (*Catostomus commersonii*) followed closely by the pumpkinseed sunfish. No brook trout were observed at this location.

Whitmore Brook

Whitmore Brook is a part of the Passaic watershed and is located within Sterling Forest State Park. Two sampling locations were surveyed.

General habitat
In general the riparian zone along the banks of the stream is mixed deciduous. The most abundant trees between the two sites are hemlock and black birch with the occasional yellow birch, witch hazel and beech. The stream bed composition varied but both sites showed a large amount of rubble with varying amounts of boulders, gravel and sand. The first site surveyed was 100% pool while the second site was 90% pool at the time of the survey.

Water Quality
The quality of the water at Whitmore Brook is potentially good. Water temperatures were low (17°C; air temperature: 19°C) and specific conductivity was moderate (68 and 78 μScm^{-1}). The pH was acidic (4.5 and 4.9), however the survey was conducted just following a significant rain event. Flow was moderate (0.056-0.123 m^3s^{-1}) across both sites.

E. West Point Military Reservation

West Point's reservation includes approximately 11,000 acres of forest, though there is fragmentation of these lands. Two streams in this area, Cascade Brook and Cat Hollow Brook, have the potential to be good habitat for brook trout, though there are not currently wild, self-sustaining populations in these places. There are significant security issues with providing access to West Point's land. In addition, cadet training exercises on the property, including artillery exercises, may impede access at times. For the purposes of this project, the Consortium decided to focus on more accessible lands.

IV. Conclusions

A. Status of Brook Trout Populations

The Consortium's assessment supports and details the Eastern Brook Trout Joint Venture's previous reporting of greatly reduced presence of wild brook trout in the Hudson Highlands. Canvassing of previously un-surveyed streams confirmed that without a significant investment in restoration, habitat for the brook trout is quite limited in this region, due to low summertime flows and areas with low tree cover and resultant warming of streams. Drought is a serious threat to aquatic habitats around this region, with many streams reported to run dry in the summer season. Future restoration efforts must address whether there are enough natural, cool-water refugia in priority streams, and whether more could be created to sustain brook trout populations through drought seasons. Many of the cold-water streams that are fishable

already have established populations or are stocked with aggressive and invasive fish species; both are significant limiting factors.

Significant efforts should be made to protect any remaining heritage strains of brook trout in the Hudson Highlands. The DEC has some protections in place, as streams in the Hudson and Passaic River drainages that host established fish populations, including brook trout, are designated as "Trout Streams" or "Trout Spawning" waters by the DEC's Division of Water, prohibiting development that would adversely impact these streams. However, more could be done to ease the stresses on established brook trout populations, which are genetically isolated and inhabit streams that may run dry or warm to unsuitable temperatures in the summer season. Another challenge in protecting or extending brook trout habitat would be mitigation of the threats downstream, in the form of brown trout and other invasive fish species.

B. Priority Streams

Wild Populations

Doodletown Creek
Pine Meadow Brook
Stillwater Brook
Timp Brook
Torne Brook

The Consortium's recommendation is that genetic analysis be done on the brook trout populations in Doodletown Creek, Pine Meadow Brook, and Stillwater Brook, as this work has not been done before. Further research into historical stocking practices is required in order to confirm that Timp and Torne Brook have not been stocked by state park management. DEC records indicate that these streams have not been stocked by their agency in the past several decades. Dr. King's initial genetic finding, indicating no strong evidence of hatchery influence in the Timp and Torne Brook populations, needs follow up. It is possible that these wild strains still maintain their ancestral genetic heritage, and that they could be of high value to future restoration efforts. Further genetic studies, such as coalescent analysis, would be the next step in determining whether this is the case.

These five streams with wild populations should receive focus in any future conservation or restoration-related work on brook trout in the region. If the Timp and Torne Brook strains show promise for population enhancement or further protection, and if they are thriving in current stream conditions, then in the future it would be worth exploring with project partners whether habitat might be extended for these populations. All of this work should be undertaken under the leadership of qualified aquatic biologists as part of a carefully controlled, long-term research study.

Possible Conducive Habitat

Black Rock Brook
Cascade Brook
Canterbury Brook
Indian Kills Creek

Three streams in Black Rock Forest and one in Sterling Forest State Park are worth exploring as potential habitat for permanently self-sustaining brook trout populations. While no streams in Black Rock Forest have contained brook trout for most of the 1900s, in the late 1990s forest staff began a brook trout rear-and-release program using eggs from fish thought to be native to the Connetquot River on Long Island. Black Rock Brook, and its tributary which flows from Black Rock Forest's Upper Reservoir, currently hosts overwintering brook trout, though it is uncertain whether the population is fully self-sustaining. Only a few fish have been identified as likely results of in-stream reproduction. In 2010, Forest Manager John Brady worked with student volunteers on brook trout habitat improvement of Black Rock Brook, excavating the stream bed, adding boulders, and creating dams to enhance two deep pools which may serve as refugia and future spawning grounds. The two pools are informally named "Buster's Bend" and "Birch Spring Hill" and are located near Aleck Meadow Reservoir. Due to its consistent stream flow, Black Rock Brook is likely the stream of greatest interest in Black Rock Forest for any future re-introduction effort, conceivably working with Highlands heritage strains if these can be identified.

Both Cascade and Canterbury Brook represent fragmented habitat for brook trout. Nevertheless, brook trout do persist through late summer and over-winter in both streams. A section of Canterbury Brook in the northern part of the Forest and the segment of Cascade that runs through Glycerine Hollow at the southeastern edge of the Forest appear to be particularly conducive habitat for brook trout. Further restoration work is planned for both these streams to improve conditions and extend potential habitat for brook trout.

Future restoration efforts could explore the possibility of reintroducing brook trout to upper stream portions of Indian Kill Creek in Sterling Forest State Park. Stream conditions are cool and clear, though there are no survey records indicating brook trout and the Consortium's survey team did not observe any. The DEC found brook trout here in 1936, but has not surveyed the stream since. The stream has not been stocked. DEC Region 3 staff indicate that water exiting a wetlands/impoundment near Long Swamp Road apparently warms the stream in the summer season, potentially limiting brook trout habitat below this point.

Other Streams of Interest

Horse Chock Brook
Mineral Spring Brook
Storm King Clove

Wild brook trout were observed in Horse Chock Brook in the late 1980s, but since that time drought has impacted large portions of the stream. If time and resources allow, the Consortium could revisit Horse Chock to explore whether any brook trout have survived in refugia despite the dry streambed observed in August 2010. This stream is a possible focus of restoration efforts as conditions were once conducive for brook trout, and as the DEC had not had a stocking policy for Horse Chock Brook. Instream flows sufficient to support brook trout would need to be negotiated with the managers of the reservoirs upstream.

Mineral Spring Brook flows through West Point and Black Rock Forest, and brook trout have been observed in segments of the stream on both properties. It has been identified as the highest quality stream on the West Point Military Reservation. However, the brook trout population is only marginally established, and drought conditions impact Mineral Spring Brook more severely than other Forest streams. It is possible that restoration could improve habitat, creating conditions where brook trout could survive drought, but this stream would not be a priority for the initial phase of restoration work.

Storm King Clove is not stocked by the DEC and its waters are cool and clear, but summertime flow is low and the stream is susceptible to drought. The stream could be evaluated for future restoration efforts since it is on permanently protected land and has many of the suitability factors for brook trout habitat. It appears that groundwater springs provide consistent cold water to at least a few of the deeper pools through the summers.

V. Next Steps

Black Rock Forest Consortium is committed to future work in the following two areas:

1. **Identifying and preserving unique genetic strains within the Highlands.** Consortium scientists may in the future take on a primary research challenge posed by existing brook trout in the Hudson Highlands: does this region have wild strains that have demonstrated survivability over long time periods? If researchers perform the genetic analyses that can answer that question, it may be worth an investment of public and private resources to ensure that the native genetic background of this species does not become extirpated in southern New York. A promising next step would be coalescent analysis of Torne and Timp Brook strains to more fully understand the genetic heritage of these putative ancestral populations, along with genetic testing of the other populations described in this assessment.

2. **Study brook trout habitat requirements within the Highlands.** As an educational program, Consortium staff continue to improve riparian conditions for the brook trout populations in Black Rock Forest streams, planting trees, enhancing breeding pools, and attempting to improve stream flow where possible. The Consortium involves students from many of its 23 member institutions in this initiative through conservation internships and short-term projects. While the focus of these Forest programs is educational, there is interest in understanding what

conditions might increase likelihood of brook trout reproduction and re-establishment. The Consortium is committed to promoting awareness of brook trout habitat requirements, while working with scientists to find funding for research on potential remnant heritage strains, and assisting with next steps if these strains are determined to be of value for restoration.

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