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A Preliminary Habitat Suitability Analysis for Brook Trout in Black Rock Forest, NY

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Salvelinus fontinalis (eastern brook trout) has been located throughout the eastern United States' coldwater streams and lakes since the last glacial retreat, but their habitats and populations have been decimated throughout the area due to various human-induced changes to the physical, biological and chemical habitat. A major technique used to reintroduce and stabilize the *S. fontinalis* population is stocking, in which farmed brook trout are introduced into the streams and lakes with the hope they will take to the habitat and naturally repopulate the waterways with offspring. One such place is Black Rock Forest, located in the Hudson Highlands of New York, situated just north of West Point Military Academy and adjacent to the Hudson River. Factors affecting brook trout population density and prosperity were analyzed at twelve locations within the forest. These factors were analyzed to determine what locations were optimal for a viable brook trout population. The primary factors negatively affecting the *S. fontinalis* population were water depth and width of the streams as well as the frequency of droughts. The factors contributing to a suitable habitat for brook trout included a self-sustaining water depth as well as turbidity levels and shade coverage. This is the first study to look at the efforts to reintroduce brook trout to the streams of Black Rock Forest. Previously, only casual observations have been noted informally; these casual observations included the absence of naturally bred brook trout within the forest's streams. Thus, the stocked *S. fontinalis* have not been shown to reproduce within the streams of the forest since the implementation of stocking. Data I collected during the summer of 2010 suggests that stocked fish are reproducing in two of the twelve tested locations. Based upon this finding, the other factors measured can be further ranked in order of importance for the viability of a brook trout population. Site manipulations were also suggested and analyzed for the improvement of the overall site in order to better suit brook trout and their repopulation without negatively affecting the natural environment of the local forest. Major solutions include the defragmentation of the streams by removal of rocks, boulders, fallen branches and logs as well as the construction of paths from the lakes within the forest to these streams using instream structures such as weirs, channel blocks and deflectors.

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Introduction

Anglers and ichthyologists have long been enthralled by the technique of introducing stocked fish species into native waters and the difficulty paired with this stocking (Nasmith *et al.*, 2010; Spoelstra et al., 2008; Donovan et al., 1997; Teixeira et al., 2007; Pearsons et al., 1999). The eastern brook trout (*Salvelinus fontinalis*), commonly just referred to as a brook trout or brookie, is one of the most common fish species that are stocked in native waters. It is a bespeckled freshwater species with a bright orange belly during spawning season (Figure 1). Its native range consisted of more than half of the southeastern coast of Canada, New England to Pennsylvania and tracts in northern Georgia, extending westward to the Great Lakes (Fish and Wildlife Service, 1982). Despite its sensitivity to environmental conditions, it is one of the most resistant fishes in the northern hemisphere (Karas, 2002). However, extreme deforestation within their natural range has led to an increase in pollution, siltation and stream warming (Fish and Wildlife Service, 1982). Consequently, the brook trout's native range has been reduced and its population severely devastated (Trout Unlimited for the Eastern Brook Trout Joint Venture, 2008). This includes a heavy reduction of population within New York State (Fish and Wildlife Service, 1982)

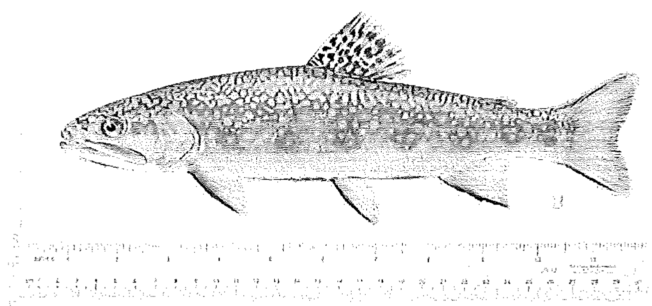

Figure 1 Brook Trout. The fish is known for its bespeckled composition along its flanks The male is especially colorful and bright during spawning season. The adult brook trout averages about fourteen inches (Cornell, 2010).

(Figure 2). Brook Trout trickle through small streams and creeks; they live in larger streams and

Brook Trout Population Status in the Eastern U.S. Range by Subwatershed

(See pages 18-19 for a larger map)

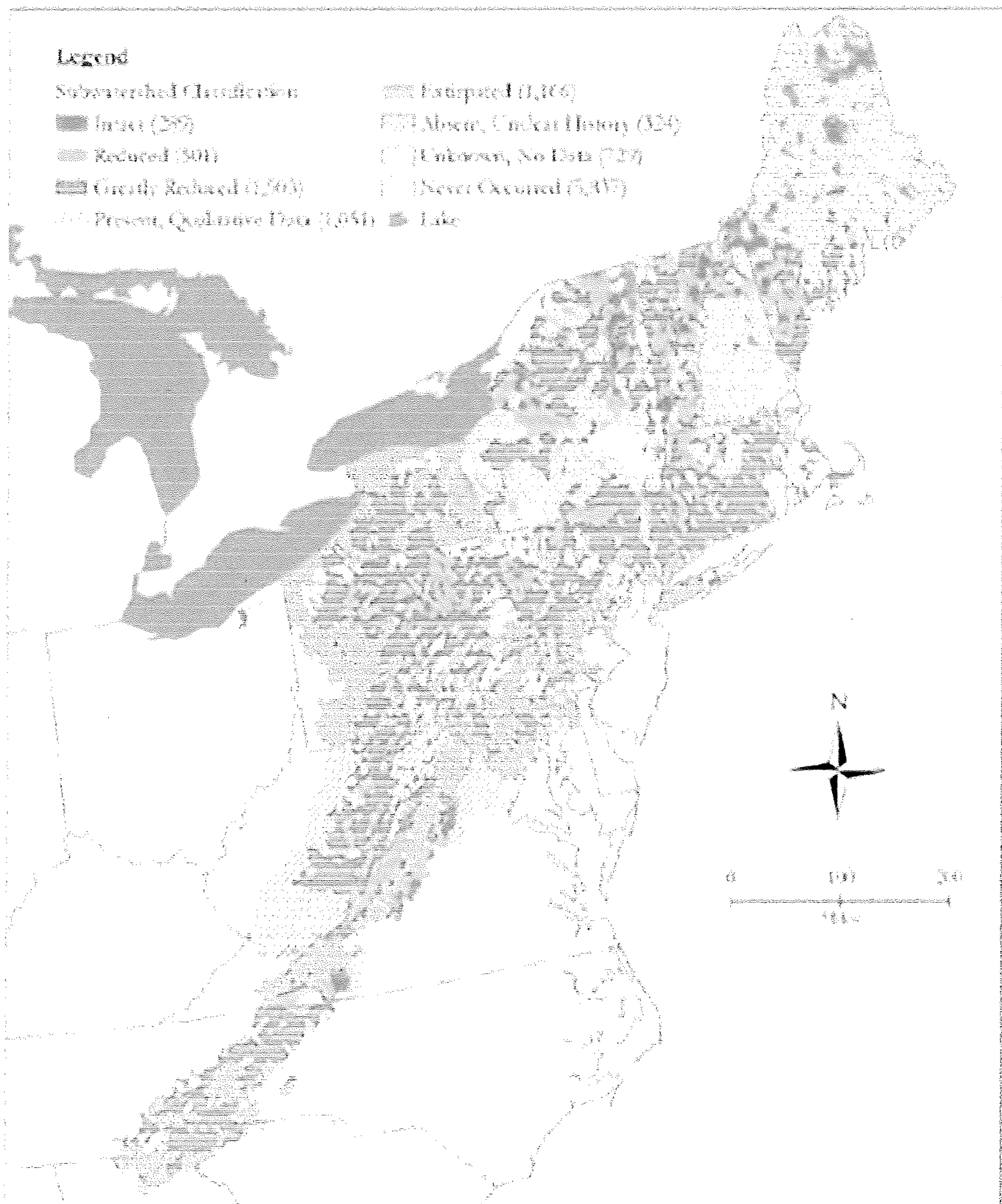

Figure 2. Brook Trout Habitat Range Map and Affected Population Densities. (Trout Unlimited for the Eastern Brook Trout Joint Venture, 2008)

lakes as well as small rivers. They can even survive in big rivers with tumbling falls and fast rapids. Brook trout are even found in brackish streams, purely saline bays as well as the oceans (Poplar-Jeffers, Petty, Anderson, Kite, & Strager, 2009). *S. fontinalis* can survive in many severe physical conditions (Karas, 2002). Brook trout can endure these extremities because of their anadromous nature. They flow with the movement of the water, utilizing minimal amounts of energy (Morinville & Rasmussen, 2006). As they flow along with the current, they catch their food and find pockets of safety for themselves. With the human development of the brook trout's natural habitat and the increase in sport fishing, however, (Doe, 1916), the brook trout population has been decimated throughout the northeast (Trout Unlimited for the Eastern Brook Trout Joint Venture, 2008). Even though the brook trout is a hardy fish, the magnitude of ecological changes and pollution within its natural habitat have been so great that the brook trout species have been wiped out in many parts of the Northeast. And many restocking efforts of brook trout have seen little success because of this magnitude of environmental problems as well as the extremely low survival rate of the stocked, farm-raised brook trout. This low survival rate can also be attributed to the lack of competitive survival skills which many farm-raised species lack. The farmed brook trout did not need to develop these competitive survival skills because they were protected from predators in the farms. They also were given all necessities; they were fed on a regular interval and raised in optimal habitat conditions (Pearsons & Hopley, 1999). When these farmed fish are stocked in streams and rivers, it can be expected that they will lose half of their body mass due to the disappearance of their safety buffers (John Brady, Forest Manager of BRF).

Habitat Index

One of the most influential factors that affect brook trout population viabilities is water temperature. Karas (2002) has argued that water temperature is the defining factor in determining the distribution of brook trout over their range. As the waters warms to 69 or 70F, the brook trout will move upstream in search of cooler water (Xu, Letcher, & Nislow, 2010). Brook trout can survive in waters with a temperature between 32 F and 72F; however, if the water temperature rests in either the lower or higher parts of this range, their reproductive capabilities start to decrease and eventually fail. This causes the brook trout to grow much slower and reach maturity much later (Teixeira & Cortes, 2007). The optimal temperature range is between 55F and 65F (Fish and Wildlife Service, 1982). It is for this reason that the brook trout migrate upstream for the summer (looking for cooler water temperatures) and downstream for the winter (looking for warmer water temperatures) (Xu, Letcher, & Nislow, 2010). The amount of dissolved oxygen is directly related to the temperature of the water. Colder water can contain dissolved oxygen, while warmer water typically has less dissolved oxygen. Brook trout require a large amount of dissolved oxygen; thus, they can usually be found in pools directly after any rapid or falls, where oxygen from the air has been pushed within the water by the falling stream of water (Fish and Wildlife Service, 1982). Although water temperature is extremely important, the most important factor is water depth according to Forest Manager John Brady. It is the one factor that is a necessity for brook trout, while all other parameters are only sufficient. A minimal depth of seven inches is needed to support brook trout, although much greater depths are preferred (Fish and Wildlife Service, 1982). Brook trout are also sensitive to pH levels of the water. They can survive in pH levels of 4.1-9.5

(Fish and Wildlife Service, 1982). Other parameters that affect the viability of a brook trout population include velocity, soil temperature, air temperature, conductivity, shade, bottom composition, and the biodiversity of species within the stream as well as vegetation outside the stream (Fish and Wildlife Service, 1982).

The brook trout's diet varies from that of an herbivore to an omnivore to a cannibal depending on the stage of life the brook trout is in. As fry and fingerlings, the brook trout consume algae and small pieces of plants. When brook trout become about twelve inches in length, they become piscivorous (fish eating) (Karas, 2002). Their growth is entirely dependent on external conditions such as availability of food, temperature, pH, turbidity and dissolved oxygen levels as well as their overall competition with other larvae and fry for both food and space (Fish and Wildlife Service, 1982).

The Problems with Stocking

A number of factors can negatively affect a brook trout population, from forestry to dams to agriculture, and from beavers to other competitive or predatory species native, non-native, and invasive. Industry and municipal development has proven to be detrimental to the brook trout's habitats and survival (Curry & Devito, 1996). The presence of brook trout indicates that the water quality is very healthy; brook trout disappearance can act as a warning sign that something is going wrong with the habitat and its water (Karas, 2002).

In response to the brook trout population crisis, conservationists alongside scientists and anglers have started stocking streams and rivers with the fish in hopes of restoring the population of a competitive pool of brook trout to their native range (Karas, 2002). Several problems relating to stocking arise. Natural brook trout are more tolerant of temperature differences, and they are more protective of their territory than the stocked brook trout (Karas, 2002). The hatchery fish have a shorter life span, living on average for only a year or two (Karas, 2002). They also migrate to less desirable upper watershed habitats; and, in general, they catch viruses more easily compared with wild brook trout (Karas, 2002).

Black Rock Forest

Brook Trout are a threatened species in many parts of their natural habitat, including in Black Rock Forest (BRF). The forest, located in the northwest of the Hudson Highlands (see , is a 4000 acre research forest, run by en environmental consortium, whose members include Barnard College and Columbia University as well as other universities and schools. The forest is a mature oak forest with four main streams: Black Rock Brook, Canterbury Brook, Cascade Brook, and Mineral Springs. The forest had a thriving brook trout population until a severe drought hit the forest in the 1960s, which caused all of the streams to dry up, thus eliminating the brook trout population. For decades, even after the streams regained their footing within the forest, the brook trout population never had an opportunity establish any kind of population. No sustainable population has been recorded before

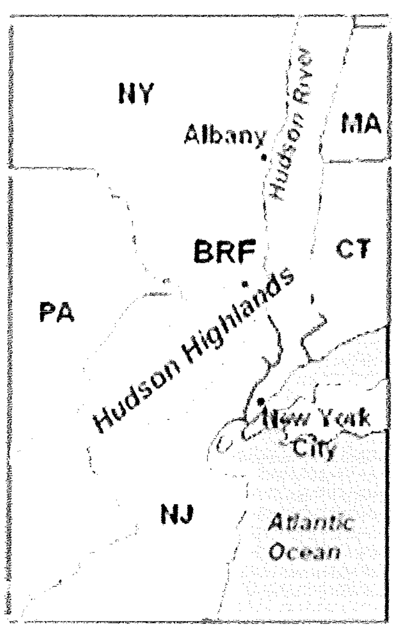

Figure 3. Map of BRF within the Hudson Highlands and the Northeast. (Brady, 2010)

this paper's research.

Starting in 2003, Forest Manager John Brady began importing stocked brook trout from brook trout he had caught in the Adirondacks and deposited about six hundred stocked brook trout in the four streams of the forest every Spring. He later began importing stocked brook trout from the Cold Spring Harbor Fish Hatchery. Between April and September, he stocks Black Rock Brook with one thousand; Canterburry Brook with three-five hundred; Cascade Brook with 200; and Mineral Spring Brook with 200. Brady also stocks the ponds of the forest. One thousand in Arthur's Brook (the area between Arthur's Pond and Aleck Meadow); five hundred in the Upper Reservoir; five hundred in Aleck Meadow; and five hundred in Arthur's Pond. Thus, every year, almost five thousand brook trout are stocked in this forest. Brady receives the farmed fish and keeps them in his aquatic room, which is filled with tanks of brook trout, each one containing hundreds of small brook trout fingerlings. He raises the brook trout, feeding them and protecting them from the natural environment until they reach a length of about four inches. The brook trout deposited are defined as fingerlings, each about four inches long. Efforts to repopulate the streams with brook trout were ambiguous; success was not known. Stocked fish could shrink to half their original size as a result of forced survival. Only brook trout smaller than forty millimeters found in the streams could be known to be the successful result of reproductive efforts according to Forest Manager John Brady.

Habitat Manipulation

Forest managers and conservationists often alter the habitat in order to increase the population size or the individual size of a targeted species. Many different techniques exist to proactively propel these species to dominate the natural habitat or at least have a viable population within the habitat. Log weirs have been a popular technique used by many to manipulate streams and small rivers (Gowan, 1996) as well as channel blocks and deflectors (Lutz, 2007).

Thesis Statement

I analyzed data I collected from the summer of 2010 to determine the optimal locations for brook trout viability within Black Rock Forest. I hypothesized that Black Rock Brook would have the greatest suitability for the brook trout. This stream is the most continuous stream within the forest. It also has the greatest average depth for the brook trout to inhabit; this stream rarely dries up. I also hypothesized that Canterbury Brook would have a low viability level for the trout and Mineral Brook will have a low suitability for brook trout as well. Canterbury Brook is fragmented; only small, shallow pools exist. Also, there is very little shade to protect the Brook Trout from the dangers of the heat from the sun. Cascade Brook has a deep, continuous run of water. However, the water is very polluted with fine material, suggesting that the water lacks adequate supplies of oxygen for the brook trout. Mineral Spring should be unsuitability for the brook trout as the brook regularly dries up several times during the year, providing no habitat for the brook trout. Finally, I hypothesized that some repopulation of brook trout will have occurred naturally within Black Rock Brook.

Methods

Two aspects of the repopulation project were measured and critiqued. First, the success of the repopulation project was determined. This was done by cataloguing brook trout population densities at three sites within each of the four streams of the forest. Site locations at each stream were determined

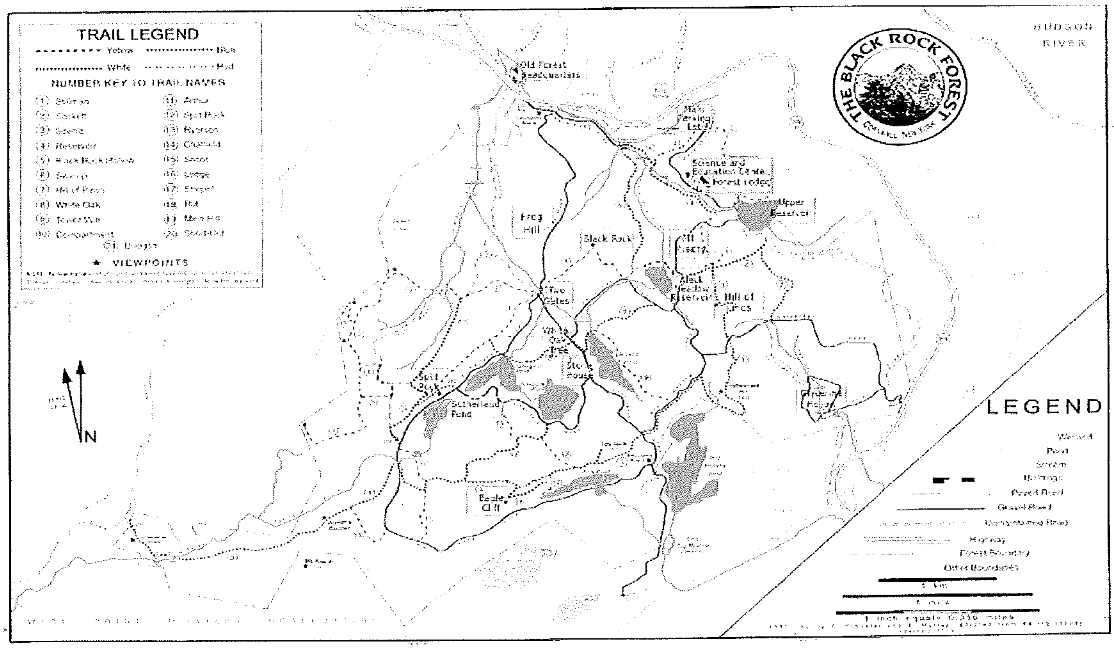

Figure 4. Map of Black Rock Forest. Red dashes indicate site locations. Altered. (Brady, 2010)

by the distance from stocking sites; sites where brook trout had been stocked were preferred and chosen (Figure 4).

Population counts were done at each of the sites with two separate functions. The first population count was done when stocking the location with brook trout in early June. The second population count was done before the stocking process to determine the qualitative viability of the stream site for brook trout. We were trying to determine if there were any brook trout in the stocking locations before we added brook trout to the location. During these processes the length of each brook trout was measured in order to see if any stream-born brook trout existed at any of the sites. Although not all brook trout with a length greater than forty millimeters are necessarily stocked survivors, brook trout with a length less than forty millimeters can be positively identified as stream-born brook trout.

The non-stocked brook trout catalogue was performed by electrofishing and seining. An electrofisher was used at one of the sites. This process involved using an electrofisher in the water. This created a current in the water that shocks the fish; the brook trout then come to the surface paralyzed and were caught by fishing nets. The electrofisher was set at 75 Voltage and 20 amps for 420 seconds (seven minutes). The fish were placed in tubs filled with water. Each one was measured for its length; its species name was also noted. The fish were then placed back into the stream. Every other fish species or amphibian was also noted and measured for its length and mass. The fish and amphibians were measured by a standard metric ruler in millimeters. They were massed by a balance. Measurements were recorded on site and transferred to an excel worksheet the same day. Seining was used alongside the electrofishing. A seine net was placed downstream, where, after the fish were shocked, they accumulated on the net. These fish were also placed in buckets; they were then measured for their length. This process allowed us to analyze the repopulating efforts of the brook trout. If any of the brook trout were smaller than forty millimeters, then they were born within the stream and were not stocked fish. Also, the population numbers of the brook trout could tell us of the survival rate of the brook trout.

The second part of the study included analyses of the physical parameters of the streams. Several parameters of the streams were measured to conduct the analyses. The temperature of the stream was measured using a thermometer. The temperature of the nearby soil on the banks of the stream was measured as is the temperature of the air. The pH level of the stream was measured using a pH meter. The conductivity and oxygen levels of the stream were measured using digital meters. The depth of the stream was measured using a meter stick; the width and length of the streams were also measured using a meter stick. The velocity of the stream was measured with a flowmeter. Turbidity was qualitatively measured by its clarity and ranked as a percentage (Wildman & Neumann, 2003).

Vegetation catalogues of the banks were conducted. Vegetation surrounding the site location was cataloged as present. Shade coverage of the sites was conducted using an optical camera and the appropriate computer program.

An index of optimal levels of all these parameters for brook trout has been published by the Wildlife and Fish Services (Fish and Wildlife Service, 1982). The parameters at the sites were ranked from 1 to 9 based upon the published levels (Rense & Scott, 2010). Sites that lacked water and had consistently shown to lack water throughout the year were termed as restricted and were automatically eliminated from being designated as suitable in any regards. The worst sites and mediocre sites were determined, thus allowing changes of certain parameters to be made for the benefit of the brook trout. The measurements and catalogues were taken during June and July, the most burdensome part of the year for brook trout. These harsh conditions allow us to see the viability of brook trout in the hardest environment that they would have to survive in (Nehring, 1993).

Results

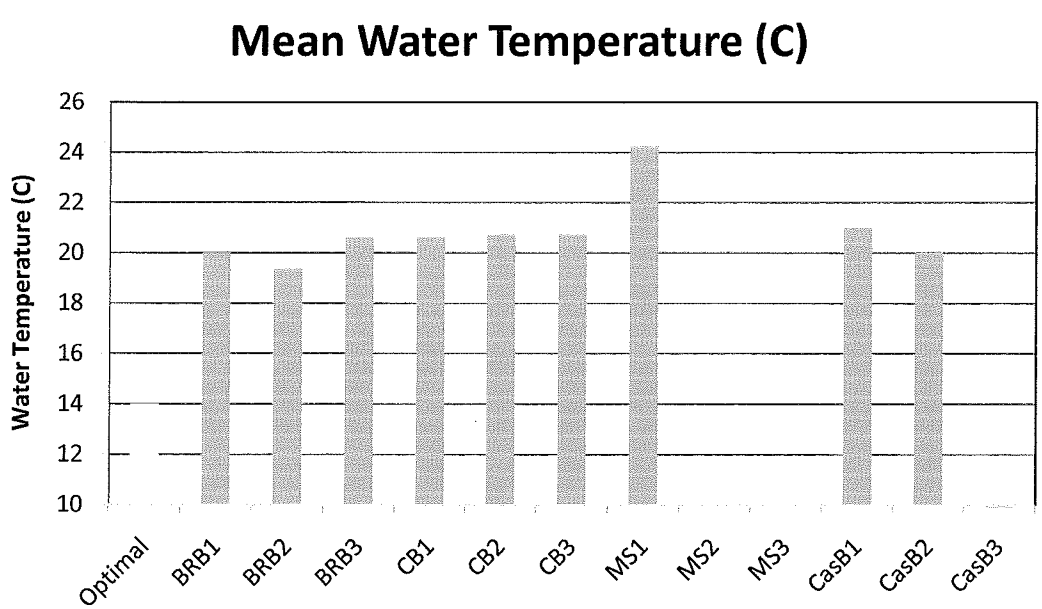

Figure 5. Average water temperature. Each site's mean water temperature was calculated and compared with the optimal temperature level for brook trout. Sites MS2, MS3 and CasB3 are not shown with a bar in the graph because no water existed at these sites.

The optimal water temperature for brook trout is 14 C (Fish and Wildlife Service, 1982). All of the sites that had water had average water temperatures that were above the optimal level (Figure 5). They ranged from 19 C to 24 C; this range of water temperature is at a poor and even detrimental temperature level for the survival of brook trout.

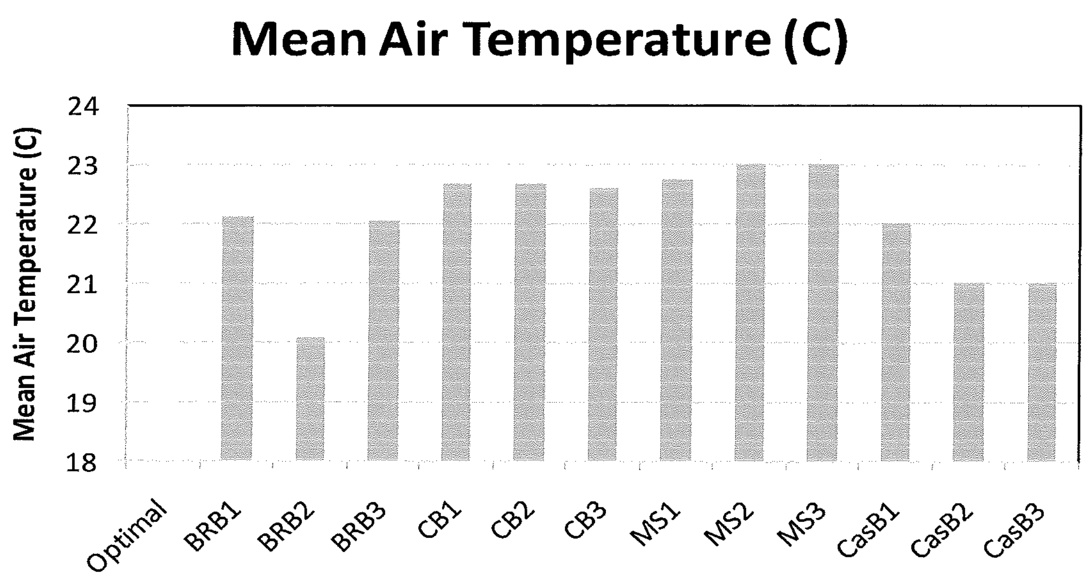

Figure 6. Average air temperature. Each site's mean air temperature was calculated and compared with the optimal air temperature level for brook trout.

The optimal air temperature for brook trout is 23.5 C (Fish and Wildlife Service, 1982). The optimal range can be between 22 C and 25 C (Karas, 2002). Nine of the twelve sites were within this optimal range; these included all of Canterbury, Mineral Spring, one of Cascade Brook and two of Black Rock Brook (Figure 6). Two of the Cascade Brook sites had temperatures of 21 C, which falls slightly below the optimal range; this temperature still is a good level for the survival and viability for the brook trout (Figure 6). Black Rock Brook 2 had an average temperature of slightly above 20 C. Again, although not within the optimal range, 20 C still falls within a healthy, suitable air temperature range for brook trout.

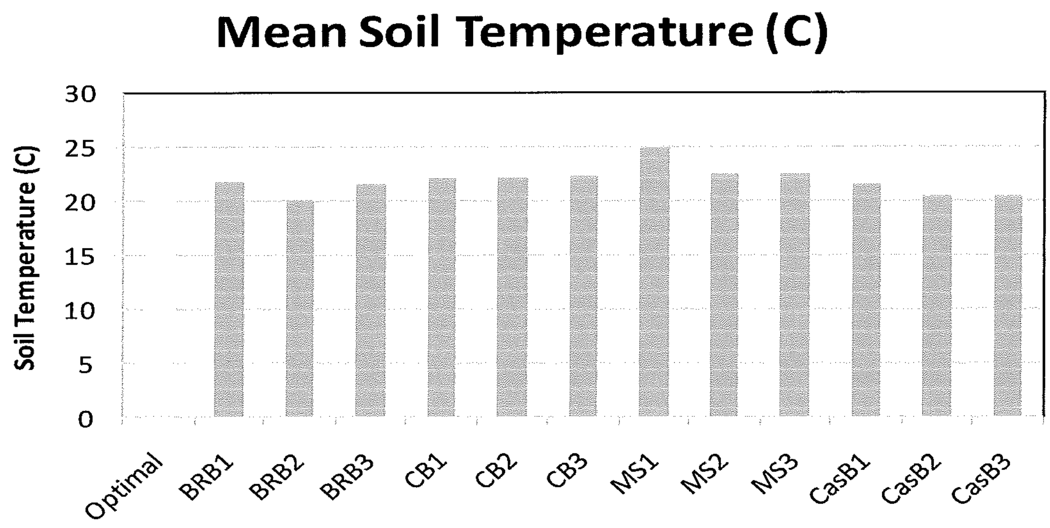

Figure 7. Average soil temperature. Each site's mean soil temperature was calculated and compared with the optimal soil temperature for brook trout.

The optimal soil temperature for brook trout is 22 C (Fish and Wildlife Service, 1982), with an optimal range of 21 C to 23 C (Karas, 2002). Eight of the twelve sites are within this optimal range, including all of Canterbury's sites, two of Black Rock Brook's, two of Mineral Spring's, and one of Cascade Brook's. The remaining four sites fall just shy of the optimal range (Figure 7).

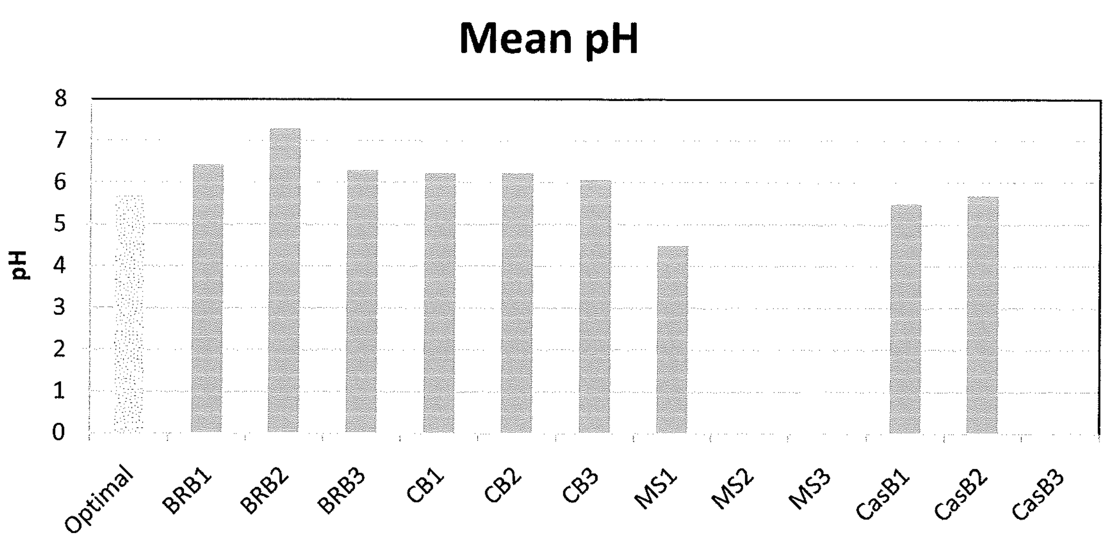

Figure 8. Average water pH of each site compared with the optimal pH for brook trout.

The optimal pH level for brook trout is 5.7 (Fish and Wildlife Service, 1982). Eight of the twelve sites contained optimal levels of pH; these included all of Cascade's, all of Canterbury's, and two of Black Rock Brook's. The last Black Rock Brook's fell slightly too high on the pH scale. Mineral Spring 1 fell slightly too low on the pH scale. Mineral Spring 2 and 3 could not be measured for pH because of their lack of water (Figure 8). MS2, MS3 and CasB3 do not have results because these sites did not have any water.

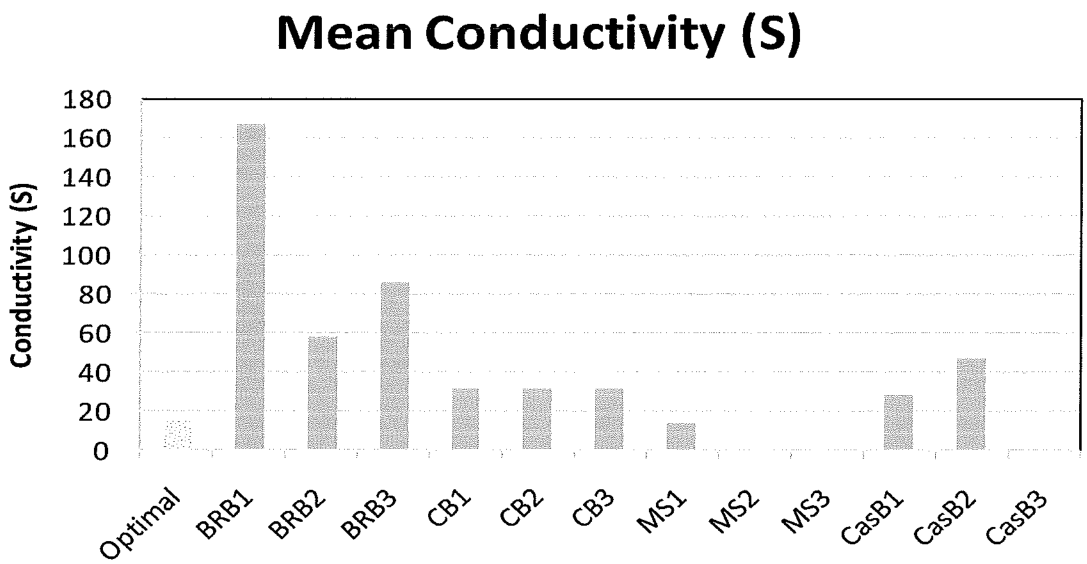

Figure 9. Average conductivity. Each site's mean conductivity was measured and compared with the optimal conductivity level for brook trout.

The optimal conductivity for brook trout is 15 S (Fish and Wildlife Service, 1982); the optimal range includes 10 S to 50 S (Karas, 2002). All water-present sites in Canterbury, Mineral Spring, and Cascade were within this range. All three sites of Black Rock Brook were well outside of this range, at 60 S, 85 S, and 165 S. These conductivity ranges are not suitable for brook trout. MS2, MS3 and CasB3 do not have results because these sites did not have any water (Figure 9).

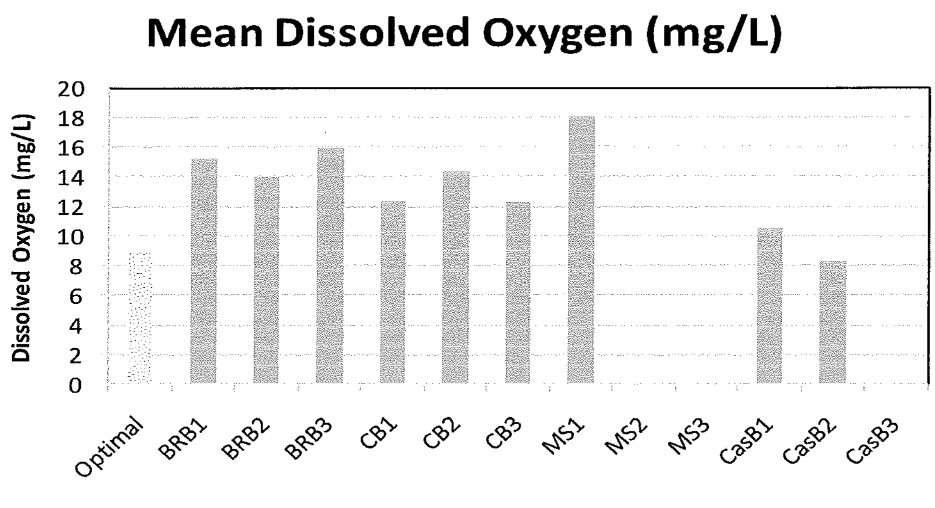

Figure 10. Average dissolved oxygen. Each site's mean dissolved oxygen (DO) was measured and compared with the optimal DO level for brook trout.

The optimal dissolved oxygen level for brook trout is at least 9 mg/L; the range is from 9mg/L to upwards (Fish and Wildlife Service, 1982) (Karas, 2002). All water-present sites were within this optimal range (Figure 10).

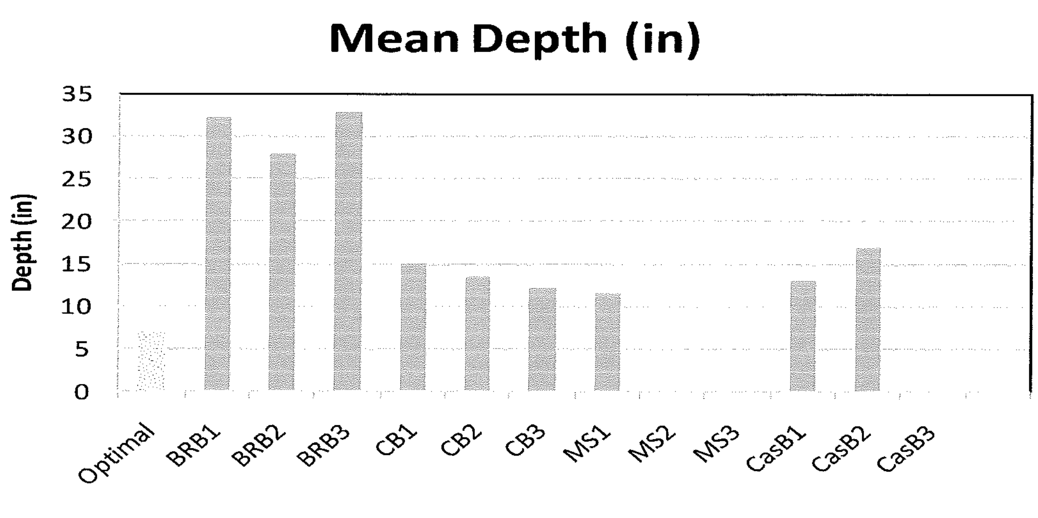

Figure 11. Average water depth. Each site's mean water depth was measured and compared with the optimal depth for brook trout.

The optimal depth for brook trout is at least seven inches. Anything greater than seven inches fits within the optimal range for brook trout (Fish and Wildlife Service, 1982) (Karas, 2002). All water-present sites fell within the optimal range (Figure 11).

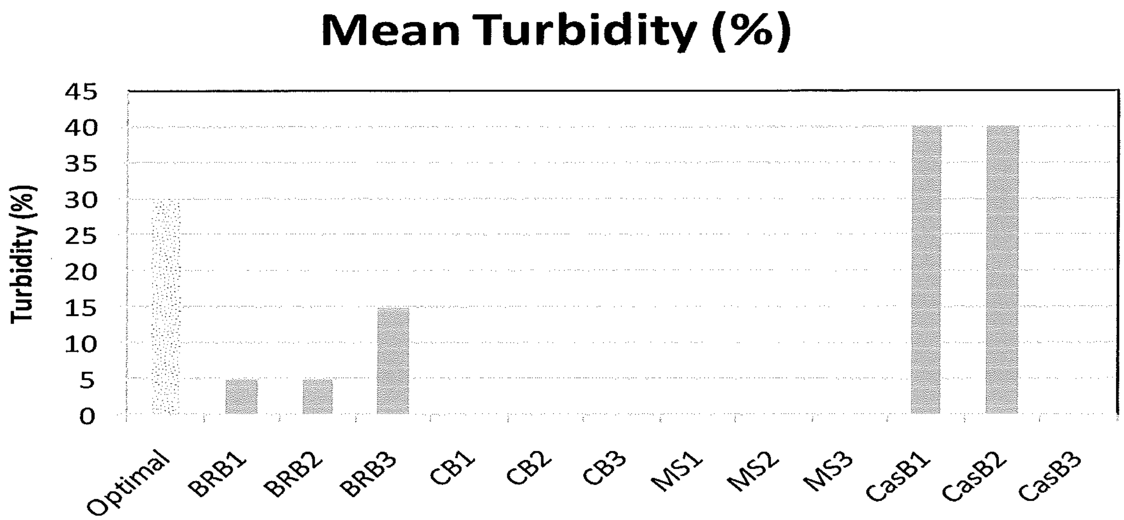

Figure 12. Site Turbidity. Each site's mean turbidity was estimated and compared with the optimal turbidity for brook trout.

The optimal turbidity level for brook trout is at about 30-50 percent clarity (Fish and Wildlife Service, 1982). Cascade Brook 1 and 2 fell into this optimal range (Figure 12). All other sites fell below this range, from 15 percent to 0 percent. CB1, CB2, CB3 and MS1 had zero turbidity. MS2, MS3 and CasB3 had no results because these sites had no water present.

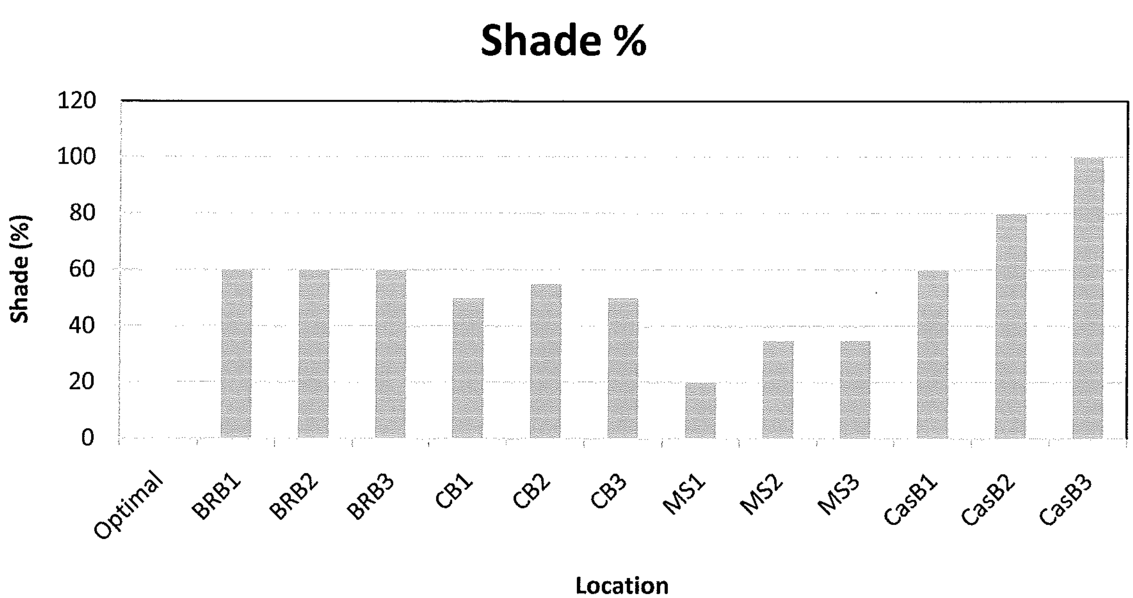

Figure 13. Shade Coverage. Each site's shade coverage was measured and compared with the optimal shade coverage for brook trout.

The optimal shade coverage for brook trout is one hundred percent (Fish and Wildlife Service, 1982). CasB3 matched the optimal level of one hundred percent (Figure 13). Every other location fell below the optimal level. Overall, the Cas sites were the best suited for brook trout. They ranged from sixty percent to one hundred percent. The BRB sites were all at sixty percent. The CB sites were in the fifties. The MS sites were the worst suitable sites. They ranged from twenty to 30 percent (Figure 13).

Velocity levels were measured with a flowmeter. The results of the BRB sites all measured at 0.5ft/s. The CB sites had the same result. MS1 had a velocity of zero or too small to be measured by the flowmeter. The CasB sites had velocities of 0.5ft/s. MS2, MS3 and CasB3 have no results because no water was present at these sites. The slow-moving waterflow of BRB, CB and CasB1(2) is optimal for brook trout at the fingerling level (Fish and Wildlife Service, 1982).

Location (Mineral Brook)	0-40mm	>40mm	Total
CasB1	1	25	26
CasB2	1	18	19

Table 1 Brook Trout Length at CasB1 and CasB2. The number of brook trout cataloged at Cascade Brook. Brook trout less than forty millimeters are indicative of locally born brook trout. Brook trout greater than forty millimeters may or may not be locally born brook trout.

In two of the sites, a single brook trout was cataloged that was indicative of being locally born within the sites (Table 1). This is the first evidence of brook trout reproducing naturally within the forest.

Discussion

The twelve locations were analyzed based upon each one's physical and chemical parameter. The most restrictive parameter was the water depth of the site. The water level should be at least seven inches deep in order to be a viable habitat for brook trout. Anything deeper than seven inches is beneficial to the habitat and the brook trout. Every location excluding Mineral Spring #1, Mineral Spring #2 and Cascade Brook #3 had water depths of at least seven inches. Mineral Spring #1, Mineral Spring #2 and Cascade Brook #3 had no water; they were completely dry. Therefore, these two locations can be excluded from the list of suitable sites for brook trout and their restoration until site manipulation has been conducted. Measurements were taken in throughout the summer season, between June and August, in order to gather parameter levels for the harshest season that brook trout would need to survive through. Thus, water depth levels at these sites would be the lowest during at least part of the entire year, providing no aquatic habitat for the brook trout. Also, given that the summer of 2010 was a particularly dry summer, water depth levels were further exacerbated by the low amount of rainfall.

The next parameter analyzed was the mean water temperature. The optimal water temperature for brook trout is around 15 C (60 F) (Fish and Wildlife Service, 1982). Each site that had water had an average water temperature of about 20 C (68 F) except for Mineral Spring #1, which had an average temperature of 24 C (75 F) (Figure 5). All of these sites therefore had higher average water temperatures than what was optimal for brook trout. These temperatures are at poor levels for brook trout suitability. Mineral Spring #1 is at a dangerously high temperature for brook trout. Although the higher than optimal temperature are present in these sites, other factors can positively contribute to the viability of brook trout at these locations. The +11C water temperature at Mineral Spring #1 can be used to deduce that the site location is unsuitable for brook trout unless changes occur in the physical habitat site.

The optimal soil temperature for brook trout is around 22 C (72 F) (Figure 7) (Fish and Wildlife Service, 1982). Each of the twelve site locations had average soil temperatures of 21-22

C (Figure 7). Mineral Spring #1 was the exception with an average soil temperature of 25 C (77 F) (Figure 7). The soil temperature is one of the two measured parameters that is the least influential for site suitability (the other one being air temperature) (Fish and Wildlife Service, 1982). However, the close range measured for eleven of the twelve sites is still an encouraging sign that these sites share the proper habitat characteristics for temperature range for the brook trout. Mineral Spring #1 exceeds the optimal level by 3C (5 F) (Figure 7); although this difference does not make or break the habitat viability situation, it does create warning signs that the location may be inappropriate for a brook trout habitat. The optimal air temperature for brook trout is around 23 C (73 F) (Figure 6) (Fish and Wildlife Service, 1982). The majority of the sites had an average air temperature of between 22 and 23 c (71-73 F) (Figure 6). Black Rock Brook #2 had an average air temperature of 20 C (68 F), while Cascade Brook #2 and #3 both had an average air temperature of 21 C (70 F) (Figure 6). Again, as noted above, the average air temperature is one of the two least important parameters that are indicative of site suitability (Fish and Wildlife Service, 1982). The majority of sites that closely mimic the optimal air temperature is positive. The other three locations that differ slightly from the rest in average air temperature are in no severe situation. The difference in temperature is slight (only 2-3 C) (Figure 7).

The fourth parameter measured was the pH. The optimal level is 5.5. BRB1 and BRB3 were at 6.5, slightly more basic than is optimal. BRB2 was at 7.5, more basic than is viable for a brook trout population. CB1, CB2, CB3 were all around 6.0. MS1 was at 4.5, more acidic than is suitable. CasB1 and CasB2 were at the optimal level of 5.5 (Figure 8). CasB1 and CasB2 are the best suited for brook trout. BRB2 and MS1 are too basic and acidic to house a brook trout population, respectively. BRB1, BRB3 and the CB sites can all be tolerated by a brook trout population. MS2, MS3 and CasB3 were not measured because not water were located at these sites. These three sites shall be restricted from the rest of the discussion section with the assumption that they are not reported because they could not be measured due to a lack of water.

The fifth parameter measured was conductivity. The optimal level for brook trout is around 15 S (Fish and Wildlife Service, 1982). BRB1 had a high conductivity of 170S (Figure 9). BRB2 and BRB3 had 60 and 80 respectively. All the CB sites were at 30. MS1 was at 15, the optimal level. CasB1 and CasB2 were at 30 and 50 respectively (Figure 9). Conductivity is ranked low in importance for brook trout viability (Cain, Hutchinson, & MacDonald, 1989). Dissolved oxygen was measured as well. The optimal level is at least 8mg/L; higher is preferred (Fish and Wildlife Service, 1982). All locations had greater than 8mg/L, thus promoting the viability of the brook trout (Figure 10). Turbidity was measured. At least a 30 percent turbidity is optimal for brook trout. BRB sites had a turbidity ranging from five percent to fifteen percent. CasB1 and CasB2 had a turbidity of forty percent, surpassing the minimum level of optimality. All other water-present locations had zero turbidity (Figure 12). Shade coverage was measured. Optimal shade coverage is one hundred percent (Fish and Wildlife Service, 1982) because the shade blocks the sun and its warming of the water. CasB1, CasB2 and CasB3 had shade coverage of 60, 80 and 100 percent, respectively. BRB sites had shade coverage of 60 percent. CB sites had shade coverage of 50 percent. MS sites had shade coverage ranging from 20 to 40 percent (Figure 13). CasB sites had the greatest suitability for brook trout in this parameter. BRB and CB sites had relatively decent shade coverage, while MS sites had poor shade coverage. The lack of shade coverage not only warms the water, but it also propels the evaporation of the stream water. Velocity levels were also measured. All water-present sites had optimal water velocities except for MS sites, where the velocity was at or near zero.

The last parameter measured, and the most important parameter measured (Brady, 2010), was water depth. The minimum water depth needed to sustain a brook trout population is seven inches (Fish and Wildlife Service, 1982). All water-present sites ranged from ten to thirty-three inches. MS2, MS3 and CasB3 had zero inches of water (Figure 11). This is the most easily changed parameter. Many different site manipulations can be done to increase water depths and pool size for MS2, MS3, CasB3 as well as the other sites.

Specie surveys were also conducted. No other fish species were noted besides brook trout and black-nosed dace. Black-nosed dace are prey for larger brook trout, so they pose no threat to the brook trout (Skehan, 1998).

The data shows that repopulation of brook trout has occurred naturally within the stream (Table 1). The implication is that the restocking efforts are beginning to work. Two brook trout that measured smaller than forty millimeters were catalogued. Brook trout measured forty millimeters can be positively identified as stream-born brook trout. These two instances occurred once in CasB1 and once in CasB2 (Table 1). These two sites are therefore suitable for brook trout and their repopulation.

By determining the site suitability of Black Rock Forest for Brook Trout, recommendations can be made for the four streams and the surrounding area for the improvement of the habitat to better serve the brook trout. Temperature and turbidity have been prime characteristics in determining the viability of a location for brook trout. With the discovery of natural brook trout within streams that have a very low turbidity with very fine sediment as the bedrock, the characteristics should be reevaluated when determining what is optimal for the brook trout habitat. The project will finally be complete with the successful reintroduction of brook trout within the four streams at Black Rock Forest.

RECOMMENDATIONS

Site management and manipulation has been a common occurrence since the early 1900's in the United States in an effort to replenish the dwindling fish populations throughout the country (Thompson, 2005) (Everest, Hohler, & Cain, 1988). Although many different techniques exist that can improve or restore a habitat, the subsequent restoration of the brook trout population is not guaranteed (Buell, 1986). Moreover, all limitations and risks should be identified with any implementation of management/restoration (Buell, 1986). However, statistically sound evidence pointing to what the limiting factor(s) is in a specific habitat takes years to accumulate (Gowan, 1996). Only a few studies have taken this time-thirteen years- to accurately define the limiting factor(s) (Nehring, 1993). Many papers have concluded that these long-term studies are irrelevant due to the large fluctuations in fish populations (Platts, 1988) (Gowan, 1996).

A major solution is the implementation of log weirs in the streams (Figure 14 and 15). Log or boulder weirs are a useful tool used to improve the habitat for aquatic plants and animals. Logs and boulders can be placed at the bottom of a stream or river, lacing their way across the width of the body of water, effectively creating a type of dam. This checks the water and allows for water levels to rise to more optimal depths. This technique can be used for diversion purposes as water is channeled to the various streams from the ponds and lakes within Black Rock Forest. Furthermore, this technique can collect and retain gravel to create the perfect spawning habitat for brook trout (Gowan, 1996) (MacDonald, Cain, & Heller, 1987). The weirs also deepen existing pools, create new pools below and above the structure, traps other sediment, aerates the water to effectively increase the level of dissolved oxygen, and promotes the deposition of organic debris effectively increasing the turbidity of the water as well as increasing the food supply for brook trout (Stream Corridor Restoration Handbook, 2010). These logs and boulders would ideally be obtained from the local environment. BRF is abundant with both. If anything, using the massive amounts of logs and boulders that permeate the forest would not only help in the creation of these weirs, but it would also reduce the forest fire danger since these logs are prime sources of fuel. A major limitation in the creation of weirs is the eventual rotting of the logs and the breakdown of the system. This can be avoided with the upkeep of the weirs by the forest manager and staff.

Due to the relatively low flow that exists within all of the four streams of the forest, log weirs are recommended over boulder weirs due to the latter's low permeability. However, boulders may be used alongside logs. The boulders used should be angular and larger than those rocks in the actual stream. The logs should come from a durable native species conveniently located in the forest. The best tree species include redwood, cedar, western laurel, aspen, cottonwood, and white fir (Stream Corridor Restoration Handbook, 2010). Black Rock Forest contains a few of these, including eastern red-cedar, quaking aspen, big-toothed aspen and cottonwood. However, the forest is dominated by oaks and maples, and these other species are erratic in their presence. The use of oak and maple logs would require a more frequent upkeep of these weirs, but there is an abundance of these tree species near the four streams, making it relatively easy to transfer the logs from the earthed ground to the streams. These natural logs should be used instead of commercially treated logs (Lutz, 2007). Furthermore, the combined logs and boulders need to be long enough to cover the entire width of the stream as well as reach several feet further on both sides. The recommended width is twelve feet longer than the stream's width on either side (Stream Corridor Restoration Handbook, 2010), but due to the relatively small width of the streams, the length could probably be cut down in half to at most six feet on either side. Due to the relatively small width and size of the streams, logs used should only have a width of six inches (Lutz, 2007). The installation of the actual weir should be conducted as non-invasively as possible with little disturbance to the stream as is possible given the situation. The weir can be built in two ways. The first should be used in the actual stream to create pools. The weir should be placed perpendicular to the flow of the water. The second form should be used to divert water from the ponds to the streams. The weir would be built at a diagonal angle to the flow of the water (Stream Corridor Restoration Handbook, 2010). The logs used in the weir should be submerged as much as possible to slow down the rate of rot. Furthermore, the logs should be trenched between three to five feet into the bank off the stream to ensure the structure does not easily dismantle itself due to natural factors (Lutz, 2007). The logs can be permanently trenched into the stream bed by drilling and pinning with rebar (reinforcement bar) about every few feet along the long (Lutz, 2007). If boulders and rocks are used, to prevent them from dismantling from one another, they should be cabled together and anchored to fixed features.

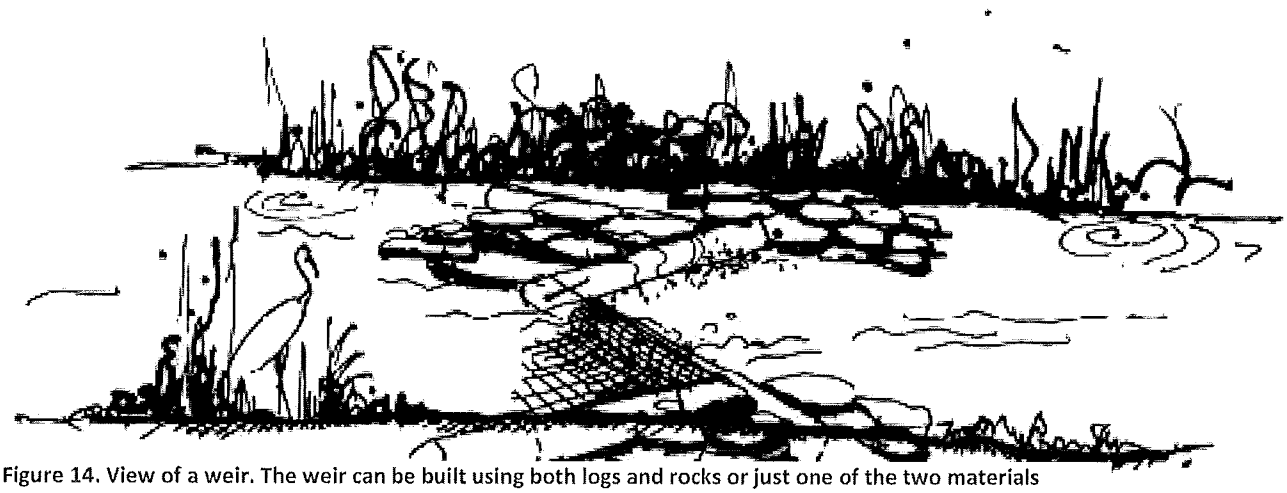

Figure 14. View of a weir. The weir can be built using both logs and rocks or just one of the two materials depending on the situation (Stream Corridor Restoration Handbook, 2010).

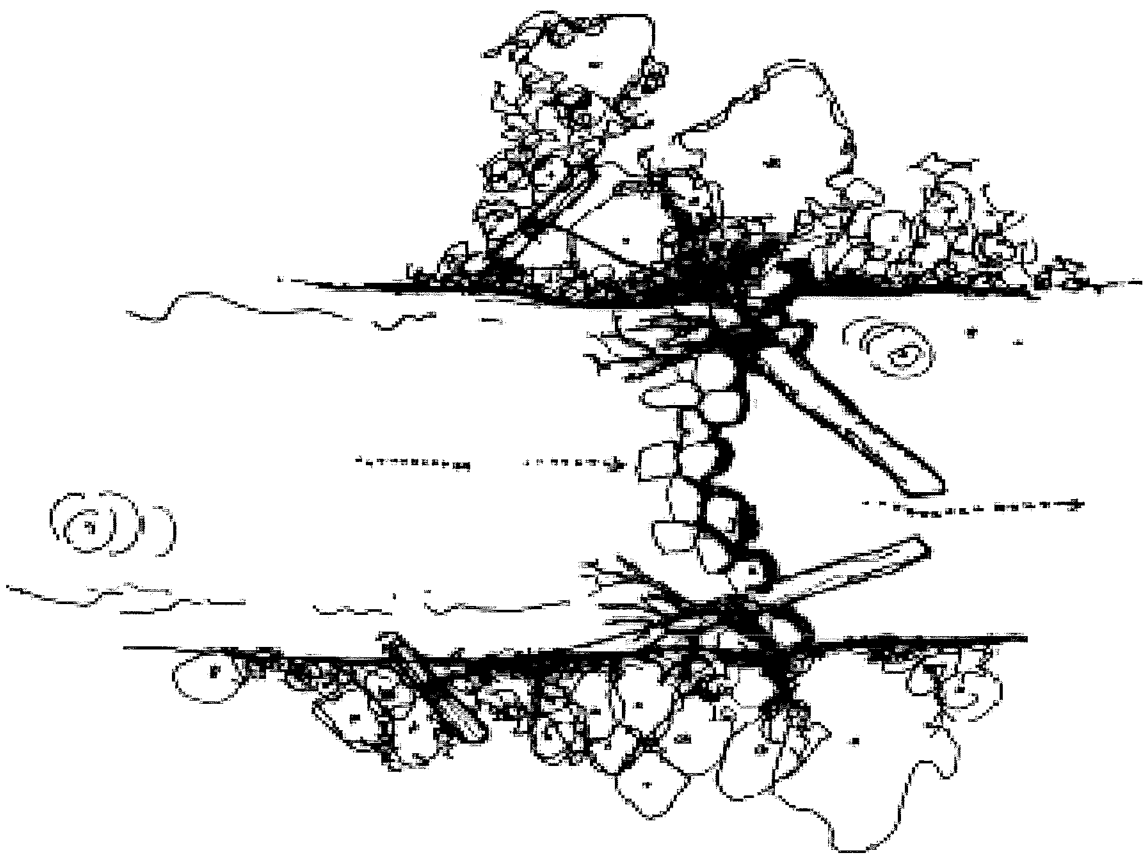

Figure 15. Ariel view of the weir from Figure 14.

Many studies have been conducted to test whether weirs are beneficial to maintaining fish populations. Generally, the weirs increased the mean depth, pool volume, total coverage, and the proportion of fine-sediment within one to two years (Gowan, 1996). The abundance and size of the fish also increased (Gowan, 1996). Streambed boards should be paired with weirs (Lutz, 2007). Rough-cut hemlock boards are typically used with a thickness of one inch. The boards should be at least six inches wide and long. Narrower and shorter boards easily break (Lutz, 2007). Like the logs, the boards should be completely submerged under the water to slow the rotting process (Lutz, 2007) (Gowan, 1996).

In addition to these weirs, other infrastructures can be used to alter the stream parameters and direction of flow including sills, diggers, wings, and diagonal series (Cain, Hutchinson, & MacDonald, 1989) (Shaw, Umatilla River Basin Anadromus Fish Habitat Enhancement Project, 1995) (Bonneville Power Administration, 1997). These techniques have also seen great success in the creation of suitable habitats for fish species (Medal, Hohler, & MacDonald, 1988). These instream structures should never be built higher than the elevation of the stream's banks or the bankfull; they should also always be built slightly at an upward slope from the stream (Lutz, 2007). The bankfull can be easily identified by the habitat's shape and the streams apparent cutting channel (Figure 16). The bankfull water flow can be used most effectively to altar water channels and should always be the first spot to build alteration constructions (Lutz, 2007).

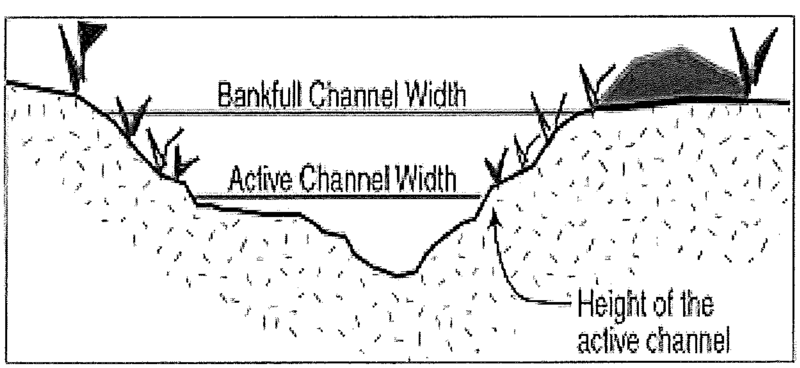

Figure 16. Bankfull cross-section view. The bankfull is usually above the actual active stream level (Lutz, 2007).

Riparian fences is another technique that can be used to prevent deer and other large mammals from destroying the banks of the streams (Smith & Brown, 1990) (Shaw, Umatilla River Basin Anadromus Fish Habitat Enhancement Project, 1994) . Irrigation withdrawal screens is another technique (Smith & Brown, 1990) that although traditionally used to keep fish out of irrigation canals can be used to keep brook trout out of unsuitable parts of the various streams. These techniques cannot be successful unless paired with constant maintainance (USDOE Bonneville Power Administration, 1994). The placement of large rocks into larger sections of the streams can enhance the aquatic habitat as well. The water flow will scour a deeper pocket around the rocks, creating a nice cover for the brook trout (Lutz, 2007) (Figure 17). These rocks should be large enough that they will not be moved by the stream. They should also be placed in the middle of the stream and not near the

Figure 17. Boulder Placement. Boulders and rocks can be used as management tools to enhance the habitat for aquatic species (Lutz, 2007).

banks (Lutz, 2007). Deflectors, another tool, can be used to narrow the stream channel and thus deepened the water depth of the stream (Figure 18) (Lalo & Lutz, 1994). The deflectors are places at a thirty degree angle in order to prevent damming from occurring while simultaneously providing a nice small habitat for the brook trout against the structure; a sixty degree deflector is paired with the thirty degree structure in order to channel any water back into the stream (Figure 18). These deflectors can be constructed with different materials. One option is to use stones, thus creating an irregular rip-rap formation. Logs can be used alongside the stones to create log-faced deflectors (Figure 19). One of the bigger problems with the four streams in BRF is the low-flow of the streams. A relatively easy solution is the diversion of the water from the lakes and ponds in the forest to the stream channels. This can be easily done by the construction of log frame channel blocks (Barbour, Gerristen, Snyder, & Stribling, 1999). The block is constructed by placing two parallel logs along the proposed channel path, slowly building on this structure with perpendicular branches and

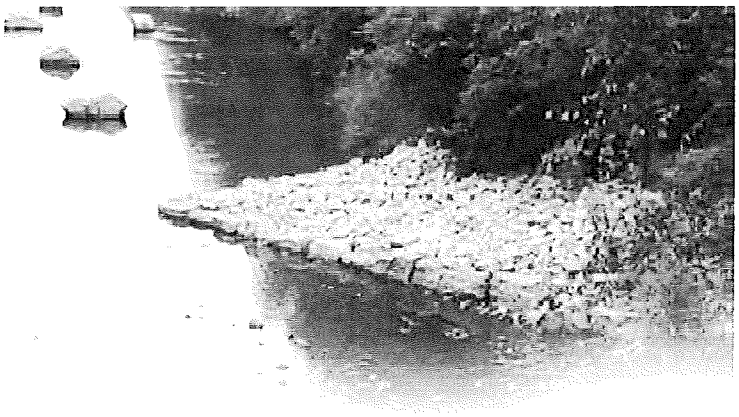

Figure 18. Deflector. These deflectors can be built alongside the river or stream to proactively direct the direction of the waterflow as well as create side coverage for brook trout (Lutz, 2007).

Figure 19. Log-faced deflector. Deflectors can be made from both rock sand logs as well. The log takes more time to maintain as it will slowly erode and decompose (Lutz, 2007).

smaller logs. Finally, boulders and stones are placed within this structure. The entire structure thus blocks water flow from a specific direction and diverts it to another direction (Figure 20). Stone channel blocks can be constructed as well. These are entirely made up of stones and boulders. These are usually used for larger streams (Lutz, 2007).

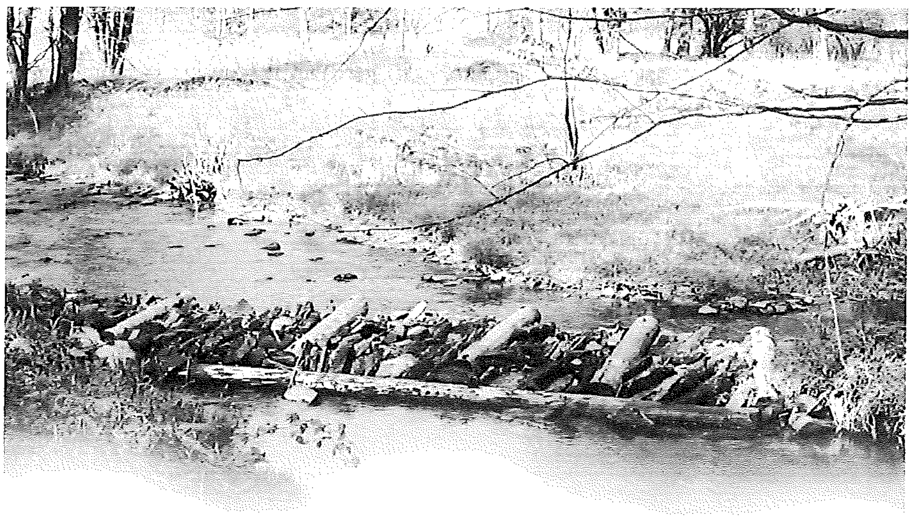

Figure 20. Log channel block. These channel blocks serve as a type of dam, preventing the flow of water in a certain direction, but channeling it into a new direction (Lutz, 2007).

All of these structures should be built during early summer through mid-fall when normal flow conditions are at their lowest (Lutz, 2007). The last recommendation involves the continuation of the restocking project. Brook trout should d be stocked within all of the streams until population levels are stable and the brook trout are repopulating in the streams on a larger scale.

Many other techniques and tools exist. But, the primary goal at the present is maintaining and restoring the streams to proper water depths. This can be achieved by the habitat enhancement tools of weirs, channel blocks, boulder placements, and deflectors. Once these have been established, the conditions and parameters of the streams are likely to change. Hopefully, this initial step will encourage the brook trout to survive and repopulate within the streams.

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Appendices

Location	0-4in
BRB1	0
BRB2	0
BRB3	0
CB1	0
CB2	0
CB3	0
MS1	1
MS2	1
MS3	0
CasB1	0
CasB2	0
CasB3	0

Raw Data

	BRB #1	BRB #2	BRB #3
Date	7/8/2010	6/30/2010	7/8/2010
Water Temperature	20.5	17C	22
Air Temperature	23	14.3C	23.7
Soil Temperature	22.5	16C	23
pH	6.9	10.3	6.9
Conductivity	64	60	156
DO	12.8	8.3	18.2
Velocity	0	0	0
Shade	95%	NA	60%
Depth	27.5	20in	35.625
Other species	BND, water hoppers	BND	toads/tadpoles
Relative Age of BT	NA		NA
Outside species	sugar maple, witchhazel, tulip, fern		paper birch, dogwood, black birch, witch-hazel
Bottom	90% boulder; 5% 1-4; 5% less than .25		15% boulder; 60% 1-4; 20%1-.25; 5% less than .25
Notes	Lots of moss.		A few sticks in the water. A few leaves. The water is very clear and colorless.
Date	7/15/2010	7/8/2010	7/15/2010
Water Temperature	20.5	20.5	20
Air Temperature	23	25.5	22.9
Soil Temperature	22.4	24	21
pH	6.2	6.9	6.1

Conductivity	211	63	53
DO	14.2	13.3	14.3
Velocity	0.5	0	0.5
Shade	NA	90%	NA
Depth	35.25	29.75	29.85
Other species	NA	BT (2 large noted) BND	BND, WH
Relative Age of BT	NA	large (several inches)	NA
Outside species	witchhazel, sugar maple, canadian mayflower?	witchhazel, red maple, hemlock, sugar maple, fern	NA
Bottom	NA	20% boulder; 75% .25-1;5% less than .25	NA
Notes	poison ivy?	Lots of moss.	NA
Date	7/22/2010	7/15/2010	
Water Temperature	19	20	
Air Temperature	20.5	22	
Soil Temperature	20.5	21.5	
pH	6.2	6.1	
Conductivity	225	54	
DO	18.6	14.5	
Velocity	0.5	0.5	
Shade	NA	NA	
Depth	33.75	29.5	
Other species	NA	1 large BT, lots of BND, lots of yearling BT	
Relative Age of BT	NA	Yearlings/adult	
Outside species	NA	NA	
Bottom	NA	NA	
Notes	NA	NA	
Date		7/22/2010	7/22/2010
Water Temperature		20	19.8
Air Temperature		20.5	19.5
Soil Temperature		20	20.5
pH		5.9	5.9
Conductivity		55	49
DO		19.7	15.4
Velocity		0.5	0.5
Shade		NA	NA
Depth		32.3	33.125
Other species		NA	NA
Relative Age of BT		NA	NA
Outside species		NA	NA
Bottom		NA	NA
Notes		NA	NA

	CB #1	CB #2	CB #3
Date	7/8/2010	7/8/2010	7/8/2010
Water Temperature	21	21.5	21.5
Air Temperature	24	24	23.8
Soil Temperature	23.25	24	24.5
pH	6.9	6.9	6.5
Conductivity	28	28	28
DO	11.1	12.8	10
Velocity	0	0	0
Shade	80%	95%	95%
Depth	12.875	12.75	7.5
Other species	BT	BT	water hoppers
Relative Age of BT	yearlings	yearlings	yearlings
Outside species	tulip, fern, chestnut oak	fern, red maple	fern, tulip
Bottom	40% Boulder; 25% 1-4; 10% 1-.25; 25% less than .25	60% boulder; 5% 1-4; 5% 1-.25; 30% less than .25	50% boulder; 25% 1-4; 5% 1-.25; 20% less than .25
Notes	Lots of Moss.	Lots of Moss.	Moss.
Date	7/15/2010	7/15/2010	7/15/2010
Water Temperature	20.5	20.6	20.7
Air Temperature	22.5	24.5	23.5
Soil Temperature	22.5	22	22
pH	6.3	6.3	6.3
Conductivity	26	26	27
DO	10.4	13.7	9.3
Velocity	0.5	0.5	0.5
Shade	50%	SAME	30%
Depth	14.5	13.5	7.5
Other species	abundant BT	abundant BT	WH
Relative Age of BT	yearlings	yearlings	NA
Outside species	SAME	SAME	SAME
Bottom	SAME	SAME	SAME
Notes			No BT
Date			
Water Temperature			
Air Temperature			
Soil Temperature			
pH			
Conductivity			
DO			
Velocity			
Shade			
Depth			

Other species			
Relative Age of BT			
Outside species			
Bottom			
Notes			
Date	7/22/2010	7/22/2010	7/22/2010
Water Temperature	20.4	20.1	20
Air Temperature	21.5	19.5	20.5
Soil Temperature	20.5	20.5	20.25
pH	5.5	5.5	5.4
Conductivity	40	40	41
DO	15.6	16.6	17.4
Velocity	0.5	0.5	0.5
Shade	NA	NA	NA
Depth	17.65	14.4	17.4
Other species	NA	NA	NA
Relative Age of BT	NA	NA	NA
Outside species	NA	NA	NA
Bottom	NA	NA	NA
Notes	NA	NA	NA
	CB #1	CB #2	CB #3
Date	7/8/2010	7/8/2010	7/8/2010
Water Temperature	21	21.5	21.5
Air Temperature	24	24	23.8
Soil Temperature	23.25	24	24.5
pH	6.9	6.9	6.5
Conductivity	28	28	28
DO	11.1	12.8	10
Velocity	0	0	0
Shade	80%	95%	95%
Depth	12.875	12.75	7.5

	MS #1	MS #2	MS #3
Date	7/9/2010	7/14/2010	7/14/2010
Water Temperature	25.5	NA	NA
Air Temperature	24	23	23
Soil Temperature	27	22.5	22.5
pH	4.5	NA	NA
Conductivity	14	NA	NA
DO	16.2	NA	NA
Velocity	0	NA	NA
Shade	20%	35%	35%
Depth	0	0	0

Other species	water hoppers	NA	NA
Relative Age of BT	NA	NA	NA
Outside species	blueberry, oak, woodpeckers, moles		
Bottom	100% less than .25	90% boulder; 10%1-4	90% boulder; 10%1-5
Notes	Very turbid.	Completely dried up	Completely dried up
Date	7/14/2010		
Water Temperature	23		
Air Temperature	21.5		
Soil Temperature	22.8		
pH	4.5		
Conductivity	14		
DO	19.9		
Velocity	0		
Shade	SAME		
Depth	11.6		
Other species	NA		
Relative Age of BT	NA		
Outside species	SAME		
Bottom	SAME		
Notes	RAINY/MISTY		

	CasB#1	CB #2	CB #3
Date	7/14/2010	7/14/2010	7/14/2010
Water Temperature	21	20	NA
Air Temperature	22	21	21
Soil Temperature	21.5	20.5	20.5
pH	5.5	5.7	NA
Conductivity	28	47	NA
DO	10.6	8.3	NA
Velocity	0	0	NA
Shade	60%	80%	100%
Depth	13.125	17	0
Other species	water hoppers; frogs	frogs, water hoppers	NA
Relative Age of BT	NA	NA	NA
Outside species	moss	witchhazel, moss	N
Bottom	25% 1-4; 25% 1-.25; 50% less than .25	90% less than .25; 10% 1-.25	100% Boulder
Notes	Very turbid		Completely dried up

	Control Parameters
Date	7/14/2010
Water Temperature	22
Air Temperature	23.5
Soil Temperature	22

pH	5.7
Conductivity	15
DO	8.5
Velocity	0.5
Shade	50%
Depth	32.75
Other species	BT
Relative Age of BT	yearlings, adult (several inches long)
Outside species	tulip, striped maple
Bottom	75% boulder; 20% 1-4; 5% less than .25
Notes	Very abundant population of BT

Fish Survey

Date	Location	Species	Length	Mass	pH	Abundance	Release	Notes	V	Amp	Time (s)
7/19/2010	Stream Station	Beetle larvae				Very Abundant					
		BT	165	49	6.5	Not Applicable	Below Y Intersection	No electrofishing; just seining/netting			
		BT	220	101	6.5	Not Applicable	Below Y Intersection	No electrofishing; just seining/netting			
		BT	195	178	6.5	Not Applicable	Below Y Intersection	No electrofishing; just seining/netting			
		CC	55	2	6.5	Not Applicable	Below Y Intersection	No electrofishing; just seining/netting			
		Dragonfly				Several					
		Salamander				Several					
		Water Beetle				Several					
		Water Striders				Very Abundant					

		Wood frogs				Several					
7/19/2010	Below Y Intersection	BT	175	53	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BND	25	2	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	155	35	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	160	40	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	155	36	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	130	21	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	160	37	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	145	25	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	95	8	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	120	18	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	95	8	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420

		BT	85	8	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	82	6	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	101	9.5	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	105	10	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	81	6	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	100	9	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	84	6	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	lost	lost	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	93	7	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	101	13	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	81	5	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	99	8	6	NA	Below Y Intersection	Electrofishing/seining/netti	75	20	420

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		BT	105	10	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	100	16	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	109	9	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		BT	115	10	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	140	26	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	120	15	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	115	11	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	125	21	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	130	23	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	100	10	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	170	48	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	130	24	6	NA	Below Y Intersecti	Electrofishing/sein	75	20	420

							on	ing/netting			
		CC	150	35	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	100	7	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	140	33	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	155	36	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	133	23	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	136	23	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	125	19	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	132	30	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	105	11	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	115	18	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	102	11	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	104	11	6	NA	Below Y	Electrofis	75	20	420

							Intersection	hing/seining/netting			
		CC	91	9	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	68	4	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	68	4	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	90	10	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	119	18	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	100	10	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	115	20	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	93	8	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		CC	126	20	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		RT	185	63	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		RT	160	36	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420

		RT	160	40	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		RT	155	39	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		RT	150	33	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		RT	135	27	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		RT	164	44	6	NA	Below Y Intersection	Electrofishing/seining/netting	75	20	420
		Wood frog	NA	NA	6	Several					
7/19/2010	Penny Bridge	BT	110	10	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BND	25	less than 1	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	100	9	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	150	36	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	85	6	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	110	12	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197

		BT	65	3	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	74	3	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	93	10	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	90	8	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	80	4	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	88	4	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	95	8	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	74	3	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	150	27	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	157	38	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	89	7	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	170	47	6.5	NA	Penny Bridge	Electrofishing/seining/netti	75	20	197

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		BT	80	5	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		BT	77	6	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	100	11	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	104	12	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	155	37	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	90	7	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	112	17	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	125	19	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	178	56	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	135	24	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	131	21	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	102	15	6.5	NA	Penny Bridge	Electrofishing/sein	75	20	197

								ing/netting			
		CC	114	17	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	145	29	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	124	19	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	124	17	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	122	17	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	160	41	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	126	18	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	123	19	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	113	17	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	118	17	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	106	15	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	94	90	6.5	NA	Penny	Electrofis	75	20	197

							Bridge	hing/seining/netting			
		CC	100	11	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		RT	165	48	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		RT	183	62	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		RT	167	45	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		Tadpole	92	10	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197
		CC	100	10	6.5	NA	Penny Bridge	Electrofishing/seining/netting	75	20	197