PINE CREEK HEADWATERS HEMLOCK PLAN: THERMAL REFUGE PRIORITIZATION

Plant a Tree, Shade a Trout

Pine Creek Watershed Council

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This project was spearheaded by the Pine Creek Watershed Council's Water and Biological Committee consisting of a collaboration of several agencies, non-profit organizations, and local community members. The Committee consists of the following individuals/organizations:

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Thank you!

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Purpose

The purpose of the Headwater Hemlock plan is to address the negative ecological impacts associated with the potential large-scale loss of the eastern hemlock due to hemlock woolly adelgid (*Adelges tsugae*) and other stressors, Specifically, this plan seeks to offer guidance that will lead to an increase in conifer cover in headwater brook trout streams within the Pine Creek Watershed.

Implementation of this plan is not intended to replace the functionality of eastern hemlock in the Pine Creek Watershed. Hemlocks provide unique characteristics to an ecosystem. Rather, the intention is to retain some of the attributes present in climax riparian forests, including: stream shading, erosion control and regulated hydrology. This will be achieved through understory plantings, in-stream habitat enhancement, and adaptive management of invasive species in key riparian areas.

Background

Eastern Brook Trout

Temperatures below 70 degrees F are support the health and well-being of trout and other salmonids, with optimum conditions ranging from 55-65 degrees. While it is believed that trout can withstand short periods of increased temperatures up to 72 degrees, exposure to temperatures of 75 degrees for a matter of hours is normally lethal (Eastern Brook Trout Joint Venture 2005).

Figure 2: Pine Creek Watershed Brook Trout
Photo credit: Kim Gridley

In a study completed in the southern Appalachia's, the removal of riparian forest vegetation increased summer stream temperatures from 66 degrees to 73 degrees. In one instance, stream temperature increased by approximately 12 degrees (Swift and Messer 1971.)

Eastern brook trout populations are struggling throughout much of their range due to sub-standard water quality, sedimentation, stream connectivity (access to spawning grounds), and shifting hydrologic regimes. According to the Eastern Brook Trout Joint Venture, brook trout in the eastern US are impaired with extirpation occurring in 21% of sub-watersheds that contain suitable habitat.

Eastern Hemlock

The Eastern hemlock encompasses approximately 38,450 hectares (95,000 acres) across the Pine Creek Watershed, many of which are located within riparian corridors along high quality headwater streams. According to the USDA's Forest Health Technology Enterprise team, eastern hemlock provides approximately $969 per hectare per year in ecosystem services. Within the Pine Creek Watershed, eastern hemlock provides a variety of ecological benefits for wildlife species and contribute to the aesthetic appeal of the watershed. The Pine Creek Watershed is home to a Scenic River, Important Bird and Mammal Areas (IBA, IMA). In addition, sports fishing and outdoor recreation bring many thousands of people and nearly a million dollars annually into this rural area.

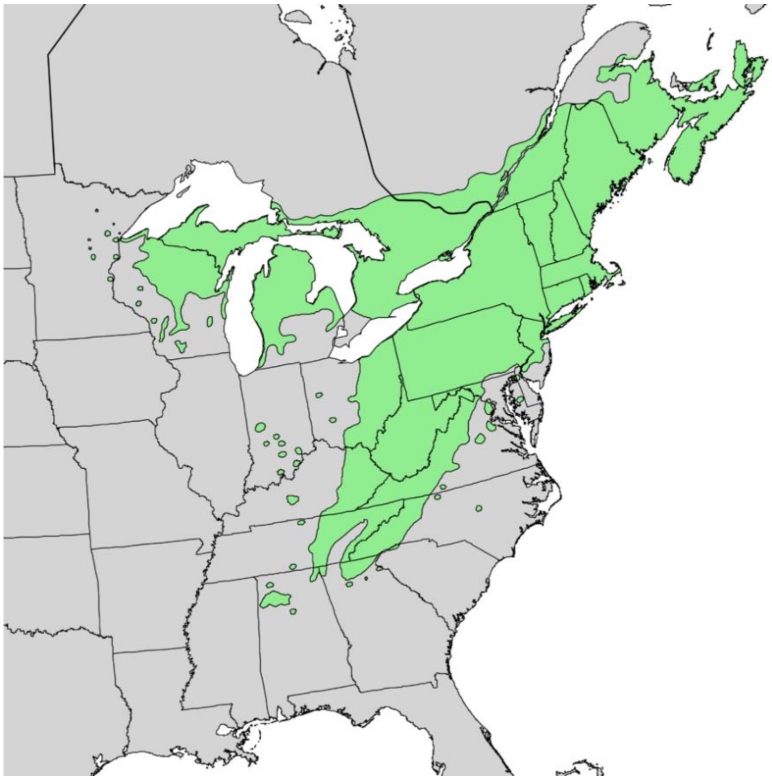


Figure 3: By Elbert L. Little, Jr., of the U.S. Department of Agriculture, Forest Service - USGS Geosciences and Environmental Change Science Center: Digital Representations of Tree Species Range Maps from: Elbert L. Little, Jr. (1971), Atlas of United States trees, Vol. 1, conifers and important hardwoods: U.S. Department of Agriculture Miscellaneous Publication 1146, 9 p., 200 maps., Public Domain, https://commons.wikimedia.org/w/index.php?curid=30496844

Eastern Hemlock Management Plan (EHCP), PA DCNR

While reforestation with HWA resistant eastern hemlock is the goal, this may be many years from fruition, if ever. In areas with dying or heavily damaged hemlock (70% defoliation or greater), thought should be made on influencing regeneration, preferably of conifers. It will be more practical and cost effective to manage for tree species that are already present in the canopy or understory of the site, and supplement with some underplanting. Attention should be made to promote conditions that favor the establishment of desired and appropriately adapted tree species in the understory. Potential conifer species for replanting can be found in the following table, which was compiled by the USDA Forest Service staff in Allegheny National Forest. With exception to Norway spruce (which was not included by Allegheny National Forest staff due to non-native planting restrictions), the table presents native conifer species. Although the Bureau promotes the use of native species whenever feasible, potential non-native candidates for supplemental plantings are provided also.[1, 2] Native conifers may be ineffective at filling the niche left by hemlock, warranting the use of non-native species. Although Norway spruce is not native to North America, it has been widely used for reforestation projects in the northeastern United States and has a drooping branch structure that may provide more suitable thermal cover for riparian areas and associated wildlife.

[1] As of 8/23/17 at our Hemlock Summit at the USGS Northern Appalachian Research Laboratory in Asaph we were informed by the Bureau of Forestry personnel and the authors of the Eastern Hemlock

Conservation Plan in attendance that Norway Spruce has been taken off the list of approved species for underplanting. The primary reason given was: it is not a native tree. There are also some concerns that the Norway alters the habitat by lowering pH and increasing solubility of Aluminum. In addition, the needles of the tree are not preferred by the macro-invertebrate community as forage and the canopy is not preferred by native birds, insects, or arachnids.

[2]The Water & Biological Committee has developed a study design to explore these concerns. Currently we have set up a paired watershed study on tributaries of headwater streams looking at the impact of spruce (principally Norway Spruce) and hemlock. This study design incorporates water quality, temperature regimes, aquatic macro-invertebrates and fishes. In addition, the forest soils in these watersheds are being studied. In partnership with National Trout Unlimited, the results of this study are included in this report as an appendix.

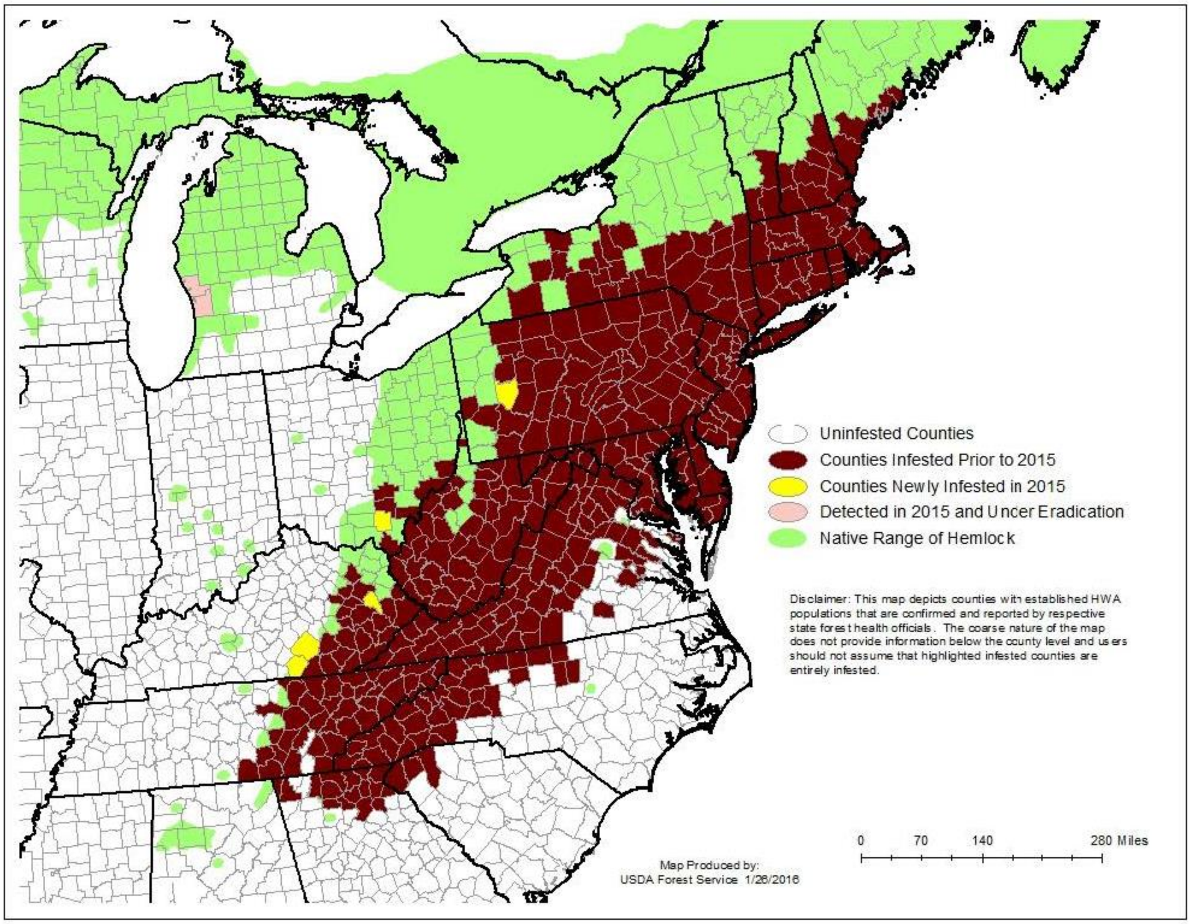
Hemlock Woolly Adelgid

Hemlock woolly adelgid (HWA) is an aphid-like insect originating from Asia. HWA arrived in the Eastern Unites States in the early 1950's and was first discovered in southeastern PA in 1969 (USDA 2004.) Since that time, some populations of hemlock, especially in the southern states, have experienced large scale mortality. HWA feed on cells at the needle base, depleting the trees food reserves from storage cells. Feeding will lead to needle desiccation, discoloration and loss. Die back of major limbs typically occur within two years of infestation and begins at the base of the tree moving into the upper crown. (Nuckolls 2007).

Figure 4: Eastern Hemlock mortality due to HWA infestation in the Southeastern US. Photo credit: US Forest Service

Currently, HWA is present in approximately half of the eastern hemlock range (USDA 2014). Due to a lack of natural predators and low resistance to infestations, HWA has been able to spread seemingly unchecked. It is estimated that HWA disperse approximately 12-18 miles/year (USDA 2004). The largest factor controlling the northern spread of HWA is winter mortality associated with cold intolerance. In lab studies, HWA could not survive temperatures at -30 to -40 degrees F and in Connecticut, HWA displayed 90% mortality at temperatures below -5 degrees (USDA 2004). As HWA moves north, eastern hemlock is more abundant and dispersal to adjacent stands is easier (Ellison 2014). Once infested, the rate of hemlock mortality varies greatly depending on several factors. Mortality has been observed as early as 2 years but may take a 12-15-year period or longer depending on other factors (USDA 2004). Regionally, research in the Delaware Water Gap found mortality had not occurred after 20 years post-infestation. Trees may stand for 6 to 8 years following mortality (Orwig). Factors such as drought, location, other diseases and pests, such as elongate hemlock scale, can drastically increase the rate of mortality. Many chronically infested stands exhibit >90% mortality within 10 years after initial infestation (Ellison 2014)

Figure 5: Range of Hemlock Woolly Adelgid Infestation in the Eastern US. USDA Forest Service, 2016



Currently, state agencies are using a variety of methods to control the spread and impacts of HWA including both chemical and biological controls. In the Pine Creek Watershed, the Bureau of Forestry has implemented chemical insecticide treatments in several areas. As chemical treatments are costly and time-consuming, these methods are used at only the most ecologically and socially important locations, leaving many hundreds of acres of hemlock unprotected. Biological control has been implemented in the Pine Creek Watershed as well, with the release of predatory beetle species that feed on HWA in its native range. Biological control is a very long-term strategy and cannot be depended upon to save trees in the short-term. It is likely that only a combination of many strategies will succeed in protecting hemlock and the ecological value it provides.

State Forest Eastern Hemlock Treatment Program

Eastern Hemlock conservation is a very high priority for DCNR Bureau of Forestry throughout Pennsylvania. The Bureau's Eastern Hemlock Conservation Plan outlines hemlock's importance, insect & disease threats including Hemlock Woolly Adelgid (HWA), Elongate Hemlock Scale (EHS), and others, and management strategies to conserve hemlock in the face of these threats. The Bureau has implemented many of these management strategies in various locations throughout the state, and Bureau staff survey yearly for eastern hemlock health stressors to determine the extent and severity of insect & disease related decline and mortality (General and Permanent Hemlock Surveys).

In the Pine Creek Watershed, in addition to surveys, the Bureau maintains a planting of seedlings grown from cuttings of New Jersey's "Bulletproof Hemlock" stand at the Waterville BOF office. This New Jersey hemlock stand has been infested with HWA for decades and each year adelgids experience high levels of mortality on this particular group of hemlocks. Experiments on these trees are ongoing, and Pennsylvania has received several seedlings for planting and testing for the future. Forest District and Forest Health Division staff have also selected and treated many Hemlock stands with insecticide to protect trees from HWA and EHS in the Watershed, and Forest District staff have completed plantings of surrogate conifers such as white pine and red spruce, to supplement conifer benefits on the landscape as eastern hemlocks are impacted.

Criteria for treatment site selection are contained in the Eastern Hemlock Conservation Plan and include watershed and water quality protection, high recreational use areas, areas of exceptional aesthetic and/or historic value, areas of exceptional wildlife habitat or biodiversity value (including old growth remnants), and leading edge or isolated infestations. Hemlock stands that Forest District staff select are delineated based on extent of hemlock canopy and features such as riparian corridors, trail buffers, picnic and camping areas, etc. Once an area is selected for treatment and delineated, a treatment plan is developed. The treatment plan includes determination of what insecticide and treatment method will be used, as well as best time of year to treat and the resources necessary to execute the treatment. If EHS is not present, chemical formulations with the active ingredient imidacloprid are the most ideal. If EHS is present, however, the active ingredient dinotefuran is used as it controls both HWA and EHS. The number of years in between treatments is determined by the active ingredient used; imidacloprid controls HWA longer than dinotefuran.

The Pine Creek Watershed contains many high priority hemlock populations, and it will not be possible to treat them all. Currently, Bureau of Forestry staff treat a total of 16 different areas throughout the watershed (Table 1), including both State Parks and State Forest land. In Lycoming and Tioga Counties, EHS has been found in or near all treatment sites and dinotefuran has been used to control HWA and EHS. In Potter County treatment sites EHS has so far not been found, and imidacloprid has been used for treatments. EHS is moving westward however, and the use of dinotefuran will eventually become necessary at all treatment sites in the watershed.

In the future, the Bureau of Forestry will continue to treat priority sites, including the 16 current treatment sites and additional sites selected by Forest District, State Parks, Forest Health Division staff. The Bureau will continue to conduct yearly surveys, throughout the watershed and including permanent Hemlock survey plots in Lycoming County beginning in winter 2018-2019. Continued surveys will provide the Bureau and partners with information on rates of hemlock decline and forest vegetation response, coupled with HWA summer and winter mortality numbers and weather tracking. This data will be used into the future to gauge the status of Pine Creek Watershed hemlock and predict the need for intervention in various parts of the Watershed, either to protect eastern hemlock directly, or to protect ecosystem services provided by hemlock forests on Bureau lands.

Table 1: PA DCNR BOF Eastern Hemlock Treatment Areas in the Pine Creek Watershed

Complex	Name	Ownership	County	Year Last Treated	Acreage
Colton Point State Park	Rim Picnic Area	State Park	Tioga	2017	32.8
Colton Point State Park	Campground	State Park	Tioga	2017	23.6
District 12	Lower Pine Bottom	State Forest	Lycoming	2016	10.2
District 12	Waterville Shop	State Forest	Lycoming	2016	19.4
District 12	Wagner Farm	State Forest	Lycoming	2006	5.9
District 12	Bark Cabin NA	State Forest	Lycoming	2012	17.5
District 16	Asaph Picnic Area	State Forest	Tioga	2017	39.2
District 16	Darling Run	State Forest	Tioga	2017	5.8
District 16	Benjamin Hollow	State Forest	Tioga	2010	3.7
District 16	Burdic Run	State Forest	Tioga	2010	1.0
Lyman Run State Park	Lower Campground	State Park	Potter	2016	12.7
Leonard Harrison State Park	Northside Parking Lot Picnic Area	State Park	Tioga	2015	17.5
Little Pine State Park	Upper Pine Bottom Picnic Area	State Park	Lycoming	2016	1.5
Little Pine State Park	Lower Picnic Area	State Park	Lycoming	2016	11.8
Little Pine State Park	Group Tenting	State Park	Lycoming	2016	12.7
Little Pine State Park	Panther Run Trail	State Park	Lycoming	2016	11.2

Understanding the Threats

Effects of large-scale hemlock mortality in riparian areas

- ✓ Loss of stream shading due to removal of hemlock from riparian areas
- ✓ Changes in transpiration rates (influx of deciduous species)
    - Higher peak flows, lower summer flows
- ✓ Increased nitrate leaching
- ✓ Increased sedimentation
- ✓ Loss of habitat for aquatic and terrestrial species
- ✓ Influx of invasive plant species
- ✓ Climate change
    - Warmer climate will expand HWA's northern range
    - Increases in air temps may increase stream temps
    - Frequent drought conditions will make hemlock more susceptible to HWA and will also decrease stream flows

Impacts of Climate Change and Invasive Species Colonization in a Hemlock Dominant Post-Mortality Scenario

Eastern Hemlock serves many functions within headwater stream systems. They provide deep shading, year-round transpiration, and high snow interception rates which help to mediate soil temperatures and stabilize stream base flows and temperatures (Ellison et al 2005). According to climate predictions, suitable hemlock habitat is projected to decline. In addition, a warming climate will increase the northward dispersal of HWA (Frumhoff et al. 2007). Eastern hemlock is intolerant to drought making trees much more susceptible to mortality associated with HWA infestations (USDA 2004). An increase in air temperature due to a changing climate will have a direct effect on water temperatures. Additional concerns include an increase in drought scenarios, the loss of stream shading, and a decrease in summer flows due to altered transpiration rates (Frumhoff et al 2007).

Transpiration rates are impacted due to changes in species composition after hemlock mortality. Riparian corridors that have suffered large scale Eastern Hemlock mortality, due to HWA, experience an influx of primarily deciduous species. Orwig noted that rapid recolonization of black birch occurred at most sites along with low densities of red maple and oaks.

In locations with high deer densities native deciduous species struggle to establish, leading to an increase in pioneer communities and invasive species establishment. Communities can include an influx of Japanese barberry, multiflora rose and oriental bittersweet. Not only does establishment of an invasive layer detrimentally effect the native vegetation, but Japanese barberry are associated with dense populations of high blacklegged ticks (Ward – Cornell Hemlock Studies). Another invasive plant species of concern within the Pine Creek Watershed is Japanese knotweed. At monitoring locations within the Delaware Water Gap National Recreational Area between 1994 and 2003, invasive plants were found in 35% of hemlock mortality sites where no invasive species were previously observed (Eschtruth 2006). When coniferous stands are replaced with deciduous species, the stands exhibit thinner canopies with increased canopy gaps, altered transpiration rates, and a shift in habitat availability for aquatic and terrestrial species.

It is estimated that at the stand scale, the loss of hemlock will result in transpiration reductions reaching 30% in the spring and winter (Ford and Vose – Cornell Hemlock Studies). Changes in transpiration may lead to higher peak flows, quicker flow attainment, lower summer flows and an inability to sustain stable year-round flows. Higher peak flows and quicker attainment may increase sedimentation rates. Sedimentation will also increase due to tree mortality and loss of root structure. Following large scale hemlock mortality, increased nitrate leaching due to increased nitrification rates and inorganic nitrogen availability may affect stream water quality and productivity.

Additional Forest Species Impacts

There are a variety of wildlife species, aquatic and terrestrial, which utilize hemlock habitat. Large scale mortality would have a deleterious effect on a multitude of species directly and indirectly through trophic cascades. Some species are considered hemlock specialists, depending on the unique habitat for their primary life processes.

It is estimated that ninety-six bird species and forty-seven mammal species utilize hemlock stands in the northeast. Bird species found to be strongly associated with eastern hemlock habitat include: great horned owls, long-eared owls, northern saw-whet owls, blue-headed vireo, blue jay, red-breasted nuthatch, hermit thrush and black-throated green warblers (Yamasaki et al) as well as blackburnian warblers and Acadian flycatchers (USDA 2004.) The black-throated green warbler and blue headed vireo are considered hemlock obligates because they are only found in forests with hemlocks (USDA 2014.) Eastern hemlocks provide seed sources for pine siskin, goldfinch, red crossbill and evening grosbeak.

Mammal species strongly associated with eastern hemlocks include snowshoe hare, red squirrel, deer mouse, southern red-backed vole, porcupine, red fox, black bear, marten, bobcat and white-tailed deer. In New England, fisher use eastern hemlock for den sites. Another important ecological feature provided by eastern hemlock is their superior ability to provide thermal refuge for species such as white-tailed deer. Not only do the stands provide important windbreaks, they also provide browse during winter months (Reay).

In freshwater systems, streams that flow through hemlock-dominated forests support unique assemblages of species that are intolerant of seasonal drying including: salamanders, fish and invertebrates (USDA 2014.) Ninety-five insect species and three mite species have also association with eastern hemlock (Turcotte-Cornell Hemlock Studies.)

Unique understory plant species may also be impacted due to a loss of shading associated with hemlock stands.

The Pine Creek Watershed

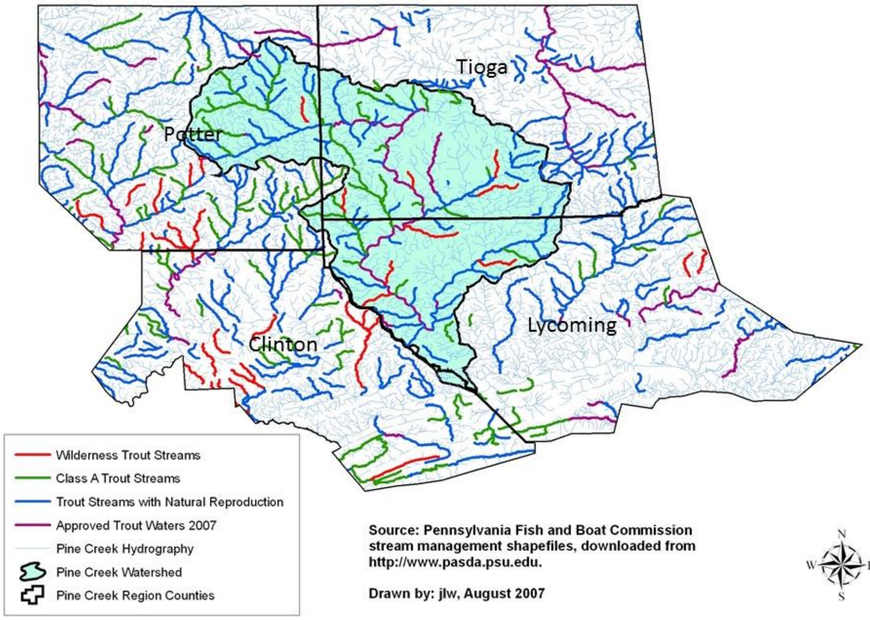


Figure 6: The Pine Creek Region - Special Water Designations

Pine Creek is the second largest tributary of the West Branch Susquehanna River and lies within the counties of Potter, Tioga, and Lycoming counties in Pennsylvania. The Pine Creek watershed covers 981 square miles and is just over 87 miles long, with about 23 miles within Tioga County designated as a Pennsylvania Scenic River. Within the watershed lies 17 sub-basins and the total number of stream miles when added up for the watershed is 1,614 miles. (Rivers Conservation Plan).

Historically, the forests dominating the hills and valleys of the Pine Creek watershed were found throughout the northern Allegheny Plateau. The characteristic species were white pine, hemlock, American chestnut, red maple, mixed oaks, sugar maple, American Beech, sweet birch, yellow poplar and black cherry.

The total drainage area of the entire Pine Creek watershed is approximately 981 square miles or 627,840 acres. The four largest tributaries in the Pine Creek watershed include: Marsh Creek, Cedar Run, Slate Run, and Babb Creek. The drainage areas of each of these tributaries is greater than 70 square miles. In the Pine Creek watershed, there are 143.1 miles of stream that have been designated as Class A Wild Trout Water

Fisheries

There are a total of 1623.3 miles of stream in the Pine Creek watershed. Of those, 980.1 miles (60.3%) are classified as High-Quality Cold-Water Fisheries (HQ-CWF). Another 529.2 miles (32.6%) are designated as Cold-Water Fisheries (CWF). There are 56.6 miles (3.5%) designated Exceptional Value. In addition, a 57.9-mile stretch of Pine Creek is designated as a High Quality-Trout Stocked Fishery. These 57.9 miles account for 3.6% of the total stream miles in the Pine Creek watershed. Pine Creek tributaries and their fisheries designations are listed in the table below.

Stream Fisheries Designation

- ✓ Elk Run HQ-CWF
- ✓ Long Run EV-CWF
- ✓ Marsh Creek CWF
- ✓ Babb Creek CWF
- ✓ Wilson Creek CWF
- ✓ Stony Fork CWF
- ✓ Cedar Run EV
- ✓ Slate Run EV
- ✓ Blockhouse Creek CWF

Land Use

Approximately 71 sq. miles or 7% of Pine Creek watershed is devoted to agricultural production.
According to the statistics available from the Chesapeake Bay Program, the vast majority of the Pine Creek watershed consists of naturally vegetated forest land cover. Approximately .3% of the lower Pine Creek watershed from Jersey Shore north to Galeton is developed. All of the other sub-watersheds had 0.1% developed area or less. The main difference between the sub-watersheds regarding land cover is the amount of agricultural land which varies from a high of 20.2% in the Babb Creek watershed to a low of 2.7% in the West Branch of Pine Creek upstream of Galeton. (RCP)

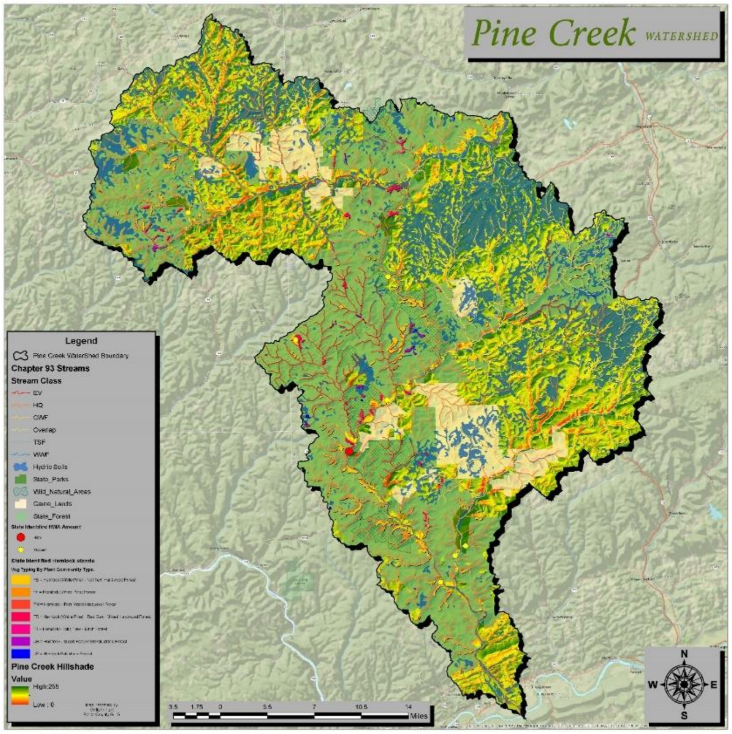


Figure 7: Pine Creek Watershed Map, Stream and Forest Typing

Land Ownership

Over half of the 981 square mile of watershed, approximately 512 square miles, is in public holdings. Those lands include four state forests, eight state parks, and seven tracts of State Game Lands. The majority of the public land is state forest, approximately 410 square miles. (Insert Map 5 from RCP). These lands are managed and maintained by the Pennsylvania Department of Conservation and Natural Resources (DCNR), the Pennsylvania Game Commission (PGC), the Pennsylvania Fish and Boat Commission (PFBC), and various municipal entities. (RCP).

Stream Impairments

The distinct differences in the landscape and soils between the West and North Branch portions of the Susquehanna River in Tioga County account for the distinctions in the water quality issues that exist respectively in the Pine and Tioga watersheds. Pine Creek as a whole is relatively pristine in comparison with many streams within the county. The West Branch of Pine Creek, which runs parallel to Route 6 and begins in Potter County, was recently upgraded to an Exceptional Value stream. The main stem of Pine Creek is designated a High Quality/Cold Water Fishery. Much of the explanation behind the water quality of Pine Creek lies in the fact that a majority of the watershed is publicly owned by the PA DCNR Bureau of Forestry and the PA Game Commission. Public awareness of water quality and conservation efforts in the Pine Creek watershed have been long standing, due largely to recreation opportunities in the watershed.

Surprisingly, many of Pine Creek's tributaries are impaired from a variety of causes that belie the health of the main stem. The water quality conditions, impairments, and current efforts of the major tributaries to Pine Creek are outlined below, including Marsh Creek, Charleston Creek, Babb Creek, and Wilson Creek. Marsh Creek is one of the largest streams in the headwaters of Pine Creek and receives all of the runoff from Wellsboro and the surrounding area. Under Chapter 93, Marsh Creek is a Warm Water Fishery from its source to Strait Run and a Cold-Water Fishery from Strait run to the confluence with mainstem Pine Creek. The upper portion is rather developed while the lower end is more rural and the stream has ample access to its floodplain. The upper end is also much more channelized while the downstream part of Marsh Creek is very sinuous and allows for filtering of sediments and slowing of floodwater velocities. Multiple impaired tributaries enter Marsh Creek, including Charleston Creek, Kelsey Creek, Morris Branch, Horse Thief Run, Dantz Run, Heise Run, and Darling Run. Sediment is the main cause for impairment, although issues of flow alteration, organic enrichment, and low dissolved oxygen are also prevalent. Please see Table 2 for more information on impaired streams in the Pine Creek Watershed. In contrast to the impaired streams, numerous High-Quality Coldwater Fisheries feed Marsh Creek once as it turns and flows West/Southwest, including: Baldwin Run, Strait Run, Canada Run, and Asaph Run. The watersheds of these headwater streams are almost entirely held within State Forest land. Charleston Creek is one of the larger tributaries to Marsh Creek. Designated a Warm Water Fishery although it once held trout, the headwaters of Charleston Creek are mostly rural with some agriculture, although due to its proximity to Wellsboro the Charleston Creek watershed feels developmental pressures, too. Hamilton Lake, a local flood control dam, is located approximately half way down Charleston Creek and serves as Wellsboro’s secondary source of drinking water. Because of the impoundment of Charleston Creek, the downstream portion suffers from organic enrichment and low dissolved oxygen impairments. Below the dam, all of the urban runoff and stormwater from Route 6 and the industry and commercial businesses that surround it drain into Charleston Creek, leading to significant impairments. It should be noted that the headwaters of the watershed contain a well field (in Brownlee) that serves as the primary municipal drinking water source for Wellsboro.

Historically, Babb Creek was impaired from acid mine drainage to the point that it was unable to support aquatic life. However, past and current efforts by the Babb Creek Watershed Association have brought back most of the main stem of Babb Creek. These associations have also been working to remediate portions of Wilson Creek by treating discharges on the Rattler Mountain side. Other than AMD impacts, the Babb Creek watershed is mostly forested with a majority of it being publicly owned by the Bureau of Forestry and the PA Game Commission. Nickel Brook and Long Run, both Exceptional Value streams, feed Babb Creek. Stony Fork, which is a large tributary to Babb Creek, is roughly 38 square miles and is impaired by AMD and agriculture. The headwaters of Stony Fork are mostly agricultural while the lower portion is contained within State Forest Land and would most likely not be impaired if it were not for AMD issues in Paint Run.

Wilson Creek, like Charleston Creek, is close enough to Wellsboro to experience increased developmental pressures and subsequent urban impairments. The lower portion of Wilson is impaired by AMD. However, the BCWA is currently focusing efforts on treating the many discharges that drain to Wilson Creek. The Anna S Treatment Complex and the Rattler Mountain projects are very large systems that work to treat several large discharges. The group also is/or plans on working on the Mitchell Mine discharge. By contrast, the upper portions of Wilson Creek are impaired by agricultural activities.

Table 2: Pine Creek Stream Impairments (Tioga County Chesapeake Bay Tributary Strategy)

Stream Name	Length Assessed (mi)	Water Use	Source of Impairment	Cause of Impairment	Priority	Year Listed
Babb Creek	0.7	CWF	Abandoned Mine Drainage	Metals, pH	Medium	2002
Babb Creek	7.8	CWF	Abandoned Mine Drainage	Metals, pH	Medium	1996, 2002
Babb Creek	2.6	CWF	Abandoned Mine Drainage	Metals, pH	Medium	1996, 2002
Babb Creek	3.5	CWF	Abandoned Mine Drainage	Metals	Medium	1996
Babb Creek Rattler Run Slide Hollow Wilson Creek	3.7	CWF	Abandoned Mine Drainage	pH	Medium	1998
Basswood Run	1.0	CWF	Abandoned Mine Drainage	Metals, pH	Medium	2002
Charleston Creek	2.0	WWF	Channelization Upstream Impoundment Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers	Flow Alterations Organic Enrich/Low DO Siltation Water/Flow	Low Medium Low	2002
Dantz Run	4.2	CWF	Road Runoff	Siltation	Medium	2002
Darling Run	0.8	HQ-CWF	Road Runoff	Siltation Water/Flow Variability	Medium Low	2002
Heise Run	2.1	CWF	Road Runoff Highway, Road, Bridge Const.	Siltation Siltation	Medium Medium	2002
Horse Thief Run	1.0	CWF	Road Runoff	Siltation	Medium	2002
Kelsey Creek	0.7	WWF	Channelization Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers	Flow Alterations Siltation Water/Flow Variability	Low Medium Low	2002
Lick Creek	4.1	CWF	Abandoned Mine Drainage	Metals, pH	Medium	2002
Marsh Creek	1.4	WWF	Urban Runoff/Storm Sewers Upstream Impoundment Urban Runoff/Storm Sewers	Water/ Flow Variability Organic/Low DO Siltation	Low Medium	1996 2002
Morris Branch	0.7	WWF	Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers Channelization	Water/Flow Variability Siltation	Low Medium Low	2002
Paint Run	4.0	CWF	Abandoned Mine Drainage	Metals, pH	Medium	2002
Stony Fork	0.4	CWF	Abandoned Mine Drainage	Metals, pH	Medium	2002
West Branch	3.6	CWF	Agriculture	Siltation	Medium	2002
Wilson Creek	2.3	CWF	Abandoned Mine Drainage	Metals, pH	Medium	1996, 2002
Wilson Creek	0.9	CWF	Abandoned Mine Drainage	Metals, pH	Medium	1996, 2002
Wilson Creek	11.1	CWF	Agriculture	Siltation	Medium	1996

The Pine Creek Watershed Assessment

Parameters were chosen based on their ability to effect hemlock mortality after HWA infestations. Stand location exhibits a relatively strong correlation with hemlock mortality (Young et al). "Hemlocks on southwest slopes tend to experience more rapid mortality than those on northeast facing slopes and stands deep in ravines seem more tolerant of adelgid than those stands on benches at the top of a ravine (USDA 2004.)" In addition, stands located on a side slope position also exhibit more rapid mortality. Many of the position parameters indicate how crucial water availability is for hemlock survival (Pontius et al).

Due to the size of the Pine Creek Watershed, a basic initial ranking is necessary when developing specific sites for implementation. To attempt to analyze the entire watershed based on a variety of specific site parameters would not be feasible or efficient. Initially, the watershed is broken down into smaller, HUC 12 watersheds. Each individual at the HUC 12 scale will then be analyzed using in depth ranking parameters in order to develop a plan for implementation. HUC 12 watersheds are prioritized based on their latitudinal location. Those southernmost watersheds located within the Pine Creek drainage will take precedence over northern areas. Beginning at the southernmost point best reflects hemlock stands with presumably the highest rate of HWA infestation due to temperature, and a higher prevalence of other stressors such as elongate hemlock scale.

Once a HUC 12 watershed is chosen, it is then analyzed based on the following parameters:

Is the stand located within a current or proposed chemical treatment area?
Is eastern hemlock present at the site?
Is HWA present at the site?
Stream classification
Stand aspect
Stand elevation
Stand slope
Aesthetic value
Accessibility
Presence of T&E species (PNDI search)

The parameters will be analyzed remotely through GIS maps created specifically for the Headwater Hemlock Project.

GIS Analysis

Desktop analysis which included:

Creation of a data catalog of identified hemlock stands and other conifers in the watershed.
We also inventoried all of the chapter 93 streams and HUC 12 watersheds. Narrowed down sites based on exposure (southern), accessibility (drive-up), viewshed (high visibility to public) and stand composition (presence of hemlock in stand). The primary focus was on HQ and EV streams which encompass the majority of the watershed. All sites were chosen on public lands due to lack of data on private lands and accessibility concerns.

The group met with DCNR and requested geo layers that included: treatment sites and sites with presence of HWA. We began narrowing down the sites not included in current or ongoing treatment program. As part of the process we began to identify paired adjacent watersheds with prominently hemlock, mixed conifer, and deciduous. With the intention of illustrating the importance of hemlock in producing a thermal refuge for cold-water aquatic species such as brook trout. Water monitoring sites were identified and installed following this step.

- Lesson Learned: DCNR's data is not readily available. *Solution: It was necessary for the data to be directly requested by our DCNR staff representative on the project committee.*

Once the first season's data was collected, our maps were published to ArcGIS online in preparation for expanded field data collection. Concurrently, we developed our field data collection survey using ESRI's survey 123 software. Data collected using tablets or smartphones with Survey 123 app installed was functional offline and in the field. Once collected the data is backed up wirelessly and then is visible on the ArcGIS online published map.

- Lesson Learned: Initial requests for the project team to prioritize on the map independently was not successful. Technology and time availability limited members ability outside of meetings. *Solution: Spending time together during meetings to workshop prioritization was much more successful.*

Data Collection:
We began the data collection process during our second season of temperature logger deployment by using personal mobile devices for data collection. We quickly found that not all mobile devices are compatible with Survey 123. Data was collected initially at our prior year temperature locations. In addition, we added previously identified priority HUC12 sites that did not already have temperature data collection sites.

- Lesson learned: Survey 123 was not compatible with all mobile devices as anticipated and data needed to be collected multiple times due to loss during wireless transmission. *Solution: We ended up purchasing compatible equipment that is centrally housed and loaned out upon request. In addition, we developed a paper form for field survey data collection.*

2017-2019 Baseline Continuous Temperature Monitoring Sites in Pine Creek priority watersheds:

1. Lyman Run (above and below the dam)
2. Johnson Brook
3. Phoenix Run
4. 4 Mile Creek
5. O'Connor Branch
6. Slide Island Draft
7. Cedar Run, East Branch
8. Mine hole Creek
9. Marsh Creek

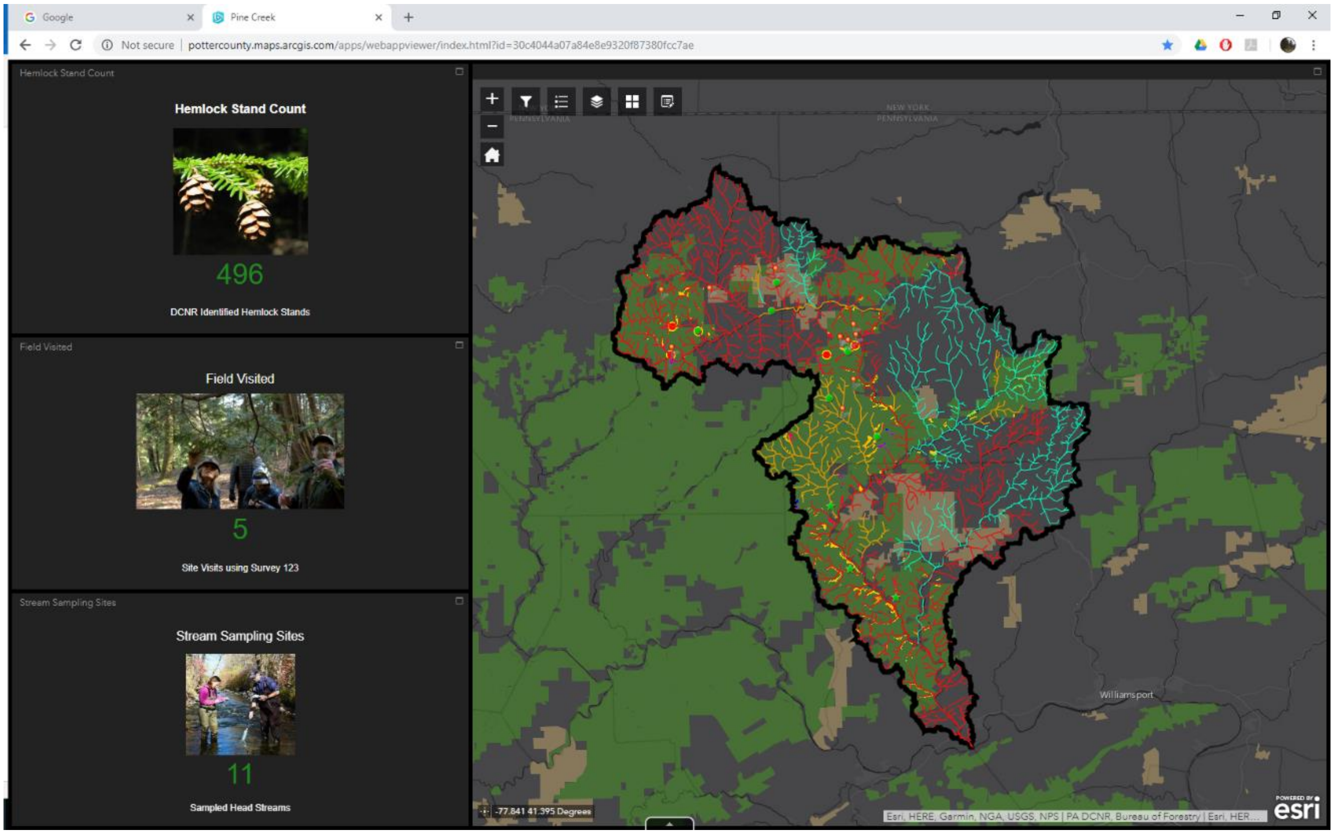


Figure 8: Pine Creek Watershed, Analysis Tool

Link to map: https://tinyurl.com/yb5xpwhy

Figure 9: Pine Creek Watershed Analysis Tool, QR code

Next Steps

Continue field data assessments using survey 123 and prioritization using the ArcGIS online web map tool. The potential exists to expand onto privately owned land and allow private landowners to participate through self-assessment. This tool can be used on an ongoing basis in the watershed or used as a template for other watersheds.

Expand upon the existing database to incorporate field data in to the map's data features with the intention to provide an open data source for hemlock related projects and activities.

Site Assessment

Upon completion of GIS analysis based on the ranking parameters, sites will be listed in order of highest to lowest priority within the HUC12 watershed. The number of sites within the HUC12 will determine how many sites will be chosen for implementation. Implementation on 25% percent of the top-ranking streams within the watershed will be used as a starting point to make sure that resources are not expended completely on just the southern HUC 12s within the watershed. For example, within the Cushman watershed, there are eight potential sites present that could be considered for implementation. Using 25%, 2 sites will be assessed for plantings.

Additional data collection will take place beyond the immediate area of interest. Special consideration will be given to sites that have invasive plant species present during site assessment. In that scenario, measures will be taken to record species, locations, and create a plan of action for control. Notes will also be made if healthy hemlock trees appear in stands that are otherwise exhibiting mortality. The healthy individuals may be ‘putatively resistant’ and seed collection will occur.

Additional ranking parameters upon field investigation
Visible hemlock mortality
Presence of invasive plant species
Age of stand

General Data Collection
Soil type
% Canopy cover
Species composition
% herbaceous understory
Coordinates/GPS offset
Stream temp
Stream flow
Visible hydrology
Recent precipitation (w/i past 7 days)

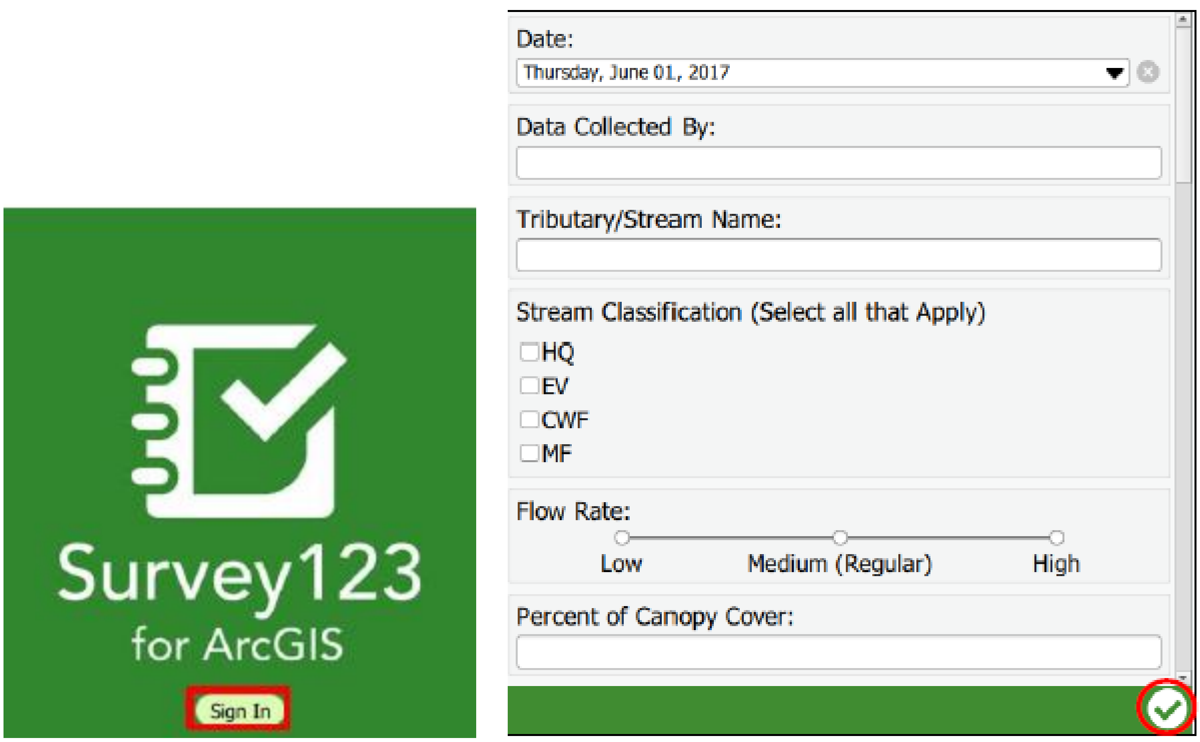


Figure 10: Survey123 data collection form

Additional Data Collection-why, how and where

Data collection will occur as part of the ranking system as well as on sites that are not currently being considered as high priority for plantings. The parameters listed will be collected in the field through the digital program Survey 123. Survey 123 can be used on smartphones, tablets and laptops and is not reliant on cellular signal for use. Data can be added and saved while out of service.

Survey 123 data
Baseline temperature data

Replacement Species Selection

Unfortunately, Eastern Hemlock have not shown resistance to HWA and have not been successful hybridizing with resistant species such as Chinese Hemlock and Western (Mountain) Hemlock. At this time there is still hope that an HWA resistant strain of Hemlock is being developed. Depending on funding availability, there may be options for successful protection or reintroduction of hemlock into a devastated watershed. While using chemical treatment on existing high-quality stands is the preferred treatment, the amount of chemical needed is cost prohibitive to consider widespread eradication. Investing in young trees, which require less chemical, may be a temporary solution for keeping hemlock alive until a long-term HWA control option is established.

The unique characteristics and functions associate with stands of eastern hemlock are irreplaceable. The goal with selecting replacement species is to retain as many characteristics as possible. Those characteristics include year-round transpiration and thermal refuge for organisms, both aquatic and terrestrial. In order to retain year-round transpiration, it is necessary for supplemental plantings to consist primarily of conifer species. Because natural replacement is dominated by deciduous trees, it is necessary to proactively establish a conifer presence before complete mortality and natural succession takes place. Monoculture plantings are not recommended for multiple reasons. It is recognized that a single species cannot duplicate the key role of eastern hemlock so it will be necessary to use multiple species. A monoculture would also put the riparian corridors at risk when considering the potential of future invasive species. A single species plantation can suffer complete mortality whereas a mix will enable conifer survivorship and retain a portion of the benefits considered during initial planting.

Challenges:

Eastern hemlock is extremely shade tolerant. They are able to survive in as little as 5% of full sunlight (USDA 2004) enabling them to regenerate without openings in the canopy. When selecting a replacement species, shade tolerance should be a consideration. The site conditions may dictate what species can be planted and within what part of the hemlock stand. If the hemlock canopy appears to be mostly intact, a more shade tolerant species may be necessary. After site assessment, and other conifer species present on the site are noted, they can be used as a starting point when selecting which species to plant. Based on their presence, you know that site conditions must be suitable.

Replacement Species Considerations
Shade tolerance
Resistance to browse
Canopy size

Stock availability
Native
3+ species per site
Transpiration rate

Species selection
Rhododendron, a potential evergreen supplemental planting species, lacks leaf area compared to a healthy hemlock tree therefore would not sustain comparable transpiration rates (Farmer 2013). There is some indication in North Carolina that Rhododendron is becoming invasive on sites decimated by HWA and Hemlock mortality.

“Eastern hemlock is the most shade tolerant tree species in the Eastern United States and is able to survive in the understory with as little as 5 percent of full sunlight (USDA Plan Eastern Hemlock Forests: Guidelines to Minimize the Impacts of Hemlock Woolly Adelgid.)”
Red spruce is considered critical habitat for the northern flying squirrel, a PA endangered species. “prefer a mature mixed-deciduous-hemlock/spruce/fir stands with closed canopies, open ground cover with a rhododendron component, and a thick leaf litter. The best habitats have a red spruce component (PA Wildlife Action Plan.)”

“Prefer moist to very moist acidic soils with good drainage (USDA 2004)”

A Species Selection Matrix (below) has been developed using the species list in the EHCP, illustrating the characteristics and habitat requirements for several potential replacement conifer species. They all have some characteristic that will lower the success or viability of the underplanting in declining hemlock stands. Our current work on the Headwater Hemlock Project and the Planning Grant through the Coldwater Heritage Partnership of Trout Unlimited will be addressing the prioritization of locations of concern selecting approved replacement tree species and implementing understory plantings in an effort to retain some of the ecological services associated with hemlock dominated riparian areas in the Pine Creek Watershed.

Table 3: Species Selection Matrix

Headwaters Hemlock Project - Species Selection Matrix								5/18/2018
Species selection for replacement (underplanting) of Hemlock in anticipation of the lost due to Hemlock Wooly Adelgid								
Primarily for Hemlock Associated Community Types along Headwater Tributaries - Hemlock Palustrine & Hemlock - Mixed Hardwood Palustrine Forest Types								
Species	**White Pine**	**Black Spruce**	**Red Spruce**	**White Spruce**	**Norway Spruce**	**N.White Cedar**	**Balsam Fir**	**Rhododendron**
Habitat Characteristics	lacks lower limbs	lower limbs	lacks lower limbs	lower limbs	lower limbs	lacks lower limbs	lower limbs	lower limbs
Site Requirements	Well Drained	Bogs & Peat	High Elevation	Wide Range	Cool, Humid	Moist Alkaline	Moist, Acidic	Moist
Shade Tolerance	I	T	T-VT	I	T - VT	T	VT	VT
Deer Browse	P	NP	Browsed/NP	NP	NP	P	Browsed/NP	NP
Range	Widely Adapted	Northern Range	Northern Range	Northern Range	Widely Adapted	Northern Range	Northern Range	Adapted
Other			Not native to NCPA	Not native to PA	Non-native*	Not native to NCPA		Invasive in NC*
Cost/Availablity >300	2-0 @ 0.27	2-0 @0.59		2-0 @ 0.38	2-0 @ 0.29	2-0 @ 0.54	3-0 @ 0.30	
Acceptable	Exhibits characteristics that are preferrable for underplanting							
Not Acceptable	Exhibits characteristics that are not preferrable for underplanting							
Non-native*	BOF has removed Norway from potential species for underplanting - policy issue of native vs non-native species.							
* 8/23/017	Norway will not be on the list of potential species for Strategy 2.3! Reference D. Eagans 2 pager in Draft form..........							
Invasive in NC*	Evidence in North Carolina that Rhododendron is becoming invasive after loss of Hemlock. Macroinvertebrate impacts due to changes in the food web.							
Codes								
Shade Tolerance	T=Tolerance VT=Very Tolerant I=Intermediate							
Deer Browse	P=Preferred NP=Not Preffered							
Adapted from DCNR Eastern Hemlock Conservation Plan, Faulkenberry & Shultzabarger 2014								

Planting Locations – Public and Private Lands

Cooperation with public land agencies such as the PA Department of Conservation and Natural Resources, Bureau of Forestry and the Pennsylvania Game Commission are fundamental relationships for implementation of this project. Species selection on public land will be guided by the Eastern Hemlock Conservation Plan Potential Replacement Species. Species outlined in the plan include: red spruce *(Picea rubens)*, white spruce *(Picea glauca)*, black spruce *(Picea mariana)*, balsam fir *(Abies balsamea)*, northern white-cedar *(Thuja occidentalis)*, and eastern white pine *(Pinus strobus)*. Other species may be considered on a case by case basis pending agency approval.

Private landowners that may be interested in addressing the potential loss of hemlock on their property are currently being contacted by the Pine Creek Watershed Council to gage interest in participating. While much of the Pine Creek Watershed is public land, during the HUC12 rankings, the possibility exists that a private landowner will own a high-ranking site and be willing to participate. In this circumstance, the landowner will be contacted to discuss the options and gauge their willingness to participate in the project.

Once an access agreement is granted, project participants will work with the landowner to establish which species will work for their property. While species selection will still be based on a site assessment, there is more flexibility on plantings compared to public land requirements. If a landowner decides to plant a species such as Norway Spruce, a non-native naturalized species, they may have the opportunity to do so.

Short Term Maintenance Considerations

Annually, during the spring planting season, the Pine Creek Watershed Council will provide training to volunteers. Training will include:

- Project and site/species overview
- Safety overview
- Equipment overview
- Recommended tree spacing

In addition, the Pine Creek Watershed Council members will document species and the number of trees planted at each site. The planting locations will be mapped as part of the implementation data collection using Survey 123 and GPS. Our standard operating procedures can be found in the appendix of this document.

Long term maintenance & monitoring

Based on the limited resources and extent of the Headwater Hemlock Project, the Pine Creek Watershed Council will implement a random monitoring and replacement schedule of planted sites. If funding can be secured replanting and expansion of the project will be continued. With the mapping and locations of planted sites, available volunteers from the PCWC will revisit, replant, and monitor the survival of conifers throughout the watershed as time and material allow.

Limitations and Additional Research

The biggest limitation for our project is the extent of Eastern Hemlock in the Pine Creek Watershed. According to the US Forest Service there are 96,000 acres of Hemlock in the watershed. Our analysis will help narrow down our focus area to riparian corridors along Class A Wild Trout streams, equating to many miles of remaining stream corridors with the potential for enhancement.

During the development of the plan it became apparent that the institution policies governing implementation of direct action and intervention on the watershed headwaters was becoming a quagmire of conflicting ideologies, policies and process. The lack of consensus within the Bureau of Forestry on appropriate species for riparian planting has required the committee to look further at the science of ecosystem health and resiliency. To that end we have developed a study design and research component to the plan.

With additional funding from Shell Appalachia we have started, along with our long-term stream temperature data initiative, paired watershed analysis and soils conditions under two scenarios. One is existing Hemlock dominated watersheds and the other is spruce (primarily Norway Spruce) dominated watersheds.

Trout Unlimited researchers are studying the macro-invertebrate and fishery conditions in these paired watersheds. The results are cataloged in the appendix.

Volunteers from the Water & Biological Committee of the Pine Creek Watershed Council have gathered soils data (pH and Aluminum Toxicity) for the paired watersheds and other locations in the watershed.

Figure 11: Hemlock stand in headwaters of Slate Run, soil monitoring site. Photo Credit: Jim Weaver

It is our hypothesis that there is little or no appreciable impact to water quality and/or fish habitat from historic spruce plantations in the watershed. The concerns (Brinkly and Valentine) that Norway Spruce lowers the pH in forest stands and therefore increases aluminum solubility and toxicity more than a native Hemlock stand. Based on this information and research we have preliminary data showing that Hemlock stands are more acidic and increase aluminum sensitivity more than Norway Spruce. The following table shows lower pH and increased aluminum sensitivity in Hemlock stands. We attempted to bracket the Hemlock Spruce data with White Pine as per the Brinkly & Valentine study to give some further credence to our hypothesis.

Table 4: Paired Watershed Study, Preliminary Soils Data

Headwater Hemlock Project - Soils Data — ***Preliminary*** — 12/3/2018

Paired Watersheds on Tioga State Forest — jaw

Serial #	Date Sampled	Site	H/S	Plot#	Soil Type	pH	Ca (mg/kg)	Al (mg/kg)	Ca:Al Ratio*
			Cedar Run Paired						
52481	5/18/2018	EBF	H	1	Ab	3.5	46.77	20.5	1.51
52482	5/18/2018	SIC	S	1	OgD	4.5	93.14	6.73	9.15
			Four Mile Run Paired						
52483	5/18/2018	OBF	H	1	OTF	3.7	42.36	21.37	1.31
52484	5/18/2018	LBF	S	1	OTF	4	60.94	18.01	2.24
			Other Hemlock and Spruce Plots						
52485	8/17/2018	RTF	H	2	OTF	4.2	11.95	45.31	0.17
52510	8/17/2018	THE	S	2	ChC	4.7	91.72	11.74	5.16
52511	9/28/2018	CMP	H	3	OgB	4.6	12.31	29.23	0.28
52512	9/28/2018	ALP	S	3	CvB	4.8	8.49	15.04	0.37
			White Pine Plots						
04820	11/20/2018	RAS	W	4	LsD	4.3	56.2	35.5	1.05
52513	11/20/2018	ASA	W	4	OTF	4.6	45.64	17.9	1.68
52514	11/20/2018	CPS	W	4	OgB	4.9	182.79	3.35	36.06

H = Hemlock S = Spruce W = White Pine

*Ca:Al Ratio - Ratios of greater than 1 indicates relatively small risk of Aluminum toxicity

	Site Locations	Latitude*	Longitude*
EBC	East Branch Cedar Run	41.62928	77.51935
SIC	Slide Island Draft	41.64296	77.49005
OBF	O'Connor Branch of L. Branch Four Mile Run	41.68904	77.48669
LBF	Left Branch Four Mile Run	41.69429	77.49358
RTF	Refuge Trail Four Mile Run	41.69844	77.47141
THE	Thompson Hollow Elk Run	41.68436	77.52112
ALP	Algarine Swamp	41.54591	77.4837
CMP	Cushman Headwaters	41.59323	77.57533
CPS	Colton Point State Park	41.70326	77.46648
ASA	Asaph @ Scotch Pine Hollow	41.78453	77.43728
RAS	Right Asaph & Sand Road	41.81961	77.45639

*NAD 83

Soil Descriptions (from Tioga County Soils Survey 1981)	
Ab	Alluvial Land
OgD	Oquaga channery loam, 20-30% slopes
OgB	Oquaga Channery loam, 0-8% slopes
OTF	Oquaga and Lordstown, very steep
ChC	Chenango gravely loam 12-20% slopes
CvB	Cookport channery loam 0-8% slopes
LsD	Lordstown channery loam 12-30% slopes

Soils Analysis completed by:

PSU Agricultural Analytical Services Laboratory
Pennsylvania State University
111 Ag Analytical Svcs Lab
University Park, PA 16802
814-863-0841
aaslab@psu.edu
www.aasl.psu.edu

Recommendations

Recommendations/Areas of Concern and Opportunity

An area of opportunity exists for the propagation of HWA biological controls in "field insectaries". Many are difficult and expensive to raise in laboratories, making field insectaries, natural or semi-natural settings where the predators can get existing HWA as food and go through normal life cycles, a logical method of production. For HWA, predatory beetles and predatory silver flies are two types of HWA biological controls that are being released and tested in the eastern United States. Field insectaries are essentially hemlock hedges that can support enough HWA for predators to feed on and propagate, while maintaining a high enough level of tree health to stay alive, continuing to "raise" adelgids and their predators. Planting or finding suitable hemlock hedges in the Watershed to slate for predator releases in the future is an area of opportunity for the Council and partners. I should state that finding/planting on private lands that don't have some sort of long-term protection agreement will be pretty tenuous, because our federal partners absolutely need the strictest assurance that the hedge wouldn't be altered in the future at any point. Even with easements, private lands may not go over well for something like this. But plantings and insectaries take a bit to maintain, with the actual site prep and planting, and then continual pruning and care, so having partners that can help is a definite area of opportunity!

Other insect and disease threats to hemlock health are becoming more and more noticeable throughout the state, such as Scirococcus tip blight, a fungus that has been increasing in incidence over the past 5 years. Many fungal pathogens have been increasing in virulence due to wetter-than-normal springs for the past several years; Scirococcus is no exception. Scirococcus has been found throughout the Watershed at varying levels, and has the potential to exacerbate hemlock health issues. Another fungal pathogen, fabrella needle blight (*Fabrella tsugae*), can also impact eastern hemlock fairly severely, and is found throughout the state. Fabrella has not seemed to be increasing in incidence state-wide as some other fungal pathogens are, but it is found in the Pine Creek Watershed and may be important as a secondary stressor.

From the Species matrix it is apparent that some of the species available for planting are northern forest trees. The range of Black, White and Red Spruce are either high elevation species or from northern ecotones. In light of the shifting climate data most of these trees will not be suitable for warming habitats. The only conifer that is adapted to climate change scenarios is Norway Spruce. Due to the unpredictable shifts in climate and habitat conditions we will be planting a variety of species to provide some diversity and potential fit to future conditions.

The forests of northcentral Pennsylvania where historically 80% Conifers and 20% Hardwoods. After the logging era this has reversed. There is significant regeneration of conifers, mainly White Pine and Hemlock in the understory of our forests. Given the current even age classes, species composition and historical evidence the forest is shifting back to the former climax forest of dominant conifer old growth.

Based on these factors the simple easy low hanging fruit here is to get out and plant some conifers. The DCNR initiative for planting 9 million trees in 20 years is a place to start. We can start by planting riparian buffers with conifers. There are miles of stream corridor that have few if any conifers. We will simplify the planting priority to Class A Wild Trout Streams and plant a mix of conifer species of White Pine, Red, Black or White Spruce and Balsam Fir (and Norway Spruce on private lands.)

In the meantime, we continue to work with the BOF to reach consensus on native vs non-native trees. As the climate shifts, only the white pine is left to fill the void in our evergreen component on the forest. Fully half of the indigenous dominant conifers will be gone. Once the State Tree is extirpated from the woods, we will only have the Cry of the White Pine unless we assist nature in increasing the biodiversity of our forest.

Future Funding Opportunities

- Coldwater Heritage Partnership: Implementation Funding
- Trout Unlimited: Embrace a Stream Program
- PA Department of Environmental Protection: Growing Greener
- PA Department of Conservation and Natural Resources: Community Conservation Partnership Program
- Municipal Act 13 Funds
- Shell Appalachia
- Wildlife Conservation Society: Climate Adaptation Fund

Current and Potential Partners

- Trout Unlimited – Local Chapters and National
- County Conservation Districts (Tioga, Potter, Lycoming)
- PA Fish and Boat Commission
- PA Department of Conservation and Natural Resources
- Local Area School Districts
- Mansfield University
- Lock Haven University
- Lycoming College
- Susquehanna University
- Local governmental organizations
- PA Game Commission
- Pine Creek Preservation Association
- County Planning Departments (Tioga, Potter, Lycoming)
- US Geological Survey, Northern Appalachian Research Station
- US Forest Service
- US Fish and Wildlife Service
- Private Forest Landowners

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Appendices

Appendix 1: Eastern Hemlock and Norway Spruce Biological Study, Trout Unlimited, February, 2019.

Appendix 2: Pine Creek Headwater Hemlocks: Watershed Scale Implementation planning for adaptively managing the impact of Hemlock Woolly Adelgid (HWA), *Adelgis tsugae* on Northern Appalachian Forests (POSTER)

Appendix 3: Survey123 Hemlock Data Sheet Tutorial

Appendix 4: Headwater Hemlock Site Characteristics Field Data Sheet

Appendix 1

Eastern Hemlock and Norway Spruce Biological Study

Report provided by Trout Unlimited
February 2019

Background
Pine Creek Watershed Council (PCWC) requested technical assistance from Trout Unlimited (TU) to compare fishery and benthic macroinvertebrate communities in streams bordered by Eastern Hemlock (*Tsuga canadensis)* or Norway Spruce (*Picea abies)* as the dominant riparian vegetation. The purpose of this study is to provide a small-scale, pilot study of biological communities to determine if riparian areas dominated by Norway Spruce provide similar instream ecosystem conditions as those dominated by the native Eastern Hemlock. Eastern Hemlock trees have been devastated by the invasion of the Hemlock Wooly Adelgid (*Adelges tsugae)* (HWA), an aphid-like insect native to Japan that was introduced to the Eastern USA in the late 1980's and has spread northward, decimating Eastern Hemlock stands. Orwig et al. (2003) characterized the current threat as "continued HWA infestation will lead to unprecedented hemlock loss throughout the north-eastern USA, regardless of site conditions or location." Eastern hemlocks stands dominate ridgetop and headwater geographies, providing canopy and stream cover to coldwater habitats. The loss of the eastern hemlock would eliminate this crucial stream cover, leading to the warming of coldwater ecosystems.

PCWC identified two paired watersheds within Pine Creek to compare for this study. There were two watersheds in Cedar Run and two in Fourmile Run, each with one site dominanted by eastern hemlock cover and the other by Norway spruce in the riparian areas (Table 1, Figure 1).

Table 1. Site locations and dominant evergreen species at each site.

Stream Name	Report ID	Tree species	Latitude	Longitude
East Branch Cedar	EBC	Eastern Hemlock	41.62821	-77.5197
Slide Island Cedar	SIC	Norway Spruce	41.61611	-77.4951
O'Connor Branch Fourmile	OBF	Eastern Hemlock	41.68939	-77.4867
Left Branch Fourmile	LBF	Norway Spruce	41.68986	-77.4869

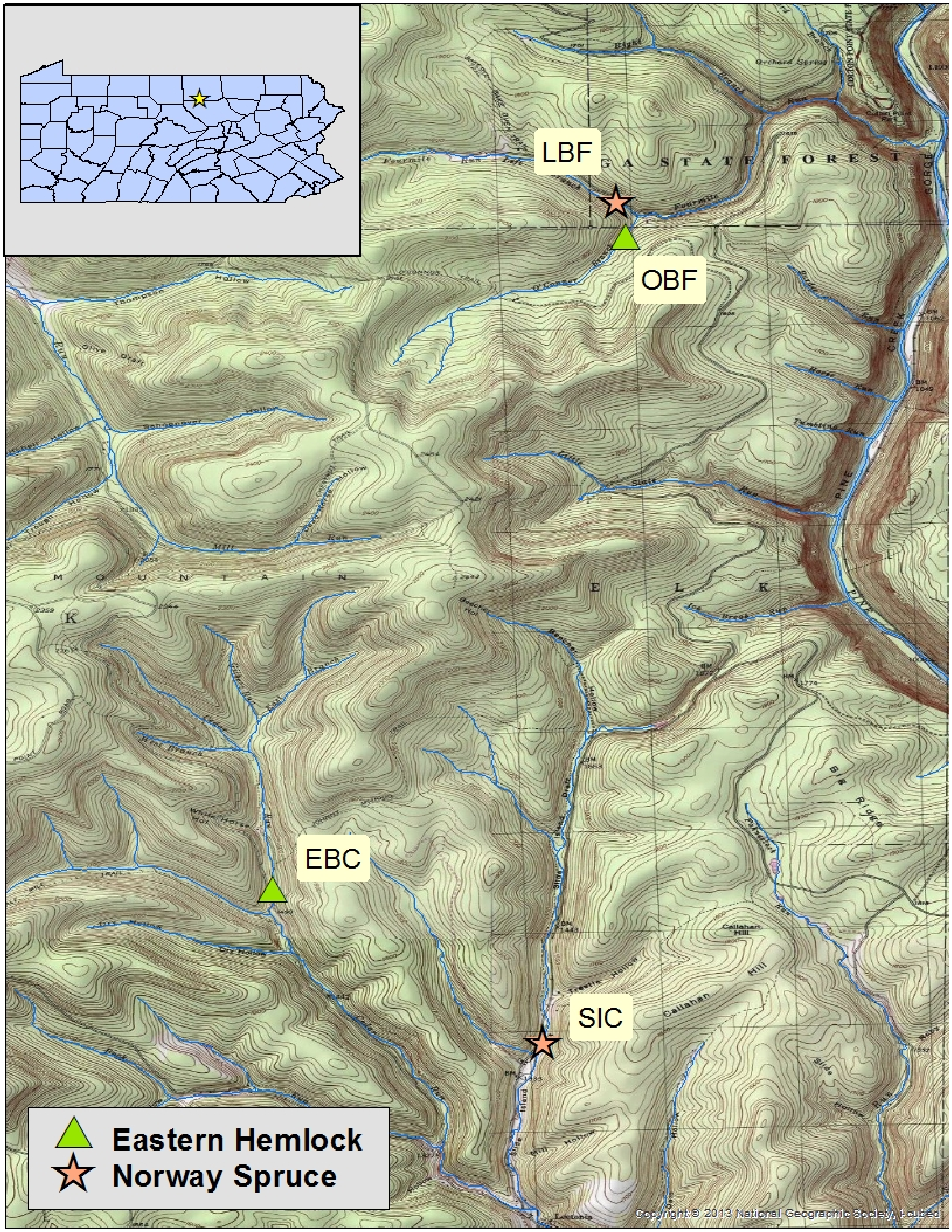


Figure 1. Site locations within the Pine Creek watershed, Tioga County.

Methods

Habitat Assessments

Habitat was evaluated for 100 meters at each sample site using DEP's *Water Quality Network Habitat Assessment* form, which considers the following twelve parameters: instream cover, epifaunal substrate, embeddedness, velocity/depth regimes, channel alteration, sediment deposition, frequency of riffles, channel flow status, condition of banks, bank vegetative protection, grazing or other disruptive pressure, and riparian vegetation zone width. These parameters are explained in Appendix A. Each parameter is given a score (from 0 – 20) based on a visual survey of the sample site. The scores from each parameter are summed to obtain an overall habitat score. The habitat scoring system is as follows: the "optimal" category scores from 240 to 192, "suboptimal" from 180-132, "marginal" from 120 – 72, and "poor" is a site with a combined score less than 60. The gaps between these categories are left to the discretion of the investigator's best professional judgment.

Fishery Surveys

Fisheries data were collected using battery powered backpack electrofishing gear using pulsed direct current. A Smith-Root model LR-24 backpack electrofisher was used for each of the surveys. Electrofishing proceeded straight upstream from the beginning of each sample site for 100 meters. Blocking nets or natural stream breaks were used to reduce migration of fish out of the survey section. Removal depletion (three pass) methods were used at all sites. Trout were kept in live wells until all passes were completed and could be measured for total length (millimeter) and weight (grams). Survey length and five representative stream widths were measured in tenths of meters.

Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate collections were made according to DEP's Instream Comprehensive Evaluation (ICE) protocol (specifically section C.1.b. *Antidegradation Surveys*). In short, benthic macroinvertebrate samples consisted of a combination of six D-frame efforts in a 100-meter stream section. These efforts were spread out so as to select the best riffle habitat areas with varying depths. Each effort consisted of an area of 1 m^2 to a depth of at least 4 inches as substrate allowed and was conducted with a 500 micron mesh 12-inch diameter D-frame kick net. The six individual efforts were composited and preserved with ethanol for processing in the laboratory. No sub-sampling was required for these samples as the individual counts were less than or near 200. Individuals were identified by taxonomists certified by the North American Benthological Society to genus or to the next highest possible taxonomic level. Samples containing 160 to 240 individuals were evaluated according to the six metrics comprising the DEP's Index of Biological Integrity (IBI) (Total Taxa Richness, EPT Taxa Richness, Beck's Index V.3, Shannon Diversity, Hilsenhoff Biotic Index, and Percent Sensitive Individuals). Appendix B contains a description of each of these six metrics.

Results

Habitat Assessments
All four sites were scored as optimal habitat (Table 2). East Branch Cedar Run, Slide Island Cedar Run, and Left Branch Fourmile Run each paralleled forestry roads to varying extents, which negatively affected habitat parameters such as riparian vegetative width, but did not reduce the overall score below the optimal rating. Left Branch Fourmile Run had the smallest average stream width (2.5m) and was lacking adult trout habitat (such as pools, undercut banks, stable wood debris, boulders) as reflected in its habitat score. Less than optimal habitat parameters may have resulted in fewer adult trout found in the 100m section assessed for fishery populations in Left Branch Fourmile Run.

Table 2. Habitat assessment scores for each site color-coded to express optimal-poor habitat quality.

Habitat Parameter	EBC	SIC	OBF	LBF
Instream Cover (Fish)	18	18	19	12
Epifaunal Substrate	18	19	18	20
Embeddedness	16	17	18	17
Velocity/Depth Regimes	18	18	18	13
Channel Alteration	16	16	19	15
Sediment Deposition	17	17	18	16
Frequency of Riffles	20	19	19	20
Channel Flow Status	18	16	18	19
Condition of Banks	17	16	19	19
Bank Vegetative Protection	16	17	20	18
Grazing or Other Disruptive Pressure	17	16	20	16
Riparian Vegetative Zone Width	16	15	20	14
Total Habitat Score	**207**	**204**	**226**	**199**
Mean Stream Width (m)	**2.97**	**4.01**	**3.24**	**2.54**

OPTIMAL
SUBOPTIMAL
MARGINAL
POOR

Fishery Surveys
Fishery surveys were completed at all four sites on June 8 by TU staff, Tioga County Conservation District Staff, Pine Creek Watershed Council members, and Tiadaghton TU members (Figure 2). Brook trout (*Salvelinus fontinalis*) were found at all sites and brown trout (*Salmo trutta)* were found in lesser numbers in the paired watersheds of Cedar Run (Table 3, Figure 3). Sculpin (Cottus *spp.*) were found at all sites except the O'Connor Branch Fourmile Run where brook trout were the only species. Slide Island Cedar Run also contained blacknose dace (*Rhinichthys atratulus)* and longnose dace (*Rhinichthys cataractae*) in addition to brook trout, brown trout, and sculpin.

Brook trout were found in lower numbers in Left Branch Fourmile (Table 3); however, habitat characteristics may explain the difference. The majority of the 100 meter reach surveyed at this site was shallow riffle habitat with an average width of 2.5m. All other sites surveyed had well developed pools and stable adult trout habitat.


Figure 2. TU staff, PWC members, and TU members electro-fish O'Connor Branch Fourmile Run June 2018.

Table 3. Size class distribution and abundance of trout found at the four sample sites.

Size Class (mm)	EBC		SIC		OBF	LBF
	BRK	BRN	BRK	BRN	BRK	BRK
25-49	10		13	2	7	4
50-74			9	2	11	8
75-99	2			1		
100-124	5		8	2	4	
125-149	5		4		15	5
150-174	5		6	2	2	2
175-199	2		2	1	3	
200-224		1		1		
225-249						
250-274				1		
Total/ Species	**29**	**1**	**42**	**12**	**42**	**19**
TOTAL	**30**		**54**			

Figure 3. Tioga County Conservation District staff measures a brown trout at East Branch Cedar Run.

Table 4. Biomass calculations and population metrics for each site and trout species.

Site	Species	Biomass (kg/ha)	Population Metrics		CPUE (#/hr)
			Density (N/ha)	Zippin Estimate (N)	
EBC	Brook	19.2	996	32	68
	Brown	3.1	34	1	2
	Both	**22.3**	**1,030**	**33**	**70**
SIC	Brook	16.7	1,049	42	81
	Brown	12.0	300	12	23
	Both	**28.7**	**1,349**	**54**	**104**
OBF	Brook	**23.8**	**1,296**	**43**	**73**
LBF	Brook	**8.9**	**748**	**19**	**58**

Benthic Macroinvertebrates

Each of the four sites were attaining their aquatic life use (high quality or exceptional value coldwater fisheries), which would require a minimum IBI score of 63 or greater (Table 5, Figure 4). The time of year (May) that these samples were collected coincides with many benthic macroinvertebrate taxa transitioning from their aquatic form into their terrestrial lifeform and are no longer found in the stream. (Figure 5). Regardless of the sampling date, all sites showed high numbers of sensitive taxa (all sites had EPT taxa richness >15 as well as >60% sensitive individuals) and represent high quality, diverse coldwater aquatic ecosystems. In high quality streams such as these, a closer look at the biological metrics associated with the community is necessary to understand potential differences among communities.

Table 5. Biological metrics and IBI calculations for macroinvertebrate samples.

Biological Metrics	Observed Values			
	EBC	SIC	OBF	LBF
Total Taxa Richness	30	37	32	33
EPT Taxa Richness	15	21	18	17
Beck's Index, version 3	36	39	39	34
Hilsenhoff Biotic Index	2.62	2.40	2.34	2.04
Shannon Diversity	2.85	3.18	2.87	2.63
Percent Sensitive Individuals	61.8	61.2	64.4	74.7
Total IBI Score	**88.1**	**94.3**	**93.7**	**92.9**

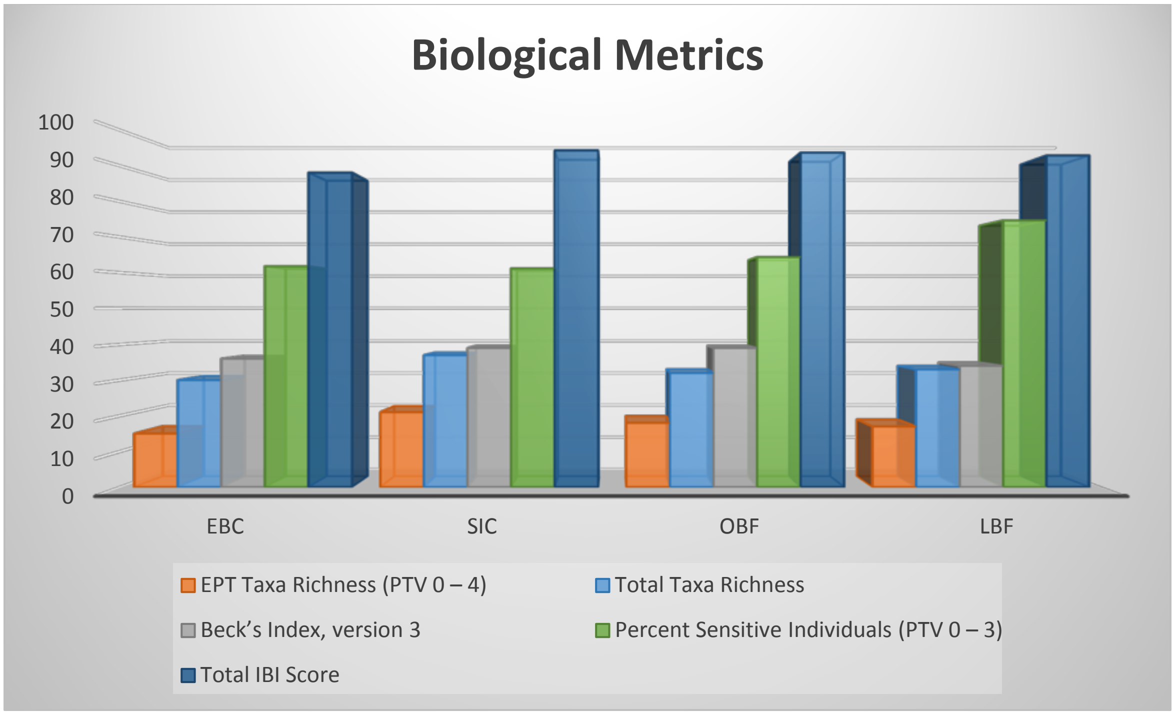


Figure 4. Biological metrics for benthic macroinvertebrate samples at each site.

Pollution tolerant values (PTV) are used to help quantify sensitive vs pollution tolerant taxa in a sample. PTVs range from 0-10, 0 being extremely intolerant to pollution and 10 being extremely tolerant. With many different types of potential pollution sources, not all PTVs will reflect all pollution scenarios. Two genus of the family *Plecoptera* (stoneflies) that have low PTV numbers, (reflecting their sensitivity to nitrate pollution) are found to be tolerant of acidic conditions; *Leuctra* and *Amphinemura*. While these taxa are common and widespread in coldwater ecosystems, the presence and abundance of these taxa has potential to distort biological metrics depending on their abundance and the presence of other sensitive taxa. Table 6 displays the representation of these taxa in the samples. The abundances of these taxa at all four sites, relative to the percent sensitive individuals, would not suggest acidic conditions.

Table 6. Percentage of taxa of the family *Plecoptera* (stoneflies) that have low pollution tolerance values (suggesting they would be negatively impacted by anthropomorphic activity) but are known to be **acid tolerant** and can sometimes indicate acidic aquatic conditions.

	EBC	SIC	OBF	LBF
Leuctra, Amphinemura	6.0%	0.9%	3.4%	1.8%

Figure 5. Large adult stonefly of the genus *Pteronarcys* (common terrestrial name: salmon fly) found at O'Connor Branch Fourmile Run.

Functional feeding groups (FFG) are a method to investigate differences in macroinvertebrate communities based on their feeding technique. West Virginia Department of Environmental Protection identifies functional feeding groups as scrapers (grazers), which consume algae and associated material; shredders, which consume leaf litter or other coarse particulate organic matter (CPOM), including wood; collectors (gatherers), which collect fine particulate organic matter (FPOM) from the stream bottom; filterers, which collect FPOM from the water column using a variety of filters; and predators, which feed on other consumers. A sixth category includes species that do not fit neatly into the other categories such as parasites. (WV.DEP.gov) It is important to keep in mind, however, that many benthic macroinvertebrates use a variety of food acquisition methods. Figures 6-8 illustrate the representation of FFG among all sample sites.

Functional Feeding Designations:
PR=predator
GC=gatherer/collector
FC=filter/collector
SC=scraper
SH=shredder

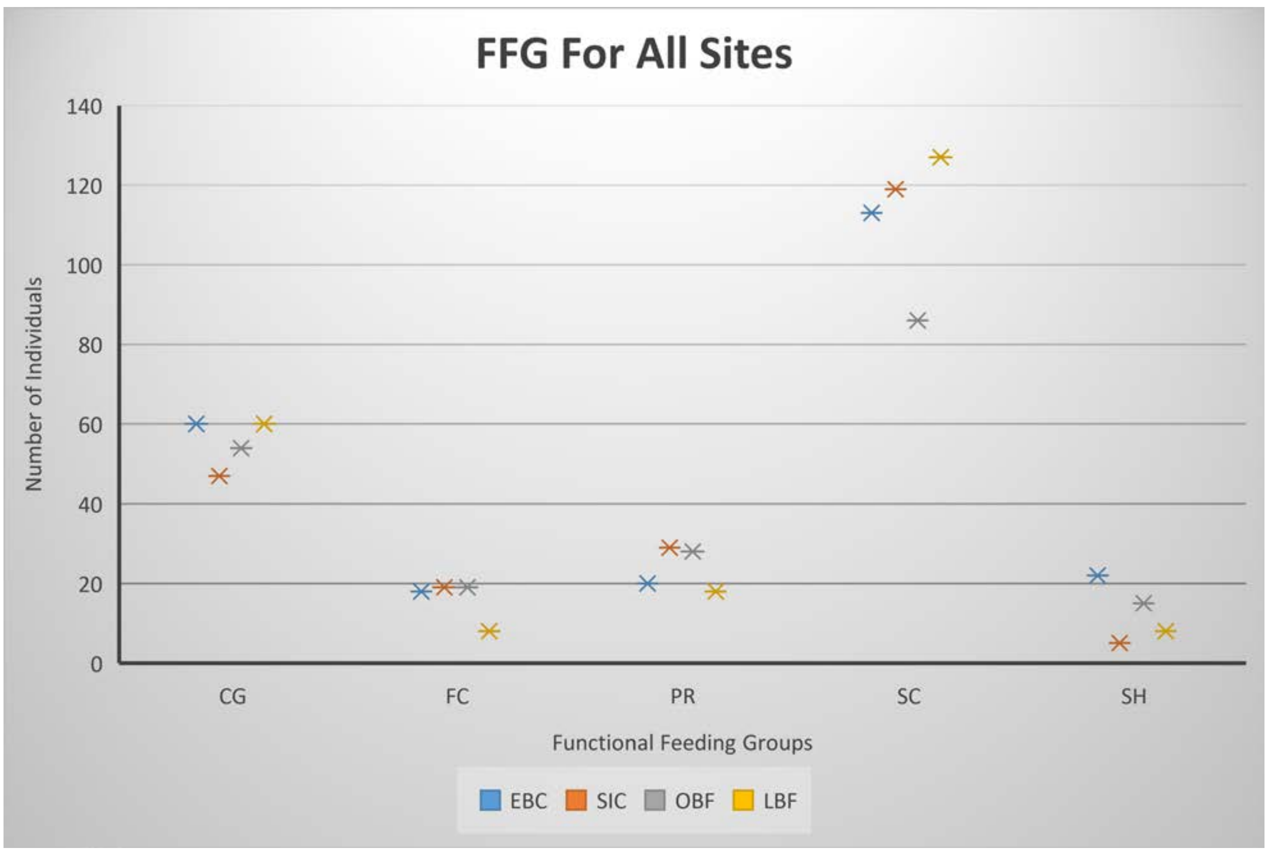


Figure 6. Functional feeding groups at all sites.

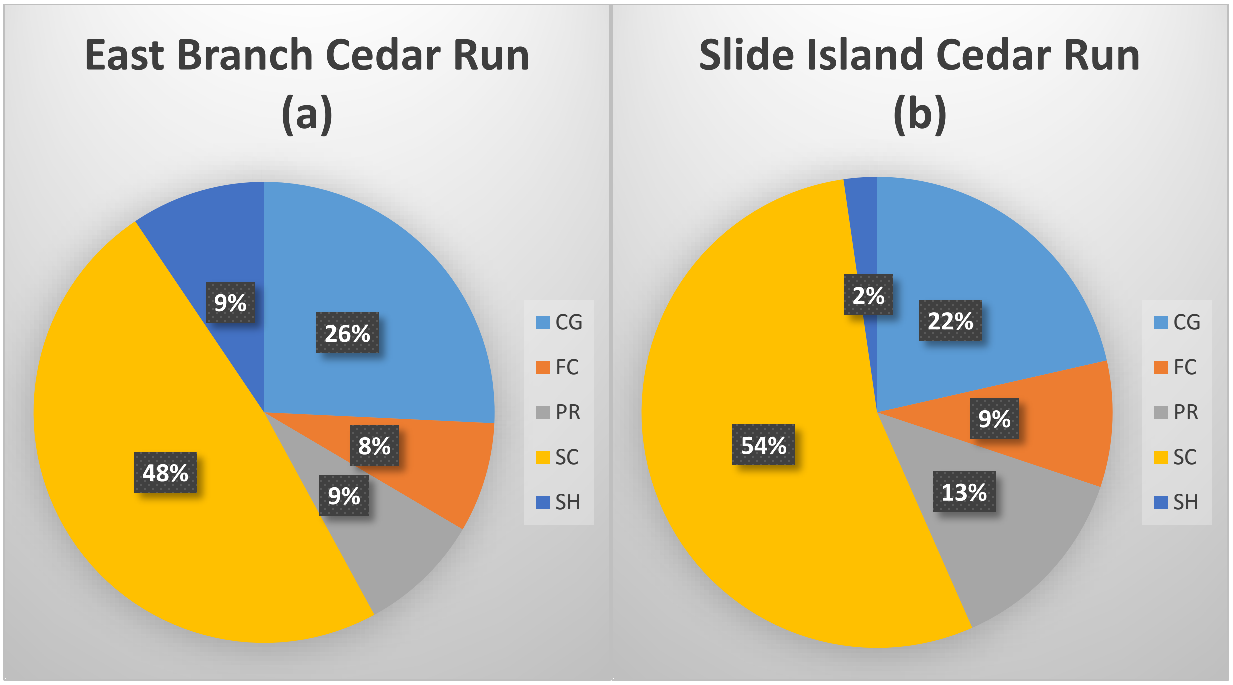


Figure 7a-b: Percentage breakdown of functional feeding guilds for East Branch Cedar Run (a) and Slide Island Cedar Run (b).

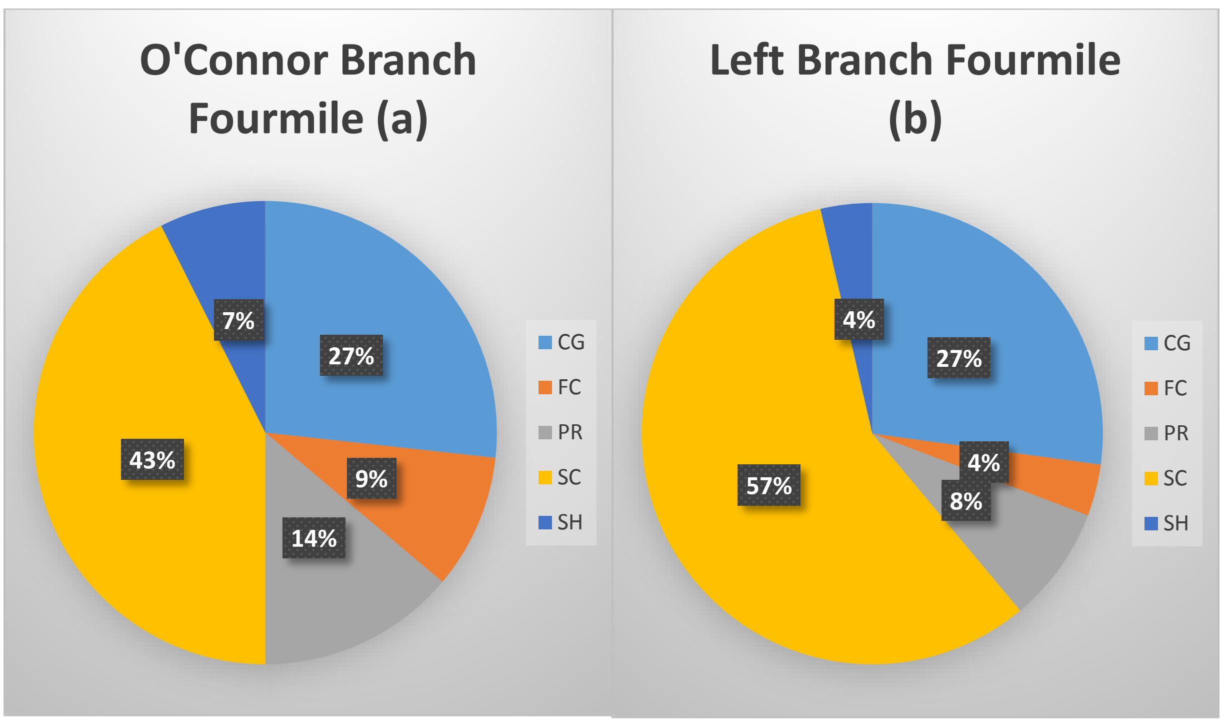


Figure 8a-b: Percentage breakdown of FFG for O'Connor Branch Fourmile Run (a) and Left Branch Fourmile Run (b).

Summary

The habitat at all sites scored as optimal but the presence of forestry roads at some sites negatively impacted those parameters effected by the road. A narrow stream width and lack of adult trout habitat in the form of pools and undercut banks in Left Branch Fourmile Run may explain the lower numbers and biomass of trout at that site. Biological metrics for the benthic macroinvertebrate communities had little variation among all sites. Percent sensitive individuals and EPT taxa richness were similar at all sites. While there were slightly higher percentages of acid tolerant stoneflies in the hemlock streams, their abundance and representation in the sample does not suggest acidic conditions at any sites. It is important to note that those stonefly taxa are commonly found in coldwater streams. All functional feeding groups were represented similarly at each site. The dominant riparian vegetation being conifers at all sites explains the lower percentage of shredders, who typically rely on leaves from deciduous trees. The data in this report only reflect conditions at these four sites over a short period of time and should not be extrapolated to other watersheds without further investigation.

Appendix A: DEP Instream Comprehensive Evaluation habitat assessment parameters.

Instream Fish Cover - evaluates the percent makeup of the substrate (boulders, cobble, other rock material) and submerged objects (logs, undercut banks) that provide refuge for fish.

Epifaunal Substrate - evaluates riffle quality, i.e. areal extent relative to stream width and dominant substrate materials that are present.

Embeddedness - estimates the percent (vertical depth) of the substrate interstitial spaces filled with fine sediments. (pool substrate characterization: evaluates the dominant type of substrate materials.

Velocity/Depth Regime - evaluates the presence/absence of four velocity/depth regimes - fast-deep, fast-shallow, slow-deep, and slow-shallow.

Channel Alteration - primarily evaluates the extent of channelization or dredging but can include any other forms of channel disruptions that would be detrimental to the habitat.

Sediment Deposition - estimates the extent of sediment effects in the formation of islands, point bars, and pool deposition.

Riffle Frequency (pool/riffle or run/bend ratio) - estimates the frequency of riffle occurrence based on stream width.

Channel Flow Status - estimates the areal extent of exposed substrates due to water level or flow conditions.

Condition of Banks - evaluates the extent of bank failure or signs of erosion.

Bank Vegetative Protection - estimates the extent of stream bank that is covered by plant growth providing stability through well-developed root systems.

Grazing or Other Disruptive Pressures - evaluates disruptions to surrounding land vegetation due to common human activities, such as crop harvesting, lawn care, excavations, fill, construction projects, and other intrusive activities.

Riparian Vegetative Zone Width - estimates the width of protective buffer strips or riparian zones. This is a rating of the buffer strip with the least width.

APPENDIX B: Description of Instream Comprehensive Evaluation biological metrics that were used in this project.

<u>Total Abundance</u>

The total abundance is the total number of organisms collected in a sample or sub-sample.

<u>Dominant Taxa Abundance</u>

This metric is the total number of individual organisms collected in a sample or sub-subsample that belong to the taxa containing the greatest numbers of individuals.

<u>Taxa Richness</u>

This is a count of the total number of taxa in a sample or sub-sample. This metric is expected to decrease with increasing anthropogenic stress to a stream ecosystem, reflecting loss of taxa and increasing dominance of a few pollution-tolerant taxa.

<u>% EPT Taxa</u>

This metric is the percentage of the sample that is comprised of the number of taxa belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). Common names for these orders are mayflies, stoneflies, and caddisflies, respectively. The aquatic life stages of these three insect orders are generally considered sensitive to, or intolerant of, pollution (Lenat and Penrose 1996). This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of taxa from these largely pollution-sensitive orders.

<u>Shannon Diversity Index</u>

The Shannon Diversity Index is a community composition metric that takes into account both taxonomic richness and evenness of individuals across taxa of a sample or sub-sample. In general, this metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive taxa and increasing dominance of a few pollution-tolerant taxa.

<u>Hilsenhoff Biotic Index</u>

This community composition and tolerance metric is calculated as an average of the number of individuals in a sample or sub-sample, weighted by pollution tolerance values. The Hilsenhoff Biotic Index was developed by William Hilsenhoff (Hilsenhoff 1977, 1987; Klemm et al. 1990) and generally increases with increasing ecosystem stress, reflecting dominance of pollution-tolerant organisms. Pollution tolerance values used to calculate this metric are largely based on organic nutrient pollution. Therefore, care should be given when interpreting this metric for stream ecosystems that are largely impacted by acidic pollution from abandoned mine drainage or acid deposition.

Beck's Biotic Index

This metric combines taxonomic richness and pollution tolerance. It is a weighted count of taxa with PTVs of 0, 1, or 2. It is based on the work of William H. Beck in 1955. The metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-sensitive taxa.

Percent (%) Sensitive Individuals

This community composition and tolerance metric is the percentage of individuals with PTVs of 0 to 3 in a sample or sub-sample and is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-sensitive organisms

Appendix C: Macroinvertebrates and their enumeration identified at each site.

Order	Family	PA Taxon	SIC	LBF	OBF	EBC
Oligochaeta	Oligochaeta	Oligochaeta	1		2	
Basommatophora	Lymnaeidae	Lymnaeidae		1		
Coleoptera	Psephenidae	Ectopria	14		2	16
		Psephenus	3			
	Elmidae	Optioservus	12	12	1	1
		Oulimnius	15	17	35	27
		Promoresia		1		29
Decapoda	Cambaridae	Cambarus	1			
		Cambaridae			3	
Diptera	Athericidae	Atherix	4			6
	Empididae	Chelifera	3			
		Oreogeton			1	
	Chironomidae	Chironomidae	6	7	12	16
	Tipulidae	Hexatoma	1	2	7	
		Antocha		1		2
		Dicranota		1		
		Pseudolimnophila				2
	Simuliidae	Prosimulium				2
		Simulium		1	1	4
	Ceratopogonidae	Bezzia			1	
	Psychodidae	Pericoma				1
Ephemeroptera	Baetidae	Acentrella	6	3		
		Baetis	10	4	7	16
		Diphetor		1	1	
	Heptageniidae	Cinygmula	4	12	19	2
		Leucrocuta	5			1
		Maccaffertium	1	1		2
		Stenacron	1			
		Epeorus	29	20	22	25
	Ephemerellidae	Drunella	8	61	22	10
		Ephemerella	20	35	7	23
		Teloganopsis	2			
	Leptophlebiidae	Leptophlebiidae	3		3	

Order	Family	PA Taxon	SIC	LBF	OBF	EBC
Megaloptera	Corydalidae	Nigronia	3			
Odonata	Gomphidae	Gomphidae	3	3	2	5
		Lanthus				2
Plecoptera	Perlidae	Acroneuria	8			2
		Agnetina				1
	Nemouridae	Amphinemura	2	1	1	2
	Pteronarcyidae	Pteronarcys	2	2	2	8
	Peltoperlidae	Tallaperla	1		2	
	Chloroperlidae	Chloroperlidae		2	6	
		Sweltsa		2	5	
	Leuctridae	Leuctra		3	6	12
	Perlodidae	Malirekus		5	1	
Trichoptera	Glossosomatidae	Agapetus	15		1	1
	Hydropsychidae	Ceratopsyche	5	1	1	1
		Diplectrona	10	3	17	11
	Philopotamidae	Dolophilodes	2			
	Uenoidae	Neophylax	7	7	2	
	Polycentropodidae	Polycentropus	1			
	Odontoceridae	Psilotreta	3		1	1
	Rhyacophilidae	Rhyacophila	1	3	5	2
	Limnephilidae	Goera		1		
	Hydroptilidae	Hydroptila		1		
	Lepidostomatidae	Lepidostoma		2	4	
	Molannidae	Molanna		2		
Veneroida	Sphaeriidae	Sphaeriidae	1	3		
TOTAL COUNT			**219**	**221**	**202**	**233**

Appendix 2

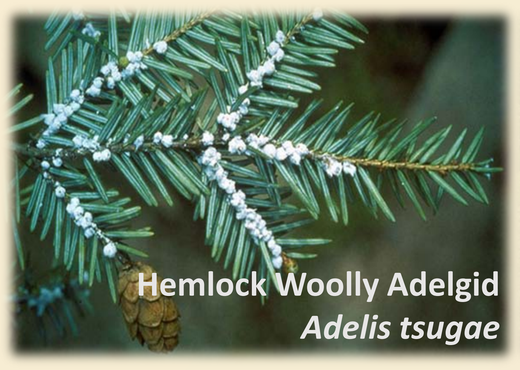
Pine Creek Headwater Hemlocks

Watershed scale planning for adaptively managing the impact of Hemlock Woolly Adelgid *(HWA)*, *Adelgis tsugae* on Northern Appalachian Forests

Kimberlie Gridley (Tioga County Planning), Jim Weaver (Pine Creek Watershed Council), Liz Costanzo-Kreger (Pine Creek Watershed Council), Jared Dickerson (Potter County CD), Will Hunt (Potter County Planning), Chris Firestone (DCNR), Dan Spooner (George Mason University)

Problem

- ***The headwaters of the Pine Creek watershed support a high quality cold-water ecosystem.*** *Local communities, eco-tourists, and sports-fishers find solace and economic support from the goods and services provisioned by the watershed.*
- ***Hemlock forest stands are a central component to the health and functioning of the Pine Creek watershed*** *by maintaining a natural flow regime, stable riverbanks and soils, and providing thermal refuge to native brook trout, Salvelinus fontinalis.*
- ***Impacts of rising summer temperatures and the infestation of invasive species,*** *such as the Hemlock Woolly Adelgid (HWA) are* ***threatening the cold water heritage*** *of the upper Pine Creek Watershed.*
- *In our region this aphid-like insect, feeds on the starches stored in the young twig tissue of the Eastern Hemlock , Tsuga canadensis, inhibiting growth and threatening long-term survival of the tree. (Pest Alert, USDA, 2005)*



Preemptive Strike

"We seek to identify priority reaches for planting mixed conifer species that could replace the function of the Eastern Hemlock in the Pine Creek head-watersheds, mitigating the effect of the loss of this climax forest species to our landscape."
~Pine Creek Watershed Council, 2016 CHP Planning Grant Proposal

Approach:

- Plant a variety of conifer species native or adapted to the Northeastern US as an understory to existing Eastern Hemlock stands in headwater streams in the Pine Creek Watershed.
- Engage local volunteer watershed organizations and individuals
- Technical assistance and program coordination will be provided by the Pine Creek Watershed Council (PCWC) partners (see below).
- Conservation District Watershed Specialists in the Pine Creek Watershed will provide program oversight.

Program Goals:

- To provide volunteers with a location map, tools and seedlings to plant in areas with Eastern Hemlock as the predominant species.
- In areas with dying or heavily damaged hemlock (70% defoliation or greater), our focus is to influence regeneration of ecosystem function, using a variety of conifer species.

Note: *Native conifers may be ineffective at filling the niche left by hemlock, warranting the use of non-native species. Although Norway spruce may be used to replace eastern hemlock, planting another native conifer (for example, white pine, red spruce, or white spruce) will increase opportunities for wildlife endemic to the area. A mixture of species will be required to compensate for the loss of Eastern Hemlock.*

Project Partners:

pennsylvania DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
TIOGA COUNTY CONSERVATION DISTRICT
TROUT UNLIMITED
Pine Creek Watershed Council
Potter County Conservation District
COLDWATER HERITAGE PARTNERSHIP
Potter County, Pennsylvania
Tioga County Pennsylvania

Development of the Headwater Hemlock Plan

The initial Plan will focus on headwater tributaries within the Pine Creek Watershed, Pennsylvania.

Steps for Completion within the Pine Creek Watershed

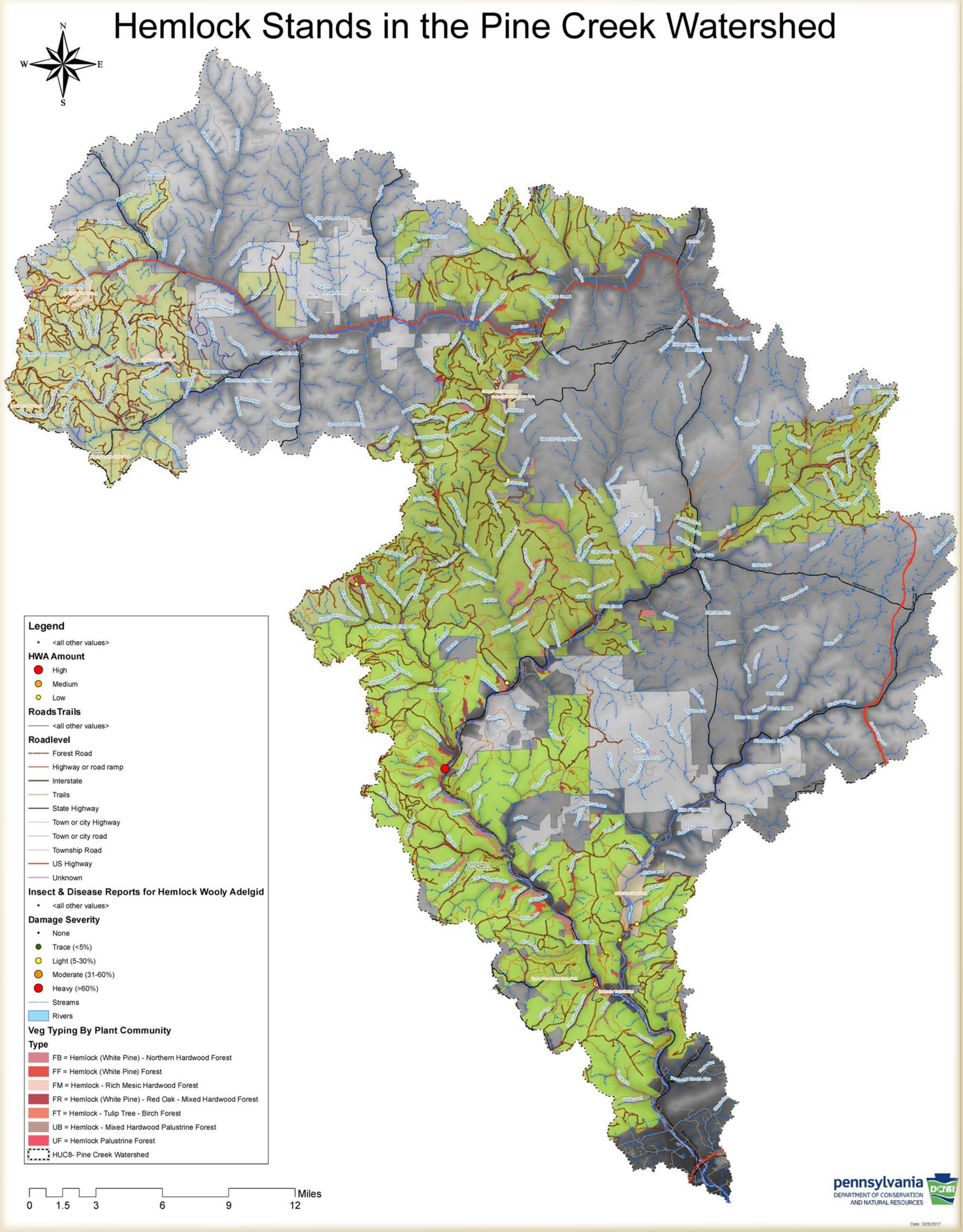
1) Delineate sub-watersheds (HUC12) within Pine Creek.
2) Begin ranking at southernmost sub-watersheds moving north throughout Pine Crk.

Ranking criteria within a sub-watershed

- *Is stand within treatment area? (DCNR defined and treated)*
- *Eastern Hemlock distribution*
- *Hemlock Woolly Adelgid (HWA) distribution*
- *Stream classification*
- *Stand aspect*
- *Stand elevation*
- *Stand slope*
- *Aesthetic value*
- *Accessibility*
- *Presence of Threatened and Endangered (T&E) species*

3) Identify top priority sites.

Note: *Sub-watershed criteria will be determined using GIS mapping.*
Field based site assessments will take place once top priority sites are determined.

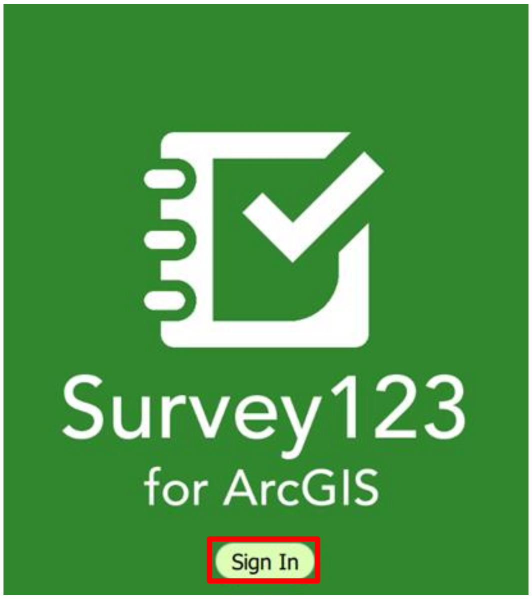


Project contact:
Kimberlie Gridley, *Planning Specialist, Tioga County, PA*
kgridley@tiogacountypa.us, 570-723-8251

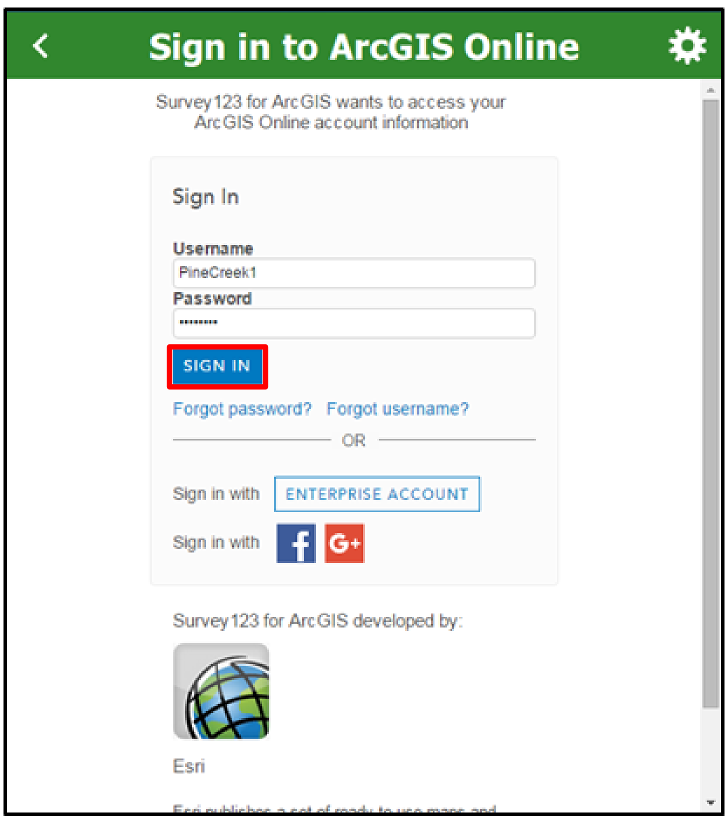
Appendix 3

Survey123 Hemlock Data Sheet Tutorial -

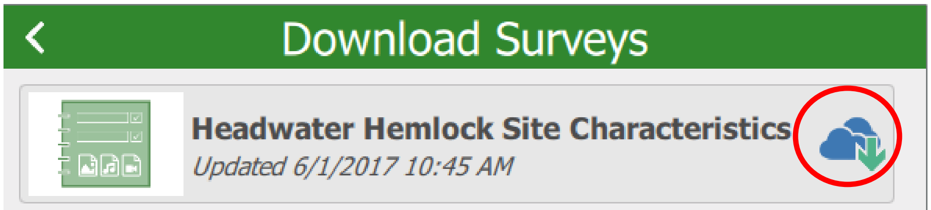
1. Download Survey123 for ArcGIS on your Desktop, Laptop, Tablet, Phone, or other device. (Device will need to be connected to the internet)
2. Open the application. It should show you a screen like this. Click "Sign In"



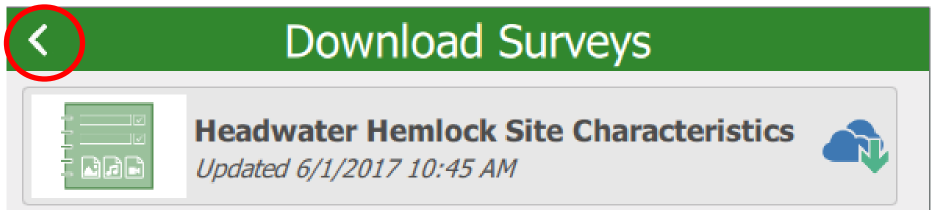
3. Enter Login Information. Username – **PineCreek1**. Password – **hemlock1.** Click on "Sign In"



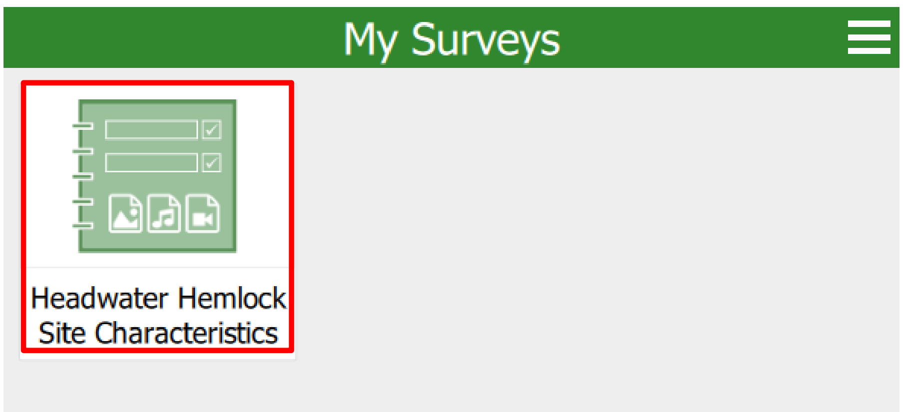
4. Once signed in the program will prompt you to download a survey. Click the download button next to “Headwaters Hemlock Site Characteristics”



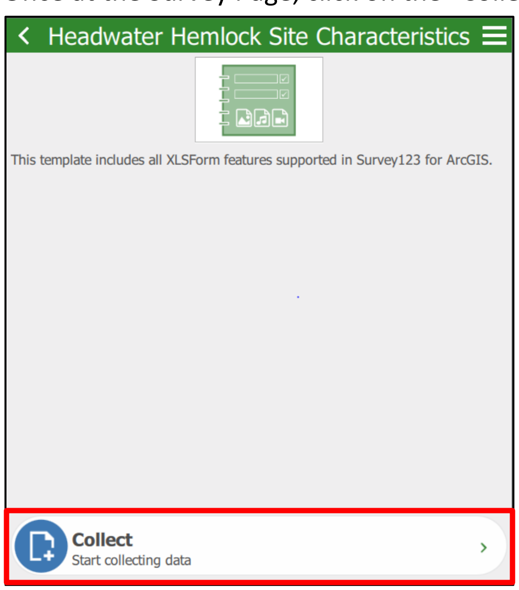
5. Once download is complete, click the back arrow to return to the “My Surveys” Page.



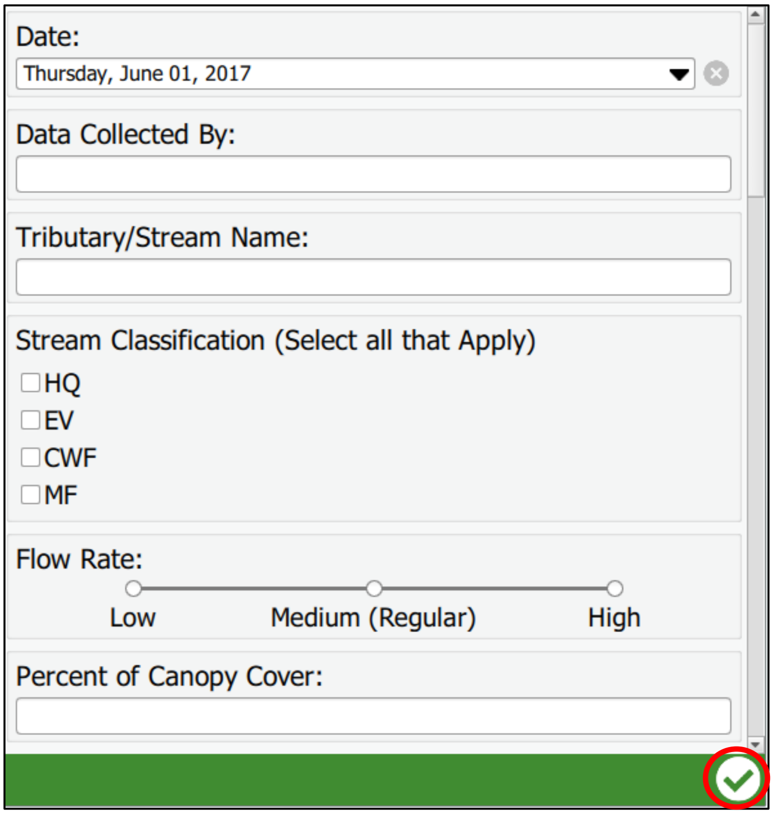
6. Once at the “My Surveys” Page, click on the icon for the “Headwater Hemlock Site Characteristics” Survey



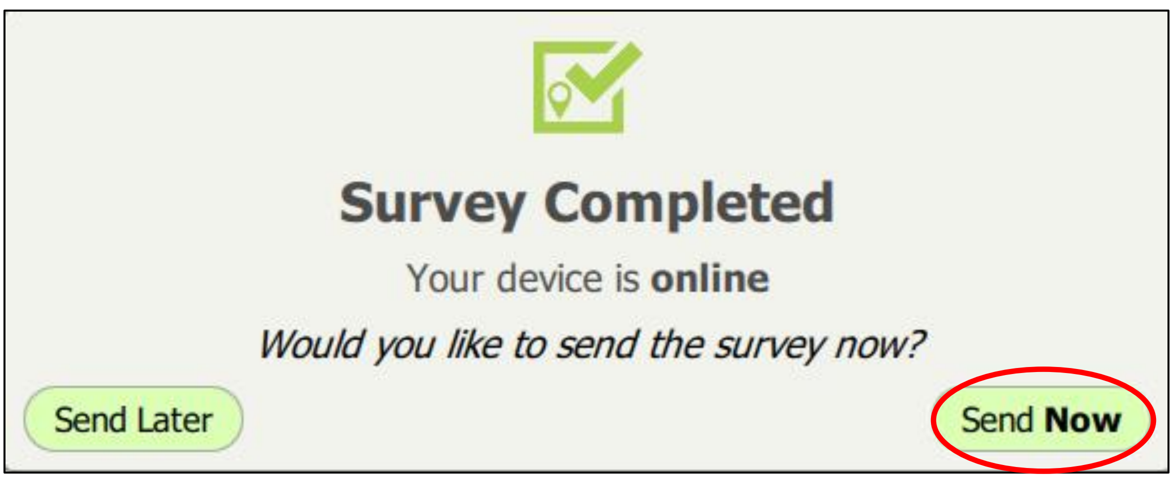
7. Once at the Survey Page, click on the “Collect” button to begin Data Collection.



8. Complete the survey, when survey is complete to the best or your knowledge press the check button in the bottom right corner.

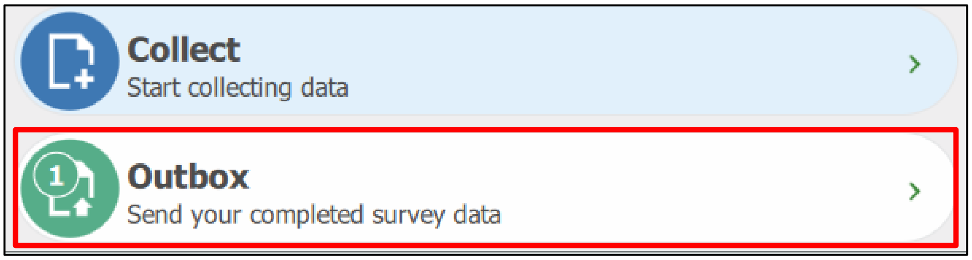


9. If you are connected to the internet you will have the option to send your survey immediately. Press "Send Now" to send the survey.

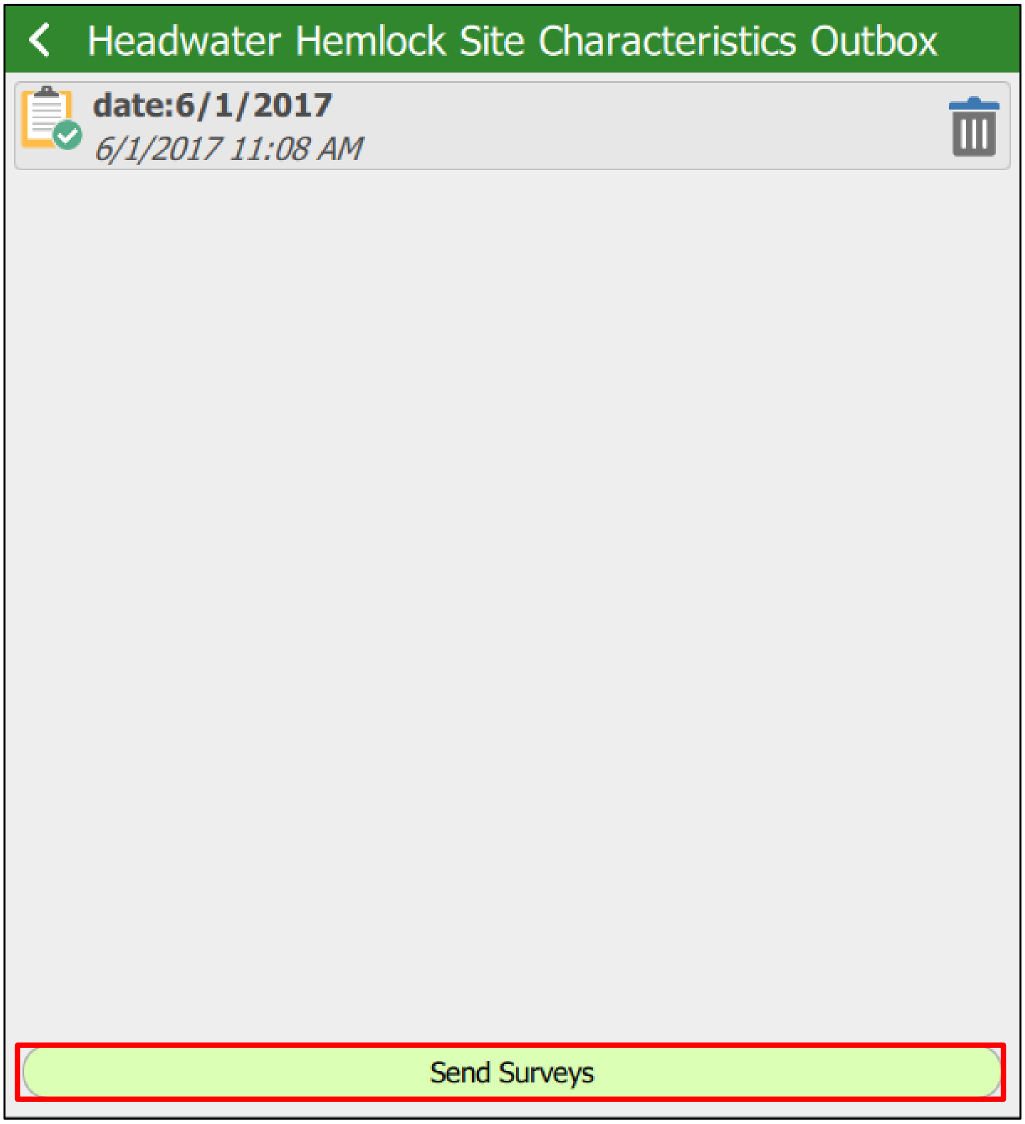


10. If your device is offline you will have to store your survey and send it later when device is reconnected to the internet.

11. To send stored surveys you go to the survey page from step 8, rather than clicking “Collect” you will click “Outbox”



12. In the outbox, clicking “Send Surveys” will send all stored surveys to the online data base.



13. Congratulations, you have added to our knowledge of Hemlock Stands in the Pine Creek Watershed. Feel free to press the “Collect” button from step 8 and continue to collect data.

HELPFUL INFORMATION: Any technical Issues/questions with the survey should be directed to Jared Dickerson at 814-320-4015. Handheld GPS is helpful if your device does not have a built in GPS.

Appendix 4

Headwater Hemlock Site Characteristics

Date: _____________ **Data Collected by:** _____________ **Tributary:** ___________________________

GPS location: _______________________________ **Location stored:** _______________

Stream Classification:

EV HQ CWF

Hemlock Distribution:

Presence (circle one): YES NO *Extent of Stand (est. length/width):* ________________

Average age: _____________ *% Stand Mortality:* ___________

HWA Distribution/Severity:

Distribution: Present Absent *Severity:* mild moderate severe

Species Composition:

Conifers (list): ____ *% of total:* __________

Deciduous (list): ____ *% of total:* __________

Treatment Area (circle one):

YES NO *Treatment Type:*

Stand Orientation (circle all that apply):

SW NE Ravine Bottom Ravine Top Public Visibility

Accessibility (circle one):

Easy Moderate Difficult

NOTES: