Detecting Climate Change in Wetlands in the Adirondack Park: No-Cost Extension 2016

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Executive Summary

The objectives of the no-cost extension of EPA Wetland Program Development Grant CD#96295000, "Detecting Climate Change in Adirondack Wetlands," were to (1) continue phenological monitoring of wetlands by citizen scientists, (2) complete additional Tier III wetland condition assessments, and (3) retrieve, array and conduct preliminary analysis of environmental condition data from data loggers deployed at study sites. This work was conducted by project partners through a contract to the Research Foundation of the SUNY College of Environmental Science and Forestry. In 2016 we more than doubled the number of site visits and phenological surveys by citizen scientists, taking full advantage of the citizen science data interface built for the project. We conducted six Tier III wetland condition assessments following protocols established by the project. We retrieved data from temperature, water level and precipitation data loggers to characterize environmental conditions at our study sites. Project partners are actively exploring funding sources in order to continue citizen science outreach and data analysis.

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Project Overview

The New York State Adirondack Park Agency (APA) was awarded Wetland Protection Program Development grant (CD #97208000) in 2011 to establish a network of long-term wetland monitoring sites that enable analysis of wetland responses to climate change. The goals of this project were met by identifying wetlands vulnerable to climate change, and developing 1) protocols and criteria for detecting and monitoring climate change effects, 2) data collection training modules for citizen science volunteers, and 3) a web-based GIS database to analyze, interpret, and disseminate information on wetland and watershed condition. In 2014, Phase II of the project titled "Detecting Climate Change in Adirondack Wetlands" (CD #96295000) was funded and the project partners began the implementation of the first comprehensive climate change effects detection program for wetlands in the Adirondacks consistent with national climate change detection networks. To accomplish the objectives APA partnered with the New York Natural Heritage Program, the State University of New York College of Environmental Science and Forestry, and Paul Smith's College. Due to unforeseen changes in project staffing and equipment needs we requested a no-cost extension of the project to continue monitoring wetlands considered vulnerable to climate change in the Adirondacks. This no-cost extension was overseen by the State University of New York College of Environmental Science and Forestry and implemented through a contract to Borealis Consulting, L.L.C. The objectives of the no-cost extension phase of this project were to 1) continue monitoring phenological indicators of targeted wetlands with citizen scientists, 2) complete wetland condition assessments at additional sites, and 3) continue with trial monitoring of important climate change indicators in targeted wetlands via installation of data loggers. The final products of this project include a network of trained volunteers committed to long-term monitoring of wetlands, a wetland condition database that includes wetland phenology data, an improved website and application (app), preliminary data analysis, and dissemination of the data to the public.

Citizen Science Training and Phenological data collection

Volunteer training

In spring of 2016 we conducted four citizen science volunteer training workshops with the goal of engaging and preparing volunteers for the phenological data collection field season. These training sessions occurred at two locations: the Adirondack Visitor's Interpretive Center in Newcomb, New York and the Paul Smith's College Visitor's Interpretive Center in Paul Smith's New York, on four separate days in April and May, 2016. The goal of these training workshops was to provide hands-on experience with monitoring protocols and make the citizen science volunteers more comfortable with species identifications, data collection and data entry. During the workshops we reviewed identification of target species, protocols for birds, amphibians and plant surveys, entered the data via the app and entered paper data via the website.

Nineteen attendees participated in the workshops (Table 1). These workshops used materials developed under Phase I and Phase II of this project and for some of the attendees this was their 3rd or 4th training workshop as they attended 2014 and 2015 workshops as well.

Figure 1: Citizen scientist workshop participants observing birds during a 2015 workshop at the Adirondack Visitor's Interpretive Center in Newcomb, NY.

Table 1: Date, location and number of attendees of citizen science training workshops.

Citizen Science Training Workshops			
Date	**Location**	**Number of Attendees**	**Comment**
Saturday, April 09, 2016	Paul Smith's College VIC	10	
Saturday, April 23, 2016	Newcomb	0	No attendance because Newcomb's school vacation was scheduled that week.
Saturday, May 07, 2016	Newcomb	5	
Saturday, May 14, 2016	Paul Smith's College VIC	4	Home school group attended

In addition to these formal training workshops, we conducted a number of informal field trainings and presentations throughout the year, engaging both active citizen scientist volunteers and individuals entirely new to the project (Table 2). These informal training sessions focused on review and practice of phenological survey protocols in the field, species identification, general introductions to wetland and peatland ecology, and the overall goals of the project.

Table 2: Dates, location and number of attendees of informal field training workshops

Informal Citizen Science Field workshops			
Date	**Location**	**Number of Attendees**	**Comment**
Wednesday, April 06, 2016	Wild Center, Tupper Lake	3	Wild Center Staff
Thursday, April 14, 2016	Bloomingdale Bog	3	Volunteer Training
Wednesday, May 11, 2016	Silver Lake Bog	1	Volunteer Training
Tuesday, July 05, 2016	Wild Center, Tupper Lake	4	Youth Program
Wednesday, September 14, 2016	Silver Lake Bog	18	SUNY Plattsburgh Field Ecology Class presentation
Thursday, September 29, 2016	Bloomingdale Bog/ Brighton Bog	8	SUNY Plattsburgh Wetland Ecology Class presentation
Tuesday, November 15, 2016	Bloomingdale Bog	4	Youth/Adult Program

As expected there were far fewer attendees of the 2016 training workshops than the previous years. A likely reason for fewer attendees was that with the limited budget of the no-cost extension we intentionally did not focus on recruiting new volunteers. Rather, our objective was to retain trained volunteers, increase their active involvement and increase the number of site visits and surveys. Additionally, we offered only four volunteer training workshops rather than the six offered in 2015. See further discussion below.

Phenological Data Collection

In 2016, despite fewer participants in our training workshops, we more than doubled participation in terms of the number of site visits and number of submitted phenological surveys. We also increased the percentage of surveys submitted by volunteers as opposed to project staff (Figure 2).

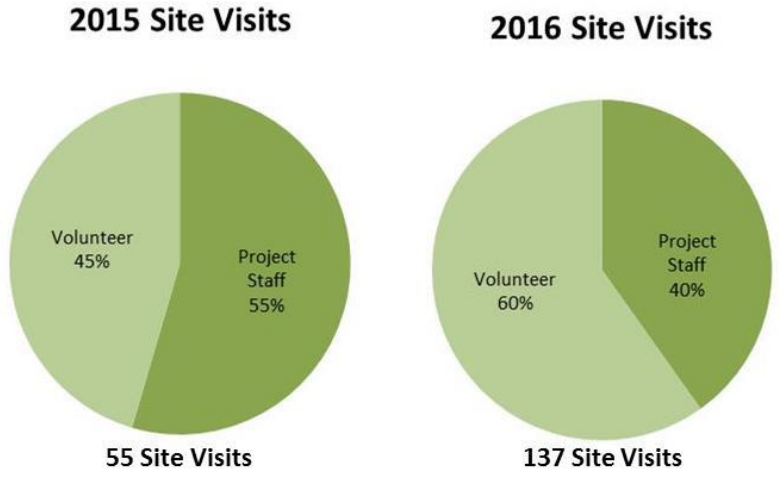

Figure 2: Number of site visits by volunteers and project staff completed in 2015 and 2016.

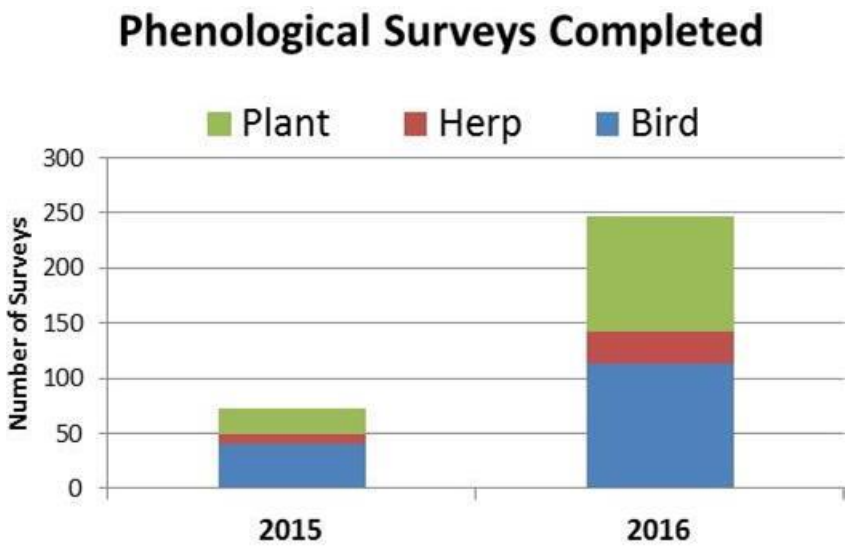

Figure 3: Phenological survey types in 2015 and 2016. The number of surveys nearly quadrupled in 2016 as compared to 2015 though the proportion of survey types (i.e., bird, plant, and amphibian or "herp") remained the same.

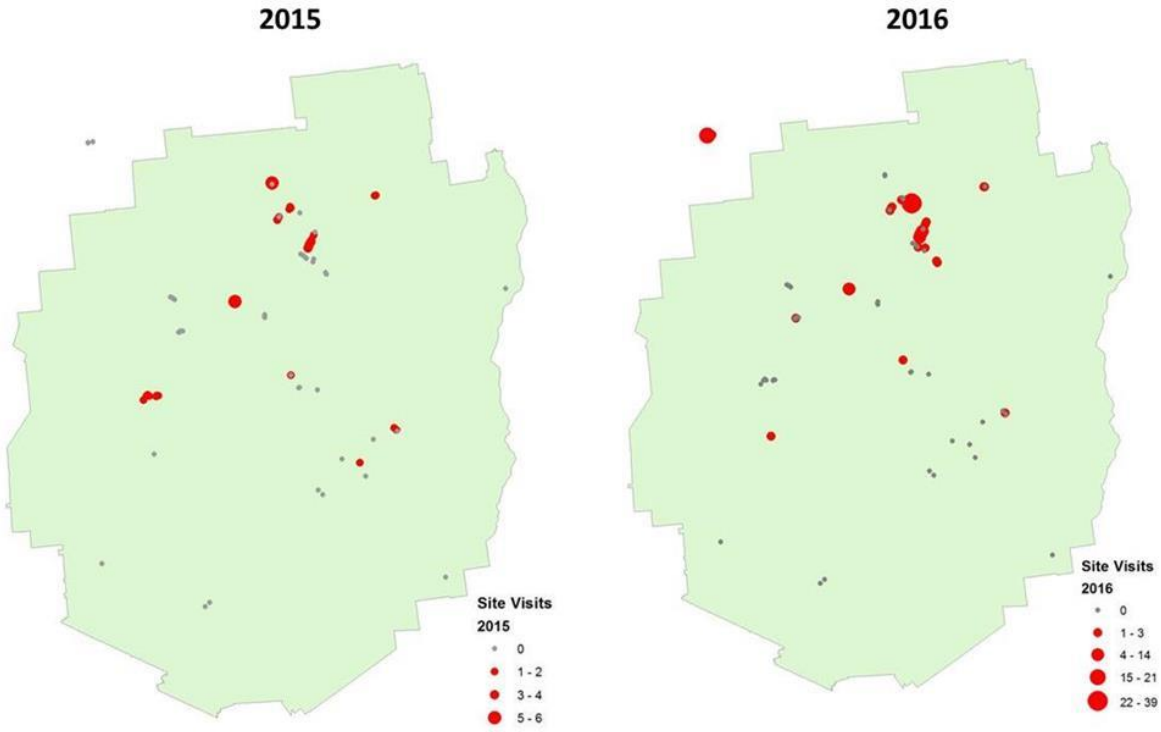

Figure 4: Spatial distribution of site visits by volunteers and project staff in 2015 and 2016. Generally the locations of site visits remained the same, though in 2015 there were a few more in the southern Adirondacks.

For each site visit there can be up to three surveys (i.e., amphibian/herp, bird, and plant). We increased the number of surveys that were submitted by volunteers in 2016 by more than fourfold, while the proportion of survey types generally remained the same (see Figure 3). Herpetological surveys were least well-represented, likely because frogs and toads tend to be most active in the evening. Most trainings were during the day, thus volunteers may not have felt confident in identifying different species of anurans. While in 2016 the number of site visits and surveys increased, the spatial distribution of sites that were surveyed changed only slightly due to the inclusion of sites that were chosen to accommodate the volunteers rather than through the selection methodologies of Phase I of the project (Figure 4). These data can also be viewed at the project website: http://adirondackatlas.org/boreal_wetlands/.

Discussion and Next Steps

The no-cost extension phase of this project successfully expanded citizen scientist participation to make good use of the training and data infrastructure (i.e., the database and app) developed earlier in the project. This expansion of participation may be attributed to training efforts and outreach which enabled citizen scientists to develop confidence in their observations. Although we did not collect pre- and post-training data as that was not a part of our project, repeat interactions between the project team and volunteers may have improved participation, retention and skill acquisition. Throughout the project volunteers expressed reluctance to submit data because they did not want to submit misidentified species or were self-conscious about submitting observations of only one or two species. We were able to overcome this reluctance by communicating that they do not need to be an expert, that even single species identification can provide valid data for making inferences, and that this was as much a process of engagement and an opportunity to learn, as a rigorous survey procedure.

Another factor that may have contributed to the increase in participation in 2016 was that we allotted more time to go into the field with volunteers to practice protocols and identification in a field setting. As shown by educational studies (e.g., Fukami 2013), hands-on, field-based training sessions can improve participant performance and confidence. Finally, we expanded observation points to include sites that, while they were not directly within our survey sites, were favorite locations for individual volunteers to visit, that had appropriate habitat. The expansion of the observation points empowered volunteers, to the point where a single volunteer submitted surveys from dozens of site visits from a boreal wetland site near her residence.

While participation expanded in 2016 there remain a number of issues to resolve as the project moves forward without EPA support. First, the data infrastructure is still not used to its fullest capacity. We could vastly expand participation in terms of number of citizen scientists, sites visited and surveys submitted. The limits to participation by volunteers in the project include a number of factors. The Adirondacks is a large rural area with many transient (summer only) residents and visitors: finding and retaining volunteers interested in the work is challenging. As the project moves forward we must focus on ways of identifying and cultivating potential volunteers. Our success in 2016 can be attributed to a small number of ‘Super Volunteers’ that were intensely engaged in the project and surveyed their sites numerous times. Successfully identifying and cultivating such individuals provided useful phenological data but expanding the

extent of data collection through both space and time would make the project more self-sustaining and useful.

Throughout Phase II of the project we were aware of the juxtaposition of managing both a volunteer-based citizen science program and a professional scientist wetland condition assessment program. As discussed in the Phase I final report, we aspired to balance these two interests: empirical data on peatland vegetation was critical to establishing a reference condition in a climate change context, while the volunteer program was critical to detect change over time in these vulnerable wetlands. Retrospectively, one of the biggest challenges to the project was the lack of a full-time volunteer coordinator. This role was overseen by either the project coordinator or other project staff, all of whom had other responsibilities during the project. A clearly designated volunteer coordinator would have perhaps led to greater participation by citizen scientists.

Transferability of the project has been achieved by sharing the project summary, protocols and web database as examples to a number of organizations outside the project partner team, including:

- United States Geological Survey, Troy NY office
- New York State Office of Information Technology Services (OITS produces an annual "GIS State of the State" conference address in which the project featured)
- Bijagual Ecological Reserve, Costa Rica
- Vermont Monitoring Cooperative
- Global Environmental Change Initiative, SUNY ESF

Looking ahead to 2017 Project Partners plan to continue the volunteer citizen scientist phenological monitoring and is working to identify funding sources to support training workshops. Because the data infrastructure is in place and an engaged group of volunteers has been established, the costs needed to support such an effort are limited. We are planning a meeting among project partners in early 2017 to discuss future efforts related to this.

Wetland Condition Assessments

Intensive vegetation assessment (Tier III)

Wetland condition assessments of boreal peatlands were completed at 28 sites over the course of this two-phased project in order to establish biotic reference conditions. At the end of 2015 we had not met our goal of surveying 30 sites and two remaining sites were targeted for the 2016 no-cost extension. Because of the logistics of access we were only able to sample one of the two sites targeted. However, we had a relationship with the Adirondack Chapter of the Nature Conservancy (TNC) for the duration of the project as their land holdings are the sites of a number of peatlands that were selected for sampling. This led to TNC adopting our methodologies for five intensive vegetation surveys of boreal peatlands on their properties, and separately funding these surveys with data housed at our partner organization, the New York Natural Heritage Program. Including these additional sites, five intensive vegetation surveys were added to the ecological communities database in 2016 to establish reference conditions of boreal peatlands vulnerable to climate change (Table 3). A short synopsis of the results of these intensive vegetation surveys follows.

Table 3: Dates and locations of intensive vegetation surveys completed in 2016. Data from these surveys are housed at the New York Natural Heritage Program in Albany, NY.

Date	Location	System	Subsystem	Community	Comment
9/1/2016	Marcy Swamp/Boreas	Palustrine	Forested Peatland	Black Spruce Tamarack Bog	Targeted in Phase II
7/19/2016	Follensby Outlet Marsh	Palustrine	Open Peatland	Medium Fen	Not targeted in Phase II
7/20/2016	Follensby Outlet Marsh	Palustrine	Open Peatland	Medium Fen	Not targeted in Phase II
7/27/2016	Follensby (south)	Palustrine	Open Peatland	Sedge Meadow	Not targeted in Phase II
8/10/2016	Follensby (south)	Palustrine	Open Peatland	Medium Fen	Not targeted in Phase II

We had identified the Marcy Swamp/Boreas wetland complex in 2013 as a ‘charismatic megawetland’ of the Ausable/Hudson River watersheds. With the help of the New York State Department of Environmental Conservation Division of Lands and Forests we were able to access a randomly-located point on the northern end of the Boreas tract on September 1, 2016. This site was a black-spruce tamarack bog with abundant sign of moose. The data appear in the ecological community forms in Appendix A of this report. During the Tier I landscape assessment we had interpreted the community in which our randomly located sample site as a Palustrine forested peatland, Northern white cedar swamp (NWCS). The interpretation was based on field observations of this wetland site just to the north at the hiking trail. Our randomly selected point turned out to be a Palustrine forested peatland, Black spruce tamarack bog (BS-

TB). Trees were dominated by *Picea mariana* (black spruce) with scattered *Larix laricina* (larch). Shrubs were dominated by *Ilex mucronata* (mountain holly), *Viburnum nudum* (northern wild-raisin), and *Kalmia angustifolia* (sheep laurel). The herbaceous layer was sparse and dominated by *Carex aquatalis* and *C. trisperma*. Sphagnum mosses dominated the non-vascular layer. There seemed to be a high amount of black spruce mortality, perhaps due to normal disturbances and the presence of *Arceuthobium pusillum* (dwarf mistletoe), a native parasitic angiosperm common to this ecological community. Sampling in early September prevented us from capturing the presence of ephemeral species (e.g., orchids) at this site. The pH of the ground water was 4.0 and the conductivity was 76.1 µs/cm. The depth of the peat was greater than 3 m (the length of the probe). A notable observation was the presence of six moose scats, heavy signs of browse on northern wild raisin, and a moose bed - all within our 1000 m^2 plot.

Medium fen sites surveyed in the Follensby Outlet Marsh are more typical of medium fen vegetation communities and similar to a site surveyed as part of Phase II approximately 5 km downstream in 2015. Two randomly selected sites were surveyed in the large continuous peatland complex that lies between Follensby Pond and the Raquette River. The first medium fen site was closer to the outlet stream and had areas of vegetation recently inundated in high water. This site was dominated by herbaceous plants including *Osmunda regalis* (royal fern), the sedges *Carex aquatalis* (water sedge) and *C. oligosperma* (few-seeded sedge). *Myrica gale* (sweet gale) dominated the shrub layer. There were a number of residual species (i.e., species occurring outside the four 100 m^2 subplots) in the plot as a corner of it crossed the outlet stream. The second medium fen site was located on the upland margin of this peatland complex and is a shrub-dominated medium fen with sparse *Acer rubrum* (red maple) and *Thuja occidentalis* (northern white cedar) trees. The shrub layer of this site was dominated by *Myrica gale* (sweet gale) and *Aronia melanocarpa* (black chokeberry) with herbaceous plants like *Carex aquatalis* (water sedge) and *Osmunda regalis* (royal fern). These two sites occur on a thinner layer of peat than is normally expected (Edinger et. al. 2014).

A third medium fen site was surveyed on August 10, 2016. This site was interpreted from the aerial imagery as a dwarf shrub bog (DSB) and while *Chamaedaphne calyculata* (leatherleaf, a species typical of DSB and recognizable from aerial imagery) surrounds the perimeter of this wetland complex it is far richer both in terms of plant diversity and nutrient availability. This site was dominated by shrubs like *Myrica gale* (sweet gale) and *Alnus incana* var. *rugosa* (speckled alder), with a high diversity of other shrubs including *Chamaedaphne calyculata* (leatherleaf), *Rubus hispidus* (swamp dewberry), *R. alleghaniensis* (blackberry), *Spiraea tomentosa* (steeple bush), *Spiraea alba* (meadowsweet), and *Vaccinium myrtilloides* (velvet-leaved blueberry). There was a sparse cover of trees including *Acer rubrum* (red maple), *Thuja occidentalis* (northern white cedar), *Salix sp.* (willow), *Larix laricina* (tamarack) and *Picea mariana* (black spruce). There was a high diversity of herbaceous plants which are slightly taller than the shrub layer. There was bare calcareous substrate (marble) in the stream bed that crossed the plot and 15 – 30 cm of peat accumulation as you moved away from the stream channel. The pH of the

stagnant water in this streambed was 7.4 - far higher than that expected of medium fens which normally range from pH 4.5 – 6.5 in other parts of the state (NYNHP 2016) - though this may not reflect the pH of ground water. A sample of rock from the neighboring uplands was identified as marble (Dr. David Franzi, personal communication 2016) which confirms the high calcium substrate in this area. The site had been dammed by beaver within the past ten years making this wetland community an atypical and exceptionally rich medium fen for the Adirondacks. The high pH and presence of calcareous rocks in and near this wetland make it a high-value conservation site in terms of regional plant diversity, particularly in the Adirondack region where such bedrock types are rare.

We sampled a sedge meadow on July 27, 2016. This wetland was interpreted as a dwarf shrub bog (DSB) from aerial images but upon field inspection we found this to be an area of sedge meadow within a large alder dominated wetland that stretches along a small tributary to the southwest of Follensby Pond. The herbaceous layer of this sedge meadow covered 87% of the plot and was dominated by tussock sedge with a smaller component of *Calamagrostis canadensis* (blue-joint grass). Other herbaceous plants included *Lysimachia terrestris* (swamp candles), *Hypericum fraseri* (northern marsh St. John's-wort), and *H. perforatum* (common St. John's-wort). The shrub layer made up only 14% of the cover of the plot and included *Spiraea tomentosa* (steeple bush), *Spiraea alba* (meadowsweet), and *Alnus incana* (speckled alder). There were a few scattered *Acer rubrum* (red maple) and Pinus strobus (eastern white pine) seedlings. There were a total of 32 vascular plant species in the sedge meadow plot. The depth of peat was measured at 1.66 m and a soil pit was dug to 1 m. Ground water from this soil pit had a pH of 5.66 and conductivity of 40.3 µs/cm.

Discussion and Next Steps

The data we collected as part of this project vastly expanded the information available about peatland ecological communities in the Adirondacks. This is important because these peatlands contribute disproportionately to biodiversity and are considered vulnerable to climate change globally (e.g., Lachance et al. 2005). Yet, they may serve as ecological refugia in the Adirondacks where topography and climate create favorable conditions for their persistence (e.g. Raney et al. 2014). These data are housed at the New York Natural Heritage Program in Albany, NY and can contribute to refining the ecological community classification system in New York State. Most importantly, the intention of this project was to establish a picture-in-time baseline of the wetlands to allow for future analysis of changes. Thus the 33 completed plots should be resurveyed in the future to better understand the response of peatland vegetation to climate change as well as broad-scale anthropogenic stressors in the Adirondacks such as atmospheric deposition of nitrogen.

Environmental Monitoring of Climate Change Indicators

Introduction

Cold air, the duration of snowpack and water budget are all important climatic factors in the ecology of peatlands (e.g., Crum 1988, Curtis 1959, Heijmans 2013). As part of Phase II of this project our goal was to create a reference characterization at a point in time of environmental conditions of peatlands and test the feasibility, cost and effectiveness of using data logger technology to achieve this objective. The time requirements of data logger array deployment prohibited us from compiling these data at the end of 2015. Logger data was retrieved and compiled in fall of 2016 as part of the no-cost extension. The following is an account of the status of monitoring at each site and preliminary results.

Figure 5: Distribution of sites where temperature data loggers were deployed as part of this project. The grey circles indicate data loggers that were deployed from 2015 – 2016 and the red circles indicate sites where data logger array deployment continues.

Temperature data logger arrays provide two important measures of climatic conditions: microsite temperature and duration of snowpack. Microsite temperature is obtained from a data logger at 1 m above the surface of the peatland and shielded from direct solar radiation. From the 1 m data logger we can obtain daily minimum, mean, and maximum temperatures, allowing us to calculate a number of other important variables such as duration of frost-free periods, growing degree days and estimates of evapotranspiration. Comparing these temperature data to fine-scale climate data

(e.g., PRISM 2016) allow us to refine our understanding of relationships between peatland microclimates, broader-scale temperature estimates, and ecological community response to shifting climatic variables.

The duration of snowpack is estimated from a temperature logger placed at the surface of the peatland and not shielded from direct solar radiation. From this ground-level data logger we can estimate the duration of time that the data logger is covered with snow by assuming that when the difference between the daily high and daily low is close to 0° C the logger is insulated by the snowpack. Water level loggers in ground water wells in peatlands allow us to calculate the relative distance to groundwater from the peatland surface and to estimate hydrologic budget at a site. Precipitation data loggers can provide information that is critical to understanding the hydrologic inputs to a peatland site from rainfall.

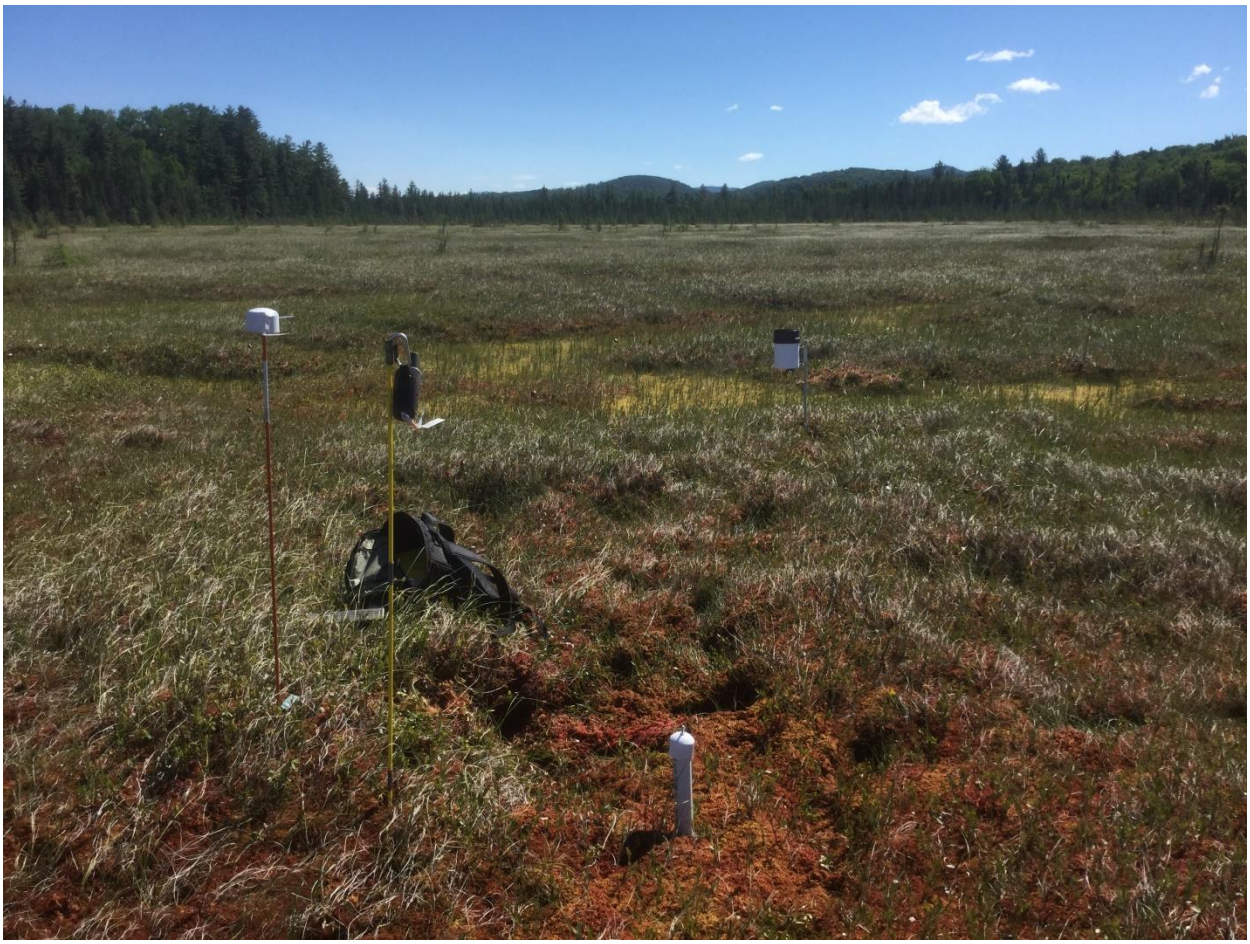

Figure 6: A typical data logger deployment with temperature data logger array (left), a groundwater well with water level and barometric pressure logger (front center), and rain gauge (back right). Note that the yellow probe right of the temperature data logger array is for measuring the depth of the peat deposit.

Sites for data logger deployment were selected subjectively based on accessibility and landscape characteristics (e.g., variability in elevation and watershed size). Temperature data logger arrays consisted of two temperature data loggers (Hobo Pendant 64k, Onset Computer Corp.) randomly located in un-forested peatland sites and mounted on a 2 m long, 5 mm diameter fiberglass pole driven ~1 m into the peat. One temperature data logger was at ground level (0 cm) and exposed to full sun and one was at 100 cm above the ground beneath a solar shield (2" PVC end cap). Water level data loggers (Hobo U20, Onset Computer Corp.) were deployed in ground water wells (3.8 cm diameter x 125 cm PVC well screen) that had been placed into the peat soils to 100 cm depth. At selected sites barometric pressure sensors (Hobo U20, Onset Computer Corp.) were placed at the top of the ground water well approximately 10 cm above the surface of the peat. The water level and barometric pressure loggers were attached to the cover of the well screen with a cable. Rain gauges (Hobo RG3, Onset Computer Corp.) were deployed at two sites attached to 1.27 cm diameter x 150 cm fiberglass rods that were inserted into the peat soils and leveled on deployment. Figure 6 shows a complete data logger deployment at Spring Pond Bog summer 2016. All of the data loggers recorded at two hour intervals throughout the course of deployment.

Results

Throughout Phase II of this project data loggers were deployed at 13 sites to monitor environmental variables. An overview of the extent of these data is shown in Table 4. Temperature data from our four initial pilot sites (Glacial Lake St. Agnes (GLSA) Big Bog, GLSA Small Bog, Paul Smith's VIC, and Silver Lake Bog) dates to fall of 2013. Both Silver Lake Bog and the Paul Smith's VIC had water level data loggers and precipitation gauges throughout 2015 and 2016. In June 2016 we deployed temperature, water level, and precipitation data logger arrays at Spring Pond Bog from June through October. All other sites had temperature data logger arrays deployed in 2015 and retrieved in 2016 (see Table 4 for precise dates).

These are preliminary data and conclusions must wait until a detailed analysis takes place. The data that have been reviewed confirm observations that peatland communities are colder than the surrounding uplands with minimum monthly temperatures often dropping to below or near freezing (Figure 7).

Table 4: Survey Sites where data loggers were deployed. Comments include information about environmental variables monitored, duration of monitoring and status of monitoring at each site.

Survey Site	UTM X	UTMY	DEPLOY DATE	RETREIVAL DATE	Comments
Silver Lake Bog	588534	4929249	8/10/2015	9/14/16	Silver Lake Bog was a pilot site; monitoring began in 2014. The site had a temperature data logger array for the entire monitoring period recording at 2-hour increments, a water level data logger in a ground water well and a rain gauge were deployed at the site in 2015.
Paul Smith's College VIC	558153	4921437	7/29/2015	10/9/2016	Paul Smith's VIC peatland was a pilot site so monitoring began in 2014. The site had a temperature data logger array for the entire monitoring period recording at 2 hour increments, a water level data logger in a ground water well and a rain gauge were deployed at the site in 2014.
Bloomingdale Bog	568192	4914622	7/30/2015	9/7/2016	Temperature data logging array only for the duration noted here. Battery Failure in 1 m logger leaving data only through Jan. 2016.
Piercefield	530988	4898696	8/3/2015	11/8/2016	Temperature data logging array only for the duration noted here.
GLSA Small Bog	518236	4866258	8/7/2015	6/14/2016	The GLSA Small Bog was a pilot site and temperature monitoring began here in 2013. The site has 2 temperature data logger arrays. A water level logger in a ground-water well was installed in 2014. Two weather stations monitoring temperature, precipitation, wind and barometric pressure are in the uplands in the vicinity of this site. These weather stations are maintained by Shingle Shanty Preserve and Research Station.
Osgood	514650	4924817	8/5/2015	9/14/2016	Temperature data logging array only.
Hoffman	595588	4856451	8/6/2015	11/17/2016	Temperature data logging array only.
Meacham	555838	4932640	8/12/2015	11/1/2016	Temperature data logging array only.
GLSA Big Bog	518686	4867457	8/21/2015		The GLSA Big Bog was a pilot site and temperature monitoring began here in 2013. The site has 2 temperature

Survey Site	UTM X	UTMY	DEPLOY DATE	RETREIVAL DATE	Comments
					data logger arrays. A water level logger in a ground-water well was installed in 2014. Two separate weather stations monitoring temperature, precipitation, wind and barometric pressure are in the uplands in the vicinity of this site.
Brandreth South Fen	523641	4859210	8/20/2015		Temperature data logging array. Data will be retrieved and loggers will be deployed under supervision of SUNY ESF Newcomb.
Ferd's Bog	520271	4848454	8/13/2015	11/17/2016	Temperature data logging array only.
GLSA Esker Fen	520790	4866401	8/21/2015		Temperature data logging array only. Shingle Shanty weather stations are in the vicinity in the uplands. Data will be retrieved and loggers will be deployed under supervision of SUNY ESF Newcomb.
Wolf Lake Fen	562722	4873235	11/27/2016		2 temperature data logging arrays deployed in November 2016. Data will be retrieved and loggers will be deployed under supervision of SUNY ESF Newcomb.
Spring Pond Bog	539992	4912923	6/24/2016	10/27/2016	We were permitted access to this site in 2016. Deployment included a temperature data logger array, water level logger in ground water well with barometric pressure at top of well, and a rain gauge. All loggers recording data at 2 hour intervals.

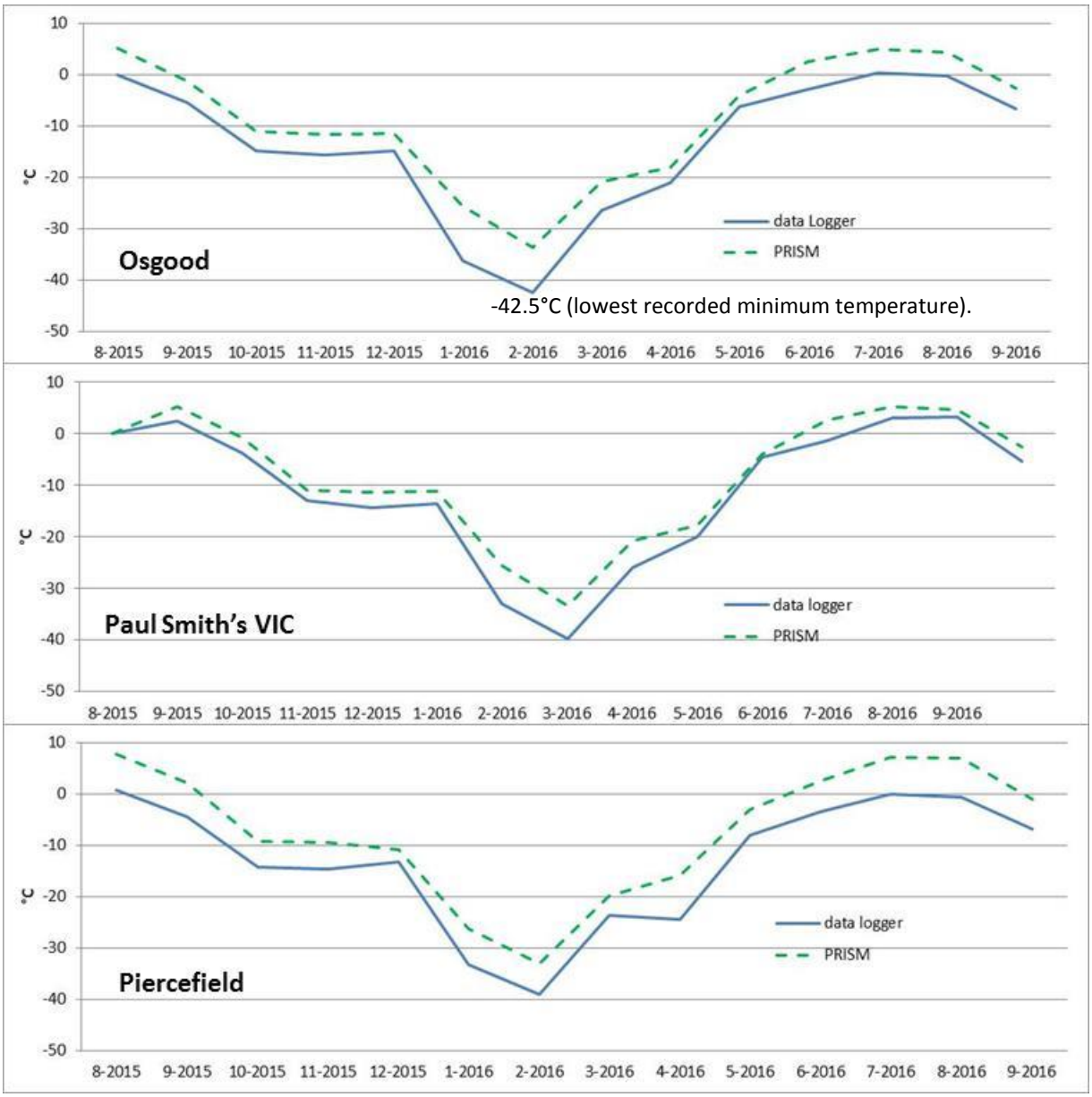

Figure 7: Preliminary data from 3 of 13 survey sites showing monthly minimum temperatures from data loggers in unforested peatlands (solid line) compared to 4 km^2 gridded historic climate data (PRISM; dashed line) for the same locations.

Discussion and Next Steps

A comprehensive analysis of these data is beyond the scope of this project. However, preliminary results from temperature data logger arrays show that air temperature in peatland sites tends to be cooler than that projected by fine-scale gridded climate data (PRISM 2016; see Figure 7). This is not surprising because the PRISM model relies on a regression function between climate and elevation, the latter of which is averaged across a 4km grid (Daly et al. 2002). This likely leads to overestimation of temperatures in peatlands within that grid since peatlands generally occur at the lowest elevations where cold air sinks. Further analysis of these data will be useful in improving the understanding of variability within the scale of the PRISM data and the role of microclimate to these ecological communities.

We anticipate the following steps to analyze the environmental condition data and are actively seeking funding and partnerships to do so:

1. Use regression analysis to compare modeled PRISM data with data collected at each site.
2. Determine if the coefficient produced from regressing predicted temperatures (i.e., PRISM data) and measured temperatures (i.e., our data) is better than simply altering the PRISM data model to use the elevation of the data logger in the peatland site rather than the mean elevation of the 4km grid.
3. Develop long-term temperature norms for peatland sites using the best estimator from step 2.
4. Explore developing a more generalized model of temperature in peatlands based on watershed size, elevation and other topographical variables (e.g., watershed steepness and shape) that could affect temperature variation.
5. Calculate evapotranspiration from sites with water level and precipitation loggers and use this to develop a regression estimator for potential evapotranspiration using only temperature data loggers (i.e., Thornwaite equation; Mitsch and Goselink 2015).
6. Review additional literature regarding microclimate in peatland community, its relation to hydrology in view of our data, and vegetation response to microclimate.
7. Develop conceptual models of vegetation response based on a better understanding of temperature and hydrology.

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Appendix A: Ecological Community Forms

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