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MEMO

To: Patty Gambarini, Pioneer Valley Planning Commission

From: Mark June-Wells, Ph.D., New England Environmental, Inc.

Date: August 26th, 2014

Project: Arcadia and Metacomet Lakes Quantitative Plant Study

RE: Plant Surveys – Arcadia and Metacomet Lake

Dear Patty,

The plant survey that was conducted on Arcadia and Metacomet Lakes of Belchertown, Massachusetts during July of 2014 used a random block design. These designs are well documented in contemporary ecological literature and are well suited for characterizing the structures of aquatic plant communities. Furthermore, these designs afford the data analyst the ability to mathematically characterize the plant community with a 95-99% species detection rate.

The basic structure of this technique, as it applies to Arcadia and Metacomet Lakes, is that 20 georeferenced points were established from 0.1 – 4m. At each point, the plant community was sampled using a grapple tied to a 20m line; four grapple samples were taken at each point. The plant species collected were given rank abundances by two independent observers. The ranks were as follows: 1 - rare, 2 – present but not abundant, 3 – abundant but not dominant, 4 - dominant, or 5 – dense monoculture. Using these data, community metrics were established (i.e. species relative abundances, diversity, and richness) as they apply to depth.

Finally, a full littoral zone survey was conducted by slowly motoring around the entire perimeter of the lake. Species were identified visually after collection with a long handled rake or grapple. This portion of the protocol was used to create a vegetation map, which indicates the relative locations of all species throughout the water body.

Sincerely,

New England Environmental, Inc.

Mark June-Wells, Ph.D.
Certified Lake Manager and ESA Certified

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MEMO

To: Pioneer Valley Planning Commission

From: Mark June-Wells, Ph.D., New England Environmental, Inc.

Date: January 17, 2015

Project: Quantitative Plant Study – Arcadia and Metacomet Lakes

RE: QAPP – Quantitative Plant Study

Dear Patty,

Attached to this memo is the QAPP for the Quantitative Plant Assessments of Arcadia and Metacomet Lakes in Belchertown, MA.

If there are any questions or required modifications please do not hesitate to contact me.

Sincerely,
New England Environmental, Inc.

Mark June-Wells
ESA Certified Ecologist and Certified Lake Manager
Restoration Division

QUANTITATIVE PLANT ASSESSMENTS – ARCADIA AND METACOMET LAKES

Approved by: **Signature**

New England Environmental Inc.

_____ _____

Pioneer Valley Planning Commission

_____ _____

Massachusetts Department of Environmental Protection

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PROJECT DESCRIPTION

Arcadia and Metacomet Lakes are currently being assessed for water quality and plant control measures are underway to manage populations of *Cabomba caroliniana* and *Myriophyllum heterophyllum*. A recent analysis of water quality, which was also to include an assessment of the effectiveness of plant control measures, identified a gap in the ecological data. That gap was the lack of contemporary plant data from Arcadia and Metacomet Lakes, which made the assessment of plant control measure difficult. The main purpose of this study is to fill the knowledge gap as it relates to the composition of the plant community within the two lakes.

The quantitative plant assessment will provide the following information:

1) Inventory of all aquatic plant species in Arcadia and Metacomet Lakes.
2) Determine the relative abundances of each species in the lakes.
3) Model the distribution of each species as they relate to depth, light, and sediment type.
4) Determine the distribution of non-native plant species in the lakes.
5) Map the distribution of non-native plant species.
6) From those data, make recommendations on plant control and peat mat removal.

SITE DESCRIPTION

Arcadia (42°18'48.51N, 72°25'41.80W) and Metacomet (42°18'20.84N, 72°25'56.56W) Lakes, located in Belchertown, Massachusetts, are a contiguous hydrologic structure that are 33 (13.2ha) and 52 acres (20.8ha), respectively. The watershed feeding these lakes is approximately 1.8 square miles and the lower reaches of this watershed are comprised of moderate residential development. Furthermore, these lakes are denoted as Category 5 waters on the *Massachusetts Year 2012 Integrated List of Waters* for the presence of non-native species (*Cabomba caroliniana* and *Myriophyllum heterophyllum*). Arcadia and Metacomet Lakes are also on this list for nutrient eutrophication and dissolved oxygen depletion, respectively (Figure 1).

Arcadia and Metacomet Lakes are classified as oligotrophic to mesotrophic according to their average phosphorus concentrations. However with the increasing rate of human influence and potential productivity of non-native plant species in this system, the future health of these lakes is at risk. The trending of lakes toward more eutrophic conditions as a result of internal enrichment processes (plant productivity and senescence) characterizes the need for understanding the relative structure of these aquatic plant communities.

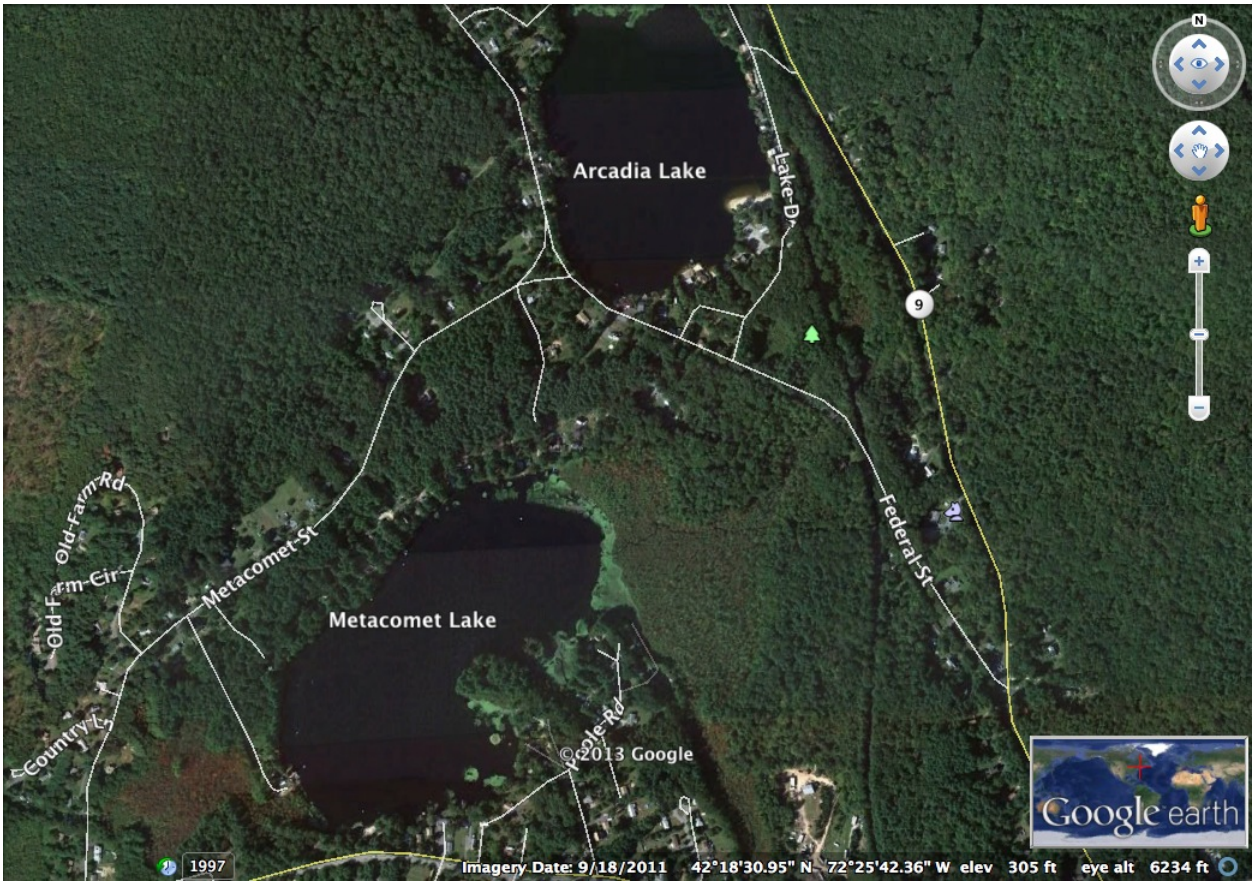

Figure 1: Aerial imagery of Arcadia and Metacomet Lakes (Belchertown, MA).

RESPONSIBLE AGENCIES AND PARTICIPATING ORGANIZATIONS

The responsible agency is The Pioneer Valley Planning Commission. This study is being developed and conducted by New England Environmental, Inc. (NEE). NEE is comprised of a variety of environmental professionals including Limnologist and Plant Ecologist, Mark June-Wells, Ph.D and is based in Amherst, Massachusetts.

PROJECT ORGANIZATION ROLES AND RESPONSIBILITIES

Patty Gambarini (Project Manager)
Senior Environmental Planner
Pioneer Valley Planning Commission
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Springfield, MA 01104
Phone: (413) 781-6045
Fax: (413) 732-2593

Mark June-Wells, Ph.D. (Principle Investigator)
Limnologist and Plant Ecologist

Certified Lake Manager/ ESA Certified Ecologist
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PERMIT REQUIREMENTS

No permits are required for aquatic plant assessments or collection of abiotic data.

HISTORY, PREVIOUS STUDIES, AND REGULATORY INVOLVEMENT

Arcadia and Metacomet Lakes are being targeted for this assessment because they have suffered cultural eutrophication and house priority non-native plant species. Non-native plant species are known to act as internal phosphorus sources and compromise the recreational value of water bodies.

A number of in-lake studies have been conducted in recent years. They are:

1) Diagnostic and Feasibility Study of Arcadia and Metacomet Lakes – Lycott Environmental (1985)
    a. Addressed strategies for plant and nutrient management protocols.
2) Water Quality Assessment – Fuss and O'Neill (2011)
    a. Addressed water quality trends.
3) Water Quality Assessment – PVPC and New England Environmental Incorporated
    a. Evaluated spatial, temporal, and weather associated trends in water quality data.

Plant control – Aquatic Control Technology (2012)

This plant control program used Fluridone and estimated 60% of the water body contained non-native plant species.

PROJECT DATA QUALITY OBJECTIVES

1) To establish a random-block-design using georeferenced points (repeatable).
2) To establish a 'species-level' inventory of plants residing in each lake (comprehensive and precise).
3) To determine the mathematical distribution/abundances of species in each lake as they relate to soil-type, light, and depth (comparable).
4) Create a database of plant species distributions and abundances that can be used in management decision-making processes (relevant).

QUESTIONS TO BE ANSWERED

1) What plant species are present in these lakes?
2) What level of plant diversity exists in each water body?
3) What are the abiotic preferences of each resident species?
4) How does diversity relate to the measured abiotic preferences?
5) What is the abundance and distribution of each non-native species?
6) As per the data set, what are potential strategies for managing non-native species reliably and responsibly?

GENERAL CATEGORIES OF INFORMATION REQUIRED TO ANSWER QUESTIONS

This assessment is aimed at understanding the structure of the aquatic plant community and its future dynamics. The analysis will include the following data types:

1) Geo Grid (points)
2) Abiotic (continuous)
3) Plant Abundance (Rank)

SPECIFIC MEASUREMENTS AND CRITERIA OF ASSESSMENT

To meet the purposes and questions of this study the following specific measurements will be taken:

1) 25 georeferenced points per lake.
    a. Using a Trimble GPS unit with ~1m resolution.
2) At each point, plants will be sampled using a grapple.

a. Species will be identified following Crow and Hellquist 2000 - *Aquatic and wetland plants of northeastern North America I/II. Madison (WI): University of Wisconsin Press.*
b. Each plant species' abundance will be logged using a rank abundance technique. The following classifications will be used:
    i. 0 – Absent
    ii. 1 – Rare
    iii. 2 – Present
    iv. 3 – Abundant
    v. 4 – Dominant
    vi. 5 – Monoculture

3) At each point, the following abiotic variables will be measured:
    a. Depth
        i. Measured with a weighted tape.
    b. Light
        i. Calculated from depth, the Secchi depth, and the solar constant using the following formula:
            1. $\mathbf{I_z = e^{(-kz)} * I_o}$ where I_z = intensity at depth (z), e is Euler's number, k is the attenuation coefficient of light in water (1.7) multiplied by the secchi depth for the lake, z is the depth, and I_o is the solar constant (340w/m^2).
    c. Soil Type
        i. A qualitative assessment conducted by evaluating a sample collected using an Ekman Dredge.
        ii. Classes
            1. Gravel
            2. Sand
            3. Mud
            4. Organic Muck (Leaves, etc..)

REPRESENTATIVENESS OF DATA

The field sampling protocol was designed to evaluate the plant community structure throughout the full extent of each water body. It has been widely accepted in literature that random-block designs are well suited to achieve that goal. Furthermore, these designs allow for relatively rapid assessments and do not require large monetary inputs making them ideal for baseline data collection. Current literature also notes that these techniques are capable of deriving small-scale abiotic/plant trends when coupled with specific statistical techniques. Finally, these types of techniques are suitable to develop baseline inventories and distributions for future comparisons.

The specific data that will be collected during this initiative will provide the following characteristics of the plant community:

1) Plant abundance assessments
2) Plant distribution assessments
3) Plant diversity assessments

Based on those outcomes, which will be derived with the use of statistical techniques, these data are pertinent to the goals of The Pioneer Valley Planning Commissions goals and, representative of the structure of the plant community including changes in structure with repeated assessments.

DATA ANALYSIS PROCEDURES

To answer the questions and fulfill the purposes of this study, statistical modeling techniques will be used following the data collection protocol. Since no control sites or comparison lakes will be used, mathematical modeling techniques will be used to characterize the plant communities of Arcadia and Metacomet Lakes. Given the focus of this study and the goals of The Pioneer Valley Planning Commission, the lack of cross-lake comparisons or that of control sites should not be viewed as study weaknesses.

The types of models will be selected using an assessment technique known as Akaike Information Criteria (AIC) and can include log, polynomial, exponential or linear models. Though the mathematical influences of the log, polynomial, and exponential models can be confounding to some, the purpose of these models is to explain the pattern of plant distribution and graphically display the results. Therefore, the results associated with model development will be understandable to all invested parties.

COMPARABILITY OF MODELS AND DATA

The primary purpose of this initiative is to develop a data set and results database that is comparable over temporal scales. All portions of this study are comparable. Those data collected are, in themselves, comparable using simple assessment techniques. Furthermore, the models are also comparable to newly developed models by a competent statistician. The result is an unparalleled comparability that is built into this initiative.

COMPLETENESS AND PRECISION OF DATA

No technique is without a level of uncertainty. The presented technique is widely accepted in the scientific literature and has been shown to meet the mathematical threshold of sampling energy vs. detection limits; in simpler terms, this technique has been shown to detect 99% of species present. Furthermore, it has been shown to detect 99% of the variability in a system. It should be noted that the sampling number (n=25 per lake) was not arbitrarily denoted. That amount of sampling was

selected based on sampling efforts vs. detection of species in lakes of similar size. Based on these principles we assert that the completeness of data collected during this initiative should be satisfactory.

Precision of data collection depends, primarily, on the questions requiring answers. Given that the questions being addressed by this study are targeting the dynamics of the 'in-lake' plant communities of Arcadia and Metacomet Lakes, the precision of data collected during this initiative is suitable. We are interested in developing distributions of species in each lake and relating those distributions to basic abiotic factors. Therefore, point assessments are ideal for this type of plant community analysis. The only lack of precision that would be advantageous to increase is that of sediment characterization. However, the addition of chemical assessments to this study would inflate the cost substantially and would then not be possible. It would be advantageous to incorporate those analyses in future studies. To develop the inventory and the baseline structural properties of plant communities in these lakes, the current level of precision is suitable.

ACCURACY OF DATA AND MODELS

The accuracy of data point position is assumed to be high (=1m resolution).

The accuracy of plant identification is completely dependent on the skill of the individual conducting the research. The limnologist (Mark June-Wells, Ph.D.) has professional training in plant identification and holds a degree in plant community ecology, which requires an expert-level ability to identify plant species. Accuracy of plant identification are assumed to be high during this study.

Data model accuracy is a relative estimation because they are theoretical and can vary based on what factors are measured. The only way to increase accuracy of statistical models is to increase the number of abiotic factors measured. However, increasing the number of important factors would increase cost of this study significantly. Moreover, the models developed during this initiative can be manipulated later as more data becomes available to further increase their accuracy. Following this study, the models will have suitable accuracy to satisfy the purposes and questions presented in the earlier text.

DATA AND MODEL ACCEPTANCE CRITERIA

Data collected during this initiative will be accepted using a variety of criteria, which are listed below:

1) GPS
    a. A minimum of 5 satellites available during point logging.
2) Plant Data

a. Field and laboratory agreement of plant identification.
b. Two independent observers agreeing upon the rank abundance at each point.

3) Depth Data
    a. Two measurements at each point (average the two).
4) Light Data
    a. Two independent people conduct light calculations.
5) Soil Data
    a. Agreement between two independent observers classifying the sediment type.

Models will be accepted using the AIC and Monte Carlo Permutation Test. The model with the highest level of significance and the lowest AIC will be used.

DATA AND MODEL REVIEW

Data will be assessed by NEE's Limnologist, Mark June-Wells, Ph.D. He has significant experience in data QC/QA and statistical analysis. He will assess the data structure and confirm its reliability.

Mark June-Wells, Ph.D. will conduct the data analysis and model building. Therefore, his experience in these areas will allow him to make decisions about model reliability.

DATA BASE MANAGEMENT

Databases developed and results obtained during this initiative will be stored on cloud servers and made available to all invested parties.

STUDY DESIGN

The Quantitative Plant Study will be conducted in early July, when aquatic vegetation has reached its peak. All data will be collected over two days (one day per lake) and will adhere to the following protocol:

1) 25 points will be randomly chosen and will be evenly divided among the following depth classes: *(if depth does not afford the use of 5 depth classes, the number of samples will be modified to allow for even data point distribution. The total number of points will be as close to 25 as possible.)*
    a. 0-1m
    b. 1-2m
    c. 2-3m
    d. 3-4m (if available)
    e. 4-5m (if available)

2) At each point, water depth will be measured twice using a weighted tape and averaged.
3) At each point, a soil sample will be collected and classified by the two observers.
4) At each point, plants will be sampled with a grapple, identified by NEE's Limnologist, and given rank abundances by the two observers. (Identifications will be confirmed in the laboratory)
5) At noon, a Secchi measurement will be taken at the deepest point of the lake.
6) Data will be logged on field data sheets.
7) Data will be analyzed for structural properties and models will be developed using R.

EQUIPMENT

1) GPS Unit
2) PFD's
3) First Aid Kit
4) Sample Bags
5) Ekman Dredge
6) Data Sheets

FIELD DATA DOCUMENTATION

All data will be collected on data sheets that will be retained at NEE. Plant species encountered during this study will be collected, confirmed, and preserved in NEE's herbarium. All collected species will be logged with sheets that identify the GPS location. Furthermore, the herbarium sheets will identify the species, denote the date it was collected, and identify the collector.

Photographs of each water body will be taken. Photographs of each species will also be taken.

MODIFICATIONS TO STUDY DESIGN

We do not anticipate any modifications to the presented study design.