



Fostering Tomorrow's Environmental Leaders at Thetford Academy:

Recommendations for Engaging Students in Outdoor
Education and Environmental Studies

**Environmental Studies 50
Dartmouth College, Spring 2015**

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Executive Summary

How can Thetford Academy become a local leader in environmental education? Throughout this collaborative project with Thetford Academy, Dartmouth students have addressed five central themes that foster a culture of sustainability and environmental leadership around place-based learning and engagement. These themes are: outdoor education, Ompompanoosuc River curriculum, trails, food sustainability, and solar power. The outdoor education group's central contribution was a method for cultural change through outdoor classroom activities and a proposed outdoor extracurricular program. Expanding on curricular adaptations, the Ompompanoosuc River group provides recommendations for an integrated environmental studies curriculum for 11th and 12th grade students. The trails group investigated the forest surrounding TA, identifying potential educational sites and a proposed trail that utilizes property near the Ompompanoosuc River and owned by Thetford Academy. The food sustainability group focused on awareness about healthy and sustainable eating habits through a proposed expansion of the TA greenhouse and an Annual Food Day. Finally, the solar group developed a business plan detailing the options for solar energy at TA, which has potential economic, educational, and environmental benefits. In summation, these recommendations should be considered key leverage points for developing a culture of outdoor education and environmental awareness at TA.

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**Chapter 1: Introduction to Sustainability Recommendation for
Thetford Academy**

1.1 Introduction

Throughout the spring of 2015, Dartmouth students from Environmental Studies (ENVS) 50- “Environmental Problem Analysis and Policy Formation”, worked with Thetford Academy (TA) to address a number of environmental issues and opportunities facing the school. Under the guidance of Professor Nick Reo and Dr. Karen Bieluch, students were divided in five groups that each focused on different projects at TA. This is the second year in a row that a section of ENVS 50 has worked with TA and some sections of this report build on the recommendations in the 2014 report. Sitting on a 284 acre campus surrounded by woods and open space, TA has a unique opportunity to integrate outdoor education into the school’s culture and become a local leader in environmental education.

The five groups focused on the following topics: (1) food sustainability, (2) Ompompanoosuc River curriculum, (3) outdoor education, (4) solar power and (5) trail mapping and trail crew design. Each group worked closely with TA faculty, staff, students, and outside experts in order to develop the recommendations in this report. The goal of this report is to present deliverables that will help TA become an environmental leader through its energy use, curriculum, and extracurricular programs.

Food Sustainability

The food sustainability group developed recommendations based on two objectives: enhancing the greenhouse at TA through the use of aquaponics and promoting awareness among students about healthy and sustainable eating habits. Aquaponics would help students learn about food systems and could be included in various classes to teach students critical science concepts. The goal of the food recommendations is to encourage TA students to eat healthier and take more interest in the source of the food they consume. An annual Food Day at TA would help build student interest around healthy and sustainable eating. The Food Day would help students learn about sustainable and organic farms, efforts to address hunger and improve food access, animal welfare in the food system, and fair working conditions for food and farm workers.

Ompompanoosuc River Curriculum

TA's close proximity to the Ompompanoosuc River offers the opportunity to incorporate field based learning in environmental science classes. The water group developed a curriculum for high school level environmental science classes. Topics for classroom lesson plans and field labs are included in the curriculum. The curriculum focuses on core environmental science concepts and the local river ecosystem. Integrating field studies into classes would strengthen TA's environmental science classes and give students valuable field research experience.

Outdoor Education

TA's expansive campus with ample environmental resources offers the opportunity to integrate practical hands-on learning and place-based education in classes. Outdoor education has been shown to improve educational outcomes, and thus could enhance the existing curriculum at TA. Establishing an extracurricular outdoor club would further increase opportunities for students and build a culture at TA based on outdoor education. Student surveys indicate that there is significant student interest in an outdoor extracurricular program at TA. With these insights in mind, the outdoor education group developed plans for TA to incorporate outdoor education in classes through place-based activities which are reinforced by and support a proposed extracurricular outdoor club.

Solar Energy

The solar group was tasked with developing a business plan for installing solar power on TA's campus. The business plan presents potential ownership models for installing solar power, expected financial savings with each model, and recommendations on what model would be the best fit for TA. The business plan also provides details on selecting a site for solar installation on campus and incorporating solar power into the curriculum of classes. The cost of solar power has fallen significantly in recent years, making it a financially viable option for providing TA's electricity. Installing solar power would help TA save money on electricity costs and reduce carbon emissions.

Trail Mapping

TA has an extensive trail system on its property, but there is no comprehensive map of the area between the campus and the Ompompanoosuc River. The trail design and collaborative cartography group focused on mapping out the area around TA, including trails and natural points of interest, to facilitate outdoor education and environmental accessibility. The group provided recommendations for a new path to further utilize property owned by TA, in addition to putting forth a plan to revitalize and maintain existing trails that provide TA with access to the Ompompanoosuc River, to be completed by a trail crew comprised of TA students. The collaborative cartography group's mission is to promote the exploration of and curiosity for the natural world surrounding Thetford Academy.

Chapter 2: Food Sustainability

Alison Lanois, Carrie Wolf, Charles Grant, Patrick Hand, Stuart Maeder

2.1 Introduction: Food Systems and Sustainability

Last year, Dartmouth students in Environmental Studies (ENVS) 50 studied the food system and sustainability at Thetford Academy. They analyzed the school's food sourcing and came up with alternatives that would enhance TA's environmental viability. They prioritized finding alternatives that sourced local foods, were transparent about their supply chain, and had good animal welfare policies. They suggested that TA combine sourcing local foods with other food sustainability initiatives.

Given the work completed in last year's ENVS 50 class, we decided it was necessary to find fun and engaging ways to get students to participate in sustainable practices. This year we decided to produce a tangible deliverable for Thetford Academy that the students would enjoy and the school would benefit from. Presently, one of the teachers at Thetford Academy runs an agriculture business class that focuses on growing foods in the school greenhouse and selling them at the end of the growing season to teachers who want them. This class integrates both the ecological and economic aspects of growing food and helps students understand what it takes in terms of time, money, and resources to produce what they eat. Keeping in mind the goals of this class, we decided that an aquaponics system would be a great way to enhance the use of the TA greenhouse. Tending to an aquaponics system would introduce students to new scientific concepts including water chemistry and fish ecology along with business opportunities such as harvesting the fish and selling them or working with a research group to help out with a study. Thus, there are a multitude of opportunities for integrating aquaponics into a curricular setting.

In addition to our aquaponics project for the greenhouse, we also wanted to address healthy and sustainable eating practices among Thetford Academy students. The two main tenets of sustainable eating are (1) consuming foods that support you as a person (i.e. maintain your health and are economically feasible) and (2) having a diet that does not impose unnecessary harm on the environment. We will be targeting Casey's track team to begin the discussion about sustainable eating habits at Thetford Academy. This project is titled Sustainable Eating and will inform student athletes why certain foods will enhance their performance, why eating locally sourced foods is good for the economy and the

environment, and how they can find affordable products to meet their financial needs. We will also discuss how Thetford Academy can start an annual Food Day in October in which students take ownership of these ideas and promote a sustainable lifestyle to their peers.

At the end of the term we presented our work to the TA board of trustees, outlining our goals and initiatives for this sustainable foods project. We offered several standards of aquaponic systems for the board to choose from, ranging in price and size. In addition, we outlined how they can start to shift the culture of TA towards sustainable eating and environmental awareness. We hope that by providing the board with several options, they will have the necessary information to decide how to best implement these projects.

2.2 Aquaculture

Adding an aquaculture system to the greenhouse at Thetford academy is an excellent option for increasing awareness of food systems among students and emphasizing environmentally sustainable options. There are many factors to consider when designing the aquaculture system.

Most experts assert that Tilapia are one of the best species for aquaculture due to their hardiness and their feeding preferences (A. Kapuscinski, personal communication, May 6, 2015). Tilapia can withstand a much wider pH range than most species. Though their maximum growth occurs around a pH of 7, they can survive when pH levels drop as low as 2 (FAO 2015). Similarly, Tilapia can tolerate temperatures as low as 12 degrees Celsius and as high as 42 degrees Celsius, though their optimal temperature is around 30 degrees Celsius (FAO 2015). These wide biological tolerances make Tilapia an ideal species for TA students to work with due to their resilience and tolerance for a range of conditions.

Tilapia can also survive under a wide variety of feeding conditions. In order to maximize growth rates, the fish can be fed up to 5% of their body weight as 'fingerlings' and 4% of their body weight when they are larger. However, they can maintain their size on as little as 1.5% of their body weight (A. Stiek, personal communication, May 14, 2015). While they can be fed once a day, smaller feedings multiple times a day can help maximize growth (Biswas & Takeuchi 2003). Care should be taken to ensure the fish are not fed more

than they can consume immediately, as excess food can be damaging to the water quality conditions.

There are certain conditions the greenhouse must meet in order to implement an effective, sustainable aquaculture system. Temperature regulation is key to this goal (A. Kapuscinski, personal communication, May 6, 2015). If the greenhouse maintains sufficient warmth year round to prevent the need for the use of heaters in the tanks, much less energy is needed to maintain the system. Water quality must be measured regularly to assess the level of ammonium and nitrite, pH, dissolved oxygen, and the temperature in each tank (A. Kapuscinski, personal communication, May 6, 2015).

We recommend the use of numerous smaller tanks as opposed to several larger tanks. One of the benefits of this arrangement is greater educational possibilities. Having 8-10 tanks would mean individual students or small groups of students could take on responsibility for the care of the fish in each tank. Additionally, experiments to evaluate different types of food, aquaponics set up, etc. could be conducted more accurately with a greater number of tanks to allow for more experimental groups. Tanks are likely to be the most expensive part of the system, though cheaper options do exist (for example, aquaculture systems can be conducted easily in standard household aquarium tanks).

2.3 Aquaponics

Aquaponics is the integration of aquaculture and hydroponics. An aquaponic system is a valuable tool for increasing productivity, economic efficiency, reducing waste, and ecological impact. Aquaponics involves the raising of plants in soil free environments and the rearing of fish in relatively small bodies of water. In regards to a small-scale operation, like the one proposed for Thetford Academy, a hydroponic system could be an invaluable teaching tool while also efficiently utilizing the limited space in the greenhouse.

Separately, aquaculture and hydroponics have several drawbacks. Aquaculture requires monitoring and removal of excess nutrients, and hydroponics requires expensive chemicals to provide sufficient nutrients to the plants. Both are also more labor intensive on their own. However, an aquaponics system utilizes both drawbacks in a mutually beneficial manner.

As fish grow and feed, waste effluent builds up and degrades the overall water quality in the tank. The largest problems associated with water quality are oxygen depletion, accumulation of organic matter, inorganic nitrogen, ammonia, and CO (Rakocy 2006). Fortunately, effluent from the fish serves as a means of irrigation and organic fertilization for the plants in the water. The plants effectively recycle the water themselves, reducing labor. Having plants that feed off of the dissolved nutrients of fish waste at no cost reduces labor costs and saves money. Additionally, the dissolved nutrients that the plants absorb minimize water use, water exchange, labor, and heating costs. The combined production of fish and plant maximizes the production value of space.

The essential parts of an aquaponics system are a fish tank, a biofilter, a removal component for solids, and a hydroponic component. For Thetford Academy, we believe that the simplest aquaponic system would probably be the best option. We recommend using a system of floating beds that would rest upon the water to grow the plants. The floating plant beds would reduce costs by removing the need for a water pump to a separate plant station, would remove the need to water the plants, and be an efficient use of space. The floating rafts are also ideal for cultivating leafy green plants, such as lettuce, cabbage, and many of the plants already growing in the TA greenhouse. Small holes are drilled through the raft and nets and hung from them. Seedlings are placed into these nets and their roots grow into the water. The drawback with rafts is that the fish, if able, will eat the roots and severely stunt the growth of the plant. This problem is easily remedied with a cheap plastic net used as a partition between the raft nets and fish (A. Stiek, personal interview, May 14th).

Many types of plants have been used in aquaponic systems. If the aim of the project is to maximize profits then small herbs will sell for the most per amount of area required. If the aim is grow plants quickly and easily, then basic plants with low nutrient requirements are best. These include plants like lettuce, cabbage, watercress, and bok choy, many of which are already grown in the Thetford greenhouse (Diver 2006). Because these plants grow relatively quickly they are less prone to pest problems. On the other hand, fruit bearing plants have a much longer culture period. Longer culture periods equate to a greater risk from disease and pest. They also produce less edible biomass than leafy plants. Nevertheless, all the plants can be used as valuable teaching tools for managing a business.

For example, fruits grown in the dead of winter could be sold at a premium; culinary herbs could also be sold at higher prices than many larger plants (Diver 2006).

We have researched several other aquaponic systems for TA to consider implementing: a flood and drain system, Barrel Ponics™, Nutrient Film Technique, and Deep Water Culture (raft system) (Bernstein 2011).

A flood and drain system consists of a separate grow and fish tank(s), the water from the fish tank(s) is pumped into the grow bed, which is situated above the fish tank. The water pumped into the grow bed returns to the fish tank through gravity (Bernstein 2011). This system requires a pump to move water from the fish tank to the bed and a syphon to allow for the return water.

Barrel Ponics™ is an aquaponics system invented by a man named Travis Hughey, the system was invented and designed so that it is inexpensive, can use recycled materials, and can be built anywhere. It is comprised of three separate tanks, requires the use of a pump, and a syphon. A picture is included below for explanation.

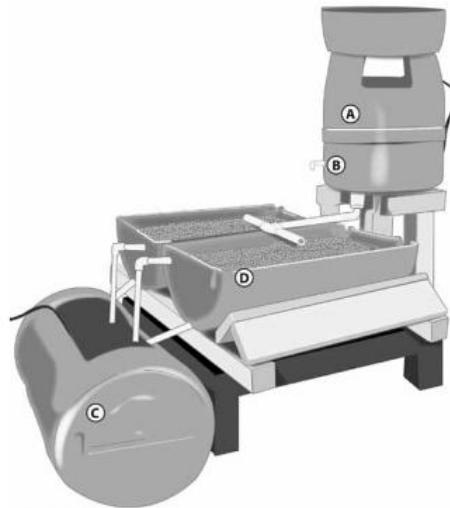


Figure 1. *Barrel Ponics* (Bernstein 2011)

The fish tank © pumps water into the water tank (A). When the tank fills enough, the weight of the water will fill a counterweight which opens the syphon (B) allowing the effluent water to flow into the grow beds (D). The mechanism is similar to that of a toilet valve. The counterweight has a small hole in it that allows water to drain from it, but at a slower rate than the tank itself. The grow beds tend not to contain soil, but rather another

medium such as gravel, perlite, coarse sand, etc (Bernstein 2011). When the tanks drains enough the syphon will stop flooding the grow beds, the counterweight will continue to drain into the grow beds. When the counterweight is light enough, the syphon will close and the process repeats (Hughey 2005). Additionally, a floating raft may be placed on top of tank A to grow plants.

A deep water culture system or raft system consists of suspending plants in polystyrene rafts so their roots are exposed to effluent water. This system can be done it two ways. The first way is to grow the plants in the same tank as the fish. This maximizes space, but requires a filtration tank to remove solid waste from the single tank.

Additionally, the rafts have to have some means of separating the fish from the roots of the plant, otherwise the tilapia will eat them (A. Stiek, personal communication, May 14, 2015). The second way is to have separate a grow tank(s) and fish tank(s). In this system the plants are grown in rafts floating in deep water channels that have a constant flow of water from the fish tank (Somerville 2014). The premise is the same, there is just a separation from the fish. This system requires a pump and also tend to have a filtration tank or sump tank.

A nutrient film technique is very similar to a deep water channel system. The major differences in the system design are that instead of rats and deep water channels, plants are grown in PVC pipes with a thin film of nutrient rich water flowing (Somerville 2014). However, these last systems tend to be more expensive than the others mentioned above and therefore primarily used in larger scale aquaponics (Somerville 2014).

2.4 Curricular Implementation of Aquaponics

In addition to the ecological and economic gains from an Aquaponic system in TA's greenhouse, we believe there are also curricular and educational gains to be made as well. According to aquaponics experts, Hart, Webb, and Danylchuk, "using aquaponics in education may serve the dual purpose of preparing future practitioners while giving students the opportunity for active learning, which parallels the goals of contemporary science education in the United States" (Hart et al. 2013). Additionally, Junge argues that

aquaponic implementation in education as the ideal manifestation of “system thinking... a central skill in education for sustainability” (Junge et al. 2014).

Even in its most simplistic version, a dynamic aquaponic system requires time for management in terms of monitoring water supply and population dynamics, inputting food and fresh water, observing both inter and intra species interaction, as well as observation of individual species habits. Junge explains that, aquaponics teaches students, “how to analyze systems, name the system variables and get a general idea of a system’s inner structure” (Junge et al. 2014). With sustainable efficiency in mind coupled with a motive to maximize TA’s gains, we recommend that TA creates a monitoring scheme that will succeed not only because of its low time input requirements for TA faculty, but also because of its widespread academic benefits. From a curricular perspective we aim to target students at all school levels, using aquaponics as a tool to teach a wide array of natural sciences, as well as “promote scientific literacy” [Junge, Wilhelm & Hofstetter 2014:235].

In her UMASS-Amherst master’s thesis, Emily Hart writes that, “aquaponics practitioners must be comfortable with the design and construction of systems, the physics of water flow, testing and troubleshooting water chemistry and the biology of both fish and plants in order to sustain a system in the long-term” (Hart 2013). The cross-disciplinary nature of an aquaponic system can provide curricular models for Biology, Chemistry, Environmental Studies, Social Studies, and Culinary Arts as shown below. Moreover, the management of an aquaponics system can incorporate business, finance, and marketing into the student’s education. Not only that, but it also cultivates a culture of sustainability at TA guiding these students in becoming tomorrow’s future environmental leaders by (a) encouraging responsibility, leadership, and teamwork and (b) developing a sense of community and social equity (Hart 2013).

For optimal implementation, different teachers and classes at TA will engage with the aquaponic system through the lens of a wide-range of academic disciplines, which will provide for system upkeep and provide students with a unique educational experience. According to Junge, Wilhelm & Hofstetter (2014), students actively engaged in study in conjunction with academically implemented aquaponic systems showed positive development in the following areas:

1. Training in system thinking (aquaponics helps to improve system thinking competences).
2. Training in proper monitoring, measuring, and study of a dynamic system (contribution to scientific literacy).
3. Training in planning, and implementing the plan (competence to steering of systems, ability for practical system management and system control).
4. Independent working in groups and increase of self-esteem
5. Contact with fish and plants (i.e. environmental education which is close to everyday life).

Thetford Academy: <i>Biology</i>	Learning Goals: Students will understand the numerous biological interactions that take place in an aquaponic setting, how these interactions take place independently of one another, and most importantly how and why these interactions affect one another.
Specific Class Suggestions: <ul style="list-style-type: none"> • <i>Flow of Matter and Energy Through the Biosphere</i> (Grade 8) • <i>Essentials of Biology: An Introduction to the Science of Life</i> (Grade 10) 	Practical System Management: <ul style="list-style-type: none"> • Species evaluation for inclusion in future systems <ul style="list-style-type: none"> • What fish and/or plant species is best suited for aquaponics and why? • Monitoring of population growth dynamics <ul style="list-style-type: none"> • Population growth schemes • Optimal tank population studies • Monitoring of species feeding and reproductive habits
Essential Questions: In what ways does life thrive and interact in a controlled Aquaponic system?	Additional Resources: <ul style="list-style-type: none"> • https://www.agronomy.org/files/jnrlse/issues/2002/e00-15k.pdf • http://www.extension.org/mediawiki/files/2/28/Hydroponics_with_Aquaculture.pdf
Essential Content and Understanding: <ul style="list-style-type: none"> • Understanding of ecology and general habitat interaction • Opportunity to interact with and study species living in a closed natural system • Understanding of the growth and development of localized microorganisms and their relationships and effects on local fish 	<ul style="list-style-type: none"> • In depth understanding of trophic levels within an ecosystem and the methodology of energy as it passes through a system

Thetford Academy: Chemistry

Specific Class Suggestions:

- *Chemistry I: The Study of Matter* (Grades 11-12)
- *Advanced Chemistry* (Grades 11-12)

Essential Questions: What are the chemical building blocks of life and how may they alter the way organisms thrive in their ecosystem?

Essential Content and Understanding:

- Offers model through which to study soil health and productivity
- Offers a hands on system in which to run student-centered water quality testing
- Develops understanding of lab equipment and the processes of running a scientific experiment

Learning Goals: Students will understand the key chemical components of agriculture systems and how to measure, decipher, and control the levels of such components in both natural and constructed settings.

Practical System Management:

- Regular monitoring of water quality
- Oversight of plant support material in regards to physical support as well as nutrition

Additional Resources:

- <http://fshs.org/proceedings-o/2004-vol-117/079-083.pdf>
- Effect of flow rate on water quality parameters and plant growth of water spinach (*ipomoea aquatica*) in an aquaponic recirculating system. A. Endut et al. (2012). *Desalination and Water Treatment* (5:1-3).

Thetford Academy: *Environmental Studies*

Specific Class Suggestions:

- *Introduction to Laboratory Science* (Grade 7)
- *Conceptual Physical Science* (Grade 9)
- *Horticulture* (Grades 10-12)
- *Environmental Science: The Connecticut River Watershed: Its History, Geology, Biology, and Chemistry* (Grades 11-12)

Essential Questions: What is a closed loop system? How may we relate a constructed system to the naturally occurring systems all around us? What role do agriculture systems play in climate and environmental issues?

Essential Content and Understanding:

- Understanding of how to design and test an experiment based within the aquaponics model
- Develop comfort in deciphering the different parts of a system, what these parts do, and in what ways they interact with one another
- Use the aquaponic system as a micro study by which to provide example for larger natural systems (i.e. Connecticut River)
- Understand the concept of heat budgeting and water's heat retention capacity. How does the Aquaponic system affect local greenhouse temperatures?

Learning Goals: Students will understand the inner workings of dynamic systems and the ways in which they function. Specifically, they will understand terms such as closed-loop, feedback cycle, and self regulation.

Practical System Management:

- Study of systems affect of greenhouse's temperature
- Study of systems energy consumption
- Fish Waste Management
- Fish Nutrition Management

Additional Resources:

- S. Diver. Aquaponics-Integration of Hydroponic with Aquaculture. *Horticulture Systems Guide.* National Center for Appropriate Technology(2000)

Thetford Academy: Social Studies

Specific Class Suggestions:

- *Why What You Eat Matters I: An Introduction to Local, Regional, and Global Food Systems* (Grades 9-12)
- *Why What You Eat Matters II: An Introduction to Local, Regional, and Global Food Systems* (Grades 9-12)
- *Economics* (Grades 11-12)
- *Business Mathematics* (Grades 11-12)

Essential Questions: In what ways do commercial agriculture systems interact with human social systems? What roles do they play in our economy? What social role does food play in our society?

Essential Content and Understanding:

- Use the aquaponic system as a real life example through which to develop a real world business model for implementation
- Understand the role of agriculture in a modern societal setting and develop a feel for the way modern agriculture shapes our economy and environment
- Explore modern initiatives to eat and produce food sustainably, using the aquaponics system as a jumping off point
- Increase food 'legibility' by deciphering the difference food labels (certified organic, fair trade, etc.)

Learning Goals: Students will understand both that our lives and economies depend on agro-food systems, and how these systems interact in financial and business settings.

Practical System Management:

- Design business aspect of fish and agriculture harvest, creating a business plan and long term strategy for the aquaponic system to support itself as a business.

Additional Resources:

- *Journal of Agriculture and Environmental Ethics*
- *Journal of Agriculture and Human Values*

Thetford Academy: Culinary Arts

Specific Class Suggestions:

- *Cooking for Health* (Grades 9-10)

Essential Questions: What does it mean for food to be certified organic? How do different foods affect the human body?

Essential Content and Understanding:

- Increase food 'legibility' by deciphering the difference food labels (certified organic, fair trade, etc.)
- Understanding of fresh ingredients and the benefits of eating and cooking with healthy foods
- Basic understanding of how to grow ones own fresh ingredients at home (basil, mint, tomatoes, etc.)

Learning Goals: Students will understand the systems from which their food comes, how to decipher the labeling of foods, and how to use fresh ingredients in culinary practice.

Practical System Management:

- Harvest of fish and agriculture

Additional Resources:

- Feenstra, G. Local food systems and sustainable communities. *American Journal of Alternative Agriculture*(12.1)
- Liquori et al. The Cookshop Program: Outcome Evaluation of a Nutrition Education Program Linking Lunchroom Food Experiences with Classroom Cooking Experiences. *Journal of Nutrition Education*(30.5); pp. 302-313.

2.5 Aquaponics Implementation

The first step to implementing a system is acquiring the necessary supplies. Here is a list of the fundamental components of constructing and maintaining involved in an aquaponics system:

System Parts

- Tanks--Inert plastic or fiberglass is preferable
- Bio-filters
- Air stones
- Juvenile tilapia
- Water source (free of chlorine)
- Mechanical Filter

Tank Maintenance

- Dissolved Oxygen Meter
- Thermometer
- Ammonium Testing Supplies
- Nitrite testing supplies
- Fish Feed
- pH meter

Choosing appropriate tanks is very important to system design (A. Sitek, personal interview, May 14th 2015). The type of tanks used should reflect the goals of the system. First, if the goal is to maximize food production, we recommend fewer, shallow tanks to maximize surface area for plant growth. Second, if the goal is to maximize fish production, we suggest deeper tanks that can accommodate larger volumes of fish. Finally, if the goal is to optimize the education potential of the system we recommend using multiple (5-10) smaller tanks made of clear plastic or glass so that the fish and plant growth can be viewed easily. A system with many tanks allows more students to (1) take ownership of caring for the fish and (2) run experiments on the fish by comparing growth rates and water chemistry conditions (A. Kapuscinski, personal interview, May 6th 2015). Polyethylene tanks are preferable because they are cheap, inert, UV resistant (which can destroy plastic),

and have the necessary food-grade characteristics (Somerville 2014). Luckily, these tanks are in ready supply and can be used as soon as they are cleaned out.

While aquaculture systems can be expensive, there are also low cost options that would meet Thetford Academy’s goals for food production and education. Below we have included some low cost examples.

Supplies	Where to purchase:	Estimated Price	Link
Polyethylene Drums-55 gallons	Craigslist Grainger	\$12 (used) \$150-200 (new)	https://nh.craigslist.org/search/sss?query=55+gallon+barrel+plastic http://www.grainger.com/category/catalog/N-1z0ds8f
Polyethylene Tanks-275 and 330 gallons	Craigslist	\$100	https://nh.craigslist.org/search/sss?query=polyethylene+tanks
Dissolved Oxygen Meter	Amazon	\$165	http://www.amazon.com/Milwaukee-Economy-Portable-Dissolved-Calibration/dp/B007Z4KKIQ/ref=sr_1_1?s=industrial&ie=UTF8&qid=1432557862&sr=1-1&keywords=dissolved+oxygen+meter
Thermometer	Amazon	\$20	http://www.amazon.com/HM-Digital-Thermometer-Measurement-Resolution/dp/B0002T6L5M/ref=sr_1_1?s=industrial&ie=UTF8&qid=1432

			562335&sr=1-1&keywords=thermometer+aquaculture
pH meter	Amazon	\$15	http://www.amazon.com/s/ref=nb_sb_noss_1?url=search-alias%3Dindustrial&field-keywords=ph+meter+for+water&rh=n%3A16310091%2Ck%3Aph+meter+for+water
Ammonium/nitrite testing supplies	Carolina Science	\$35	
fish	White Brook Tilapia Farm	\$2 a fish	http://tilapiasource.com/blue-tilapia-fingerlings.html
biofilter nitrifying bacteria	Carolina Science	\$15	http://www.carolina.com/tanks-and-accessories/quickstart-aquarium-solution/672295.pr?catId=&mCat=&ssCat=&ssCat=&question=nitrifying+bacteria
feed	Premium Fish Food	\$2 a pound	http://premiumfishfood.com/tilapia-fingerling-pellet.html
Air Stone (one per tank)	Amazon	\$5	http://www.amazon.com/1-inch-Mineral-Release-Aquarium-Airstone/dp/B00CQGXB8/ref=sr_1_fkmr0_1?ie=UTF8&qid=1432565933&

			sr=8-1- fkmr0&keywords=aquaculture+airsto ne
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The maintenance of the aquaponics system is both an opportunity for student involvement and something that should be considered seriously before a system is implemented. The fish can be fed as little as once a day, though multiple smaller feedings will increase growth rates (A. Kapuscinski, personal communication, May 6, 2015). Perhaps the most important step is to ensure the tanks are not overfed. Individuals should observe the fish to ensure they are consuming all of the food put in the tanks as excess food can distort water chemistry levels (A. Kapuscinski, personal communication, May 6, 2015).

Similarly water chemistry should be conducted regularly to ensure the health of the fish. The water in each tank should be tested several times a week (depending on how volatile the tank conditions are) for ammonium and nitrite which can be toxic to the fish when present in excess amounts (Alexander Stiek, personal communication, May 14, 2015). Temperature, pH levels, and dissolved oxygen levels should be tested daily as these are conditions that can change rapidly and cause immediate harm to the fish.

Biofilters are an important part of sustaining a healthy aquaculture system (Alexander Stiek, personal communication, May 14, 2015). Biofilters contain nitrifying bacteria which are critical to converting the ammonia (NH₃) fish excrete to nitrite (NO₂-) and then to nitrate (NO₃). Both Ammonia and nitrite are toxic to fish in large quantities and both unconsumed fish food and fish excrement can lead to dangerously high amounts (Southern Regional Aquaculture Center, 2013). Biofilters help mitigate this by providing surface area such as plastic, fiberglass, ceramic or rock for nitrifying bacteria to grow on. In order to create an effective biofilter, the chosen biofilter medium should be “seeded” with nitrifying bacteria and cultivated before the Tilapia arrive (Southern Regional Aquaculture Center, 2013).

The buildup of solid fish waste can be a problem for aquaponic systems. While it usually does not affect small scale productions as fish stock tends to be low (Somerville 2014), it may better to err on the side of caution. A mechanical filter serves to remove solid

or suspended fish waste from the tank because, as mentioned above, harmful gases are released through anaerobic decomposition. A mechanical clarifier is a relatively cheap and simple way of removing fish waste from a system. It is a separate tank that water flows through in the bottom and out through a pipe at the top of the tank (Somerville 2014). It works because solid materials tend to sink to the bottom and therefore does not reach the outflow pipe. Additionally, a screen can be attached to the out-pipe to help stop the flow of floating waste.

Complete aquaponic systems have a wide range of prices depending on the size and complexity of the system. From our research, we have found systems ranging between \$2,995-\$15,000. Self assembly and construction of a simple aquaponics system can be relatively cheap and engages students who invest time and effort into its construction.

2.6 Sustainable Eating at Thetford

Sustainable eating is comprised of two main pillars. The first pillar is eating foods that do not impose unnecessary harms on the environment. The second pillar is eating foods that provide an individual with the necessary nutrients and sustenance to maintain a happy and healthy life. The typical American diet, consisting of carbohydrates, sugars, and trans fats has led to an upsurge in obesity, diabetes, and heart disease (Drewnowski et. al 1992). Annually, the country spends approximately \$150 billion to cover these health care costs (Drewnowski et. al 1992). Contrary to common belief, fast food is actually more expensive, due to the long term health problems it induces and the correlating costs of care (Hyman 2013). Eating smart, defined as eating a nutritious and balanced diet, both enhances an individual's quality of life and is socially responsible. Introducing kids to new fruits, vegetables, and whole grains—along with a few basic recipes—can put them on track to making smart food choices for life. Simultaneously, children who are cognizant of where their food is sourced from have a greater likelihood of avoiding chronic diseases because it is typically leaner and unprocessed compared to factory bred meat that is fatty and injected with hormones (Stitt 1996).

Socially responsible eating begins with educating youth about making informed decisions about their diet (Stitt 1996). It is important that children know the right

questions to ask including where their food is coming from. Expanding on the example above, large scale meat production has taken a toll on the environment and students should be informed of their options to eat grass fed meat from animals that were ethically raised and slaughtered (Capper 2014).

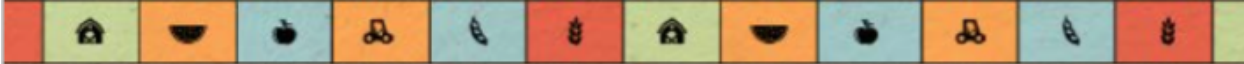
Food Day is a youth educational program based on making smart food choices. The organization envisions providing food that is healthy, affordable, and holds high regard for the environment, farm animals, and the people who grow, harvest, and serve it. Food Day's platform is very broad and goes across all sectors of the food movement, from public health to animal welfare. Food Day is held every year on October 24th. Food Day 2015 focused on food education as a way to improve our diets, address obesity and other health issues, and started with schools and campuses (see Figure 2). We suggest that Thetford Academy engage in Food Day this October in order to enhance their movement towards establishing a sustainable eating environment on campus (Foodday.org 2015).

There are five main priorities of Food, which are described below:

- (1) Promote safer, healthier diets: The foods we eat should promote, not undermine, our good health. Yet, every year we spend billions on obesity-related health care costs (Stitt, 1996).
- (2) Support sustainable and organic farms: Currently, sustainable farms receive little to no federal support and often lack market access to make them competitive. Meanwhile, the largest 10 percent of industrialized farms - which contribute to poor health and severe environmental degradation - receive 75 percent of all farm subsidies
- (3) Reduce hunger and improve food access: At present, approximately 50 million Americans are considered "food insecure", or near hunger, and Supplemental Nutrition Assistance Program (SNAP) participation is at an all-time high. SNAP is vital to reducing hunger, but the program's budget is under constant attack while federal measures to increase food access are minimal.
- (4) Reform factory farms to protect the environment and farm animals: Today, most farm animals are confined in "factory farms" - sometimes containing as many as 50,000- 100,000 cattle, hens, or pigs. These practices result in

needless animal abuse and illness, environmental degradation, and harm the people who live in and around those facilities.

(5) Support fair working conditions for food and farm workers: 20 million workers throughout the U.S. food system harvest, process, ship, sell, cook, and serve the food we eat every day. And yet, many farmworkers earn well below poverty levels.



Food Day in Schools

What is Food Day?

Food Day inspires Americans to change their diets and our food policies. Every October 24, thousands of events all around the country bring Americans together to celebrate and enjoy real food and to push for improved food policies.

This annual event involves some of the country's most prominent food movement leaders, including chefs, farmers, doctors, teachers, and parents.

In 2014, Food Day will once again focus on food education. Children who know where our food comes from and how to cook meals will have a big advantage when it comes to being healthy and avoiding obesity, and other health problems.

How should schools get involved


- Food Day is an opportunity to convene a broad coalition of educators, administrators, school boards and community organizations to plan activities that will educate, inspire, and mobilize participants of all ages.
- Food Day makes a special effort to provide materials to school children to promote healthy, sustainable, accessible and fair food in schools.
- With rates of childhood obesity soaring— at the same time that millions of children have limited access to healthy, fresh food—the Food Day effort is especially relevant to our nation's youth and schools.

What resources does Food Day provide?

- Connection to other partners through the Food Day network.
- Listing on the national map at www.FoodDay.org or in the blog.
- Access to Food Day online resources and printed materials.

Who is partnering with Food Day?

The national network spans the public, non-profit, and private sectors, and includes the National Education Association, National Farm to School Network, Real Food Challenge, Jamie Oliver's Food Revolution, and hundreds of others.



How can my school participate?

- Suggest to nutrition service directors that there be a special menu or menu item on or leading up to the week of Food Day, especially if they are seeking ways to highlight new meal standards set by the USDA.
- Hold a Food Day Youth Debate to engage students in topics related to healthy foods, obesity and food access.
- Host a "Chef in the Classroom" event to connect local chefs with students and the Food Day movement.
- Encourage school gardens to have special events for Food Day or kickoff a plan for a spring garden.
- Use the **5-day Food Day curriculum** (written by a group of professors in the Food Studies department of Columbia Teachers College). Also see our Guide for Schools on the Resources page of www.FoodDay.org.
- Celebrate Farm to School Week and National Farm to School Month in October with Food Day activities
- Sign up for email updates through www.FoodDay.org, follow @FoodDay2014 on twitter and "Like" us on Facebook!

Figure 2. *Food Day in Schools* (Foodday.org 2015).

2.7 Nutrient Guidelines for Food Day at TA 2016

Food Day is an opportunity to improve the health and well-being of your community by making healthy food more accessible to everyone. So, when planning your Food Day events, activities, and celebrations, be sure to offer healthy food and beverage options for

everyone to enjoy! Here are suggested guidelines to follow when planning your meal and snack options:

General Recommendations:

- Support healthier choices, provide leadership and role modeling, and help to create a social norm around healthier choices and behaviours.
- Place healthier foods and beverages in prominent positions, where they are most likely to be seen and more likely to be chosen.
- Ensure healthier options are attractively presented, appealing, and taste good.

Nutrition Recommendations:

- Offer reasonable portion sizes.
- In buffet lines or self-service, support sensible portions by offering reasonably sized entrées and appropriately sized serving utensils and plates.
- Do not offer full-calorie sugar-sweetened beverages. Serve water, 100% juice, 100% juice diluted with water, low- fat or non-fat milk, or calcium and vitamin-D fortified soy beverages with 40 calories or less per container.
- Offer fruits and/or vegetables every time food is served.
- Use whole grains whenever possible (100% whole grain or whole grain as the first ingredient).
- Make the majority of the meat options poultry, fish, shellfish, or lean (unprocessed) meat. Seek alternatives to red and processed meat.
- Provide a vegetarian option.
- Replace all desserts and pastries with fruit or other healthful foods.
- Whenever possible, offer foods prepared in a healthy way (grilled, baked, poached, roasted, braised, or broiled). Avoid fried foods.
- Serve healthier condiments and dressings and offer them on the side.
- Look for and try to offer lower-sodium options.
- Make water the default beverage.

(Foodday.org 2015)

To help begin a cultural change toward sustainable eating at Thetford Academy, we are advocating that the track team take initiative and set an example of healthy eating.

Athletic teams are tight knit groups and leaders in their communities. Thetford has the opportunity to utilize athletic groups and encourage them to serve as role models to make a change at the school.

With the help of Dartmouth Athletic Dietitian Claudette Peck, and Dartmouth Peak Performance, we have a three step process for the track athletes to follow, which include hydration, pre-event nutrition, and snacking throughout (Peck 2015).

Hydration Schedule

- Before practice (2 hours), or as soon as you wake up (if morning practice) drink 2 cups of fluid (preferable water, or sports drink)
- Before Practice (15-30 min) or performance consume another 1 cup of fluid.
- During practice or competition: 2-3 cups/hour. Sports drinks are a beneficial choice if practice or competition lasts 1 hour or longer, or you are losing a lot of sweat due to heat and humidity.
- After practice: know your sweat loss and replace 2 cups of fluid for every pound of sweat lost.

Meal and Food Ideas for pre-competition

3-4 Hours Before Exercise (fiber-containing whole grain carbohydrates & lean proteins & some minimal fats)

- Peanut butter & honey on Multi-grain toast + milk, fruit
- eggs, 1 slice cheese, whole grain toast or english muffin, fruit, water
- Oatmeal with brown sugar and almonds + skim milk, banana
- Low-fat cottage cheese + cut-up fruit + crackers + water
- Lean hamburger on bun with lettuce & tomato + side salad + fruit
- Turkey and Swiss sandwich on whole wheat with avocado + fruit + water
- Low-fat tuna melt sandwich + fruit cup + fat-free yogurt

30-60 Minutes Before Exercise (30-60g Carbs to top-off fuel reserves)

- Sports drink or water
- Sports gel, sport beans or gummies, sports bar
- Piece of fruit or jam sandwich
- Bagel, english muffin, whole grain bread with jam or PB

- Banana
- Applesauce
- Pretzels
- Fruit roll-ups
- Jello-brand gelatin

Foods to Pack for Snacking Throughout the Day For All-Day Events

- Trail mix
- Granola bars
- Peanut butter filled pretzels
- Cereal, nut, dried fruit combo (Oatmeal squares, almonds, raisins)
- Portable fruit (apple, banana, grapes) and nuts
- Lean meat jerky (Turkey Jerky)
- 1 oz sunflower seeds, pepitas, or toasted pumpkin seeds
- Energy bars (20-30g Carbohydrate, 8-10g protein, 6g fiber)

Things To Remember To Optimize Your Training Diet

- Consume a carbohydrate-rich snack or meal before exercise to top off muscle stores
- With pre-competition jitters, liquid meal replacements may be a better choice than whole foods.
- Include small amounts of protein in your pre-exercise meal(s). Protein helps build and repair muscle tissue. Adequate protein before exercise may help reduce post-exercise soreness.
- Choose pre-exercise meal(s) that are low in fat and fiber to ensure optimal digestion.
- Get adequate rest daily (7-8 restful hours of sleep)
- Stay well hydrated (minimum 90 fl oz females, 120 fl oz males)
- Limit unnecessary calorie contribution from high fat foods, desserts, and alcoholic beverages.
- Make wise decisions about fueling your body every day, not just the day of the event.

(Peck 2015)

2.8 Conclusion

After carefully assessing the needs and interests of Thetford Academy and its students, we developed a plan that would enhance the existing educational programs at TA, while also adding new ones to compliment them. We observed Casey's agricultural business class and found room in the program and in the greenhouse for expansion. Our review of the existing research led us to believe that aquaponics would be the best system we could suggest TA implement. Aquaponics systems would be a useful tool for teaching students about business, environmental conservation, and personal health. Not only that, but the fish can be harvested and sold. Moreover, the water and nutrients from the plants and fish are reused and recycled by one another, all of the produce is locally grown imposing minimal harm on the environment, and the foods grown are part of a healthy nutritious diet that sustains the human body. We believe that the aquaponics project combined with Food Day will help enhance the sustainability culture at TA and inspire students to take better care of their environment and their own bodies.

Chapter 3: Developing an ENVS Curriculum Focused on the Ompompanoosuc River at TA

Alison Dyer, Christopher Kipouras, Kendall Kraus, Leehi Yona, Ryan Bullock

3.1 Introduction

Thetford Academy is known as an institution of hands-on, interactive learning that places students at the center of the action to maximize their engagement with the material. TA is looking to become a place of environmental leadership and stewardship, rebranding the Academy as a place where students can develop into future leaders in sustainability. Our group's task was to blend these two missions through the development of an integrated curriculum for Thetford Academy's Environmental Sciences Class for juniors and seniors. The new curriculum focuses heavily on the incorporation of studies on the Ompompanoosuc River into the course, giving students a valuable experienced-based understanding of field-based research and enabling them to connect topics in the course to their own lives.

This document serves as a guideline to implementing this lab and field-based curriculum. It will outline the types of studies and field work that students will conduct and how to incorporate this research into broader class projects. Most likely, these class projects will take the form of weekly focus topics with lab components to ensure that the material is understood in a conceptual and physical sense. This research will help inform students' individual projects and encourage them to take ownership of their work. The outline will also cover basic logistical concerns surrounding the introduction of the program including, but not limited to, lab materials, transportation to and from the river, and budget constraints. It also describes any other concerns which may need to be vetted for implementation purposes and other recommendations.

3.2 Methods of Research

We developed these recommendations through meetings and conversations with Thetford Academy faculty to determine (1) what needs can feasibly be met, (2) which Dartmouth faculty advised what studies, (3) the Watershed Council that described what tests are currently being done on the River, and (4) a survey sent to current Environmental Sciences students at Thetford to gauge student interest. We elected to use these resources because we thought it critical to strike an appropriate balance between what the faculty and students want, while keeping in mind logistical constraints and the skill levels of high school students.

Students were surveyed using a GoogleForm distributed by Environmental Sciences teachers Gary Engler and Len Whitaker to current and past Environmental Sciences students, making it a small sample of approximately 30 juniors and seniors. Responses reaffirmed our previous findings that students are interested in engaging in more extensive field research. Past courses have included small-scale lab days which are tied into the lectures, and students have indicated interest that these labs become the focus of future course curriculum. Most students stated that they initially selected this course because they were interested in the outdoors and would like to see more outdoor integration. Using these recommendations, we hope to structure future Environmental Sciences courses around field research conducted by students.

Through these discussions, we identified four possible overarching areas of study on the Ompompanoosuc, with subsections when needed:

1. Gathering macroinvertebrate samples
2. Measuring pH, mineral, and trace element levels
3. Riverbank studies
 - a. Mapping river erosion patterns
 - b. Studying river plants, wildlife and riparian vegetation
 - c. Phenology
4. Measuring *E.coli* levels and counting coliform bacteria

Each area of study contains a field component that help students learn to collect and analyze data and create professional scientific reports. In addition, these have all been identified through conversations with the Watershed Council and Thetford Academy as needing more study on the Ompompanoosuc River, but are also representative of broader issues facing rivers today allowing students to connect to regional and national databases for comparison studies. They also provide interesting insight into the ecology of river systems and allow for an interactive learning experience with regards to their management.

Our recommendations allow for a smooth transition from the old to the new curriculums. This field-based learning experience is designed to give students the most

hands-on learning experience possible and prepare them for future environmental research. The field of environmental sciences is ever-changing, so it is critical for the next generation to understand how these systems work physically as well as conceptually. We hope to provide them with the tools they need to succeed, and to aid Thetford Academy in becoming a leader in environmental stewardship, education and place-based learning.

3.3 Environmental Science Course Integration

To integrate any of the listed topics into course curriculum, we recommend creating an overarching lab question for the students to answer. Questions should be broad and it could even be possible to have students create their own question at the beginning of a term. Also, students should understand how the data they collect contributes directly to efforts to increase water quality in the Ompompanoosuc. Their data will be sent to a group working on monitoring the river. The list of contacts from this group is listed in Appendix G. Their data will be used in comparison with existing data or to fill gaps from areas the team has not studied. This summer, the group studying the Ompompanoosuc will be collecting water samples bi-weekly from various points (see in Appendix) in order to measure levels of E.coli. They hope to also measure phosphate and pH levels as well. Finally, we will provide a detailed example of an environmental curriculum based on the Benthic Macroinvertebrate focus area.

Mary Childs and others working on monitoring the river at these various points stated that it would still be helpful if students collect data from nearby streams by Thetford Academy and send it to them. Should students want to collect or study a point already being monitored (see *Map A*), the group also welcomes that data as they can use it comparatively to what they will collect in the summer.

An example of an outlined course curriculum could look as follows:

Outlined Course Curriculum- Water Quality in the Ompompanoosuc & More

(See diagram illustrating this outline in Appendix)

- I. Introduction/ Schedule of course etc.
- II. Ask Lab Questions

- A. This will be directed at whatever data the students will collect this term
- B. Ex: “How do pH levels reflect water quality in the Ompompanoosuc?”
- III. Collect Data to answer this question → field trip!
 - A. Water samples
 - B. Analysis of riparian vegetation
 - C. Analysis of wetland health based on aerial footage & observation
- IV. Analyze the data
 - A. This could take longer than one class period
 - B. Potentially work on in portions
 - 1. ex: study for first half then lecture second half of course
- V. Weekly Topics:
 - A. Why is Water Important?
 - B. What are the other ways to test water quality?
 - 1. pH, nitrates & phosphates, monitoring wildlife, riparian buffers, e.coli, etc.
- C. Ecology of River Systems
- D. Specific: Ompompanoosuc
 - 1. Study of E.coli & Phosphorous levels
 - a) Round of water samples taken in 2006 and 2007 and another round of samples (from the points listed in the map above) will be taken this summer
 - (1) Taking bi-weekly samples from up to 14 locations
 - 2. Study of trace metals due to proximity to Elizabeth mine
 - 3. Riparian buffer planting in various locations in West Fairlee
 - 4. Where is the pollution coming from?
 - a) Locating point sources through maps and potential field excursions
- E. Climate Change
 - 1. How are water systems impacted?
 - 2. Why are they important?

3.4 Potential Study Focus Areas

1. Benthic Macroinvertebrates:

Benthic macroinvertebrates are low-lying invertebrate insects typically found under rocks within shallow rivers (Rosenberg and Resh eds. 1993). There are many different classes and species of invertebrates found in the riverbeds, and their relative abundance sheds light on the water quality of the river in which they are found.

The monitoring of benthic macroinvertebrates is important within the context of disturbance. These organisms are more sensitive to small changes in waterbeds, including changes from rocky to sandy beds, water temperature, and pollution. In such a way, the impacts of many different environmental problems can be identified through aquatic macroinvertebrate testing. Examples of these bigger problems include dam formation, climatic changes, and the implementation of flood buffers, among others.

Most studies have focused on macroinvertebrates and fish in the Ompompanoosuc to study water quality levels. Particularly after the closing of The Elizabeth Mine, the Vermont Department of Environmental Conservation (VTDEC) noted especially low numbers of macroinvertebrates and fish in areas of the river downstream from the mine. After a recovery project by VTDEC was implemented, levels of aquatic life were brought back up to acceptable levels (EPA 2015). However, given that research has probably fallen off it could be very helpful for students to study macroinvertebrates or fish levels in a portion of the river.

A benthic macroinvertebrate laboratory unit would entail multiple pre- and post-lab lectures, as well as data collection and analysis (Layne 2013). Students will be introduced to the larger issue being challenged (for example, river modification as a buffer for increasing floods due to climate change), and given a natural history of benthic macroinvertebrates. Following this introduction, students will be taught methods for collecting invertebrates, which can be accomplished by wading into shallow waters with D-nets and shaking off rocks to catch invertebrates. The macroinvertebrates will then be placed into ethanol containers for preservation and identification back at TA. Following identification, an Excel file will be kept to count the individuals of specific taxa, creating a data set that will grow to be long-term as the years go by. Finally, a comparison of the

different numbers of benthic macroinvertebrates between different study sites will be conducted to draw a broader understanding of how their populations change depending on environmental factors.

2. pH, Phosphate & Nitrate Levels:

a. Nitrate and Phosphate Levels

Excess nitrate and phosphate levels in water systems can negatively impact water quality. The formation of algal blooms can outcompete native wildlife and the formation of dangerous bacteria negatively alter water systems. Therefore, studying these levels in the Ompompanoosuc directly relates to determining water quality levels.

Regarding a curriculum, students would take samples of water of the Ompompanoosuc at one or various locations and then analyze the data and send their results to contacts working on monitoring the Ompompanoosuc.

b. pH Levels

Measuring pH is another way to test water quality. Given the history of metal pollution from the Elizabeth mine it could be interesting for students to measure pH on their own and learn about the history of pollution from the mine and the efforts done to restore levels. When testing pH, most healthy waters are in the 6.5 to 8.5 range and it would interesting to see where the Ompompanoosuc falls.

pH plays a significant role in determining many of the chemical and biological processes that occur in a body of water, making it of utmost importance to monitor and maintain healthy levels. Like in most ecosystems, plant and organism biodiversity is a high priority, and pH has a direct effect on species richness and diversity. While some aquatic species function best in more basic water and some prefer acidity, a range from 6.5 to 8.5 generally yields the most species diversity and best overall river health. When pH levels begin to stray from this optimal range, organisms begin to experience stress to their physiological systems and reduced rates of reproduction. In cases of extreme acidity, toxic elements in the water become mobile and are more easily absorbed by surrounding plants

and animals. In an intimate and complex ecosystem such as a river, these toxins spread quickly and increase in potency through a process called biomagnification.

The pH scale measures the concentration of the hydrogen (H^+) and hydroxide (OH^-) ions that make up water ($H^+ + OH^- = H_2O$). A neutral pH (7.0) is yielded when the concentrations of both ions are equal, water becomes acidic when more hydrogen ions are present and basic when there are more hydroxide ions. There are multiple available options for measuring pH each with varying prices depending on desired accuracy and location of testing. For pH measurements requiring extreme accuracy and precision, water should be tested using a laboratory grade pH meter and electrode. This method calculates the electric potential across an electrode when immersed in a sample of water providing pinpoint measurements of both ion concentrations. Unfortunately, the advanced accuracy and reliability of this method comes at a high cost (\$250 - \$1,000) and requires the use of a laboratory to execute this procedure. An additional inconvenience is that the testing must be performed within 2 hours of acquiring the sample because at that point atmospheric CO_2 begins to dissolve in the water and neutralize the pH, skewing the data (EPA 2012).

The alternative option for measuring pH involves the use of pH pocket pals and color comparators. pH pocket pals are hand-held instruments that provide a digital reading of pH when dipped into the water sample. Color comparators are inserted into water and turn one of two colors that determine whether the sample is either basic or acidic, and the intensity of the color indicates the magnitude to which the sample is basic or acidic. Although this method is relatively lacking in accuracy and precision, it is much cheaper (~\$50) and can be performed on site making it the more attractive option for what is trying to be accomplished by the students at Thetford Academy.

3. RiverBank Studies

a. Mapping River Erosion Patterns

The “stability” of a river is determined by the maintenance of certain key functions of a river including flow of water, shape and slope of the channel, and sediment load. If any of these factors alter drastically, river stability is reduced and erosion of the stream bed or banks will occur. Determining levels of erosion are relevant to understanding water

quality because the prevention of erosion is necessary to maintain the ecosystems involved with the river, both aquatic and terrestrial.

When studying erosion, students at Thetford Academy would make observations along the Ompompanoosuc and identify areas where erosion is visible and determine the cause/type of erosion, any long-term consequences for involved ecosystems, and potential solutions to restore stability to the eroded area. The areas chosen to study could be the points that will be studied by the local watershed (see Map A) or areas near the local streams closer to TA.

However, obstacles arise when applying this research to the environmental studies curriculum. The issue is that Bear Creek Environmental from Strafford, VT has already produced a fully comprehensive erosion mapping and analysis of the Ompompanoosuc, and mapping erosion patterns will require students to cover large distances relative to other areas of research, which will conflict with limited class time. Therefore any student investment in erosion research would only serve an educational purpose, and it would be difficult to provide any significant amount of additional or updated data to any environmental entities in search of it.

b. Studying River Plants, Wildlife, and Riparian Vegetation

Studying river wildlife and riparian vegetation is another way students could measure the health of the river system. Students can make judgements about the quality of the water by examining the area around the water way. These field studies would also serve a strong educational purpose by getting the students outdoors and learning about the environment they live in. The most relevant topic would be creating a curriculum around riparian vegetation due to recent efforts by water monitoring committees to restore these areas on the Ompompanoosuc. These efforts to replant riparian vegetation make a large impact to the river systems by containing sediment flow, flooding, and stabilizing the water banks

Regarding the forested area around the Ompomanoosuc, it mostly consists of sugar maples, white birch, beech, red oak, balsam fir, red spruce, hemlock, as well as red and white pines and Norway Spruce (Vermont Fish & Wildlife Department). Common mammals include: deer, black bear, moose, coyote, fox, snowshoe hare, fisher, bobcat, and

gray squirrel. Common birds to look for are wild turkey, osprey, great-horned owl, and goshawk. Students could first learn about these different types of trees, mammals, and birds and then go out into the field and take a count of their numbers/tracks/feces within a certain area of the river. Then, students could monitor these numbers over time and submit them to the contacts working monitoring the river. A full curriculum could be based on posing a lab question that asks how wildlife numbers represent water quality. Overall, this subject may best serve as a subtopic throughout the course to learn about the local environment and the species that inhabit it. Then students could relate this information to knowledge they learn water systems and their importance for wildlife.

In the last few years, groups monitoring the Ompompanoosuc have worked with various high schools to replant riparian vegetation. It has been recommended to us, from Mary Childs, that revamping these efforts would be very beneficial. There is also the Ompompanoosuc River for Trees program where local students help with planting efforts to build buffer zones along watershed areas.

TA could begin the curriculum by mapping out and analyzing the state of riparian vegetation along a section of the Ompompanoosuc. Then, plan and plant their own riparian buffers that students would monitor over time. Key sections of the river to work on would be sections near streams behind TA or any of the listed points on the *Map A*.

c. Phenology

Phenology is the study of biological events as it relates to changes in temperature such as climate change/ global warming (OSU). Biological events could range from different plants and trees to animals that live in the Ompompanoosuc.

Phenology is important to learn because changes in plant and animal patterns could affect the survival of other inhabitants of the ecosystem. The objective of the phenology unit would be to analyze on how temperature change affects the plant and animal cycles of the Ompompanoosuc River and understand the importance of phenology through real world application.

The curriculum for the phenology topic would first consist of conceptual lectures for the students to familiarize themselves with phenology. These conceptual lectures include: an introduction to phenology (what is phenology and why it's important) as well as how

phenology relates to the Ompompanoosuc River (what biological patterns students will be studying). Following the series of conceptual lectures, students will break into groups and focus on one specific species to study. These groups will travel weekly/ bi-weekly to the habitat of their species and take field results of the biological events of the species. An example of this would be to analyze the migration patterns of rainbow trout or brown trout during the springtime. The unit will conclude with a discussion of results and analysis of their findings.

4. Measuring *E. coli*

The Ompompanoosuc Watershed Council has historically tested the *E.coli* levels of the river in response to elevated levels found at several locations on the river in 2006 and 2007. Part of the river was closed to “contact recreation” for a time due to failure to meet Vermont water quality standards (Vermont Environmental Conservation 2010). *E.coli* 0157:H7, the shiga toxin-producing type of *E.coli* found in the Ompompanoosuc, can lead to severe stomach cramps, diarrhea and vomiting when humans come in contact with contaminated food or water, with children and the elderly particularly prone to infection (Center for Disease Control and Prevention 2014). Army Corp of Engineer studies have recorded high *E. coli* levels in part of the Union Village Dam recreation area in Thetford since 1993 at the latest but have struggled to determine the exact source of the pollutant in order to stop it (Caruso 2015).

In 2006-2007, the Ompomanoosuc Watershed Council opened its own study on the river. They found that the potential source areas for contamination are closer to West Fairlee Village than Thetford, particularly agricultural areas and the Crossroad/West Fairlee Road tributary confluence. In spite of the lower risk in Thetford, it is important to continue surveying levels in the Thetford area for public health as well as to establish a baseline comparison for the West Fairlee samples. At the conclusion of the study, the watershed council suggested continued monitoring of the *E. coli* levels in the river, a part of the project which students could easily participate in.

The Watershed Council is resuming testing in the summer of 2015 in response to elevated levels found along the river. While a majority of the testing will be occurring in the summer, they have expressed interest in continue testing into September. They hope that

Thetford Academy students will be able to participate at the Tucker Hill Road and Sandy Beach sites. If it is decided that this will be included in the curriculum, instructors should contact Mary Childs on the Watershed Council for further information (contact information is listed in the Appendix).

The testing process is very straightforward. Students would aid in the collection of water samples at various locations along the river. These samples would then be sent to a lab for total coliform analysis, after which the results returned to the students for analysis. Materials needed would be test tubes for samples and waders for those taking water samples. An alternative method would be to forgo the waders and instead take samples from the banks, being cautious to avoid sample contamination with silt or mud (EPA). The next step would be to put Thetford Academy in contact with labs which can run these tests and allow the Watershed Council access to the data so students are able to see how it can be used outside of an academic setting.

Some logistical challenges include finding a laboratory which can test the samples quickly as *E.coli* samples must be tested within six hours of being taken. Dartmouth College has worked with high schools in the past to test samples.

Homeowners must also be alerted in advance of testing days to avoid any conflicts at the sites. In addition to this, the Watershed Council's testing period is only during the summer months, meaning that Thetford Academy's testing will be a separate project. Due to these difficulties, we do not recommend that this become a main focus of the curriculum, though it could be incorporated into two or three lab days. If it is included, the Council should be contacted before any testing occurs. Contacts are listed in the Appendix.

3.5 Logistics

The major logistical concerns for the implementation of the curriculum at Thetford Academy relate to: a) transportation to and from the river (study sites), necessary equipment, funding, and relationships with the community. All components are necessary in order to for Thetford to develop as a place of environmental stewardship and leadership as well as a place for students become future sustainability leaders.

The issue of transportation to and from the Ompompanoosuc is important because the potential study areas all include active laboratory work, which constitutes constant travel. There is no path currently available that would be a reasonable walking distance for students and teacher to travel to the river. The modes of transportation could be personal vehicles, larger passenger vans, or public transportation, contingent on what is available. We recommend personal vehicles or passenger vans such as 10 or 12 person rental vans for the means of transportation because the routes to the trail require a vehicle, and these two types of vehicles are more available. All potential study areas require a certain amount of trips to the river (bi-weekly, weekly, termly). Cars and passenger vans could be the most effective means of transportation to and from the river. Further forms of transportation could be to provide bikes for the students to use to commute. The bikes could be rented and would require a small sum of money. This would be the preferred means of transportation if cars and passenger vans weren't available.

There is a range of equipment required to conduct the necessary research in all the potential study areas for the curriculum at Thetford Academy. Measuring *E. coli* requires test tubes for samples and waders for children to take water samples. Planting a riparian buffer for the students to monitor requires resources able to create the buffer. The benthic macroinvertebrates unit requires d nets and ethanol containers for the preservation of the macroinvertebrates at TA. We recommend that Thetford Academy look into any government school funding or form partnerships with local organizations of the community.

Thetford Academy aims to aid the Watershed council in gaps of their research regarding *E. coli* bacteria and the Ompompanoosuc River. There is ample room for Thetford to communicate with the Watershed council directly and form a relationship with them so that both parties are able to achieve their goals. The relationship between TA and Watershed is important for the cooperation between the two could help TA become a place of environmental stewardship. Watershed could also have other contacts such as local businesses or other councils that could provide resources for TA to achieve its curriculum.

3.6 Conclusion

We sought to develop multiple potential curricula and laboratory projects relating to the Ompompanoosuc River for Thetford Academy's junior and senior level Environmental Science class. In addition to this coursework, we are developing connections between Thetford Academy and local watershed organizations so that data collected by students can be used for water monitoring purposes, in addition to providing students with a real-world application to their class work. These course options were also created based on feedback provided by former and current students so as to create a curriculum that is both exciting and robust.

Overall, there are a variety of tools and methods to use when studying the Ompompanoosuc. Curricula incorporating the study of macroinvertebrates, pH, nitrate, and phosphate levels, or riparian vegetation seem to be most relevant to current work being done on the river. Going forward, Mary Childs and others who are implementing another round of studies of the river this summer are looking forward to the work these students will do. Studies done on streams of the river near Thetford will be helpful to their studies as would studies on points this team plans to collect already. We are excited about the practicality of this project and especially about student interest gauged from our survey. We hope that connections between the school and the watershed contacts stay firm over the summer as finalities of this course are made while the watershed team continues their water sampling. Finally, in the Appendix we have passed on a few resources recommended to us over the course of our research we believe could be helpful. We will be reachable via email and would love to hear the progress of this project going forward. We wish you all the best and really enjoyed working with this diverse group of people to achieve an attainable and exciting goal.

Chapter 4: Outdoor Education at Thetford Academy

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4.1 Preface

This chapter addresses the broad theme of “outdoor education” on two fronts: in the classroom and beyond the classroom. Place-based curriculum and an outdoor extracurricular program simultaneously address the larger goal of creating a cohesive culture around the idea of place-based education at Thetford Academy by developing student interest in outdoor education, encouraging faculty buy-in, and creating innovative ideas for outdoor education in practice. First, we introduce outdoor education from the perspective of inside and outside the classroom. Then, we elaborate on our approach to performing our research. Our findings, which indicate the leverage points and feasibility of outdoor education at Thetford Academy, are presented and discussed. Looking forward, we discuss how TA can build interest and participation in the symbiotic outdoor curriculum and extracurricular outdoor education program.

4.2 Introduction

The motivation for this project comes from Thetford Academy’s desire to create a school culture that emphasizes outdoor education. Last year, an ENVS 50 group evaluated the feasibility of implementing outdoor leadership programs at Thetford Academy. At the end of the term, the group proposed three recommendations for TA. The recommendations were to 1) incorporate outdoor leadership into Physical Education curriculum, 2) create and implement an extracurricular outdoor leadership program that takes place on a weekday, and 3) create and maintain a relationship with Dartmouth’s Tucker Foundation to hopefully implement a mentorship program (Dartmouth College 2014:106). From these results, Thetford Academy saw the opportunity to add outdoor education into their curriculum and school culture as a whole. Building from this foundation, we sought to develop actionable outdoor education activities in collaboration with TA faculty and to propose a plan to implement a comprehensive outdoor extracurricular program at TA. One leverage point for creating a culture around outdoor education at Thetford Academy is through a pedagogy of outdoor education. Outdoor education has many names: “ecological education” (Smith and Williams 1999), “community-oriented schooling” (Theobald and Curtiss 2000), and “place-based education” (Smith 2013), to name a few. The broad goal of outdoor education is “to provide meaningful contextual experiences... that complement and

expand classroom instruction” (Woodhouse and Knapp 2000). As a specific kind of outdoor education, the investigations and suggestions in this report focus on place-based education. According to Woodhouse and Knapp (2000), place-based education often has the following characteristics: the content is specific to the context, education is multidisciplinary and experiential, curricula are designed for a larger objective, and the education connects place, self, and community.

Outdoor education has been shown to benefit students and schools around the country. Unlike most traditional education programs, outdoor education combines underlying curricular components with real world applications for students (Hungerford et al. 1985). Research shows that outdoor education significantly increases student motivation and enthusiasm to learn, and it also helps students concentrate for longer periods of time (Coyle 2010). Specifically, place-based education focuses on increasing students’ intrinsic motivation. Piaget’s educational theory on motivation can be linked to place-based education and its benefit to students (Powers 2004). Place-based educators believe that by grounding education in the local community, students will see the real-world significance of what they are learning and likely become more engaged in the learning process (Powers 2004). Additionally, outdoor education helps students to “learn across disciplines and make them better real-world problem solvers” (Coyle 2010). Literature shows that place-based education is effective in improving both student engagement and achievement through practical applications of class material. Students who partake in real-world learning have been shown to be more successful than those who learn the same material from textbooks, which are more abstract (Powers 2004). And a study looking at the effects of locally-based curriculum in over 40 schools across the country showed that student achievement and behavior in the schools actually improved (Powers 2004:18). Overall, integrating place-based and outdoor education into school curriculum will be beneficial to both students and the community as a whole.

Another leverage point for creating a culture of place-based learning at TA is through an outdoor extracurricular program. Outdoor programs can take many forms and follow a variety of models. Many institutions have outdoor-focused clubs which vary in terms of programming and goals. Some focus heavily on survival skills and activities related to building outdoor leadership; others focus on environmental science, education,

and conservation initiatives, and still others engage mainly in outdoor sports and adventure activities. All of these programs provide opportunities for experiential learning and are helpful for getting participants outside, active, and involved in the natural world (Breitenstein and Ewert 1990), albeit in varying capacities.

These programs allow participants to build valuable life skills, such as interpersonal communication, conflict resolution, creative problem solving skills, and “grit” (Duckworth et al. 2007). Participation in outdoor extracurricular programs also brings participants into closer contact with nature, and in doing so help foster increased appreciation for the natural world and higher degrees of environmental awareness (Palmberg and Kuru 2010). Fostering environmental stewardship through these programs, then, can help address popular concerns, such as climate change, which will remain prevalent in the foreseeable future. Outdoor field work has been shown to not only increase test scores markedly across the board, but also has been shown to be more effective at developing cognitive skills than normal classroom work (Dillon et al. 2006). Thus, outdoor experiential education opportunities build better-equipped individuals with honed skills and higher degrees of environmental awareness and responsibility.

Considering Thetford Academy’s goals to expand their school culture and to make better use of the environmental resources surrounding the school, the purpose driving the investigation of outdoor education at TA is two-fold. First, it was critical to evaluate the leverage points for implementing outdoor education curriculum and an outdoor extracurricular program at TA by investigating available resources, collecting student input, and considering successful models for outdoor education at other schools. Second, this study produced actionable products that can generate faculty and student buy-in by providing examples of lesson plans/activities and an outdoor program.

4.3 Methodology

Participatory Action Research

Throughout the course of this project, we conducted participatory action research with our community partners at Thetford Academy. This approach was used with the explicit goal of making the local knowledge and needs of our community partners central to

this project (Minkler 2004). Below, we elaborate on the general practices that we used throughout our project and the co-development of the lesson plans/activities and outdoor program which were an end-product of this collaboration.

We initiated our project with a first meeting at Thetford Academy, where we co-created the principles and goals of this participatory research. According to Minkler (2004), it is crucial to set formal or informal ground rules early on in participatory action research (694). As such, we established the mode and frequency of communication to be expected between the Dartmouth students and TA faculty. Between subsequent meetings, collaborators disseminated information and resources crucial to the project, as was emphasized as an important principle of community-based research by Maiter, Simich, Jacobson, and Wise (2008:317). Active communication (Keen and Baldwin 2004:393) was crucial to the successful incorporation of local knowledge and the co-created outcomes of this research.

Specific to the development of the curriculum deliverables (lesson plans/activities) and extracurricular deliverables (outdoor program), it was essential that our community partners drive the lesson plan/activity and outdoor program selection. According to Minkler (2004), community-driven issue selection is a crucial aspect of participatory action research (687); this was especially true in our case, where the Dartmouth students were working in unfamiliar territory by developing lesson plans/activities to be used in classrooms and planning an extracurricular outdoor program. We recognized and welcomed TA faculty members as “local experts” (Maiter, Simich, Jacobson and Wise 2008:313) in the field of education and people familiar with the TA community. In essence, the Dartmouth collaborators synthesized the expertise of TA faculty and helped generate innovative ideas for the lesson plans/activities and outdoor program, found in Appendix C and D.

Case Studies

In terms of the case studies, we were interested in exploring successful models for outdoor education and outdoor programs at schools in similar natural environments. Before beginning our research, we laid out our research design - our guiding questions, units of analysis, and criteria for interpreting our findings - drawing on literature about

case study research methods (Yin 2003). In particular, we wanted to know what these schools' approaches were to incorporating their natural environments into the education experience, their pedagogical strategies for fostering learning experiences outdoors, and more generally what does and does not "work" for these schools.

For the curriculum sub-group, we selected two private schools located in rural, mountainous geographical regions. Based on their location, these schools would likely have experiences that could be transferable to the physicality and cultural environment at Thetford Academy. The Mountain School, which is located in Vermont, focuses on place-based learning in their semester-long academic cycles. Arthur Morgan School, which is a school in the mountains of North Carolina founded on Quaker values, emphasizes outdoor education and service learning as part of their curriculum.

The three case studies chosen by the extracurricular sub-group were Cass Lake-Bena High School eXtreme Club in Cass Lake, MN; Spartan Edge Program-Irvington High School in Fremont, CA; and the Outdoor Program at the Mountain School in Vershire, VT. The geographies, school size, and school structures of these programs differ greatly and have specific unique qualities that made these programs effective. These diverse programs were chosen based on the results of the student survey and focus group, and out of a desire to draw on a range of possible models. These programs blend components of outdoor skills development (such as wilderness survival), environmental education, life skills such as communication, physical activities, and a culminating experience. Certain components from these models may be applicable and compatible for Thetford Academy; we synthesize aspects of these programs to create a proposed club developed to specifically meet Thetford Academy's needs.

We used a mixed method approach to collecting data on these cases. First, we did a content analysis of the schools' websites and other webpages about the outdoor programs with the objective of distilling the goals and practices of these schools and programs. In addition, we interviewed alumnae and teachers/administrators from the schools (See Appendix B) to tap former students' experiences of the outdoor education pedagogy the school case studies used as well as teachers' experience and understanding of this kind of learning environment.

Survey

For the survey of TA students, we created a thirteen question survey (See Appendix A) that was used to help us assess student interest in outdoor education and programming. The students were first asked general questions about their grade and extracurricular activities so that we could compare responses across ages and interests. Next, we probed the students about their interest in going outdoors for class and what types of activities, both indoor and outdoor, they enjoyed most in their classes. These questions were aimed to help us see if the students had any strong interest in going outdoors for class, and what types of classroom activities would be best to incorporate into our curriculum suggestions. The rest of the survey included questions that were formulated by the Trails group and the Extracurricular group. One of the most important questions for the Extracurricular group was if the students were at all interested in participating in an outdoor extracurricular club. This question could help TA save time and resources if students did not want this type of club. The percentage of interested students was also needed to develop an accurate outdoor program model. Additionally, we asked what types of activities students were interested in to get more in depth knowledge about their interests. Predetermined activities were listed in this question, and there was also an option to elaborate on suggested activities that had not been listed. These activities were based on the desire from TA staff to include humanities activities in order to cater to more students' interests, as well as a desire to coordinate the extracurricular program with outdoor education occurring in TA classrooms. Notably, we based our survey development and question wording on proven methodological approaches, such as avoiding double-barrelled questions (Fowler 2008).

In order to distribute the survey, we created both an online Google Form and a paper version. Our Thetford Academy faculty leads sent the link and paper form out to teachers at the school and asked them to have their advisee groups complete the survey. Students from each grade level (7-12) took part in the survey. The students were given five days to complete the survey, and at the end of that time we collected 85 responses through the Google survey and 59 responses through the paper form.

Focus Group

The extracurricular group ran a focus group of 15 Thetford Academy students in grades 9-12. Focus groups are an appropriate data collection method when a researcher's goal is to connect on a more personal level with their subject (Arthur 2012). A focus group also provides the stakeholders, in this case the students at Thetford Academy, a greater voice in shaping the program that is being developed for them and the faculty (Arthur 2012). It allows the gathering of first-hand evidence to back up the reasoning for the structure and content of the extracurricular model that is being presented this year. Moreover, a focus group, when performed well, "can be rewarding for participants, present exciting challenges for researchers, and produce quality in-depth interactional data of a kind not possible through other methods" (Arthur 2012:191).

The focus group was facilitated during a 25-minute lunch period. There were 15 Thetford Academy student participants, two Dartmouth College student discussion facilitators, one Dartmouth College student note taker, and one Thetford Academy faculty member supervising the process. Prior to the focus group, a number of guiding questions were developed to direct the discussion in an efficient manner to make sure the key questions were being discussed. Since the time period of 25 minutes is short and limiting, the questions were narrowed down to five central inquiries: 1) What the current club and extracurricular involvement of the interested students is 2) How they envision an outdoor club and what they would get out of it 3) Their thoughts on the top five choices for outdoor activities from the online survey 4) How to compromise scheduling concerns and 5) Feedback on the current idea for the new program structure.

4.4 Results

A. Curriculum Case Studies

The Mountain School, Vershire, VT

One model school that we chose to research was the Mountain School, which is located in Vershire, Vermont. This private boarding school is coed and takes 45 students from over thirty different schools every semester (The Mountain School 2015). The entire

school is focused on placed-based learning, and much of their activities and learning involve the school's farm in rural Vermont. Their small class sizes encourage intellectual inquiry and experiential learning, and their curriculum is meant to challenge the students to not only think critically but also participate in dialogue. Many of their courses take advantage of the mountainous location, and the material is often directly relevant to students' experiences at the school (The Mountain School 2015). As the mission states, the Mountain School "cultivates a diverse and interdependent community of scholars who learn to know a place and take care of it. Through collaborative learning and shared work, students emerge from their semester prepared to reach beyond the self and focus on the common good" (The Mountain School 2015).

From the interview with alumna Kemi Mugo '10 and director of school Alden Smith, a number of themes emerged that inform our research on outdoor education in practice. First, students' learning was based on the school's specific location. As Alden Smith told us, the school seeks to "introduce students to the northern forest in such a way that they appreciate this landscape and learn how to interact with it intentionally and safely" (A. Smith, personal communication, May 17, 2015). For example, Kemi explained that there was an environmental science course that students take where they choose a site somewhere in the Mountain School's 300 acres; for the whole semester, students learn how to read the landscape and identify the history of the spot (K. Mugo, personal communication, May 13, 2015). As the final exam, students have to walk teachers around the site and make their argument for the history they uncovered. Class work throughout the Mountain School is extremely hands-on and often involves practical, real-world applications. When Kemi learned about sugaring, she studied all aspects of taking care of a place. As she described, "our knowledge had a practical, important use" (K. Mugo, personal communication, May 13, 2015) because it could be applied to their current surroundings. Additionally, the school focuses on teamwork with many group activities and also self-development with their culminating Solo trip where students camp alone on the Mountain School's land. Another theme was the evident benefits of outdoor education. Kemi emphasized the fact that she was given "tangible, practical examples of a significant portion of the environmental concepts" (K. Mugo, personal communication, May 13, 2015) she learned. Kemi explained that learning in a natural environment made everything much

more vivid, and as a result, the information has stuck with her more than any of her lectures or textbook readings. For example, on her Solo trip she learned to be much more aware of her surroundings, like when the sun rose and set, and she learned how to wait for things like water to boil. The Solo activity provided general life lessons that she was able to take into the future. Overall, the school is very focused on using place-based learning to enhance student's learning experiences and develop both teamwork and leadership skills.

Arthur Morgan School, Burnsville, NC

Another model school for outdoor education is Arthur Morgan School. Located in Burnsville, North Carolina, this private middle school (seventh through ninth grades) has created a school culture around place-based and environmental education. According to their website, their vision is "to empower [their] students to make courageous choices that may create global change by developing an awareness of our impact on social and ecological life" (AMS 2015). Students' laboratories for learning include the school farm and wilderness surrounding the community. Every week, students participate in work projects intended to "provide meaningful work needed by their community" and develop "a sense of group responsibility" (AMS 2015). The school's outdoor education culture is further reinforced by three, six, and eight-day outing trips in the region. In line with research on place-based education (Woodhouse and Knapp 2000), Arthur Morgan emphasizes service learning as part of students' learning experiences within their natural environments and greater community; as such, Arthur Morgan students participate in activities such as helping maintain mountain trails, conducting roadside cleanup, and planting a local community garden.

There are a number of themes that can be drawn from the interview with a former AMS student, Lorrie Carey '77, that inform our research on environmental education in practice. First, AMS incorporated environmental education into all dimensions of curricular education: "building a solar hours that fit into a natural environment (math, science, and industrial arts), growing food for school meals (plant science and nutrition), studying geographical features (earth science), and even folk dancing (arts)." The natural learning environment tackled what Lorrie described as "practical" lessons. For instance, on a trip to an apple farm, they "had to calculate how many bushels of apples [they] picked,

how many crates of apples that made, and how many pallets we would need to put our crates of apples on trucks to go to vendors. It was math, arts, and teamwork rolled into one big mountainside classroom.” The practical lessons used more “hands-on” approaches and capitalized on the natural environment surrounding the school. For this alumna, the interactive learning experiences at AMS increased her learning retention and had a “positive emotional impact” (L. Carey, personal communication, May 5, 2015.). As such, her learning experiences at the school extended far beyond that moment in her life; she recalls her outdoor educational experiences at AMS with great clarity, even years after completing the program.

To get a sense of the teaching/administrative perspective on outdoor education at Arthur Morgan School, we interviewed Bridget O’Hara, who is co-clerk, house parent, and spanish teacher at AMS and Jason Sterling, academic coordinator and language arts/algebra 1B teacher. Notably, the teaching philosophy at AMS is guided by the school’s history, beginning with it’s founding by Elisabeth Morgan as a Quaker school “inspired by Grundvig, Pestalozzi, and John Dewey” (B. O’Hara, personal communication, May 7, 2015). According to Jason, education at AMS occurs beyond the classroom in two main outlets: the school farm and outdoor trips. For instance, students practice “living simply” by chopping their own firewood and picking food from the school garden for their lunches. According to Bridget, the natural environment on the school campus is constantly being used as a resource in the classroom. For instance, she shared, “In one class that studied energy, students measured water flow in a stream and calculated how much energy could be harnessed with a hydroelectric dam” (B. O’Hara, personal communication, May 7, 2015). Jason also described an example of an English class unit where “one of [the] classes was titled ‘Natural Inspiration’ and was an exploration of art and nature’s influence in our creative processes. Students found a spot in the woods near school and spent time there twice a week, then debriefed in class their reflections or inspirations” (J. Sterling, personal communication, May 11, 2015). To encourage inspiration and infusion of the natural environment in AMS classrooms, they “have a flexible curriculum that encourages exploration by staff and students” (B. O’Hara, personal communication, May 7, 2015). Furthermore, Bridget views the “trips that break up the year” as critical to developing students’ “sense of self, fun, and friendship” (B. O’Hara, personal communication, May 7,

2015); the only aspect of these trips that does not always “work” is when weather dampens the experience.

Conclusions

Several insights drawn from the case studies of the Mountain School and Arthur Morgan School help to understand how to leverage outdoor education at Thetford Academy. We classified our findings into two broad themes pertaining to these schools: pedagogy (or the teaching practices) and school culture. Notably, these themes are co-constitutive and demonstrate a need for flexibility in curriculum and investment in culture-building outdoor activities.

In terms of the schools’ pedagogies, we found similar styles of teaching at these schools. Both schools used hands-on, practical approaches to teaching in the classrooms, favoring experiential learning outdoors over lectures inside a traditional classroom. Outdoor education was integrated into all aspects of curriculum, and the boundaries between subjects were often blurred (in part because of the practical approach to teaching used at these schools). Flexibility given to teachers and students in constructing and partaking in curriculum was crucial to facilitating this cross-disciplinary engagement and exploration of the surrounding natural environment. Both alumnae to whom we spoke attributed their lasting, “vivid” memories of their educational experiences at these schools to this place-based, experiential pedagogy.

Place-based curriculum was facilitated by these schools’ cultures, which adhered to values for collaboration and place-based learning reflected in their missions. Outdoor education was integrated into the schools’ larger goals and supported by the administration, faculty, and students. Beyond formalized values (seen in the schools’ mission statements), culture-building activities at the schools were critical to engaging students in outdoor education. School trips at the Mountain School (such as “Solo”) and Arthur Morgan School (such as the three, six, and eight-day trips) allowed students to bond in the natural environment, simultaneously creating a stronger sense of place. These cumulative cultural experiences, in concert with the place-based curriculum, fostered a school culture around outdoor education at these schools.

Although great insights can be drawn from these case studies, it should be noted that every school culture is different. The case study schools were both fully private schools, which is slightly different than the part-public, part-private academy style school in Thetford. These schools were also residential schools, which made it much easier to develop school cultures around place-based education. While we recognize these differences, we still see the pedagogical and cultural themes noted from our research as important aspects of outdoor education that can be adapted and scaled to fit the needs to Thetford Academy.

In sum, our case studies demonstrated two important themes in outdoor education in practice: flexible, experiential learning-based curriculum and a culture that reifies the goals of place-based learning at these model schools. Administration and faculty buy-in was necessary to formalize outdoor education goals into these schools' guiding mission statements. The schools saw students' learning as whole experiences, which was complemented by activities that encouraged student bonding. The Mountain School and AMS were successful in implementing this outdoor education pedagogy and creating a culture of outdoor learning, and cited only weather constraints as challenges to implementing these programs.

B. Extracurricular Case Studies

Cass Lake-Bena Extreme Club

Cass Lake-Bena is a public school in the town of Cass Lake, Minnesota. Located in a rural area, the student body is around 150 students (in the high school). The school has an "eXtreme Club" that is open to 8th-12th grade students who maintain "satisfactory grades, attendance, and behavior" and participate in at least four meetings per year and in at least one service or fundraising project. Although the club activities are open to the whole school, according to the program's website, if you are a member of the eXtreme club you have the benefit of priority selection for trips with limited space, reduced fees for trips, and the opportunity to help select and plan club activities. Activities in this club include climbing, hiking, learning how to rappel, high ropes course, snorkeling, scuba certification, canoeing, and wilderness survival skills. All of these activities lead up to a culminating

experience. Often, this culminating experience is a caving trip to Kentucky where students are able to put their knowledge and newfound skills to the test, although in recent years the eXtreme club has gone to Puerto Rico or white water rafting. The purpose of the activities and this club in general is to 1) make science less intimidating and more fun, 2) offer learning opportunities that go beyond the classroom, 3) generate more interest in upper level science courses, 4) explore careers in math and science, and 5) connect with other High School Science Clubs from around the country (CLBHS 2004).

An aspect of the eXtreme Club that we think would be useful for developing a program for TA is their finance strategies. Club finances come from fundraising, income from their webpage, and private donations. In order to make activities available to all students, regardless of their income, local volunteer (“work”) opportunities are arranged to help members pay their way. Such opportunities include trail maintenance for the local state park or volunteering at school related events. This volunteer time is credited as payment towards the club.

Spartan Edge Program- Irvington High School

The *Spartan Edge* program was developed by the team at *Spartan Race*, a highly successful obstacle course racing company with close to three hundred thousand finishers in 2014. Part of Spartan Race’s mission is to help build confidence through challenging people to show they are stronger and tougher than they thought. Along these same lines, the *Spartan Edge* program was developed as an initiative to help high school students learn about and develop life skills and core competencies, which will help them be successful in the future. Currently in schools, there is a systemic problem of students trying to achieve the highest grades with the least possible work and students just “doing school” instead of striving to reach their full academic potential. *Spartan Edge* addresses this problem by helping students develop grit, a key determinant of success academically and otherwise (Duckworth et al. 2007).

The program is organized around ten core values and skills, which include goal setting, commitment, ambition and motivation, focus, delayed gratification, dealing with adversity, complex problem solving, and grit. For each of these subjects, two or three teaching units were developed for curricular integration. The units range from academic

explorations (facilitated discussions and written exercises) to experiential learning activities, which in true Spartan form get kids out of their chairs, engaged, and active, include work on strategy, focus, and overcoming fear. The experiential activities reinforce the academic explorations, such as connecting goal setting with conviction and courage, commitment with the skill of deep focus, grit and dealing with adversity with complex problem solving, etc. In doing so, students are able to understand the what and why of the life skills they are developing, and are able to work to ingrain these skills (Spartan Edge n.d.).

While this program is still in its infancy, Jay Jackson, the assistant principal of the school running the pilot program at Irvington High School in Fremont, CA, believes that it has been widely successful. In Jay's opinion, individuals who have participated in the program, particularly in the extracurricular physical education component, seem to show increased levels of confidence, happiness, and fortitude, and have displayed notably increased grit, whether in conquering the optional Saturday morning challenge course or in tackling academic challenges through hard work and creative problem solving. From the lessons and core values of *Spartan Edge*, we gained valuable information that helped to shape our own program. While the activities may be different, the trait and skill development initiatives fall closely in line with what we seek to provide through our club offering - a platform for building better students and happier, more confident individuals overall.

Mountain School, Vershire, VT

The Mountain School, previously described in the "Curricular" section, can also be studied from the perspective of its applicability to an outdoor extracurricular program. As Alumnus Kemi Mugo recalled, students were required to participate in outdoor classes, Science Hikes, and the weekly Outdoor Program. During the Outdoor Program, students learned how to use a topographical map and compass to navigate to a given point, how to set up camp with a tarp and some rope, and how to tie knots. A favorite learning activity was called "Find Your Way Back to Campus". This activity consists of three or four students who are blindfolded and driven to some location away from campus. They are left with only maps, compasses, and food for lunch. The main goal of this activity is to use skills

gained from the Outdoor Program to find your way back to campus before dinnertime. All of the activities in the Outdoor Program assist students in working up towards what Kemi calls “Solo.” Solo is the final activity in the Outdoor Program where students camp completely alone (with minimal monitoring by faculty) for four days and three nights using all the skills they’ve learned from the Outdoor Program (K. Mugo, personal communication, May 13, 2015). Other activities that happen at the Mountain School are farming, sugaring, and weekly wood crew.

An aspect of Mountain School that we would like to input in our model is the idea of “necessity.” One compelling aspect of the Outdoor Program that Kemi recalls is learning about the outdoors out of necessity, not “just because” (K. Mugo, personal communication, May 13, 2015). Finally, what she loved most was that her “knowledge had a practical, important use” (K. Mugo, personal communication, May 13, 2015), demonstrating how this project ties back into the place-based learning component of our project.

C. Curriculum Survey Results

Between the online and paper surveys, we received 144 student responses encompassing grades seven through twelve. Although we received a fairly even spread across grades, the 9th grade class made up 31.3% of the survey responses. All other grades ranged from 9.7-17.4% of the responses (Figure 1). We did not ask the students their gender because this was not a relevant data point for our analyses, so the response analysis is based on the general student body and the responses will not be broken down by gender.

In the survey, we asked students about their favorite kind of class assignment. We offered a range of responses such as lectures, projects, outdoor work, and hands-on work. Although these activities can be overlapping, they individually tap into the core reason students enjoy these particular activities. Students were asked to choose all assignments that they preferred (Figure 2). Of the 144 responses, 106 of them (or 73.6%) said that one of their favorite class assignments was “hands-on.” Following hands-on, outdoor assignments made up 59% of the responses and projects were favored by 49.3% of students. The type of class assignments that were least preferred by students were lectures. Lectures made up the lowest percentage of the results with only 18.8% of

students. Notably, most students indicated in open responses that they *infrequently* went outside for classroom activities and assignments.

The students were also asked how interested they were in going outside once a week for class. Students chose from a scale of 1 (Not at all) to 4 (A lot). Answers of 1 or 2 indicated that students were not interested, while 3 and 4 indicated interest. Overall, 3 and 4 were the most common answers (Figure 3), demonstrating a great overall interest in going outside for classes. Across all grades, 83.3% of those surveyed chose 3 or 4, meaning that 120 students were interested in going outside once a week. Breaking down responses by grade shows that interest is common among all grade levels, with four being the most common response for every year. Of all the grades, the 9th grade had the highest percentage choose 4, indicating there are a large number of students who are *highly* interested in outdoor learning in this grade level. However, the 9th grade also had the highest percentage (22%) of students choose 1 or 2, so there is some disinterest among this cohort of students. By comparison, only 8% of 7th graders chose 1 or 2 when responding to this question.

Additionally, the survey asked what types of outdoor activities the students did *not* enjoy. This was an open-ended question where students could write as little or as much as they wanted. Out of the 144 surveyed, 125 of them said they enjoyed all of their outdoor activities. Of the 19 who commented on activities they did not enjoy, seven of them were due to bad weather and not being warned ahead of time that the class was going outside. Of the remaining 12, three answers involved gym class and two involved indoor class activities.

Figure 1. Number of respondents [in brackets] broken down by grade.

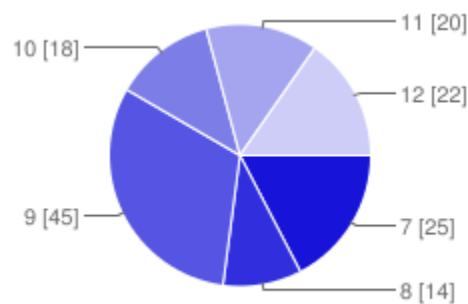


Figure 2. Students' favorite types of class assignments.

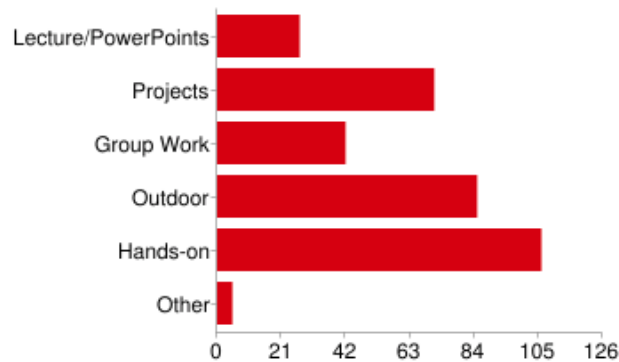
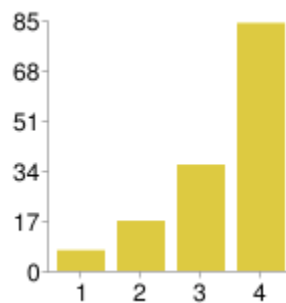


Figure 3. *Level of interest in going outside once a week for class. Responses were recorded on a scale of 1 (Not at all) to 4 (A lot).*



D. Extracurricular Survey Results

The results from our survey showed a significant level of interest in the prospect of an outdoor program. Figure 4 demonstrates that of the 144 students surveyed, 90.2% were interested in some sort of outdoor extracurricular program, and 69.4% of students were interested in having a club meeting more than once in an academic year. Given that more than half the student body expressed interest in such a program, the program seems to be viable from a general interest standpoint.

Figure 4. *Level of interest in an outdoor extracurricular club*

Yes - Quarterly Club (Meet 4x per year)	51	35.4%
Yes - Weekly Club	49	34%
Yes - One Time (ex. Mountain Day)	30	20.8%
No	14	9.7%

From the respondents who answered in the affirmative, we were able to gain quite a bit of insight into the nature of what they would like the club to encompass. We offered a list of potential activities for students to select as interesting potential club activities. The results, shown in Figure 5, indicated greatest interest in Wilderness survival, camping, overnight trips, hiking, nature photography, and astronomy, with further interest in caving, outdoor physical education/boot camp, and nature painting. Thus, the responses indicated that the club should encompass outdoor leadership initiatives in skill building alongside physical activity of varying degrees of rigor combined with academic explorations and art.

Figure 5. *Student interest in specific activities*

Wilderness Survival	94	69.1%
Camping	92	67.6%
Hiking	82	60.3%
Overnight Trip	82	60.3%
Nature Photography	76	55.9%
Astronomy	74	54.4%
Caving (learning about and possible exploration of caves)	64	47.1%
Outdoor Training/Boot camp	61	44.9%
Nature Painting	57	41.9%
Geocaching (Using GPS coordinates to locate hidden objects)	50	36.8%
Gardening	50	36.8%
Trail Work	48	35.3%
Water Quality Testing	41	30.1%
Nature Writing	29	21.3%
Citizen Science (Conducting research)	26	19.1%
Other	11	8.1%

Our third question yielded less significant data, as student’s opinions on why they would like to do the above activities ranged from “no” to “all of it” to “Don’t really know... Feeling alive? Adrenalin? View of nature?” to general interest in outdoor activities.

E. Extracurricular Focus Group Results

Results from the focus group are presented in terms of the questions as they were asked in the lunchtime meeting.

Question 1: What is your current involvement in clubs and extracurriculars such as sports?

The students who participated had all *previously* been involved in an environmental club and a robotics club. Surprisingly, nearly all 15 of the focus group participants are not

currently involved in clubs. When asked the reasoning for why they are not involved in clubs, responses included statements that they simply weren't interested in the clubs offered and that there is not enough time during the day. Most clubs are meeting during the short 25 minute lunch period, and sports often take priority in the after school time period.

It was clarified that "clubs" are in a different realm from "sports," in which almost all of the focus group participants responded that they are involved. The discussion then shifted towards the scheduling of sports that students are involved in. Girl's soccer is right after school, and boy's soccer would follow. In the last five years, boy's soccer has been at 5pm, but with a new coach hire for the next school year, this schedule could change. Many of the boy's soccer players in the focus group stated that they would be interested in going fishing during the time they had before practice. Cross country starts practice as soon as school ends, and baseball has a small lag time after school, starting at 3:30pm. When voting whether students would be more likely to sacrifice their sport or other extracurricular to join the outdoor club in the Fall or Spring season, five students voted for fall and six students voted for spring. This is a poll that should be confirmed in a follow up survey to students interested in joining the club. Prior to the focus group, there was a concern that students' involvement would be restricted by transportation limitations since the late bus leaves at 3pm, which is too early for an outdoor club hoping to have at least an hour of activity in the woods. Yet, upon discussion with the focus group students, there was a unanimous response that students would be able to drive or set up arrangements for pick-up.

Question 2: What makes a student join a club and how do they find out about it?

Students stated that a "coolness" factor is definitely involved, and that "coolness" comes about through their interest in the kinds of activities that the club would do. Others stated an attraction to participating in something that is physically active. There was also valuable input that in the past, clubs have been frustrating when only a few students show up and there is a low level of organization and an unclear sense of how to move the club forward. The students find out about clubs through assemblies, morning announcements, and word of mouth. There was positive reaction to the creation of a Facebook page for the

outdoor club, and it was concluded that students would be more likely to read a Facebook page post rather than a poster on a bulletin in the school hallway.

Question 3: What is an outdoor club to you?

To foster response to this broad question, we asked “what are the sorts of activities you envision an outdoor club involving, and what meaning or purpose do you expect to extract from an outdoor club?” The responses demonstrated a great amount of educational purpose and meaning such as learning about different trees, horticulture, learning about the environment and the different animals living in the surrounding lands, interest in skills such as fire building, shelter building, tracking, GPS, using a compass, etc. The students expressed a desire for being outside for the sake of being outside and having fun, such as kayaking. However, they also expressed sophisticated viewpoints on how these experiences can be beneficial to life skills in the future and the positive benefit of “knowing Thetford Academy lands well and having ownership over that.”

Several students also expressed a desire for hunting, fishing, and tracking. Hunting is impractical on school grounds, but fishing is an activity that could be taught as part of outdoor survival skills, and tracking can be used to “shoot” photos with a camera for practice of nature photography. It was suggested that a club webpage would be a useful portal to publish these photos and contribute to advertising for the club. The students expressed that they do not mind “curriculum” type components in the club as long as they are different from the subjects currently taught in the school curriculum. As an example, the school does not have a nature photography class, so students would be interested in that kind of activity.

Question 4: What days and times would work best for the club and which season?

This question was touched upon in question one, but we decided to discuss this important scheduling question further once the student participants had gotten a sense of what this club might look like. Friday was not a popular day of the week since it is the end of the school week, and Wednesday and Thursday were both stated as possible dates, keeping in mind that there are office hours after school on Wednesday. There was a suggestion that the club start at 2:45 or 3:15 (as opposed to 2pm right when classes end)

and it was stated that students would prefer to have a break before committing to up to two hours of hard activity in the woods. This time preference did not appear in last year's survey. One possibility for this is that the students had previously perceived the club activity to last only one hour, and therefore believed that a break would be valuable with the knowledge that it would last up to two hours.

Analysis

The focus group helped to clarify the sense of what students are interested in and what the best structure for the program would be. Before the focus group, there was some confusion about whether students wanted traditional outdoor leadership, environmental education, or an adventure/outdoor physical education experience. The responses during the focus group showed that the students valued some level of environmental education. Beyond getting outside for the sake of physical activity, they also demonstrated interest in going outdoors to learn about their surroundings. Additionally, we received useful feedback about why some clubs have been unsuccessful in the past, and what kind of structure would encourage students to join a club. We learned that it is crucial to foster significant student participation, find a schedule that best fits students' needs, and build an organized structure to avoid club disintegration.

4.5 Discussion

Curriculum

Given our survey results and case studies of schools that have successfully implemented an outdoor education pedagogy, a number of timely recommendations could guide TA towards their goal of becoming leaders in environmental education. These recommendations are grounded in discussions with TA faculty, input from TA students, and interviews with alumni and teachers/administrators at schools in similar natural environments who have developed cultures of environmental education. From the survey, it was clear that the students supported the decision to increase the level of outdoor education in classes. Significantly, the sub-section of the TA student population

from which we received the greatest number of responses was the 9th grade, likely because several of the TA collaborators for this project were 9th grade teachers. Responses from 9th graders is particularly beneficial because they will be among the first to experience outdoor education if it is implemented.

One of the biggest take-aways from this survey was the overwhelming desire to go outside for class. The large majority of students indicated that they want to go outdoors once a week for classes. Not only was it a majority, but students from *every* grade said they were interested or very interested in learning outside. When asked about activities they did not like, the most common response included inclement and cold weather or not being warned about going outside. Both of these concerns can be avoided or addressed through flexibility and planning. These survey results strongly support TA's mission of including outdoor education in their curriculum and our goals for the project. Additionally, of all the assignments listed on the survey, students were most interested in hands-on and outdoor projects. Not only does this result show student interest in going outdoors, but it also helped our group to focus in on certain types of activities. Rather than just lecturing outside, students made it evident that they wanted more hands-on assignments. Considering the expressed student interest and definitive results about preferred assignments, our group had clear direction for creating outdoor activities for various classes.

From the case studies of the Mountain School and Arthur Morgan School, two successful models for outdoor education, we know that a school's teaching pedagogy and culture are significant factors in outdoor education "working" in practice. At both of the model schools, flexible curriculum and interdisciplinary collaboration was crucial to implementing place-based education. As such, it is necessary to garner administrative and faculty buy-in around this larger goal. Communication (especially of student interest in outdoor education, as demonstrated by the survey results) and collaboration (through teams of teachers interested in finding ways to incorporate outdoor education into their curriculum) are key to generating buy-in from both of these parties when going about implementing our deliverables.

Deliverables: Lesson Plans/Activities

As previously mentioned, the deliverables produced from the place-based curriculum sub-section of this TA-Dartmouth collaboration are four actionable lesson plans/activities that can help to augment the established curriculum currently in use at TA. These four activities have a two-fold purpose: The activities are practical and innovative ideas for incorporating outdoor education into curriculum at TA. They should also be seen as a beta-test for place-based curriculum at TA that can launch a conversation at the school about outdoor education and how ideas for outdoor education can be further streamlined into classrooms to make TA a leader in environmental education. We chose to develop activities in four different subjects; these subjects and activities were chosen with interested teachers, local environmental resources, students' expressed interests, and the goal for broader cultural change in mind.

Of the four subjects we chose, two were focused on the humanities, specifically Art and English. For our art-based activity (See Appendix C), we believe it would be best utilized in the grades 9-12 "Art I and Ceramics" class. This class is taught by Karyn Neubauer, and we collaborated with her to create the proposed activity in order to make it easier to implement into her existing class. Our activity involves the natural TA surrounding and gets the students outdoors into the land. We chose to focus on nature as art in order to develop student interest in the landscape around them. By using the nature around them to create art, we believe that students will gain a greater appreciation for their surroundings and see TA's land in a different light. Additionally, nature as art allows students to not only go outside, but it also provides a hands-on, project-based activity which students indicated they enjoyed most.

For our English-based activity (See Appendix C), we believe that it would be most effective in the grade 9 "Connection to Classics" class. This class is taught by Melissa Thaxton, and we also worked with her in order to create an activity that would augment her material. Given that the New England landscape has inspired many writers, we wanted to add a place-based component to an English course. The activity we created is centered around nature writing. By focusing on the writing in the Vermont landscape, we believe that this activity will add to students' knowledge of their geographical context and inspire them to appreciate their surroundings. Notably, a large number of students indicated interest in nature writing in the student survey.

In addition to the two humanities classes, we selected two physical science classes for which we developed outdoor education augmenting activities. We suggest that our two science-focused activities, Phenology and Geocaching (See Appendix C), be incorporated into the grade 10 “Essentials of Biology” course and the grade 9 “Conceptual Physical Science” course, respectively. As TA faculty mentioned, grades 9 and 10 are the optimal time to introduce outdoor education into curriculum because students will be encouraged to get excited about place-based learning *early* in their high school careers. These classes are taught by TA faculty (Gary Engler and John Connolly) who are interested in implementing place-based instruction into their classes. Gary and John were consulted in developing these activities and lesson plans. Both activities bring students into the forest on the Thetford Academy campus and include hands-on projects in response to student interest in this learning style. These activities also contribute to the overall goal of catalyzing a cultural shift towards place-based learning at TA. The Phenology lab is, in Gary’s words, a “unifying activity” that will provide continuity over the course of each school year, as well as continuity between generations of TA students as a phenology dataset is built over the years. Additionally, the Geocaching activity will expose students to a class activity that can also be pursued in the extracurricular outdoor program at TA proposed in the next section.

Although we were forced to limit the number of fully-developed activities to four classes because of time constraints, several additional ideas for outdoor education activities in other classes came up in conversation; we will name those activities here in the hope that they can spark future activities that TA faculty develop. In a math class, students could use basic principles of statistics to estimate, for example, the density and distribution of plant or animal populations in the forest surrounding TA. Quantitative biology assignments are a natural fit for using the surrounding environment in mathematics or biology classes. A history class could explore the old stone walls, fences, and building foundations found in the forest surrounding TA to discuss the land use history of the New England landscape. Design technology courses could visit the abandoned fireplace on the TA property and discuss the functionality of this fireplace, speculating why it was constructed the way it was constructed. The possibilities for using the outdoors at TA to enhance class materials are truly endless.

Extracurricular Club

Currently, TA does not have an established outdoor club. TA faculty have proposed this project as a way of promoting education beyond the classroom that is place-specific and teaching skills that are universally applicable. While the models examined by last year's group focused heavily on physical education, our approach seeks to be more interdisciplinary, connecting skills from the arts and sciences curricula of Thetford Academy with outdoor experiential education and a degree of physical education. Our program is based on an elective club format, with weekly and quarterly meetings and a culminating experience. Feedback from the TA students through surveys and a focus group session has directed our efforts in designing this program to be based in outdoor leadership and wilderness survival, with activities including fire making, fishing, forestry, and orienteering, mixed with environmental science, nature photography, and personal reflection. This program proposal (See Appendix D) is an in-depth, scalable program for implementation which will allow the students of Thetford Academy to benefit from outdoor pursuits to build life skills and foster further appreciation of the natural world while driving a high level of stakeholder engagement for years to come.

In order to garner participation, we worked with students during our focus group to better understand what would attract them to a club. Most students suggested that although an assembly announcement would be helpful, they most often forget what is said at assembly. Students also thought that advertising with posters is not effective; instead, they would prefer communication through social media, especially Facebook. Since the majority of the students interested in an outdoor club are involved in outdoor sports, finding a time for this club is crucial. We have decided that the best time for a club (with the current TA schedule) is after office hours on Wednesday and after school (with a 30 minute break) on Thursday. Students were very adamant about asking for a 30-minute break after school before starting a club. They also said that they could find transportation if they needed to in order to participate in the club activity after office hours. There is also a late activity bus at 3PM that students could catch if needed. We elected to examine the issue of club timing through the focus group. We believe an open format discussion presented the best opportunity for us to discern a solution because we had the help of the most interested

parties. The focus group allowed us to prioritize the scheduling concerns of the students most likely to participate in the program.

Based on the survey results, we found that the students who were the most interested were in 9th and 10th grade. After consulting with TA faculty, we decided that we should focus specifically on freshman and sophomore participation, since they will be with the club the longest. In order to make this club inclusive, we will be opening it to all of Thetford Academy. Opening this club to the whole school will allow students to become exposed to outdoor culture at an earlier age. The only potential challenge would be finding transportation for the middle school students.

The survey results also presented an array of possibilities for potential activities for the outdoor club. Students expressed interest in not only the physical education aspects of the proposed program, but also in skill development and in the humanities and academic aspects, with responses including nature photography, nature writing, nature painting, water quality testing, astronomy, geocaching/orienteering, and citizen science. These activities will happen on a weekly basis and will often be led or assisted by a community expert. These experts could be anyone from a student's parent, a business, or even a Dartmouth affiliate such as the Dartmouth Outing Club members. One resource that can be used to contact community experts is the Community Directory created by the ENVS 50 class. This directory includes descriptions and contacts of experts that the ENVS 50 students encountered in their projects as well as additional people who the class reached out to beyond the first branch of experts.

In order to ensure longevity in the club, there will be membership benefits. This includes benefits such as exclusive rights to the culminating experience and deciding what activities will happen each week. We will also implement an end goal that students will have to work towards. Like the Mountain School 'Solo' trip mentioned in our case study, students will have to attend all but one of the activities and club meetings in order to be eligible for the culminating experience. The culminating experience will allow students to be in a remote area of TA land and make use of the skills that they learned through the club activities. They will be required to pitch a tent, cook, journal, and take photos. They may also compete in the obstacle course or geocaching exercises. In our survey results as well as the focus group, students were extremely enthusiastic about an overnight camping trip.

They did not have a preference of where it took place as long as it happened. We are hoping that this enthusiasm will motivate students to attend meetings and activities in order to secure a spot on the overnight trip. See Appendix D for the full description of club activities.

We also considered the structure of the outdoor extracurricular club in our proposal. There will be a small core group of elected club members. This group will be in charge of reaching out to the school and developing goals (similar to those elaborated in our case study of Spartan Edge) and activities based on what students are learning. Anyone can be a part of this core group as long as they are committed to attending the promised number of club meetings and activities. Although students must participate in most club activities in order to take part in the culminating experience, all weekly activities will be open to the school. This is especially important for students who aren't able to consistently participate in clubs due to various reasons, such as transportation difficulties and participation in sports. In addition, the core group of students will organize two workshops open to the general student body over each 10-week period of the outdoor program. An example of the workshops could be a geocaching race or a scavenger hunt. This student-organized workshop is a method by which to get non-members involved in outdoor activities and expose those students to the outdoor club experience. For further description of the program model, see Appendix D.

4.6 Future Directions

Moving forward, we have a number of recommendations for implementing the curricular and extracurricular deliverables from this project. We also recognize some of the challenges and limitations of these recommendations and consider how these struggles could be addressed. Finally, in the spirit of collaboration, we name groups with which Thetford Academy might consider working with in the future to continue striving towards leadership in environmental education.

Although we have created the content for four activities, it is important to map out the next steps for implementation. Our initial activities have been created for teachers with expressed interest in adding outdoor components to their classes. Once the teachers have added our recommendations into the curriculum, their classes will serve as a beta test for

outdoor education. This beta test can be used to generate faculty buy-in and discussions around outdoor education at Thetford Academy (See Appendix F for literature that can be disseminated to faculty). With our survey results and the teachers' evidence of successful implementation, the teachers involved can work to gain further faculty support using word-of-mouth and faculty group presentations. The proposed activities are merely a seed for other outdoor education activities, and more faculty will need to partake in adding outdoor components into their classes in order to make TA's goal of creating more place-based education possible. Additionally, one of the important characteristics of our lesson plan/activity development was that we facilitated cross-disciplinary collaboration. The hope is that, as teachers begin to add new outdoor components to their classes, they will work together and collaborate on overlapping or complementary subjects and activities. These cross-disciplinary teams could meet to discuss ideas for using the outdoors in their classrooms and/or use a blogging system to share ideas, successes, and failures. Regardless of the method of collaboration, it is important a method of recording "institutional memory" is continued so place-based curriculum ideas specific to TA classrooms can continue. Moreover, cultural activities at the school are instrumental to building and sustaining engagement in outdoor education in the classroom and should be implemented in concert with a pedagogical strategic plan.

We recognize that there are some challenges and limitations to implementing outdoor education at Thetford Academy. First, there are logistical issues to consider in carrying out outdoor activities. The outdoors are a less controlled environment than an indoor classroom, and therefore safety precautions (such as implementing "buddy systems") must be planned. Additionally, ability diversity will need to be considered, especially for class activities that involve more strenuous endeavors such as hiking. Moreover, teachers already have great time demands and need to be supported to avoid creating additional strain on teachers at TA. We feel that centralizing ideas through the proposed blog for cross-discipline collaboration can ease the load on teachers, over time, by making it easy to access successful ideas other teachers have used to make the natural environment a part of students' learning experiences. Of course, there is also tension between having flexible curriculum that we saw in the case study schools and also satisfying state learning standards. However, if outdoor education is used to *enhance*

existing curriculum, we feel that this challenge will not be so difficult to overcome. And, considering evidence of place-based learning improving students' educational outcomes (Coyle 2010; Powers 2004), this initiative may even *improve* student performance at TA.

In the future, Thetford Academy might consider collaborating with local organizations, such as A Forest for Every Classroom (FFEC) to share ideas and target professional development to place-based education. FFEC is a Vermont-based professional development program sponsored by Shelburne Farms, Marsh-Billings-Rockefeller National Park, the National Wildlife Foundation, Conservation Study Institute, and the Green Mountain National Forest (NPS 2015). While it may not be feasible for all TA faculty to go through this program, the curriculum and ideas from this program could be shared through the previously recommended blog in which faculty can share ideas for implementing outdoor education in the many disciplines represented in TA courses. Moreover, an outdoor activity could be incorporated into the faculty development period before the beginning of fall term for the purpose of sharing ideas and fostering faculty engagement.

As for the outdoor program, the next course of action would be to have the interested students identified in the survey and focus group gather with a potential faculty lead to commence the recruitment strategies discussed during the focus group. One potential faculty lead is Chris Schmidt who we have been working with to develop the outdoor program. Additionally, the faculty lead and interested students should identify potential local experts who could be contacted to volunteer and lead expeditions, sharing their knowledge of the region. As mentioned early, the Community Directory will provide many different options of people who may be interested in volunteering or assisting club advisors. Additionally, funding options should be considered for the outdoor program as many activities may require extra equipment that TA may not have. This would include sleeping bags, shelter tarps, overnight packs, and potential cellphone apps (See Appendix E for a table summary of last year's findings on funding options). To further develop our outdoor program recommendation, TA should consider fostering relationships with outside organizations (as seen in the Cass Lake-Bena case study). For instance, the club could look to institutions such as Dartmouth College for mentors or the Thetford Elementary School for mentees. These relationships would further develop our multi-layer outdoor program by providing an opportunity to learn outdoor skills, interaction with

community experts through an outdoor club, and connect with the surrounding educational community through mentorship programs.

Chapter 5: Business Plan for Solar Project at TA

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Sheridan

5.1 Introduction

Thetford Academy has the opportunity to source its electricity from renewable energy by installing solar energy on its campus. Installing solar power would decrease electricity costs and reduce greenhouse gas emissions that contribute to climate change. It is an opportune time to install solar power as the price of solar panels and installation has fallen dramatically over the past several years. Solar power at TA could also be used as an educational resource for classes reinforcing Thetford Academy's image as an environmental leader. TA has ample space with optimal conditions to install a large solar array. The ten acres of the Barrett Property would provide more than enough solar capacity to meet TA's electricity needs.

Many schools in Vermont have been installing solar power on their campuses. In fact, Thetford Elementary School (TES) provides a local example of the benefits of installing solar power. Since installing solar power, TES has saved over \$10,000 annually in electricity costs and now gets 75% of its electricity load from solar. These savings will accumulate annually throughout the 30-year life of the solar panels. In addition to saving money, TES has been very proactive in incorporating the solar array as part of its educational curriculum. TES provides a model for TA to follow, but there are some aspects that TA will not be able to replicate in regards to the financing model.

There are several potential models for installing solar power that TA could adopt. These include a power purchase agreement (PPA), outright ownership of the solar panels, and group net metering. Each model has different strengths and weaknesses in regards to financial savings, simplicity of financing the project, and workload involved in setting up the model. A PPA would be the easiest option to implement with no upfront costs and all responsibility including maintenance and legal issues taken by the outside investor, but it would have smaller savings. Outright ownership would provide greater savings over the long term, but financing the project would involve finding a grant and debt financing. TES chose the outright ownership model, but this involved substantial work to find a grant and to get a local bond passed to provide the financing. Group net metering could involve expanding the current array at TES or working with individuals in the Thetford community

to establish a site for a solar array in town. In order to have a full set of choices, TA should make a decision soon because in 2016 the federal solar investment tax credit will be reduced from 30 percent to 10 percent, which will affect the viability of the PPA model.

Our goal for this report is to present various options with clear information about the strengths and weaknesses, which will allow TA to determine the option that is the best fit. The best option for TA will depend on its priorities, whether it is simplicity of work in setting up the project or achieving the greatest financial savings. We have provided detailed financial information about potential financial savings and specifics about selecting a location for the solar array. Regardless of the option, TA should move forward with the installation of solar power. Any option will reduce TA's current electricity costs and will have very low risk, while providing the benefits of improving TA's environmental footprint and enhancing educational opportunities.

5.2 Methods

In researching this project, we have conducted meetings with TA school officials and trustee members and several local solar experts. Solar energy experts that we consulted included Bob Walker, Executive Director and Board President of the Sustainable Energy Resource Group (SERG); Erin Sterner, leader of the TES solar project and SERG education and outreach assistant; Troy McBride of Norwich Technologies; and Kevin Jones, Deputy Director, Institute for Energy and the Environment, Professor of Energy Technology and Policy of Vermont Law School. From TA, we have worked closely with Head of school, Bill Bugg, and Dean of Academics, Marc Chabot. In order to learn about the TA's expenditures on electricity use, we met with Linda Lanteigne Magoon, Director of Finance at TA. We presented the preliminary findings of our report to TA trustee members and Bruce Hyde, Director of Buildings and Grounds. Additionally we closely studied the TES solar project and built our financial model off of the TES project's financial details. Norwich Technologies assisted with setting up our financial model. Our financial model makes estimates for the savings TA would achieve for the different ownership options over the 25-year life of the solar project.

5.3 Ownership Options and Financial Outlook

Several different financing options and ownership structures are available when considering installing solar power. The largest distinction is between a power purchasing agreement (PPA) and direct ownership of the panels; other options such as group net metering can incorporate either of these components.

A. Power Purchasing Agreement (PPA)

A PPA is an arrangement between the power using entity, in this case Thetford Academy, and an outside investor (sometimes called the tax equity investor), in which the outside investor agrees to pay for the purchase, installation, and maintenance of an array on the power user's property. The outside investor is the owner of this array, and the power user has the option to purchase power, usually at a preferential rate, from them for an agreed-upon period of time. If the array covers the entirety of power user's existing electric bill, then the power user will no longer have to pay the utility company for power, as the solar array will offset the utility bill through net metering. Instead, the power user will shift their energy payments from the utility to the outside investor at a reduced rate.

A PPA is advantageous to the investor because they are able to take advantage of the 30 percent federal solar investment tax credit, which a user such as Thetford Academy is unable to use because it is a nonprofit and does not pay income taxes. With the help of this tax credit, the investor is able to offer the user an advantageous rate on electricity and still receive a return on their investment.

There are also several benefits of a PPA to the user. For one, the investor will pay for the purchase, installation, maintenance, and insurance of the panels, with no initial investment of funds by the user. Secondly, the user can contract with the investor to receive electricity at reduced prices (typically 5-10 percent lower than their existing annual electric bill) for an agreed upon period of time. Third, the user typically has the option of purchasing the panels outright after an agreed-upon period of time.

However, there are a couple drawbacks of the PPA model. To start, the savings for such an arrangement are often lower than direct ownership by 5 to 10 percent. In addition, with multiple parties involved (the user, the investor, and the solar developer, who may assist in negotiating the deal), there may be significant transaction costs involved in finding

a willing investor and negotiating a contract between the parties. This may be costly both in terms of time and money.

Overall, a PPA is considered an attractive option for someone who wants to gain the benefits of solar in the form of reduced power but does not currently have the funds to invest in an array themselves (Troy McBride, personal communication, May 6, 2015).

1. The Issue of RECs

Renewable energy credits, or RECs, are tradable commodities that represent the environmental benefits generated by solar electricity (U.S. EPA 2008). They are issued every six months to the owners of solar arrays and may be traded or retired by the owners at that time. If RECs are retired, they allow the owner to claim the environmental benefits of the energy that they are generating, which may be useful for marketing or public relations purposes. Otherwise, if they are sold to a third party, the third party may claim the environmental benefits of the renewable energy generated, while the owner of the array will not receive credit for the environmental benefits. For example, if the RECs are sold the owners of the array may be prohibited from claiming that they are 'solar powered' or are 'powered by green energy', as that benefit has been sold to another party (U.S. EPA 2008).

Under a PPA, some investors may offer increased savings for the users on power in exchange for ownership of the RECs. On the other hand, other arrangements can give the RECs to the user, allowing them to either sell the RECs themselves or retire them and take credit for the environmental benefits of renewable energy generated on their property. The prices of RECs may be highly volatile, and may not play a large role in negotiating savings under a PPA, depending on the interests of the investor (Kevin Jones, personal communication, May 8, 2015).

B. Direct Ownership

Direct ownership of a solar array allows the owner to capture all of the energy savings produced by the array, unlike a PPA in which the benefits are divided between the investor and the user. However, direct ownership also requires a significant outlay of funds upfront, which must be financed through loans or grants as available. Thetford Elementary

School chose the option of direct ownership of their array after receiving a grant for \$125,000 from the Vermont Clean Energy Development Fund, covering approximately 30 percent of their costs. The remaining 70 percent was financed through a municipal bond (20 years at 3.5 percent interest), approved by the residents of Thetford by a vote. TES' annual savings on the array are reported to be between twenty and thirty percent of their previous electric bill, allowing for insurance on the array and maintenance of the panels, with savings left over.

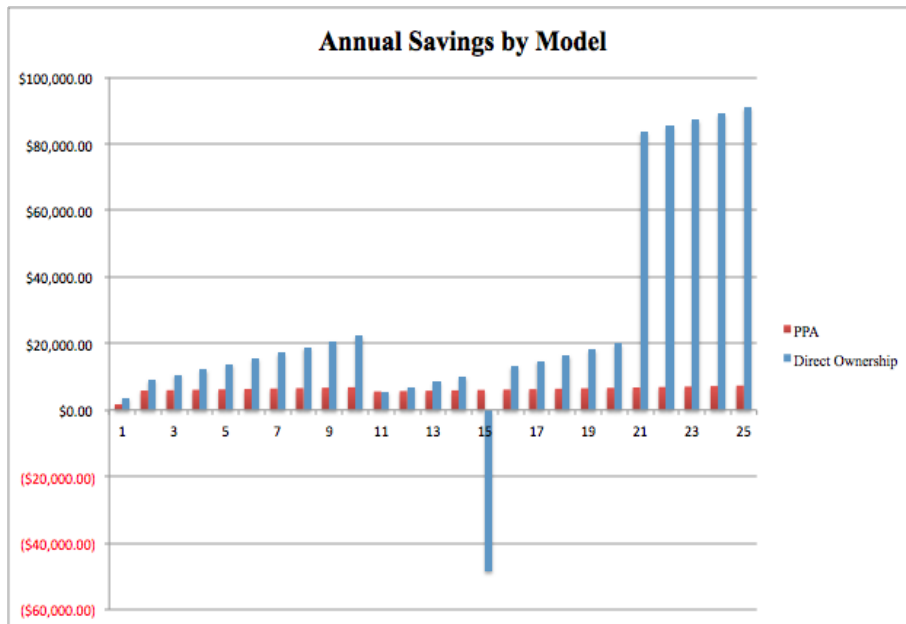
However, financing options for Thetford Academy may be significantly different from those available to TES. Grant money from the Vermont Clean Energy Development Fund is no longer available for 2015, leaving the possibility of financing the array entirely through debt. TA's electricity needs also necessitate a significantly larger array than TES, with an estimated cost of a solar array at \$880,000. Below is a detailed breakdown of TA's financial outlook under direct ownership and a power purchasing agreement. These figures were calculated with the help of TES and Norwich Technologies, who allowed us to use the financial model developed for TES. We altered the model to accommodate TA's larger electricity needs, but kept their loan terms the same (Troy McBride, personal communication, May 6, 2015).

Table 1. *Financial Outlook under PPA and Direct Ownership*

Model	No Solar	PPA	Direct Ownership
Annual Electricity Bill	\$76,000 (2014)	~\$70,000 (assuming 7.5% discount)	0
Required Investment	0	0	Est. \$880,000 for 320 kW DC array
Loan Terms	n/a	n/a	20 years at 3.5%

Annual Payments	0	0	\$68,718
Projected Net Annual Savings	0	~\$6,000 on average over 20 years	Variable; ~10,500 on average per year for first 20 years; increases significantly after loan is paid off
25-year projected net cumulative savings	0	\$154,866	\$645,871

Figure 1. *Net Annual Savings by Model*



Several assumptions went into the development of this model. First, we assumed that TA would get the same bond terms as TES, 20 years at 3.5%, and no grant. The exact terms that TA would get are dependent on whether they chose to campaign for a municipal bond or seek private financing. Second, we assumed that electricity prices would increase by 2.5 percent annually, leading to a steady increase in the solar value of TA's array

(equivalent to the electricity bill that they would be averting). Initial electricity prices are assumed to be 14.7 cents/kWH, the current rate with Green Mountain Power (Troy McBride, personal communication, 2015). This is why savings rise over time for both TA and TES. We also assumed an array generation decline of 0.5% per year, consistent with Norwich Technology's estimates.

In year 1, we include one-time \$4,000 legal costs for the price of negotiating a deal on solar for both a PPA and direct ownership. In year 10, the 4.3 cent/kWH solar adder is removed from electricity prices, leading to a decline in the solar value of the array and a drop in savings respectively. This is because Green Mountain Power removes the solar adder after ten years. The solar adder is a financial incentive that provides a credit for each kWh of solar power generated. We assume total annual maintenance and insurance costs of \$6,800 per year, building off of TES' estimate of \$15 per kWh array plus \$2,000 per year in insurance. At year 15, the inverters must be replaced, which we estimated at approximately \$60,000 increasing from TES' estimated cost of \$40,000. This cost comes into play only under direct ownership and is the only time that net annual cash flow is negative (Figure 1).

Over the first 20 years, average net annual savings under both models are modest, approaching \$6,000 per year for a PPA and \$10,500 per year for direct ownership. However, after year 20 under direct ownership, the bond is paid off and savings skyrocket, averaging \$87,000 per year. Net cumulative savings under a PPA are estimated at \$154,866; net cumulative savings under direct ownership are approximately \$645,871, with a significant portion of the savings for direct ownership coming after year 25.

Overall, while direct ownership allows for increased savings as compared with a PPA, especially in the long-term after all debt has been paid off, it creates its own issues in terms of acquiring financing. A detailed exploration of available grant opportunities is highly recommended if this option is pursued. Table 2 provides further comparison of the PPA and direct ownership options.

Table 2. *Matrix of ownership options*

Model	Pros	Cons	Timeline
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Power Purchase Agreement (PPA)	No debt financing, financier takes care of project, very little work involved for TA	Smaller financial savings	Needs to be constructed by end of 2016 before federal solar tax credit expires
Outright Ownership	Greater financial savings	Finding a grant to make financially viable, debt financing, potentially needing to pass a bond	No deadline

C. Group Net Metering

Group net metering refers to an arrangement in which multiple users draw power from an array of panels, which may cover some or all of their electricity costs. In the case of TA, it can be implemented either with a PPA or with direct ownership, and could involve TES or other members of the town.

One example of group net metering could involve the expansion of TES’ existing array to meet the power needs of TA, who would group net meter with them. TES could choose to finance this expansion and have TA pay them for power, or TA could finance the expansion through a PPA or direct ownership. If direct ownership was chosen, TA would likely need to pay TES a fee to have their panels on TES property, although this arrangement could be worked out between the two parties. This could be a viable option if TA decides that its existing property is not suitable for a solar array and would prefer to house them offsite.

A second example of group net metering could take place on TA property and involve members of the Thetford community. TA and members of the community might decide to jointly sign up for a PPA on TA property and install an array up to 500 kW in size,

enough to meet TA's needs and those of the other participants. This "bundled" PPA might be beneficial to parties with smaller electricity loads who might be less able to attract investors to do individual PPAs. Because there is no upfront cost in a PPA, multiple groups in the community could benefit from an array on TA's land, perhaps with compensation to TA for land use. Alternatively, TA could look at direct ownership options in conjunction with other parties, possibly allowing TA to generate revenue through electricity payments from these parties (Bob Walker, personal communication, May 1, 2015).

These arrangements would need to be explored in more detail with the interested parties. Bob Walker of SERG was a highly useful source of information on the possibilities of group net metering arrangements, and would be a useful resource in this area.

5.4 Funding Options

Owning a solar array generally yields the largest return on investment over time, and there are a variety of funding methods for solar energy projects. Because TA is not eligible to recoup the federal investment tax credit for solar energy, a grant would be necessary to make outright ownership more financially viable. TES was able to secure a \$125,000 grant from the Vermont Clean Energy Development Fund as a result of having a clear and well defined plan and models for their project which they were able to submit with their application (Doyle-Burr 2014). Unfortunately, the Vermont Clean Energy Development Fund has since committed its reserves to the funding of previously applied projects, and does not have the capital available to fund new projects. As indicated in an interview on May 8, 2015 with Kevin Jones, a PhD professor at the Institute for Energy and the Environment in the Vermont Law School, funding programs such as the Vermont Clean Energy Development Fund are being phased out as solar costs have consistently dropped. This fund may be available to supply a grant at a later date, but as of now is not entirely predictable. There are minimal other grant options available for such projects throughout Vermont, though one we have reached out to in order to determine Thetford Academy's eligibility is the High Energy Costs Grant for Rural Development through the Department of Agriculture (USDA 2015).

Assuming that any grant received would not cover the entire cost of the project, which if completed at 300kw would be in the range of \$900,000, the remaining portion of the project would need to be debt-financed. TES was able to secure a bond from the local community, which they are in a contract to pay back over the course of 20 years, and TA could attempt something similar. Alternatively, there are numerous banks and credit unions throughout the northeast that are willing to supply low interest rate loans for solar energy projects specifically due to their low risk and reliability in production. As seen in the models for the TES solar array, the energy savings more than cover both the repayment of the bond and all management and upkeep costs of the array throughout its entire course of production.

Site Options

Due in part to our research conducted and recommendations from Bill Bugg, Marc Chabot and the TA Buildings and Grounds Committee, our group was able to identify four potential sites for the Thetford Academy solar project.

Top of the gym:

TA Project leaders Bill Bugg and Marc Chabot identified the roof of the gymnasium as a possible location for the placement of the solar panels.

Pros:

One of the factors that made the roof of the gym an attractive location was the close proximity to campus. Having the panels on campus would allow students to be aware of the project, which could open up educational opportunities for students and having the panels on the roof of the gym would visibly market sustainability for TA. Visitors to the TA campus would see the renewable energy that TA was using.

Cons:

There are major drawbacks to the gym roof location. There would be a significant amount of inspection and testing needed to clear the roof for the weight that the solar array would carry. Another problem identified with the rooftop solar project is that the entire solar

array would not be able to fit on top of the roof. An additional site would be needed to generate enough power to meet all of TA's electricity needs.

Barrett Property:

The Barrett Property was another location that TA project leaders Bill Bugg and Marc Chabot identified as a good location for the solar project.

Pros:

Over 10 acres in size, the Barrett property is a southward facing, southward sloping, open field that is currently unused by TA. We identified the Barrett property as the most viable option for a solar project on TA property based upon the fact that the south facing and south sloping hill is ideal for solar generation. These conditions are attractive because they maximize the total sunlight that hits the panels. The total space offered by there Barrett property is also ideal for a solar array because it could contain a total of 750 kW, which although this is larger than the total electricity demand of the academy by nearly 400 kW it demonstrates the large amount of space that is available (Troy McBride, personal communication, May 6, 2015).

Cons:

One of the concerns about the Barrett property is that there are plans for constructing a track and soccer stadium in the future. If the array were to be built on the property there need to be certainty that the soccer field and track would still be able to fit on the same land.

Addition to TES:

The third possible location for the TA solar project would be to add onto the Thetford Elementary School solar array on the TES property.

Pros:

This location would make sense for TA because they would already be able to add onto the existing TES solar infrastructure and it is already a proven location for solar generation.

Cons:

A significant drawback is that this location would not have enough space to fit the entire 350 kw of solar panels that TA would require to meet its full electricity demand. This means TA could only achieve a partial solar development on this land that would not meet all of its electricity needs. If TA were to build their solar array on TES land there would also be the expectation that TES would charge TA to lease the land which would detract from the overall savings that TA would hope to gain from a solar project. This factor makes the TES addition less attractive than the Barrett property project.

Town net metering location:

This is the fourth possible option for a TA solar project site. If TA were to partner with group members within the town there is a possibility that they could establish a location where TA and the rest of the town could net meter a project. There is also a possibility a net-metered project could be a combination of the previously mentioned sites.

5.5 Thetford Elementary School Case Study

In 2014, Thetford Elementary School built a solar array on school property. The project was financed by a Thetford Town bond and a grant from the Vermont Clean Energy Development Fund.

Table 3. *TES solar project* (Erin Sterner, personal communication, April 29, 2015)

Educational Institute	Thetford Elementary School
Institute Type	Public
Ownership Structure	Directly Owned
Contract Length	N/A

Size of Solar Project	~120 kW, ground installation on school property
Initial Cost	\$470,000
Estimated Savings	\$350,000 over 25 years
Developers	Norwich Technologies
Installer	Norwich Technologies
Funding Sources	Thetford Town issued \$345,000 20 year bond @ 3.5%, \$125,000 grant from Vermont Clean Energy Development Fund
Notes	On school property

5.6 Preview of Potential Regulatory Issues

Deploying a 300 kw solar array is both a considerable investment, depending on the details of financing and ownership, as well as a notable construction project. There are regulatory hurdles that will need to be addressed in order to make solar energy a reality at Thetford Academy. In terms of the construction of the project, the primary concern is the stipulations within Act 250 of the State of Vermont Natural Resources Board pursuant to District Commons. The majority of the stipulations do not present an issue, as a solar array presents minimal to nonexistent problems of pollution, water use, congestion of main roads or being an unreasonable burden for a school or government municipality. However, when undertaking the construction of any project, it is important to consider any hydrological effects on the ground in use, and mandated that it not have “any undue adverse effects on aesthetics” or “imperil any necessary wildlife habitat” (VNRB 2014).

Given that the likely land in question is the Barrett Property, a fairly isolated piece of land owned by TA, it is unlikely to present any objections concerning aesthetics. Furthermore, this property is not home to any unique habitats or endangered wildlife, and should not present any problems on that front. Alternatively, if the land across the street from the school to the east is an option, considerations of construction within the historical district come into play. While not south-facing, this unutilized property could host an array of comparable size, though would likely require more land to do so. The necessary spacing between rows of panels would increase, and the efficiency of energy generation by the panels would drop as a result of the lack of a south facing slope. If this were the case, the panels would likely infringe on land relatively close to the backyards of homeowners in the area, and would be subject to new construction stipulations of the historical district of Thetford. Any aesthetic concerns in particular could be a major hindrance to viability of a project at that site.

In addition to Act 250, there are a number to permitting and certification processes that Thetford would need to undertake. While most of the details would be worked out with the solar provider, it is critical to be aware of the timelines involved. Norwich Technology made clear that regardless of the type of ownership or financing involved, a project the size that would make sense for Thetford Academy requires a six month period to have the property in question properly evaluated and permitted before the project can begin. Thetford Academy would also have to apply for a Certificate of Public Good through the Vermont Public Service Board as a result of the Vermont Sustainably Priced Energy Development Program (SPEED) (SPEED n.d.). It is particularly important to note that the regulatory concerns encountered will be dependent on the ownership structure of the array. If Thetford decides to purchase the array outright and maintain ownership it will bear the regulatory and maintenance responsibilities for the array. Alternatively, if Thetford engages in a PPA with an outside developer, the solar developer will be responsible for compliance with regulatory concerns and the upkeep of the array (Troy McBride, personal communication, May 6, 2015).

5.7 Educational Opportunities

With the adoption of a solar array on TA property there is great potential for teachers to include the solar array in their lesson plans. Erin Sterner, a key leader of the TES solar project, has given us key insights into the types of educational programs that have succeeded at TES and additional programs that could be expanded at TA. Erin believes that the types of projects existing at TES would be able to be implemented at TA and there could be higher level lesson plans for middle school and high school students (Erin Sterner, personal communication, April 29, 2015).

Educational program for teachers:

As exemplified by TES, having a solar array on school property can be used as a learning experience on the most basic levels ranging from learning about watts and volts to more complex levels such as conducting physics problems that have to do with the angle of the sun for maximum solar output. Regardless of the grade level, TA could develop a curriculum in science, math, computer science, or engineering to utilize the solar array in classes.

Personal energy audits:

Energy audits are another educational opportunity created by the installation of solar panels at TA. With the electricity generated by the solar installation at TA, students could conduct an electricity audit of the school to reveal how many tons of carbon are being saved with the solar array. This could be the inspiration for teachers to incorporate an energy audit into their class curriculums and have the kids create an energy audit of their own homes. It could also be used for TA to market their switch to renewable energy, withstanding the RECs are retired and not sold on the market. Professor Andy Friedland has lead similar projects in his ENVS 2 and ENVS 12 class so he could possibly be consulted to help guide this project. Current and future ENVS students at Dartmouth could help oversee the project.

Consultation from the VEEP program:

An option that TA might benefit from following would be to meet with the Vermont Energy Education Program (VEEP) academic consultants to try and add energy-based learning into their curriculums. VEEP works hands-on with students and teachers to allow them to have the resources necessary to create their own brand of energy-based learning that facilitates energy literacy into their curriculums (VEEP, n.d). To do this VEEP implements a three-pronged plan that involves training, materials and follow-up support to make these energy based curriculums to become successful. Working with VEEP could be a good way for TA teachers to learn how to implement the solar array into their curriculums and to make the most out of the opportunities that the solar panels present the school

Brief overview of TES solar education component:

Thetford Elementary has embraced the idea of using their solar panels as an educational aspect and has integrated the solar array into the curricula at TES. With the assistance of Norwich Technologies, TES has installed a solar panel equipped with a digital monitor so that the students can observe the amount of energy generated on the array at any given time. They have used this information in many classes in order to teach the students basic energy facts. Our hope is that a similar solar addition could be made on the TA campus in more dynamic ways that could expand learning in areas of physics, environmental studies and math.

5.8 Assessing Possible Developers

Site and cost estimates:

Generally, once a solar company is approached about a potential project, they provide information on site and cost estimates. This can be done in the exploratory phase without any sort of business commitment from Thetford Academy. This can be achieved by submitting an RFI, or "Request for Information." If negotiations are finalized, the solar company takes care of most work including permitting and Act 250 regulations. If the array is less than 150 kilowatts, then permitting can be done quickly and the array can be connected to 1-phase power. If the array is up to 500 kilowatts, permitting will take 4-6

months and the array will typically require 3-phase power (Bob Walker, personal communication, May 1, 2015).

Types of Panels:

There are three major solar panel designs on the market. Based on the materials used and cost of production, some panels are more expensive and some are more efficient.

Monocrystalline Silicon (Single Silicon)

These are the most efficient types of solar panels, but their high silicon content makes them expensive. This design is ideal for roofs since you need fewer panels to generate desired amount of electricity.

Polycrystalline Silicon (Multi-silicon)

These panels have lower silicon levels and are less efficient than single silicon panels. The upside is that they are less expensive. However, their placement can make up for their lack of efficiency and they still work well on roofs.

Building Integrated Photovoltaics (BIPV)

These are expensive but look like roofing tiles so they have aesthetic benefits. However, they are significantly less efficient than regular PV. You need a very sunny site and they do not last as long as regular panels. Ultimately, they are not recommended (Pure Energies).

Additionally, there are two main installation styles for solar panels: tracking (rotating) and stationary.

Tracking Solar Panels

Tracking solar panels can improve efficiency of a solar array by rotating to face the sun and maximizing sun exposure. However, these systems are more expensive and require more land since the panels must be spaced apart further. Generally, 4-7 acres per kilowatt is required. Rotating panels are only worth the additional cost if the increased energy production (from increased sun exposure) exceeds the extra cost of the tracking system

throughout the life of the solar array. This includes maintenance costs for the tracking system.

Stationary Solar Panels

Stationary panels can be adjusted seasonally. They require less land than rotating panels, generally 4-5 acres per kilowatt. Roof mounted panels generally can't be adjusted since they are difficult to access (Pure Energies).

5.9 Discussion and Next Steps

Solar power would provide financial savings and reduce TA's environmental impact. We recommend that regardless of the ownership model, TA should move forward with solar installation. Financial savings are guaranteed with very little risk. In evaluating which ownership model to select, TA will need to determine which model best matches their available resources. If there are people in the TA community who are willing to take the time to find grants and coordinate the debt financing, outright ownership is the best option since it brings the greatest financial savings. Finding a grant and coordinating the debt financing will likely require a significant amount of time and effort, as it did with the TES project. If TA lacks the capacity to organize the project, the PPA would be the best option since the outside investor takes responsibility for the project. TA will also need to determine whether it is comfortable taking on more debt. The outright ownership model would require a major upfront investment whereas the PPA would involve no upfront costs.

Any solar ownership model would save money compared to the status quo of having no solar power. Our model estimates that outright ownership would result in savings of \$748,553 during the 25-year life of the project while the PPA model would lead to \$192,280 in savings. These savings include any costs associated with the project. A decision needs to be made soon due to the reduction of the federal solar investment tax credit at the end of 2016, which will affect the viability of the PPA model. If TA decides on an ownership model besides the PPA, there is no pressing deadline since other ownership models will not involve the federal solar investment tax credit. Once TA selects an ownership option, it can

begin the RFI process with local solar developers. Various bids will be presented and TA can then select a developer for the project. We strongly encourage TA to move forward with installing solar power.

Chapter 6: Trail Design and Collective Cartography

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6.1 Introduction

As stated on their website, Thetford Academy (TA)'s theme for the 2014-15 school year is to "leave the beaten track occasionally and dive into the woods" (Thetford Academy). In order to do that, their goal was to make better use of their own property behind the campus and determine the best possible route for students to get to the Ompompanoosuc River and the Academy's lower property. Beyond increasing student visits to the river, TA wanted to increase student interaction through already existing educational opportunities in the school's backyard. Our group was tasked to help TA determine what the best possible route to the river would be— either using existing trails or building an addition to a trail through TA and another landowner's property. In this process, we evaluated existing trails and identified potential sites for educational opportunities to support the enhancement of an outdoor education curriculum. Due to difficulties in obtaining landowner agreements for a newly constructed trail, this project focused more on mapping the existing trails and their pedagogical potential.

The existing trails and potential educational sites were plotted onto a map for TA and Thetford community's use. This map would serve as a piece of "collective cartography" (Caquard 2014) in which students, teachers, and community members can add their own observations and findings to the map. This map would support TA's goal of having students interact more with the outdoors since they would be able to interact with the woods both on and off-site, physically as well as virtually. On top of building this map, we evaluated project financing options and provided trail design and construction guidelines and timelines, inspired by a case study on Rivendell Academy's Cross-Rivendell Trails Project; we recommended a trail crew model; and we created a marketing video.

Collective cartography is the cartography of "collective knowledge, made of geographic layers, personal information and collective stories [that] contributes to the reshaping of places and communities" (Caquard 2014:142). Collective cartography was initially mostly restricted to "community mapping", done by indigenous communities as an egalitarian response to conventional, elitist cartography that sought to enable communities to represent themselves and stake claims to resources (Parker 2006). With the rise of social media, "collaborative mapping" takes more precedence. Through collaborative mapping, citizens crowdsourced geospatial data through their mobile devices thanks to

user-generated mapping technologies, decreased costs in data storage and the development of infrastructures, such as communication networks and data centers (Caquard 2014). With this geospatial data, we can map (1) how ideas and information propagate in a society, which can then be used to “identify appropriate strategies for information dissemination during a crisis situation”; (2) “people’s opinions and reactions on specific topics and current events, thus improving our ability to collect precise cultural, political, economic and health data, and to do so at near real-time rates”; and (3) emerging socio-cultural hotspots (Stefanidis et al. 2013).

While collaborative mapping shows great promise to get a more nuanced view of certain spaces and how they are used, it also presents several challenges, such as data validation and the exclusion of individuals without appropriate mapping technologies. Users sometimes cannot differentiate the origins and the quality of data (e.g. authoritative or not, reliable or not) (Caquard 2014), since anyone who has the appropriate technology can willingly demerit the product. Moreover, collaborative mapping is not only about collecting geospatial data from the crowd (i.e. ‘crowdsourcing’), but also about returning this information to the crowd (i.e. ‘crowdfeeding’) (Caquard 2014). However, this data is mostly collected by private companies, like Google, and individuals who have access to these technologies. Often times, these individuals are more technologically savvy than the average person, so the information that is fed back is not necessarily representative of the entire crowd. Young and Gilmore (2013) also warn against overlooking the affective/emotional effects of crowd-sourced mapping. They argue that the process of mapping is powerful-- and not just the map itself-- because it "forces communities to come together and think about how they share the spaces in which they live" (Young and Gilmore 2013). They caution that many highly beneficial emotional effects may be lost, since the collaborative mapping process has transitioned into a more individualized process in which people contribute to maps through their mobile devices rather than through a community-gathering process.

These concerns and benefits apply to TA in different ways. Younger students, who are not allowed to have a cell phone yet, or students who cannot afford smartphone devices may be excluded from the collaborative process. Older community members, who have not had as much exposure to technology as younger generations, may also not be able to

contribute their knowledge into an online platform. Therefore, a community gathering, as recommended by Young and Gilmore, should be organized, in order to make sure everyone is included in the process. This community gathering would also address the issue of data validation since it would provide a venue for participants to revise inputted points together. Young and Gilmore also provide certain recommendations to make sure the collaborative mapping process produces positive affective/emotional effects. Ultimately, the goal is to create a map that people are excited to use, and eliciting positive emotional effects is a way to ensure that (Young and Gilmore 2013). Young and Gilmore (2013) recommend adding qualitative data, such as video and photographs, to maps because it affects viewers both on a visceral and intellectual level, it allows participants to take pride in their creativity, and it "encodes participants' performance in an authoritative technology that can be shared with government actors". We have already added some photographs, provided by Chris Schmidt, onto TA's map, and have developed a marketing video that will ideally make students, TA faculty and community members excited about the project. While the map's main purpose is to support TA's outdoor education curriculum, it will strengthen Thetford's community under the value of taking advantage of the outdoors. This collaborative map will also shed light on exactly how the community likes to use its spaces, how ideas are spread in this area, and its different socio-cultural hotspots, which could then inform future development and community-building projects. The map and videos could also lend Thetford a stronger voice when engaging with government actors. Moreover, this map will also be helpful for TA in speaking with the private landowner since they will be able to show them where their trails run across Academy land, and how little impact there would be on the private landowner's land.

6.2 Content of Existing Trails

A network of trails already exists in the forest behind TA. The general topography of most of these existing trails consists of a sizable ridge with steep ascents and descents on either side. This ridge climbs at least 100 ft and then drops down on the Ompompanoosuc River Valley. The ridge is located about halfway between TA and the river, so it cannot be

avoided. The trail cannot go straight up or down this ridge due to the steepness, so switchbacks would be necessary on any trail built along the ridge. There is also a small stream and some wetland areas that need to be taken into account in order to avoid damaging wetlands and to ensure that the trail is dry for as much of the year as possible. There is a large section of designated deer yard that we cannot cut through. We traversed these trails with Heinz Trebitz, a local expert on these woods who uses them often, as well as with Chris Schmidt and John Connolly, our faculty member partners at TA, and Seth Whitaker, a senior student from TA. We consulted David Lindahl, a TA board member and former Nordic Olympian who used to work for Morton Trails and helped design the existing Nordic trails behind TA. These trails seem to be well-used by community members and TA's sports teams; however, there is much more opportunity for the average TA student to spend more time learning in these woods after identifying areas of interest and an unforeseen access to the river.

The Woods Trail is cross-country trail of very high quality, designed by John Morton (or Morton Trails) and built by Dan Grossman in 1991. He designed the trail in a way that would use pre-existing ski trails from logging operations in order to have minimal impact on the natural environment. The trail cuts across TA and State Forest land. It is considered one of the finest cross-country trails in New England. It is 12 feet wide and 5km long, and is marked by black arrows on yellow diamonds. There is an upper loop that goes by the sports fields, then a lower loop with Ranger's Cabin in between them.

While the Woods Trail is world-renowned for cross-country skiing, it does not meet all of our partner's needs. It does not take a direct path to the river; rather, it is more of a meandering loop. It also may be too strenuous because the trail is designed to be challenging for cross-country skiers and runners, whereas TA is looking for a moderate foot-path to the river. The average person should be able to walk the path easily, but parts of the Woods Trail have some steep uphill. Another issue is that this cross-country trail is well used by cross-country running and skiing teams, so there might be scheduling conflicts if TA were to use a large portion of it for its educational foot path. Moreover, it could be dangerous, if students walk the trail unannounced and run into skiers.

That being said, the Woods Trail is in great quality, so we could definitely use some portions of it in order to minimize impact on the land. The beginning of the Upper Loop

could be useful since it is close to TA and its fields. The lower campground area could also be a good place to start and connect with several other trails.

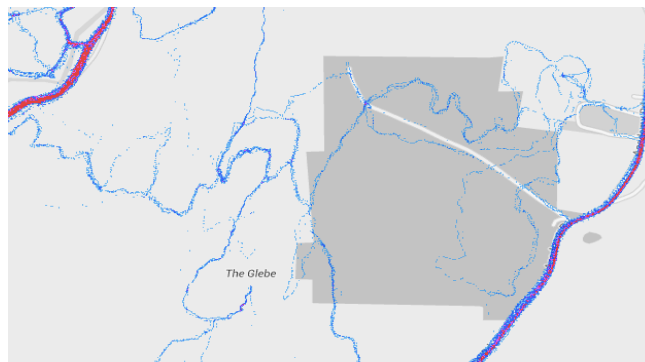
Another trail behind TA is Mimi's trail, also designed by John Morton, in honor of his wife Mimi Morton. It is a wide, well-groomed trail that passes the field, enters a pine grove, and then winds gently uphill. It is 2.6 miles long with several steeper switchbacks, and it reaches a viewpoint at the summit of Houghton Hill. Construction started in 1998 and took several years to complete due to the fact that the trail needed permission from ten landowners to go through their land. TA is facing a similar situation with a private landowner whose land is in between both of TA's properties.

The park around TA used to be a public campground. A smaller campground remains south of the lower loop. There is a wider snowmobile trail that could be utilized, but ideally the new trail would be for foot traffic only. The snowmobiling trail is active in the winter, while our trail is meant to be an all-seasons-use trail, so there may be potential conflicts. The existing snowmobile trail generally parallels the proposed route from the Academy to the river.

There is also a trail that cuts through TA land by the river, however this trail has some shortcomings in that it goes straight up the hill in a very steep A-to-B path that would be hard for an unfit person to traverse comfortably. There are also many wet points and stream crossings, which would have to be avoided.

To identify which trails are most heavily used, we can refer to this Strava Labs heat map, showing GPS data points entered by people walking and biking the trails behind TA. If the line is darker, it means more people have passed through.

Figure 1. *Strava Labs Heat Map of Trails near Thetford Academy*



6.3 Case Study: Cross-Rivendell Trails Project

The Cross-Rivendell Trail (CRT) in VT/NH provides an excellent model for a trails project at TA, and we will apply several practices and lessons from Rivendell to Thetford Academy. The CRT is a 36-mile continuous footpath connecting four towns in Vermont and New Hampshire, acting as a physical connection between the Rivendell Interstate School District (RISD). Today, the CRT is one of the most popular hiking trails in the Upper Valley, and it is used for both recreational and educational purposes. Some recreational activities include: trails runs, interpretative walks and special events. Some educational components include: educational signs as well as an online educational website that allows users to learn about the local ecology, historical spots, and more.

Sally Tomlinson first proposed the idea behind the CRT at a CO-SEED conference in 1998. CO-SEED (Community-Based School Environmental Education) is a 3-year collaboration with certain schools and communities to work together to develop place-based learning. In 2001, Tomlinson's idea would begin to materialize following a CO-SEED program sponsored by Antioch University of New England, in which, CO-SEED funded student and teacher projects and the Community School Organization (CSO) engaged in project research and consulting.

At each school, following the impetus from the CSO and the CO-SEED program, eco-teams formed consisting of interested students who volunteer outside of class. Some methods of getting students interested in joining the eco-teams included: active engagement in decision-making and planning, field trips to trails and outdoor classes, and teacher/faculty recruitment. Their main responsibility concerns monitoring the program and being trail guides. The teams were also responsible for planning weekend day hikes. Out of this, the Rivendell Trail Crew (RTC) and its summer program formed.

In May 2001, CO-SEED began conducting surveys, interviews, and discussions with community leaders, students, and teachers. At this point, David Hooke explained that the "trail up the west side of Mt. Cube, formerly part of the Appalachian Trail, had not been maintained in over a decade" (Lewis 2003). Then, by August 2001, the trail was reopened thanks to the RTC summer program and community volunteers (Lewis 2003). By 2003, the Rivendell Trail Crew (RTC) had constructed 10 miles of trail, and in 2008, the project was completed.

The major costs of the program included: equipment (shovels, axe, safety equipment), material (wood, rock, signs, fill), and labor (trail crew and trail coordinator). Fortunately, the RISD already had access to most of the equipment (owned it themselves or via the community/partnerships) and the CO-SEED program grants provided the bulk of the difference for the needed equipment. Also, much of the soil (used for fill), rock material, and wood material were collected at no cost. In addition, the RSID shares the responsibility of the salary of the Trail Coordinator with the Rivendell Trail Association (which is made up of community members and originally formed by the RSID). The labor costs of the Trail Crew are highly variable. For instance, in 2009, a \$13,000 grant to control erosion from the NH Recreational Trails Program supported 12 student trail workers for 12 weeks (Small Town News 2009). However in 2014, 26 students participated in the Rivendell Summer Trail Crew program with less than half the costs that were incurred in 2012. Essentially, the labor costs of the trail crew varies annually primarily due to the access of funds/grants. Trail maintenance is done by the summer trail crew program and from community volunteers. In 2015, the RTA took over all maintenance work and costs, thereby, outsourcing this obligation to a non-profit composed of community leaders.

RISD funded the project in a multitude of ways including: fundraising, donations/sponsorships, town contributions, and grants. First off, RISD hosts the Annual Meeting, Auction, and Dinner as well as the Annual Rivendell Ramble, which raised \$3,400 in 2015 and \$2,214 in 2013. Furthermore, merchandise (RTA and RTC) sales rose above \$900 in 2013. Plus, each of the four towns that comprise the RISD is responsible for an annual contribution to the program. In 2015, this contribution is \$450, or \$1,800 in total. Moreover, RISD has received a handful of grants including a \$13,000 grant in 2009, a \$4,280 grant in 2012 from the Davis Conservation Foundation, and a \$1,500 grant in 2007 from the Wellborn Ecology Fund.

From the Cross-Rivendell Trail model, there are several takeaways for a trails project at TA. First, the project at TA must involve the coordinated efforts of many groups including TA (administration, teachers, and students), the town of Thetford, local residents, and trail/hiking organizations. For example, TA could follow Rivendell's example if they did not want to be responsible for trail maintenance and even construction by outsourcing these responsibilities to interested organizations /community members, such as RTA. In

fact, some portions of the trail on TA land are being regularly maintained by local hikers, bikers, and snowmobilers. Therefore, both parties have much to gain by coordinating their efforts towards a mutual interest.

Another takeaway is that project construction should have a rolling timeline, in which, the availability of funds provided by grants and fundraising efforts dictate the pace and scope of the project. The strategy requires little, if any, up-front capital (and therefore risk) from TA, albeit at the expense of extending the project's timeline.

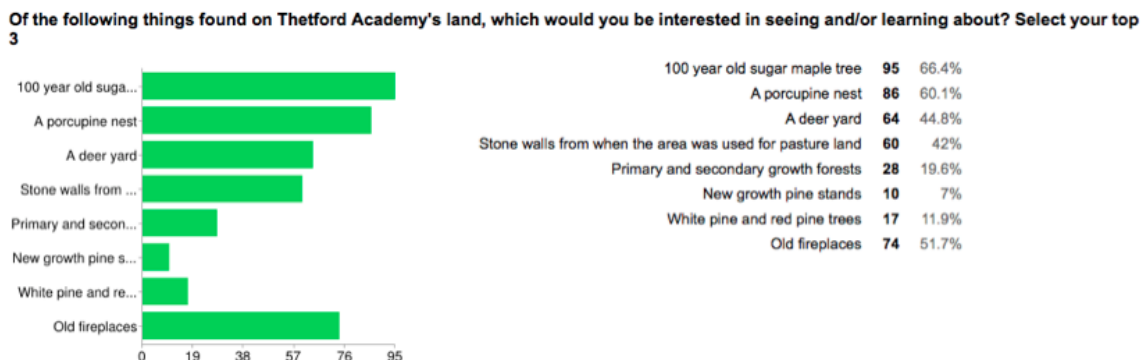
6.4 Collaboration with Outdoor Education and Water Subgroups

One of the principles of design that we identified was the need to make the trail meet the demands of teachers. In order to encourage more outdoor education, experiential learning, and utilization of the trails, we needed to understand what points of interest would be useful to teachers. We wanted to get a sense of what teachers wanted to access in the woods, or what they could see themselves incorporating into the curriculum. We could then make sure that the trail intersects as many areas of interest to teachers as possible. As Chris Schmidt stated, "we don't want to build a trail that no one wants to use."

We kept this in mind when we were hiking, and we observed many potential points of interest for curricular integration, which we recorded as waypoints. There is a wide variety in the type of waypoints we have so far because in our initial discussions with TA and the outdoor education group, we established the goal of integrating outdoor activities into humanities classes as well as science. So there are points of interest on the map that range from lookouts and clearings for nature writing to a porcupine nest that a biology class could study.

In order to learn more about what teachers wanted to see along the trail, we collaborated with the Outdoor Education group to ask a question on their survey that would address what teacher want to use the trail to see. They distributed the survey to all the teachers at TA and relayed the responses to us. Figure 2 shows the results. We found most teachers are interested in learning about the 100 year old sugar maple in their property, since 66.4% of survey respondents chose it. Figure 2 shows the results:

Figure 2. Results of Outdoor Education Survey



We also collaborated with the Outdoor Education group by helping them design their geocaching assignment. The assignment may start as an introduction to graphing (comparing two variables (latitude/longitude) with a time component (order of data points at 4 minute intervals with cache coordinates). It would also allow introduction to orbits, points of reference data collection, and inference. Each group of three could graph their path and total time. It would be interesting to see various paths, determine why they were chosen, correlating time and distance to variables not recorded (i.e. trails, topography, fences, marshes) and then discuss how those could be incorporated into a map, namely our collaborative map. Finally, students would take a photo with another member at the cache site for verification, which can also be included in our map.

We were planning on collaborating with the Water group as well to make sure the trail fits the needs of coursework involving the river. However, after walking the trails we found that the initial goal of building a more direct path to the river that allowed classes to access it during course blocks was unrealistic. It is not possible to make it to the river quickly enough to have enough time to do course work within a course block, no matter how direct the path is. Moreover, considering the design challenge of the steep ridge, we realized that a direct path would not meet the needs of making the trail easier to walk for the average person who does not exercise that often. That being said, the trail will give classes access to several streams, which the water and curricular group could utilize.

6.5 Design & Construction Timeline and Guidelines

In this section, we outline three possible project scenarios for Thetford Academy. Following the Rivendell model, all of these scenarios can be completed, but - due to funding realities - only over an extended period of time. By outlining each scenario and its pros/cons, we hope to aid TA in choosing the best project based on importance, current interests/goals, and funding opportunities. To illustrate, in 2009, Rivendell completed a large-scale water erosion project, which only occurred because of a \$13,000 grant they received for erosion control. So, each scenario may qualify for different grants, which may be the only realistic means of funding scenarios 2 and 3. Although scenarios 2 and 3 are considerably more expensive than scenario 1 and may only be plausible following a grant, they provide many more benefits. From this, our strategy is to begin scenario 1 while regularly applying for grant opportunities, which are most likely needed for scenarios 2 and 3. Consequently, funding availability will drive the timeline and selection of scenario construction.

In all three scenarios, the majority of trail maintenance and construction would be done by the TA trail crew (students), faculty leaders, volunteers, and local hiking/biking organizations. TA would create the Thetford Academy Trails Crew Summer Program, in which, the largest segment of the project would be completed. TA could also establish an annual (potentially semi-annual) volunteer TA trails work day, following the example set by Rivendell.

The TA Trails Crew would be responsible for four primary trail maintenance tasks. The first task is blazing. In a blazing system, trails are associated with respective colors, which are spraypainted on trees spread out along the respective trail. This tells the trail user which trail that person is on and whether they have deviated from the trail. The second task is brushing. This is especially needed in areas where the trail is no longer well defined or noncontiguous, like in the northeast corner. To do this, the TA trail crew would- under adult supervision- walk through the trail using loppers, bow saws, and hand pruners to clear encroaching plants and protect the integrity of the trail. The third task involves clearing blowdowns by fallen trees. We recommend that TA regularly records the conditions of each section of the trail in order to properly respond to alterations in the trail in a timely manner. To do so, trail crews should complete a 'patroller's report' after each

trip detailing trail conditions. The last task is cleaning the trail's drainage system. If this is not properly done, trails can become segmentally flooded and eroded.

Scenario 1

The most simple scenario involves making minor improvements and creating trail blazes to existing trails that, ultimately, connect the campsite at TA to the river. Because this scenario uses only existing trails, it can be completed from just a few trail volunteer days- drawing from student, faculty, and community members as well as local outdoor organizations- to complete the project. Maintenance can be completed via annual volunteer days in the summer. According to Chris Schmidt, this first scenario, at most, would cost \$2,000 (mainly labor and material costs), although it can be completed at much cheaper levels. For instance, by having just a few community and student volunteer days, TA can eliminate almost all labor costs associated with this project. Additionally, material costs would be relatively minimal. Most improvements involve physical labor with materials acquired from the local environment at no costs. Not only that, but the trails in the lower section of the map are already being maintained independently of TA. Therefore, TA can reasonably fund this scenario solely based on fundraising efforts such as a run/hike/biking event and merchandising as well as individual, municipal, and organization contributions/donations.

The biggest obstacle in scenario 1 is securing a landowner agreement with the Perry Family permitting Thetford access to sections of the trail that cut through the Perry's property. After speaking with the Perry family, they requested a paved driveway all the way from Academy Rd. to the Perry house to grant TA access to the trails on private land. Unfortunately, the Perry's request is infeasible considering it would be more expensive than the entire trails project. Consequently, unless the Perry's shift their stance, we would not be able to use this land, which would make for a more expensive and indirect trail.

Crucial for TA is the ongoing negotiation based on mutual reciprocity and respect with the Perry family in order to build the trust needed to quell Perry's justified concerns. In fact, there are many legitimate concerns for property owners in this situation. One, is the future use of the proposed trail property. Second, is the liability for hiker injury and any costs of legal defense. Ways of easing this concern include indemnification contracts and

trail sponsorships both of which would terminate Perry's liability for hiker injury. A third concern is the degradation of Perry's property from overuse, vandalism, and other management problems. Building a reciprocating relationship based on trust is truly the only way to quell this concern.

There are 5 legal arrangements for establishing a trail right of way on private property. They are: oral agreements, ownership-in-fee, easement, lease, and license. We hope to finalize an easement agreement, in which, Perry retains full rights as sole property owner but has granted the public the right to use the trail. To reduce the aforementioned concern of land degradation for property owners, the right to land access can be made conditional upon the proper treatment by public trail users. So, if hikers throw trash on Perry's land, for example, the agreement will then terminate the public's right to use the trail.

When/if this property agreement is acquired, project implementation can then begin, led by a committee composed of motivated faculty members such as Chris Schmidt and John Connolly, as well as, the student trail organization and community leaders.

Scenario 2

In the second scenario, a new foot trail would be constructed in order to create a path from the TA campsite to the lower property in the most direct way possible while considering terrain and safety. Scenario 2 also requires getting landowner permission. Unlike scenario 1, project construction would entail a full trail crew for 3 or 4 weeks and cost roughly \$8,000 according to Chris Schmidt. Because Thetford Academy is unable to commit funds to the trails project at this time, scenario 2 cannot begin until sufficient funding is raised either via fundraising efforts or grant awards. Because of this, fundraising efforts and grant applications are the most crucial first step for realizing scenario 2 [more on fundraising efforts in Deliverables section 3]. To this end, we outline several grant opportunities and how to apply to each one later in the report. With this, the student-faculty trail organization that leads this project can easily apply to these opportunities while completing other projects.

Scenario 3

In scenario 3, a trail would loop around the TA-owned parcel of land on the lower property. The entrance to the trail could be accessed from a back road along the river. Near the entrance of the trail, there is a scenic picnic/gathering area by the river great for field trips, fundraising and special events. While hiking this area, we found a network of existing trails on TA's property. From the southwest corner of the parcel, we found a stable trail that extended eastward across at least 75% of the TA parcel. We experienced some trouble while finding a continuous, suitable trail that led to the northeastern corner of the TA parcel. Although there were some patches of non-contiguous trail, we did find trails throughout most of the route, although the steepness, stability, and size of the trails would need to be addressed for this scenario. Once in the northeast corner, we found a suitable trail that extended all the way back to our point of origin completing a rectangular loop around TA's lower parcel of land. In addition, on our hike we were surprised to find that - unbeknownst to TA - the trails were being maintained. We observed that the trail was used by local hikers, mountain bikers, and snowmobilers, and we suspect that one of these affiliated local organizations most likely have been the ones maintaining these trails. Moving forward, it is imperative to collaborate with these local organizations and community members. Overall, according to Chris Schmidt's estimate, this project would require a full trail crew, last 4 weeks, and cost roughly \$8-10,000.

6.6 Conclusion

Overall, our group's primary contributions to TA are: (1) map of existing network of trails including points of interest and (2) three trail project scenarios for TA's consideration. The trail map can be constantly updated and we hope it becomes a highly valuable navigational and educational resource for Thetford. Additionally, all of these trail projects would provide for countless place-based, hands-on educational opportunities that would enhance the Academy's culture of sustainability.

Chapter 7: Summary of Recommendations

How can Thetford Academy become a local leader in environmental education? Throughout this collaborative project with Thetford Academy, Dartmouth students have addressed five central themes that foster a culture of sustainability and environmental leadership around place-based learning and engagement. These themes are: outdoor education, Ompompanoosuc River curriculum, trails, food sustainability, and solar power. The outdoor education group's central contribution was a method for cultural change through outdoor classroom activities and a proposed outdoor extracurricular program. Expanding on curricular adaptations, the Ompompanoosuc River group provides recommendations for an integrated environmental studies curriculum for 11th and 12th grade students. The trails group investigated the forest surrounding TA, identifying potential educational sites and creating collaborative map of the natural area surrounding TA. The food sustainability group focused on awareness about healthy and sustainable eating habits through a proposed expansion of the TA greenhouse and an Annual Food Day. Finally, the solar group developed a business plan detailing the options for solar energy at TA, which has potential economic, educational, and environmental benefits. In summation, these recommendations should be considered key leverage points for developing a culture of outdoor education and environmental awareness at TA.

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7. At your school(s) before Thetford Academy, what kind of outdoor activities did you enjoy?

8. Are there any parts of the nature surrounding Thetford Academy you want to learn more about? (Examples: trees, water, soil, plants, rocks, etc.)

9. Of the following things found on Thetford Academy's land, which would you be interested in learning about? Please "X" your top 3 choices

- a. 100 year old sugar maple tree
- b. A porcupine nest
- c. A deer yard
- d. Stone walls from when the area was used for pasture land
- e. Primary and secondary growth forests
- f. New growth pine stands
- g. White pine and red pine trees
- h. Old fireplaces

**10. Would you be interested in having an outdoor extracurricular program? Yes
No**

a. If **YES**, would you prefer a one-time activity (like Mountain Day) that all incoming freshman would participate in, a weekly outdoor club, or a quarterly club? (Circle one)

One-Time Weekly Club Quarterly Club (4x per year)

****The following questions relate to your response from Question 10. If you responded "No" to Question 10, you do not have to answer the following questions.****

11. Please 'X' any activities you would be interested in participating in:

- a) Wilderness Survival
- b) Nature Writing
- c) Nature Photography
- d) Nature Painting
- e) Camping
- f) Outdoor Training/Boot camp

- g) Caving (Learning about and possible exploration of caves)
- h) Geocaching (Using GPS coordinates to locate hidden objects)
- i) Trail Work
- j) Water Quality Testing
- k) Gardening
- l) Hiking
- m) Citizen Science (Conducting research)
- n) Astronomy
- o) Overnight Trip
- p) Suggestions (In the space below, please describe any other activities that you would be interested in that were not listed above)

12. What aspects of the above activities appeal to you? (e.g. " I would enjoy the aspect of learning how to make shelters of Wilderness Survival" OR "I would enjoy the animal tracking aspect of Wilderness Survival")

13. Would you be willing to participate in a focus group about a potential outdoor program? If so, please list your full name on the line below:

Appendix B. Research Instrument - Case Study Surveys

“As a part of a project we are doing at Dartmouth, we want to learn more about how some schools are incorporating outdoor education into curriculum and learning environments. Would you be willing to share your experience at XX School by responding to this survey or doing an over-the-phone interview?”

Survey for Alumnae

- Can you describe how the natural environment was incorporated into learning experiences at the school?
- What were your favorite outdoor learning experiences as a student, and why?
- What were your least favorite outdoor learning experiences as a student, and why?
- In what ways did incorporating the natural environment into curriculum enhance your learning experiences?

Survey for Administrators/Teachers

- What is the general pedagogy/teaching philosophy in terms of outdoor education at the school?
- What are some specific strategies you use for incorporating the natural environment into curriculum?
- What is working/not working vis-a-vis outdoor education at your school?

Appendix C. Deliverables - Lesson Plans/Activities

ART WITH NATURE

Purpose: Students will learn about nature as an inspiration for art by examining famous artists and practicing their own self-expression through natural art.

Objectives and Key Concepts: Upon completion of this activity, students will have a better understanding of...

1. The multidimensionality of art materials and what can be used to create art
2. The history of nature as a medium for art
3. Why artists are inspired by nature and what message can be delivered to viewers
4. How artists are able to use nature to create art
5. The meaning of transient or ephemeral art
6. How to show self expression or make a personal statement using nature as art

Grade Level/Suggested TA Class Alignment: Grades 9-12, Art I and Ceramics

Activity Overview: This activity can be used in a variety of art courses that focus on personal statements or environmental art. Through this activity, students will learn about using nature as part of their art and the ways in which artist make their own statements through art. Although the activity is only four days, it can be expanded to further study environmental artists and the power of personal statements. Additionally, the activity is currently designed to have individual work but can be altered to allow for group work instead.

Timeline:

Day One:

Homework the night before: Ask the students to Google Andy Goldsworthy and familiarize themselves with his work. For class, require the students to print off their favorite piece and write about why they chose this piece of art.

Class Discussion: Begin by discussing the many dimensions of art, and explain how conventional art materials are not the only way to create art. Everything from nature, living things, and home objects can be used to create art.

**Question for students:* What other materials can be used as art?*

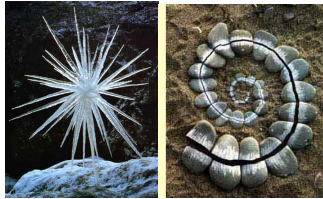
After addressing the multidimensionality of art, walk the students through the history of nature as a medium for art. For explaining the history, be sure to mention some of the early

artists and development of this form of art. To give the students a good understanding of modern day art using nature, examine the life and work of Andy Goldsworthy.

**Question for students:* Based on the homework, please share what you liked about the piece that you chose?

After, getting the students opinions, look at a few more of his famous pieces and explain how he created them and what mediums he used.

For example: "Icicle Star"-- joined with saliva, and "Pebbles Broken and Scraped"



To end the discussion, explain to students how art often makes a statement whether personal, political, environmental, etc. In order to help students get a better understanding of making a statement, have them analyze one of Andy Goldsworthy's pieces and hypothesize what message he might be trying to send to his audience.

Sample Lesson Plan Day Two:

Homework the night before: Have students brainstorm what sorts of outdoor materials they would use in their art and what type of message they would want to send.

Materials Needed:

- Paper and pencil
- Plastic bag

In Class: Begin class by telling the students that they will create their own piece of art using nature found at Thetford Academy.

(~ 20 minutes)

Ask the students to begin brainstorming art that they could create using items found in Thetford Academy's forest. Although they have not been out to see what materials can be used, they should be able to think about various designs and formations that they would find interesting.

(~50 minutes)

For most of the class, take the students out to the trail on Thetford Academy's land. Allow them to wander the trails and get inspiration from the natural materials. They should begin collecting what materials they will use, and they can also continue to brainstorm along the

way. Make sure that the students are back by a certain time so that you will have sufficient time to complete the last part of class

(~15 minutes)

At the end of class, have the students meet in pairs and discuss their idea with the other student. They should discuss what type of message they are trying to send and get feedback from their peers. Students can offer suggestions and help them to develop their art and message.

Day Three:

Allow students to work the full day on their piece of art. If they need more materials or want to alter their design, allow them to go out to the trails again to collect more materials. Tell them that the end goal is to have a final piece finished by the end of class.

Day Four:

Homework the night before: Complete the following worksheet:

Please fill out the following questions about the work of art you created. We will be presenting all of the works tomorrow during class, so these questions should give you an idea of what to share with the class:

1. What materials did you use to create your piece of art and how did you create it?
2. Why did you choose to use these materials? What was the inspiration behind the work?
3. Please explain the message or statement that you believe your piece of work expresses.



During Class:

Have each student present their individual work to the class. Ask them to discuss the questions they answered on the homework worksheet.

After the class has presented, choose a few of the pieces and display them around campus. Be sure to mark and label them so that other students will not accidentally destroy the work.

Other Notes:

Resources:

- Andy Goldsworthy: <http://www.goldsworthy.cc.gla.ac.uk/>
- Nature Art: <http://webcoist.momtastic.com/2008/12/07/modern-earth-land-art/>

Other Considerations:

Rather than having the students produce their own individual piece of art, you could also have the students work in small groups so that all their pieces of art could be displayed around campus. Additionally, student artwork could be created along the trail. This would allow students to use large objects from outdoors. The only concern would be that the works may be less visible to students, and they may not last as long as they would on a protected part of campus.

NATURE WRITING

Purpose: Students will be exposed to nature writing as a genre and will do their own nature writing in practice.

Objectives and Key Concepts: Upon completion of this activity, students will have a better understanding of...

1. What nature writing is and how it is done.
2. Literary tools used in nature writing.
3. How to think about narratives from a different perspective.

Grade Level/Suggested TA Class Alignment: 9, but can be adapted to other grades.
Recommended for “Connections to Classics”

Activity Overview: Nature writing can be an activity that accompanies any writing-based course. At base, this activity uses nature as inspiration for creating a narrative or essay that reflects a student’s observations and connection to his or her natural environment. This activity can be developed into a stand-alone unit itself that features local writers and/or it can be used to augment an established unit by emphasizing a literary tool or style. The example lesson plan demonstrates just one activity that could incorporate nature writing into an established unit: a multiple perspectives lesson in nature writing.

Timeline:

Day One: Introduction to “Nature Writing” (two parts)

First Half: Pass out copies of *Orion* magazine and have students work in teams of two to fill out worksheet “What is Nature Writing.” Debrief about students’ definitions of nature writing they created through the worksheet.

Second Half: Bring the class outside to practice journaling in nature.

Homework: Read “The Place Where You Live” and think about how these authors observed and thought about their connections to the natural environment. Think about ideas for what to observe in tomorrow’s nature writing activity, and come prepared to spend tomorrow outside practicing nature writing!

Day Two: Nature Writing in Practice

Gather in the classroom and have students collect the tools they need for the nature writing activity (notebook and pencil, appropriate outdoor attire, timekeeper). Meet outside under the pavilion and discuss instructions for what students will be turning in. Also, have students report where they will go for this activity. At the end of the class period, students will turn in their observations.

Homework: Read the short story “Dreaming in Dirt” by BK Loren and reflect on your nature journaling experience.

Day Three: Perspectives in Nature Writing (two parts)

First Half: Debrief about yesterday’s nature writing activity. Talk about last night’s reading and the perspective the author used (ie. thinking about the different things dirt does and sees over time).

Second Half: Using notes from yesterday's nature writing activity, have students pick an object near their site; they will write from that object's perspective. Collect tools needed for nature writing outside, and go outside to sit and write near the chosen object at the site. Debrief about this experience under the pavilion before returning to the school building.

Homework: Finish the essay started in class, to be turned in the next day.

Sample One-Day Lesson Plan (Day One):

- *Materials:* several copies (one for every two students) of *Orion* Magazine; notebooks, pencils, and timekeepers.
- *Procedure:*

(~40 minutes)

Instruct students to break up into partners and pass out one copy of *Orion* magazine per team. Also pass out "What is Nature Writing?" worksheet (one per person). Have students flip through/read sections of the magazine and fill out the worksheets together, talking about what they notice about the styles and themes of nature writing based on the magazine.

Debrief about students' definitions of nature writing they created by filling out the worksheet. Talk about nature writing as a genre.

(~ 40 minutes)

Have students collect tools they need for a short nature writing activity (notebooks, pencils, timekeepers, and jackets/water depending on the weather). Walk as a class to the pavilion and talk about expectations for observations (using all senses) to be turned in at the end of class, and give options for where students can do their nature journaling. Instruct students that they have 25 minutes to practice observing nature, and will meet back at the pavilion before returning to class.

(~ 5 minutes)

Return to classroom and put back any class materials used for the nature writing activity.

Homework: Read "The Place Where You Live" and think about how these authors observed and thought about their connections to the natural environment. Think about ideas for what to observe for your nature writing assignment, and come prepared to spend tomorrow outside practicing nature writing!

Other Documents:

“What is Nature Writing?” Worksheet

Name: _____ Date:

In this worksheet, you will discover and name the important characteristics that make nature writing a unique genre. Based on your observations from *Orion* magazine, you will create your own definition for “nature writing.”

Look at the article titles. What kind of things did the nature writers in this magazine write about?

Look for signs of where authors are from. Do these nature writers generally write about places they live, places they visit, or places they have never visited?

What style of writing do these nature writers use (essays, poetry, reports, etc)?

Based on the above questions and your thoughts from reading *Orion* magazine, how would you define “nature writing?” (When creating this definition, think about what nature writers write about, where they write, and how they write.)

Resources for Activities (two readings):

1. The Place Where You Live

by OUR READER

In this department of the magazine, we offer a space for people to exercise their sixth sense and tell us about their place, their connection to it, its history and future and imaginary life. It's a [web feature](#) as well.

Priscilla Kinter

HEXENKOPF HILL, PENNSYLVANIA

HEXENKOPF, the witch's head. Mountain summit in Northampton County. Peak elevation: 791 feet. Isolated prominence on a ridge of South Mountain. Home. The ghost of a headless hunter, the ghosts of witches, and strange lights have been seen here. Strange sounds come from the woods.

The stone that makes up Hexenkopf Rock is embedded with tiny flecks of mica, reflective scales that once covered the rock's entire surface. The mica has largely eroded away, but during the various times when the densely wooded hill was clearcut by owners trying to squeeze an income from their rocky property, the mica would mirror the moon and glow white in the night. Morgan le Fay could easily have lived in the brambly woods covering Hexenkopf, fingertips sparking.

When German families settled in Northampton County, their homes and barns were inhabited by *haus geister*, house spirits—leprechauns, *púca*, brownies, or Robin Goodfellow to those of other ethnic origins—half-animal creatures that lived in the caves and hills and hunted in the woods. When the Magyars (including my great-grandparents) arrived from Hungary, they found that the *manók* elves and goblins, the foxy *törpék* dwarves, the cave-dwelling *bubus* spirits, and *fene* illness demons were already there. The Germans kept watch for the ghostly *Der Schimmelreiter* who would lead his spectral army through the hills, the Hungarians for the *guta* demon who beat his victims to death.

In the late eighteenth and nineteenth centuries, it was understood that any wind blowing from Hexenkopf carried contagion and pestilence and that the entire hill was cursed and haunted, not to be trespassed on or abused. When Hexenkopf Rock glows in the moonlight, devils and spirits and ghosts roam the hill. German witches still practice on its slopes.

Perhaps it is ironic that, growing up, I never knew our hill was supposed to be cursed, or haunted, or harrowing in any way, never heard about headless ghosts or contagion winds, about mysterious lights and sounds in the trees, never knew any of it until I was decades older and far away. Or perhaps this is simply a lamentation for the richness once located just outside my back door, all too easily left behind in an urge to discover what lay beyond the next ridge.

Bob Gray

HOUSATONIC, MASSACHUSETTS

I LIVE IN one of Clark Comstock's pastures. I know this because fifty years ago I walked through here to fish and swim in the Williams River, the meandering west border of Comstock's farm. If his cows were fording the river, we'd try to jump into the swaying hollow of their hips to see if they'd carry us across. On our way we dodged fresh cow pies or whiffled them at each other when they were sun-dried.

Yet I cannot legally raise a chicken on the acre of land I tenant.

Houses, not nettles or ox-eye daisies, spring up in Mr. Comstock's fields now, like they do at another once-farm down North Plain Road a mile or so. Identical prefab colonials hug the road, staring blank-faced through the few spared evergreens.

Out back used to be a five- or six-acre white pine grove. The trees marched in orderly rows mustered by the man who bought the old farmhouse and desired exclusivity. Crows in their hundreds dropped from the pink-purple autumn evenings to roost there. When I felt mischievous, I stalked among the trees at sunset and clapped my hands just to hear the whirling racket of caws and the stage whispers of pinions. But this dusky chaos was just a weary, cautious circling, before a one- or two- or three-crow settling down again into the dark.

Deer made bold by winter's harshness walked stealthily up from the river and between our houses in the early dark to shelter from blizzards they sensed before the first flakes fell, tentative, unsure of their welcome.

Now even the pines are gone, clearcut by a developer whose dreams apparently died with the trees. Crops of thorns, sumac, and poison ivy thrive.

As I made my garden, *made* in the real sense with three decades of grass clippings, manure, and leaves dug into the gravelly undersoil, I unearthed an occasional rusty shovel, horseshoe, mattock blade, the sparse, circumstantial evidence of what once flourished here.

Lisa Hupp

KODIAK, ALASKA

A NASA astronaut's blog photo went viral this week in our community: a full moon rising over interior Alaska, the frozen white landscape curving into a blue haze. Delicate, almost lacelike snowy islands spread over the foreground, anchored in a deceptively calm North Pacific Ocean. Rugged mountains appear flattened, fjords and bays radiate out from the long spine of uplifted sea floor at the archipelago's center, and there is little sign of life.

Yet as it was posted and reposted online, a collective local pride labeled the photo as home sweet home. For many of us living on Kodiak, this image maps memories along each indentation of rocky coast.

At the north end of the archipelago, I can see Shuyak Island, where I spent my first summer here as a backcountry ranger kayaking among salmon, seals, and the occasional migrating orca. Along the western fringe, I find Uganik Bay, where my friends and neighbors fish commercially from set-net sites along the shore. I think about sitting on their cabin porch, watching the sun set across the Shelikof Strait as we drink beer from mismatched cups, the tall stalks of fireweed on the tundra illuminated bright pink in low light.

My eye skips over the landscape, remembering: the red bicycle resting against the mercantile at Larsen Bay Cannery, the Christmas we hunted deer along the icy rocks of Viekoda Bay, the downtown docks and the familiar fishing boats. Learning to weave a traditional Alutiiq grass basket at the beach. An early morning at the edge of a river, watching a bear stalk through the mist and deftly snag a passing fish . . .

It is an unlikely home, seen from space. A solitary rock in a blank blue sea. But those of us who live in this place have a different view: a rich bounty, a survival story, a confluence at the top of the world.

2. Dreaming In Dirt

by BK Loren

WHEN I SEE DIRT in my dreams, I know I'm going to have a wild sleep. All night long, stories rise up from vast expanses of gritty soil, landscapes that read like hieroglyphics, like love notes, like survival tales, like novels. When I look down at my feet, the earth becomes a pop-up book surrounding me with animals I know well and others I've never met but whose stories I read like the tales I loved as a kid, the ones where people walked with wild beasts—rabbits, deer, foxes, mountain lions—and we all shared a language, because we do. It's the language of dirt.

Every life leaves an imprint. Imagine the earth, then, like a fist that holds your actions and the actions of every living thing. When you learn to read dirt, you walk into the forest or across a city (yes, there are imprints there too), and the fisted world opens up like two palms holding a book of the best story ever told, because it is every story ever told—if you know how to read dirt.

Even the story of flight imprints in dirt. Where a magpie lands and touches the tips of its wings to the soil, where an owl swoops down and leaves five parallel arcs that embrace a sharp divot, the mark of talons extended and clenched. Sometimes the talons lead to the imprint of small feet that darted out of the night-hunter's grasp. The escape looks like commas on a page, like rainfall gone sideways on the earth. Sometimes you can see only a large almost-circle, like a period inside the parentheses of the owl's wings. That's the end of the sentence for the prey, no dashes telling of escape.

Sentences become paragraphs become novels written in dirt.

When I wake from a dream of dirt, I know I need to slow down, to look more carefully, as I do when I'm tracking. That's the lesson of dirt. There are lives you step over daily. When you walk in a wild place, you are never alone. Hiking in Colorado's Front Range, you're watched by mountain lions or foxes; or you're studied by coyotes, those tricksters who disappear like smoke that sinks into the earth rather than rising into the heavens. You cross paths with animals that walk side by side with you like some kind of post-Edenic apparitions, reminding you that the only original sin is the one of not paying attention, of

not listening to the dirt beneath your feet, the signs all around you, the names of the animals fresh on your tongue, their stories waiting to be spoken alongside your own.

When you walk, you know we are all woven together in a texture of earth that transcends the boundaries of language. If I walk where my parents walked, they, too, appear again, not in their own tracks but in visible signs: the two Canada geese they called “The Couple,” one with his distinctive limp (unnoticeable until you look at his tracks), and the other with the dot on the right side of her bill; the small pond Mom and Dad walked around daily (hand in hand at seventy-five), and the tracks—and springtime eggs—of the western painted turtle they saved from a busy road and brought here, where it has thrived long after their deaths. It’s dirt that holds my parents now, dirt that will hold the ones we have loved and their imprints forever: fossilized bones, mummified shapes caught in the act of living and dying. It’s dirt that will hold you and me.

Dirt is everywhere and records everything, retelling your story, perhaps even eons after your death, in sediments pressed into history, pressed into time. There is nothing you do that escapes record. There is nothing that the earth will not record and read back to you and others. Listen: It’s ever-present. Our lives left in dust, where our stories, always, remain.

BK Loren is the author of The Way of the River and is currently completing her first novel, Thieves. Her work has been published in Best American Spiritual Writing 2004, Parabola, and Going Alone. She is a winner of the D. H. Lawrence Fiction Award as well as the Dana Award.

From *Orion Magazine* (<https://orionmagazine.org/article/dreaming-dirt/>)

Other Considerations: Terry Osborne is a former Thetford resident and senior lecturer at Dartmouth College. He specializes in nature writing and could be contacted about integrating this activity on nature writing into curriculum. His contact information can be found below:

Email: Terry.S.Osborne@Dartmouth.edu

Further Reading:

Elder, John. 1998. *Reading the Mountains of Home*. Cambridge: Harvard University Press.
Finch, Robert and John Elder. 1990. *The Norton Book of Nature Writing*. New York: Norton.
MacArthur, Robin. 2014. *Contemporary Vermont Fiction: An Anthology*. Brattleboro: Green Writers Press.

Phenology

Purpose: Students will learn about changes in the forests around Thetford Academy as a way to understand the impact of climate change on local ecology.

Objectives and Key Concepts: Upon completion of this unit, students will have the capacity to...

1. Define phenology, niche, and climate change
2. Understand the relationship between growing season length and forest productivity
3. Understand the relationship between climate change (human impact) and tree phenology (ecological outcome)
4. Understand how changes in phenology can lead to changes in forest composition and associated wildlife habitats

Grade Level/Suggested TA Class Alignment: 10, but can be adapted to other grades.
Recommended for “Essentials of Biology: An Introduction to the Science of Life”

Setting: Woods immediately surrounding TA; suggested class meeting space under pavilion

Activity Overview: Through a series of short lab exercises, students will collect data and make observations that track changes in tree phenology over times near TA over the spring and/or fall seasons (can be adapted to “leaf out” and leaf senescence); however, this lab is recommended for the spring season. Simultaneously, students will discuss how tree ecology changes over these seasons, how these changes are affected by climate change (variation in temperature and precipitation, specifically). Furthermore, students will discuss how animal species might be affected when their niche changes because of climate change.

Timeline:

Day One: Brief outdoor lecture to define “phenology” in the context of the looming seasonal change (either start of spring or beginning of fall). Demonstrate the weekly lab activity.

Day Two: Students select their Red Maples, on which they will make their first observations (see Lab Sheet). Hold an outdoor discussion of what students found or challenges they had with the activity.

----- One week break/Other class materials

Day Three: Students make observations on Red Maples. Hold an outdoor discussion about niches based on student observations of animal around their trees.

----- One week break/Other class materials

Day Four: Students make observations on Red Maples; outdoor discussion about climate change and affect on phenology

----- One week break/Other class materials

Day Five: Students make observations on Red Maples. Hold an outdoor discussion about the relationship between climate change, phenology, and changes in niches.

----- One week break/Other class materials

Day Six: Students make last observations on Red Maples and input lab data into class Google Spreadsheet. Discuss results as a class and compare to phenology data on USANPN website to see regional change over time.

Day Seven: Lab reports due.

Note: For better results, observations could be made 2-3 times per week.

Sample One-Day Lesson Plan (Day Three):

- *Materials:* Tree Identification Booklet, Cellphone camera/digital camera, lab sheet, clipboard (or other hard writing surface), notebook, and pencil

- *Procedure:*

(~ 8 minutes)

Meet in classroom and collect materials to go outside for lab and discussion.

(~15 minutes)

Go to your flagged Red Maples in partners/teams. Be still for about five minutes while you observe and record signs of animal life (under the “Animal Checklist” on the lab sheet) you see or hear near your tree. Then, observe the tree for signs of change (i.e. buds, leaves, fruits, leaf color change, leaf dropping).

Take a canopy photo (looking directly up at the tree’s canopy) about five meters out facing away from the tree trunk in each cardinal direction. (When you upload to the computer,

name each photo as #_ordinal date_compass direction.) When this is done, make any additional notations about the plot on the lab sheet.

(~ 55 minutes)

Meet under the pavilion for class discussion. Debrief about data collection and invite students to mention any changes they noticed or anything else that came up during the lab activity. Using students' observations from their plots and their homework reading about niches, talk about niches in the surrounding environment at Thetford Academy.

(~ 5 minutes)

Return to classroom and put back any class materials used for the lab activity.

Other Documents:

Julian Date Calendar: <http://www.dm.usda.gov/procurement/toolkit/docs/calendar.pdf>

Lab Sheet

Animal Checklist: Do you see or hear...

	Date:	Date:	Date:	Date:	Date:
Birds	#____	#____	#____	#____	#____
Bumblebees	#____	#____	#____	#____	#____
Chipmunks	#____	#____	#____	#____	#____
Squirrels	#____	#____	#____	#____	#____

Other animals:

Notes on Feeding Behavior:

Tree Checklist: Do you see...

	Date:	Date:	Date:	Date:	Date:
Leaf Buds	y n ____	y n ____	y n ____	y n ____	y n ____
Flowering	y n ____	y n ____	y n ____	y n ____	y n ____

Leaves	y n _____	y n _____	y n _____	y n _____	y n _____
Increasing Leaf Size	y n _____	y n _____	y n _____	y n _____	y n _____
Colored Leaves	y n _____	y n _____	y n _____	y n _____	y n _____
Falling Leaves	y n _____	y n _____	y n _____	y n _____	y n _____
Dropped Fruit	y n _____	y n _____	y n _____	y n _____	y n _____

* Mark yes (y) for any presence, and no (n) for total absence. On the line, estimate the intensity of presence on the following 0-10 scale:

0 = 5% or less (basically none) 3 = 26 - 35% 6 = 56 - 65% 9 = 86 - 95%

1 = 6 - 15% 4 = 36 - 45% 7 = 66 - 75% 10 = 96% or more

2 = 16 - 25% 5 = 46 - 55% (about half) 8 = 76 - 85%

Other notes:

(Adapted from USA National Phenology Network: www.usanpn.org/how-observe)

Protocol for Analyzing Canopy Cover Using ImageJ:

(This activity will demonstrate yearly phenological differences collected over time at TA.)

- Download ImageJ: <http://rsbweb.nih.gov/ij/download.html>
- When ImageJ is open, open a canopy image:
File → Open
- Examine the photo to determine if the area is mostly (more than 50% shaded) canopy cover or mostly light gaps.
- Make the image 8-bit:
Image → Type → 8-bit
- Make the image a binary file:

Process → Binary → Make Binary

- If ImageJ made the canopy cover (leaves, twigs, branches, limbs, and tree trunk) black, proceed to “Analyze the Pixels”
- If ImageJ instead made the light gaps black, invert the binary assignments *before* proceeding to “Analyze the Pixels”:

Edit → Invert

- Analyze the Pixels

Analyze → Analyze Particles

In the new window, ensure that only the “Summarize” box is checked. **Click “Ok”**

The fifth column on the summary window will be titled “%Area” or “Area Fraction.” The values are the percentage of the total picture that is black: this is the percent canopy cover!

(Adapted with permission from Craig Layne, Instructor of Ecology and Evolution Teaching Laboratories, Dartmouth College.)

Other Considerations: This is a good weekly lab that can be incorporated throughout other units - a great way to break up the week and give continuity to a class! As such, it is recommended that this unit accompany a “sister unit” on plant ecology or ecosystems.

To get tree variety comparisons, sugar and Norway maples are also common trees in the area. Varieties of oak are also common and easy to find!

Also, this is a great long-term project for the school. In other words, student data can be collected yearly at the same time, so current students can build on past students’ data to see change over time.

Furthermore, students can contribute to the citizen science initiative, the “New England Leaf Out Project,” by entering their data into the following website: <http://www.nelop.net/>.

Further Reading:

Montgomery, Rebecca A. n.d. “Phenology and Climate Change: How Timing of Biological Activity Affects Forests Now and in the Future.” *University of Minnesota College of Food, Agriculture, and Natural Resource Sciences*. Retrieved May 7, 2015

(http://sfec.cfans.umn.edu/prod/groups/cfans/@pub/@cfans/@sfec/documents/asset/cfans_asset_336037.pdf).

Ovaskainen, Otso et al. 2013. “Community-Level Phenological Response to Climate Change.” *Proceedings of the National Academy of Science in the United States of America*

110(33):13434-13439.

Parry, Wayne. 2012. "Climate Change Throws Nature's Timing Out of Whack." *Live Science*. Retrieved May 7, 2015

(<http://www.livescience.com/19679-climate-change-seasons-shift-mismatch.html>).

Geographic Information Science

Purpose: Students will learn to use a GPS and find coordinates marked with geocaches and then map both their distance and graph their time.

Objectives and Key Concepts: Upon completion of this activity, students will have a better understanding of:

1. What is GPS?
2. When GPS works best and how it is used in science.
3. How to use a GPS and specific coordinates to find a location.
4. What is geocaching?
5. How to map distance traveled.
6. How to graph and the components of a graph.

Grade Level: 9, Recommended for Conceptual Physical Science

Activity Overview: This activity is to help students get a better understanding of how GPS works and how they can map and graph using different axes and legends. The activity would fit well into a physical science course or one that focuses on maps and graphs. While the students will be mapping distance and graphing time, any form of information that the teacher chooses can be graphed. Additionally, teachers can use any variety of locations for the geocaches, and it is suggested that they change the spots every year.

Timeline:

Day One:

Homework the night before: Ask students to explore this website:

<https://www.geocaching.com/play>

In Class:

**Question for students:* How many of you know what a GPS is? Can anyone tell me what it is used for?*

Discuss with the class what a GPS is and how it works. Show them a GPS as you discuss this and demonstrate one in use. Follow up with a talk about what are the many uses of a GPS.

Focus on what they are used for, why they are used, and how they are helpful in certain scenarios. Have the students practice using them and allow them to familiarize themselves with how the GPS works.

Next, ask students if they have ever heard of geocaching and have a student try and explain to the class what geocaching is. After, explain in more depth about what geocaching is, how it works, and what people use it for.

Sample Lesson Plan Day Two:

Materials needed:

Paper

Pencil

Phone with timer

GPS (one per group)

Geocaches with tags (One per group at 4 locations)

Before this activity can be started, you will need to pick three or four locations to place the geocaches for the activity. Be sure to note the coordinates of the location so that you can give them to the students.

In Class:

(~20 minutes)

Explain to the students that they will be working in groups to find hidden geocaches on the campus. They will be given four coordinates in a specific order that they must follow. As a team, they will time how long it takes to get to each geocache using their phones, and note where the geocache was hidden. Break the students up into groups and move outside.

(~55 minutes)

Once everyone is outside, give each student the coordinates to 3 or 4 geocaches in a random sequence. Have each group go to the geocaches in a different order so that the groups don't end up following each other. Ask the students to find the geocaches using their GPS and make sure that they time how long it takes them to find each geocache. As they complete the activity, have them fill out the following worksheet:

Coordinates	Length of Time to Find Geocache	Where was the geocache hidden? List the location on campus
Geocache 1:		

Geocache 2:		
Geocache 3:		
Geocache 4:		

Tell the students that they have a certain amount of time that they can spend looking for the geocaches and that at a specific time they need to head back to the meeting point on campus. The goal is for them to make it to all of the geocaches in the shortest amount of time.

(~10 minutes)

Regroup and wait for all students to return. Tell them that they will need to create a map and graph for homework that represents the path they took and the time it took to get to each geocache.

Day Three:

Homework the night before: Ask the students to watch the following video:

<https://www.youtube.com/watch?v=GUYRMdcEs00&index=132&list=PL9Ik1yJr50DpW12uoEuyClsx92o8MiNy>

In addition, ask the students to attempt to draw a rough map of the path that they took. Be sure to have them label the locations of the geocaches. Also have them draw a graph with the axes of time and distance to show how long it took them to get to each of the geocache locations.

In Class:

Begin class by asking students about the activity. Ask them about what they learned from this activity, and also ask them to explain the challenges that they faced.

After discussing the lessons and challenges, have the students get into their groups and look at each other's maps and graphs. Have them discuss the reasons that their maps look different and what they might add to make them more similar. After this group meeting, discuss as a class the necessary components of a map and graph.

Discuss with the class the importance of mapping and graphing in science and research and the information that can be read from them. Ask them what type of information they would

have wanted to know in order to improve their own maps. Also, discuss what other information they could have put on their graph other than time and distance.

Further Reading:

Forest for Every Classroom

<http://www.nps.gov/mabi/learn/education/forest-for-every-classroom.htm>

Four Corners School of Outdoor Education

<http://www.fourcornersschool.org/lesson-plans>

Appendix D. Extracurricular Club Model

Introduction and Guidelines

Faculty Advisors:

There will be two faculty advisors, one male and one female. These advisors would have complimentary skills, experience, and personalities. Community experts could also be considered for a supportive advisor position.

Programs will be run by community expert volunteers in order to integrate the Thetford community into Thetford Academy education. Community experts will be considered based on their knowledge of said activity, leadership ability, personality, and willingness to assist the club.

Costs:

Student cost will be kept to a minimum depending on the intensity of the activity. Students may need to purchase apps for their smartphones, in cases where they have these devices. Cost of participation in the club can be determined by the faculty advisors. Students who need financial aid will receive financial aid based on TA requirements.

Thetford Academy will need to purchase, depending on enrollment, approximately 10 tarps, 10 sleeping mats, 10 backpacks, and possibly winter sleeping bags, all of which may be funded through grants listed in **Appendix E**.

When:

As of now, the club will run 10 weeks during fall semester from September to early November. Club meetings will take place once a month on a Wednesday during lunch time (unless a time is set aside for clubs to meet). Activities will take place weekly on both Wednesday and Thursday so interested students can have the opportunity to attend one or both days of the activity. Activities will run from 3:15pm to 5:00pm.

The culminating experience will take place at the end of the semester. It will be three days and two nights long on lower academy land.

Who can join?

Participants must be enrolled at Thetford Academy, be academically eligible, and must attend all but one activity in order to participate in the culminating experience.

What will we be doing?

List of activities

The purpose of this club is to educate Thetford Academy students about the outdoors through various outdoor activities. Such activities will include, and not be limited to Wilderness Survival skills, Camping, Nature Photography, Hiking, Orienteering, and

Astronomy. These activities were chosen based on a survey given to Thetford Academy students as well as a focus group with Thetford Academy students.

Culminating experience

At the end of the fall semester, students will use the skills that they gained during weekly activities at an overnight culminating experience. This culminating experience will be a three day, two night camping trip on Thetford Academy owned "lower land." It will begin with hiking after school on Friday and setting up individual, male and female separate campsites for a solo experience. Having the overnight on TA land will allow students to form a bond with TA land and also decrease the overall cost of an overnight trip. The overnight trip will also allow students to put acquired skills to the test, such as setting up a tarp to sleep under, tying knots, nature photography, nature writing, geocaching, and star identification. Cell phones or technology will not be used with the exception of photography, required apps, and emergencies.

Lead and organize non-member workshops

In order to open up the activities to the whole student body, club members will organize two workshops over the 10-week period, in which any non-member could participate. This would serve many purposes such as developing the leadership, organization, and teaching skills of the club members, as well as advertising for new membership to the club in the next season. Two example activities could be a geocaching race and a scavenger hunt. Through these activities, non-members would be introduced to the practical skills that the outdoor club makes use of while having a low-commitment, one-time experience.

Activities

Obstacle Challenge Course

Of the 145 respondents to our survey, 45.3% students indicated an interest in an outdoor training/boot camp type activity. One way in which this could be implemented is through an outdoor challenge course, which could provide utility to not only the extracurricular program through physically demanding activity but also to the school's Physical Education program and sports teams. Such a course would take about twenty minutes for the average student to complete, and would contain a myriad of obstacles which, while restricted in size and difficulty by insurance liability, would provide a series of different physical challenges to push individuals to adapt and move their bodies in different ways, thus providing a way to strengthen the body and build mental fortitude. Such a course would contain elements of running as well as obstacles such as 6-foot-high walls to be scaled, army crawls under a 2.5-foot elevated rope web, low balance beams and balance exercises, over-unders, and A-frame obstacles to be cleared. This course could be used for a President's Test evaluation and could also involve station work such as push-ups, pull-ups, box jumps, and burpees. Such exercises could also be used as opt-out options for obstacles posing particular difficulty to individuals.

Hunting, Fishing & Trapping

During our focus group, we discovered that 14 out of 15 of the participants wanted more activities surrounding hunting, fishing, and trapping. In this activity, students would learn about different skills and strategies used in hunting, fishing, and trapping. This includes learning to tie knots, how to bait hooks, trap-building, tracking, and even cleaning of common game animals and fish. During this activity students would learn about the best sources of protein in the wild, why humans need proteins and fats, and even management theory surrounding game (for instance, why there is a catch and release rule and limits on hunting). Local experts could be found to assist with this activity, and based on focus group responses could possibly be found through students' family networks!

Nature Photography & Nature Writing

Nature photography is one of the top five most interesting activities based on student responses to the survey. Nature photography is a great way to introduce students to the arts and humanities through outdoor education. During this activity students will be able to learn the "ins and outs" of the camera, what makes a photo 'interesting,' and how to edit photos through programs like Photoshop. Students will be able to use these newfound skills in the wilderness as they hike through TA's trails. The photographs that students take can then be posted to the TA website in order to promote TA's outdoor club.

Although nature writing was not one of the highly favored activities based on the survey results, TA has expressed interest in getting students excited about both scientific *and* humanities-based journaling. Adding nature writing to our list of club activities will allow the club to easily link back to course curriculum. It is important for students to learn to journal while in nature in order to practice mindfulness and being present while in nature. This can be as simple as writing at the end of each week's activity, journaling about the feelings the wilderness may give a student, sketching nature, or just expressing the beauty in the simplicity of the world.

Orienteering, Map Reading, and Mapless Wilderness Navigation

In this activity, students get to learn how to navigate outdoor environments with and without maps, culminating in a geocaching experience. First, students would review maps and coordinate systems. Then, students would partake in a geocaching race. Through a geocaching app, students would be given multiple coordinates to find a small treasure hidden in the TA trail system. Inadvertently, students would be learning how to use GPS. Simultaneously, students would bring maps (including topographic maps) as a back-up and a way to help them get their bearing of their coordinates while in the woods. The club might also consider incorporating a service component to this activity, such as bringing trash bags along to the geocaching trip and collecting any garbage they encounter while on TA land.

Plant Identification and Animal Tracking

By participating in this activity, students will learn about identifying local plants and animals. First, students would learn about the “non-edibles,” such as berries that may *look* like food but are dangerous to eat. Then, students would learn about the “edibles,” such as fungi that can be scavenged in the region. Along the way students can practice identifying other common local plant species, such as trees, and animal species via their tracks or scat. These activities are combined because students can discuss the relationship between plant species and their purposes (such as food) in local animal habitats.

Wilderness Survival Basics (two part activity)

From the survey results, we found that TA students were most interested in learning wilderness survival skills. In order to fulfill TA student wishes, wilderness survival will be a two-week activity. This activity will cover key knowledge for surviving in the wild, such as where to find warmth, how long can a person survive without water, and the best way to find food sources. These topics will touch on both short-term and long-term survival in the wilderness.

In the first week of wilderness survival, students will also learn how to build a fire in both dry and wet conditions, how to use outdoor tools (mess kits, fire starters, etc.), the basics of knot tying, where to find shelter, and how to set up shelters. There will also be a focus on wilderness first aid. How to assess a patient, CPR, fractures, stable injuries, splints, hypothermia, heat illness, wounds and burns, bug bites, and back country medicine are potential topics that students can learn. In terms of camping, students will learn and follow “leave no trace” ethics.

The second half of the wilderness survival activity will be filled with “what if” scenarios. These scenarios will allow students to put their knowledge from the previous week to the test as well as help them to develop problem-solving skills, critical thinking skills, and how to think on their feet. These scenarios will be chosen from a pile of flashcards and will include identifying illnesses on a patient, acting out different injuries or illnesses, and answering wilderness survival trivia questions (i.e. how long can a person survive without water). Although students will not be in real survival situations, they can use their imaginations to consider how they might deal with a potential problem.

Astronomy

This activity will consist of learning how to orienteer via the stars, expose students to different historical and cultural exploration before maps were created, and help students to identify different constellation and star properties. Sample activities can include the study of northern star constellations, learning how to use the stars to navigate (with and without the North Star), learning about cultures that use star navigation (viewing of *The Navigators: Pathfinders of the Pacific* by Sam Low), constellation identification and mythology (Free *SkyView* App on cellphones and *Stellarium* on computers), and even

creating model rockets (baking soda and vinegar rockets). Students will have exposure to astronomical methods, and equipment during this week, but the real application and realization of this activity would occur during the Pre-Overnight experience when there would be an opportunity to observe the night sky.

Pre-Overnight Experience

Instead of an activity during week 9, all students participating in the overnight experience will be required to attend a practice overnight experience. This would be led by trip advisors and would be held at the lean-to shelters in the state park. Shelters will be separated into self identified male cabins and self identified female cabins. This would also allow students to have a nighttime experience with astronomy before the official overnight experience.

Overnight Experience

At the end of the semester there will be an opportunity to participate in a overnight culminating experience on TA land. This will be opened to anyone who has attended at least four activities as well as the wilderness survival activity. The culminating experience will allow students to use all of the knowledge gained from the club activities in practice during the overnight trip. Students will be required to set up camp, take photos, and do journal entries. Students will participate in nature hikes where they will be given the chance to identify plants and animals/tracks, geocache, create maps of TA land, and identify constellations during the nighttime. This will also give students a chance to bond with the outdoor land that Thetford has to offer.

Appendix E. Table of Possible Grants for Funding of Outdoor Club

(This table summarizes last year's group document, "List of Possible Grant Opportunities")

Grant Name	Sponsor	Amount	Requirements	Abstract	Eligibility
Explore Fund	North Face	Upper: \$25,00 Lower: \$2,500	Academic Institution, Government, Nonprofit	Programs that encourage youth outdoor participation	501 (c) (3) status
Davis Foundation Grants	Davis Conservatio Fund	Not specified, one year grant	Nonprofit	Projects related to wildlife, wildlife habitat, environmental protection and outdoor recreation that also increases volunteer activity and community involvement	Tax exempt under 501 (c) (3); not private foundations under section 509 (a) (c)
Education Grants	Jane's Trust	Upper: \$150,00 Lower:\$50,000	Nonprofit	Support for the advancement of educational opportunities and quality of underserved communities	Greater Boston Area and Eastern MA; must focus exclusively on health and welfare

Appendix F. Outdoor Education Brief

Outdoor Education Brief
 Prepared for Thetford Academy
 May 2015

<p>What is Outdoor Education?</p> <p>The goal of outdoor education, broadly speaking, is to complement classroom instruction with meaningful experiences in the out of doors.¹ Although “outdoor education” goes by many names, we focus on place-based education,² which has the following characteristics:</p> <ul style="list-style-type: none"> - educational content is specific to the environmental and social context - multidisciplinary and experiential - curriculum is often designed for a larger objective, such as learning through serving a community. <p>There are a number of reasons for using this pedagogy in classrooms, beyond making better use of the exceptional outdoor resources surrounding Thetford Academy.</p> <p>Why Does It Matter?</p> <p>Outdoor education has been</p>	<p>Enhancing Curriculum with the Outdoors</p> <p>There are several ways to integrate the natural environment of Thetford Academy into classroom learning objectives. When teaching a particular unit, think about how the outdoors can be used to teach a concept or method in practice. For instance, how can nature be used to make or inspire art? How can students learn about perspectives through nature writing? How can statistical approaches be used to understand the environment?</p> <p>Outdoor education often tends toward practical learning. As such, existing curriculum can often be adapted with outdoor activities through labs, assignments, and group work. Fortunately, a recent survey of TA students indicates that these are the classroom activities they most enjoy!</p> <p>Resources</p>
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<p>shown to benefit students in a number of ways. This pedagogy fosters student motivation and enthusiasm to learn, and helps students concentrate for longer periods of time.³ Furthermore, student achievement and behavior has improved in situations where the natural environment was used as an educational context.⁴</p> <p>Based on a recent survey of 144 Thetford Academy students, 83.3% of students are somewhat or very interested in going outside at least once per week!</p>	<p>To discover more ideas for outdoor education in your classroom, visit the following organizations' websites:</p> <ul style="list-style-type: none"> - A Forest for Every Classroom - Four Corners School of Outdoor Education - National Wildlife Federation - SEEK: Minnesota's Home of Environmental Education Resources <p>And, don't forget to share your ideas and successes with fellow TA faculty!</p>
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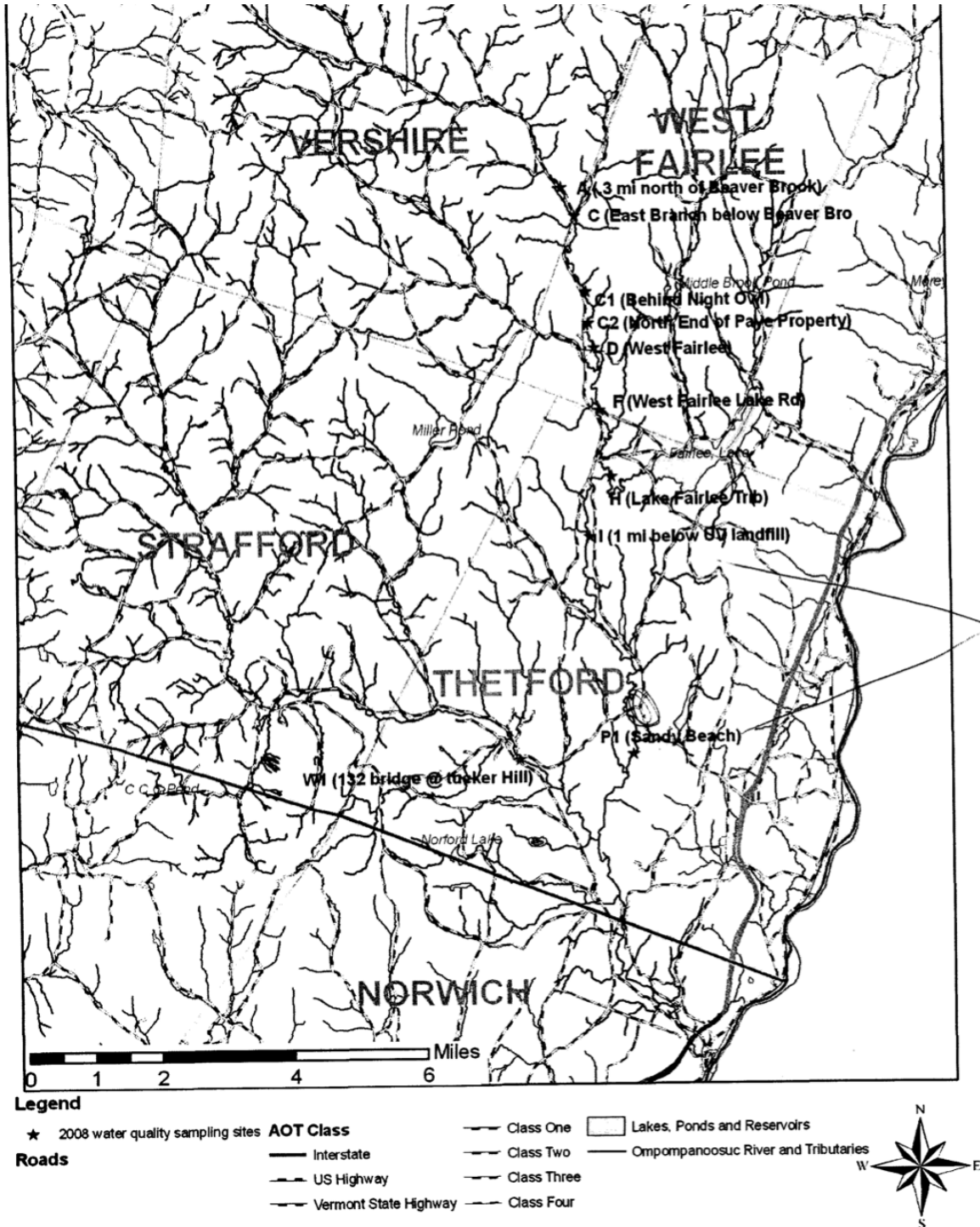
1. Woodhouse, Janice L. and Clifford E. Knapp. 2000. *Place-Based Curriculum and Instruction: Outdoor and Environmental Education Approaches*. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools.
2. Smith, Gregory A. 2013. "Place-Based Education: Practice and Impacts." Pp. 213-220 in *International Handbook of Research on Environmental Education*, edited by R. Stevenson, M. Brody, J. Dillon, and A. Wals. New York: Routledge.
3. Coyle, Kevin. *Back to School: Back Outside!* National Wildlife Federation, 1 September 2010. Web. 6 May 2015.
4. Powers, Amy. 2004. "An Evaluation of Four Place-Based Education Programs." *The Journal of Environmental Education* 35(4):17-32.

Appendix G. River Group Contacts

This is the list of contacts whom we have been coordinating with regarding data collection on the Ompompanoosuc. These are the key people who are monitoring the river and who are excited to work with the students and use the data they collect.

1. Mary Childs, District Manager at White River Natural Resources Conservation District
whiterivernrcd@gmail.com
2. Peggy Willey
peggywilley@mytopsmail.com
3. Ben Copans, Watershed Coordinator
ben.copans@state.vt.us
4. Jim Ryan
Jim.Ryan@state.vt.us
5. Ron Rhodes, North County River Steward
rrhodes@ctriver.org

Appendix H. Map A Points being Monitored on the Ompompanoosuc



Appendix I. Diagram of Course Curriculum focusing on Benthic Macroinvertebrates

2015 Thetford Academy Environment Sciences Curriculum Study Focus: The Ompompanoosuc River Grades 11-12	
<p><u>Learning Goal:</u> Students will learn how to sample and analyze benthic invertebrates from the Ompompanoosuc and apply this information to broader concepts of watershed systems and global environmental issues.</p> <p><u>Objectives:</u></p> <ol style="list-style-type: none"> 1. Learn the current water quality issues associated with the Ompompanoosuc? 2. Learn how to collect and analyze benthic macroinvertebrate data 3. Understand the other methods available for testing water quality 4. Understand the ecology of River systems 5. Gain a broad understanding of water systems and climate change 	
<p><u>Standards:</u></p> <p>Standard 3.9dd. Demonstrate understanding that natural and human communities are part of larger systems and that the interrelationships between all systems affect their sustainability</p> <p>Standard 3.11. Students interact respectfully with others, whom they have differences.</p> <p>Standard 4.1 Students take an active role in their community</p> <p>Standard 4.1a. Students plan, implement, and reflect on activities that respond to community needs.</p>	<p><u>Essential Content and Understanding:</u></p> <ul style="list-style-type: none"> • What are macro invertebrates and how does their abundance reflect water quality? <ul style="list-style-type: none"> ◦ How can each species be identified? ◦ What does the presence of a species indicate? • Become comfortable with Excel and use to collect and track data collected from the river <ul style="list-style-type: none"> ◦ Communicate the importance of a long-term data set and its role in water monitoring • Identify other methods used to measure water quality <ul style="list-style-type: none"> ◦ How does pH, phosphate & nitrate, and riparian vegetation reflect water quality? • The importance of river systems <ul style="list-style-type: none"> ◦ Ecosystem services such as sediment transportation, water supply, wildlife habitat, etc. ◦ The wildlife and habitat the Ompompanoosuc sustains • Climate Change <ul style="list-style-type: none"> ◦ What is happening? ◦ How are rivers impacted? <ul style="list-style-type: none"> ▪ Displacement, dead zones, eutrophication, stress disease (Lakes and Rivers 2011)

Appendix J. Envirothon

The Vermont Envirothon is a very cool event that works to connect students with the natural environment. We thought that this could be a cool idea for a potential field trip or even participation in the competition held in May.

<http://www.vacd.org/envirothon>

Appendix K. Ottauquechee NRCD Stream Table

The stream table is a device used to learn about river systems- specifically water, erosion, and culverts. The table can be rented to use for educational purposes and is available for rent from the Ottauquechee Natural Resources Conservation District. The main contact person is Larry Kasden. His email is LarryKasden@gmail.com or visit onrcd.org for more information. Mary Childs has noted that she would be happy to help orient you, the teachers, or the class in how to set it up, its functions, and how it models our watersheds.

Appendix L. Aerial Geographic Maps

This resource is an online mapping tool showing Vermont's natural resources. It could serve as a great learning tool to accompany lectures or engage students in homework assignments.

<http://www.anr.state.vt.us/site/html/maps.htm>

Appendix M. Thetford Academy Student Survey

TA ENVS Class Student Survey

We will be using your responses to help in designing new projects for the TA Environmental Sciences courses which focus on researching and monitoring the Ompompanoosuc River.

* Required

Why did you elect to take Environmental Sciences? *

What is your favorite part of the current Environmental Sciences class? *

If you could change one thing about the current Environmental Sciences course, what would it be? *

Would you prefer the class to be focused on individual or group projects? *

Of the following projects, which sounds interesting to you as a long-term research project? *

Select multiple if

- Measuring E. coli levels
- Measuring pH, mineral and trace element levels
- Mapping river erosion patterns
- Surveying trees and phenology
- Gathering macroinvertebrate samples
- Garbage and litter collection with analysis of impact on wildlife
- Mining and heavy metals in the River
- Studying riparian habitats

Do you have any additional project ideas or comments?

Appendix N. Trails Deliverables

After multiple meetings with Chris Schmidt and John Connolly, dedicated Thetford Academy teachers, we were able to learn of their goals and discuss each of our expectations for the project deliverables together. Below is a description of each consensually-built deliverable:

1. Thetford Collaborative Map

This collaborative map was built on a Google Maps platform. We overlaid the following layers of data: 1) a topography layer to be aware of overly steep or low areas that would prove difficult to hikers or be at risk for flooding, 2) a property boundaries layer, outlining the location of property owned by private landowners, state forest, and Thetford Academy, 3) an existing trails layer, including Morton-designed cross-country trails and informal footpaths, and 4) a GPS “waypoints” layer, identifying points of interest for potential educational sites or places. These layers can be activated and deactivated by the viewer. The map will also have the option to view in satellite imagery in order to observe key features like clearings, TA buildings and the river. We will also show TA how to obtain historical imagery from Google Earth that allows them to see what the area looked like in 1992 and 2006. The waypoints and trails were imported to an online format with the help of Professor Jonathan Chipman, Director of the Citrin Family GIS/Applied Spatial Analysis Laboratory at Dartmouth College.

The map also includes three scenarios for TA to access the Ompompanoosuc River, which were already described above under the "Design & Construction Timeline and Guidelines". The three proposed routes are color-coded, while all of the already existing trails share the same color. In any of these scenarios, TA could engage in some new trail work on the lower TA land; however, from observations during our site examination, there is already a usable trail within this property.

2. Trail Crew Model

In order to build the trail, Thetford Academy will need to hire students and form a trail crew that will participate in the planning and construction of the trail. A trail crew comprised of students, led by 1-2 Thetford Academy faculty members, will ensure that the trail becomes a meaningful aspect of the outdoor program culture at Thetford Academy, in addition to providing a valuable means of summer employment for Thetford Academy students.

The following information has been compiled from meetings with organizations that have successfully formed trail crews to build and maintain trails around the Upper Valley and the Appalachian Trail, including the Dartmouth Outing Club and Rivendell Academy, to provide recommendations to Thetford Academy on the best approach to the formation of a student trail crew.

a. Expenses and Timeline

The proposed trail for scenario 3, running through the TA-owned parcel of land on the lower property, will be approximately 5 feet wide and 1 mile long, which limits the total number of trail workers and man-hours needed to construct the trail, in addition to minimizing the overall budget needed for trail construction and maintenance. The most effective and efficient group size for the Thetford Academy trail crew would be between 5-7 students; with a crew this size, the trail would be able to be built in a single summer. The expected pace should be between 100 feet per day (20 feet per person per day for a 5 person crew) and 400 feet per day. If a crew of 5 students is working the trail 9 hours a day at a pace of 250 feet per day, they should expect to complete the trail in approximately 22 days. This totals 990 man hours. At a pay rate of \$10 per hour per person, the expected labor cost for the trail crew should be approximately \$9900. Pay rate, trail crew size, and

required person hours will vary depending on Thetford Academy student interest and the amount of funding Thetford Academy is able to secure through outside funding sources, such as grants.

Because the proposed trail is a simplistic and rustic walking trail that utilizes existing terrain in the forested land owned by Thetford Academy, material costs for trail construction and maintenance should be limited to hand tools such as saws, pickaxes, shovels, and rock bars.

These tool costs should only add a few hundred dollars to the overall budget (between \$200 and \$500, depending on the tools Thetford Academy already has access to).

Furthermore, the simplicity of the proposed trail will reduce costs needed for future maintenance, as all of the materials required for construction and upkeep should be able to be accessed from the surrounding forest habitat. Finally, Thetford Academy should consider reaching out to community members throughout the process of trail construction and maintenance, as volunteer work and equipment donations are feasible and realistic alternatives to reducing the overall cost of the project.

If the trail is constructed in the summer of 2016, maintenance should occur regularly throughout the first year in order to control for weathering and check for erosion (S. Kernan, personal communication, 2015). In the summer of 2017, Thetford Academy personnel (either a student working on the trail crew or Thetford Academy staff member) should walk along the trail, checking for things such as fallen branches or newly formed streams along the trail, and maintenance will be performed accordingly.

Month, Year	Task
February, 2016	Send out applications to students, advertise position
April, 2016	Receive and process applications, interview applicants

May, 2016	Select trail crew, notify applicants
June, 2016	Begin trail construction
July, 2016	Finalize trail construction
June, 2017	Thorough trail maintenance with potential second trail crew

b. Trail Crew Application and Selection

Advertisements and applications for a student trail crew should be sent out to students at least 4 months in advance of the proposed start date for trail construction and maintenance. Advertisements for the position should emphasize hard work, hands-on building experience, working in the outdoors, and fostering relationships with fellow Thetford Academy students. Advertisements for the trail crew can be distributed through word-of-mouth, emails, and fliers at Thetford Academy and via the Thetford community listserv, in addition to a promotional video advertising the project. Applications should explain all aspects of the position, including being in the outdoors for extended periods of time, mud and bugs, and lasting friendships. Applications should ask questions that ensure students understand the position, are willing and eager to work on a trail crew, and have personality traits that will facilitate work in a team.

Selected applicants for the trail crew should demonstrate a willingness to do physical work in all weather conditions, in addition to team spirit, enthusiasm, and a positive attitude that will facilitate teamwork. Students with prior experience with trail work, carpentry, safety certifications, and other skills relevant to working on a trail crew should be particularly encouraged to apply, but assume training will need to be performed on site for the crew members. In general, students should be selected based off their skill level, experience, and personality in order to form a united trail crew that will work well together.

3. Project Funding Options

	Scenario 1	Scenario 2	Scenario 3
Cost	< \$2,000	\$8,000	\$8-10,000

The primary means of funding these projects will be through fundraising efforts and grant opportunities, especially considering that Thetford Academy cannot afford to allocate capital to trails projects at this time.

We recommend that TA adopts some of Rivendell’s fundraising activities such as the annual dinner and auction and the annual trail run, which can bring in more than \$5,600 for the Rivendell Trail Crew annually. Furthermore, merchandising- such as annual trail hike shirts, and hiking gear- can also prove valuable, contributing close to \$1,000 in funding for Rivendell’s trails. Theoretically, these three fundraising efforts alone would be able to raise enough money to fund all three scenarios after only three years of fundraising. However, Thetford Academy most likely will have difficulty in matching these fundraising figures due to the fact that Rivendell is composed of four school districts and municipalities.

Because of this, the completion of trail projects is dependent upon the availability of funding and must be based on a rolling timeline largely determined by grants. For TA, there are multiple local, state, and federal grant programs that TA can potentially qualify for. The Recreational Trails Program (RTP) is a federal grant program intended for projects involving trail development, maintenance and restoration, development of trailside and trailhead facilities, creating accessible trails, acquisition of trail easements or fee acquisition of trail corridors, maps/publications, and purchase of trail-building tools. RTP specifies that educational projects are encouraged, but that organizations that apply to RTP for educational project funds should, “focus on public education efforts aimed at providing the public with information about trail safety, appropriate trail use, manage uses, allowable use(s), accessibility, and environmental protection” (Federal Highway Administration

2015). The grant requires that grant recipients begin a project upon grant approval and pay for a project's expenditures up front, then submit a request to FPR for reimbursement. Round of grants are available in October with a final deadline in February each year, and can apply for up to 80% of the project's total costs (Federal Highway Administration 2015). Recipients must then promise to provide a match of 20% of the total costs through in-kind donations, fundraising efforts, local taxes, or other funding sources.

Moreover, RTP also award mini grants up to \$1,000 for trail crews in Vermont during the summer. Application deadline is in May (in 2015, it was May 22) and grants are awarded in July. A [2015 RTP application form](#) can be found at nps.gov (Federal Highway Administration 2015)).

Secondly, the Land and Water Conservation Fund offers grants for outdoor recreation facility development and land acquisition to serve conservation. The fund provides up to 50% matching assistance to the state and local governments and it is administered by the Vermont Department of Forests, Parks and Recreation. The deadline to apply is in February (National Park Service).

Because of the stipulations of this grant program, certain modifications must be made to our proposed scenarios in order to qualify. Although TA has flexibility in these modifications, here is one way in which it can be done. Considering the picturesque and spacious picnic area by the river, this would be a great place for outdoor facility recreation development. In fact, Chris Schmidt has wanted to build a cabin at the spot on the river with his students for years now. A cabin could be used for field trips, overnight cabin trips, skiing trips, and other special events. Considering the project would also utilize federally owned land, the project would then qualify as an ideal candidate for the program. Moving forward with this option, we recommend that TA coordinate with the town of Thetford and local interest organizations in developing a project proposal to the LWCF that would benefit all stakeholders involved. This will broaden those who benefit from the project,

disperse the funding and construction responsibilities among the stakeholders, and increase the project's potential through the pooling of resources.

Thirdly, the Vermont Agency of Transportation Enhancement Grants awards activities that aid in the creation of a 'multi-modal and environmentally sustainable transportation system' that encourages non-motorized use and enhances Vermont's historic landscape and human scale of development. This includes projects such as: new sidewalks, bike paths, historic preservation, environmental mitigation, and more. To receive the grant, TA must commit to a local match of at least 20% of the total project cost. At least one-half of this (10% of total project cost) must be in cash. So assuming a total project cost of \$18,000, TA must provide \$3,600 (\$1,800 of which must be in cash) in order to receive the grant (Vermont Recreation and Parks Association 2015).

One way we can qualify for this grant is based on the bike trails that have been anonymously constructed. This grant could then be directed towards improving these biking trails - along with the foot trails. We can also qualify on the grounds of encouraging non-motorized transportation with scenario 1 and 2 connecting the campsite all the way to the river.

For grants offering technical assistance, one option is the National Park Service Rivers and Trails Program. This program is administered by Rivers, Trails and Conservation Assistance (RTCA), which supports community-led natural resource conservation and outdoor recreation projects (Vermont Recreation and Parks Association 2015). They provide technical assistance so communities can conserve rivers, preserve open space, and develop trails and greenways. To apply, must contact NPS as soon as possible before August 1 to discuss project proposal and submit intent to apply. Completed application is due August 1 (National Park Service 2015).

Overall, one of the first and most crucial steps moving forward is to begin the application process for these relevant grant opportunities because these grants will dictate when these projects can be funded and, thus, completed.

4. Marketing Video

To boost excitement, a marketing video showcases the enjoyment and the educational opportunities of outdoor recreation to be had by students and the Thetford community. The motto and theme of the video is “learning outside”. An important part of Thetford Academy’s dedication to the environment is student involvement in order to gain a new respect and relationship with nature that may not be possible through reading textbooks or in classroom. Viewings will excite students about the exploration of a new means of studying while garnering support from parents and other community members. Support, both through trail crew donations and increased stewardship while utilizing the trails, will add to the community and increase the quality of both the experience and maintenance of the trails. The video has a short plot of two students daydreaming of nature until a fellow classmate asks: “Do you want to learn outside?” The remaining portion highlights our group’s enjoyment of the Thetford Academy woods. Unfortunately, this version of the video does not highlight current students experiences in nature. This edition is just the beginning, to be viewed as a template to be renewed yearly or as a working model to be added annually as a nature video journal entry. The modern teenager is constantly with their phone and the camera capabilities of the device will make adding videos and photos to chronicle their recreational and educational adventures in the woods easy. The final screen reads, “What will you learn next?” urging students and others alike to take advantage of the woods behind. The video will be an essential part of the project because it will help both raise fund and recruit members to help build the trail.