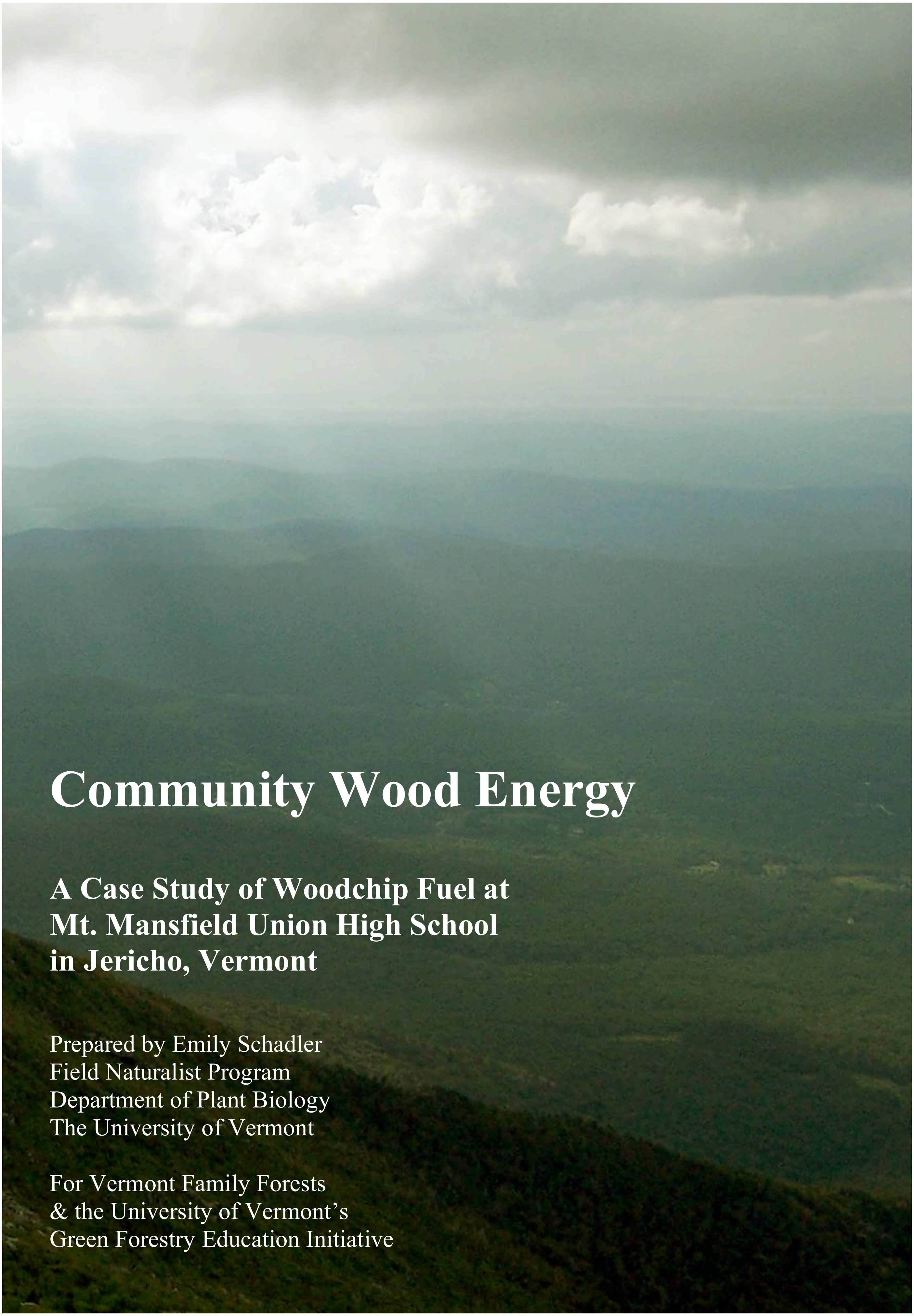

Community Wood Energy

A Case Study of Woodchip Fuel at Mt. Mansfield Union High School in Jericho, Vermont

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I. Background

As we face the realities of peak oil, climate change, and growing worldwide energy demands, the discussion about where our energy will come from in the absence of fossil fuels often turns to biomass fuels—fuels made from living or recently living biological matter. In Vermont, the primary form of biomass fuel available is wood, which is currently utilized for fuel in the form of cordwood, wood pellets, and woodchips. The latter, woodchips, has been a growing source of biomass wood fuel over the past 20 years, in part due to a push for public schools to install woodchip boilers through the Vermont Fuels for School Program[1]. Today, more than 30 public schools, as well as other facilities such as North Country Hospital and the state offices in Waterbury, heat with woodchips, while a number of other woodchip-heated facilities are expected to come online in the upcoming few years. In 2008, Middlebury College, for instance, plans to begin heating its campus with woodchips, significantly increasing the volume of woodchips used for heating in the state (Biomass Assessment Team of Vermont Family Forests, 2004).

Woodchips heat a growing number of facilities in Vermont, including over 30 public schools.

[1] Vermont Fuels for Schools is a collaboration among BERC, the Vermont Superintendents Association's School Energy Management Program (SEMP), and three state agencies: the Vermont Department of Education; the Vermont Department of Public Service; and the Vermont Department of Forests, Parks, and Recreation.

With this increasing demand for woodchips, the supply of woodchips in Vermont is starting to shift from a byproduct-based supply to a primary product-based supply. Previously, most of the woodchips in Vermont came from sawmills that produce chips from the slabs and other waste associate with their lumber production. Many of these mill residue chips are sold to pulp mills, but many also now go to the woodchip heating market. Because they are byproducts, these mill residue chips are dependent on the lumber industry. Over the past few years, however, as the demand for woodchips has been increasing, mill activity in Vermont has been gradually decreasing (Sherman, 2007b), resulting in a tightening supply of mill residue chips.

Therefore, Vermont's supply of woodchips is starting to shift toward bole chips, which are produced from the boles—or main trunks—of trees, rather than from sawmill byproducts. This shift could have significant implications for the forests of Vermont, as people begin to harvest wood specifically for the woodchip heating market. With rising fossil fuel costs and concerns about climate change, it is also likely that the demand for other forms of fuel wood, such as cordwood, wood pellets, and whole tree chips for energy generation, will also continue to rise in the future, further increasing the pressure on the forests for fuel wood.

While Vermont certainly has forest from which to harvest fuel wood, the supply of wood in the state is not endless. Consider that, according to the most recent available Forest Inventory and Analysis data, the total annual growth of Vermont's growing stock is estimated at 167,000,000 cubic feet/year. Growing stock refers to trees that are at least 5 inches in diameter at 4.5 feet above the ground. Therefore, with a cord being approximately equal to 80 cubic feet, the total annual growth of growing stock in Vermont is roughly equivalent to 2,087,500 cords/year. Given that Vermont has a population of 624,000 people, the annual per capita production of wood is about 3.35 cords/person/year. Consider also that 56% of this wood is already harvested to meet the current demand for wood (including fuel wood), which leaves just 1.5 cords/person/year available to satisfy any increase in demand for fuel wood.[2]

Therefore, the challenge arises to establish a system for procuring and utilizing fuel wood that addresses our fuel needs while benefiting (or at least maintaining) rather than degrading the health of Vermont's forests and the communities that depend on them for wood products, ecosystem services, and recreation.

In response to this challenge, Vermont Family Forests and the University of Vermont Rubenstein School's Green Forestry Education Initiative have developed the Vermont Eco-Wood Energy Project, which presents a Community Wood Energy model for procuring and utilizing fuel wood (Brynn, 2006). This Community Wood Energy model focuses around 4 central strategies that can be summarized by the acronym SELF: sustainable production, efficient use, local sourcing, and fair access. At the time that this study began, the Community Wood Energy model for woodchips was still in a largely theoretical stage, but one promising pilot project was underway in Bristol, Vermont,

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[2] The most recent available Forest Inventory and Analysis data is from 1997. 2006 data, representing 70% of Vermont FIA plots, is expected to be available in late February 2008, but state wood utilization specialist Bob Degeus reports that this data contains errors that are in the process of being worked out. A comprehensive state report is expected to be published in the spring of 2009.

dealing with the woodchip supply to Mt. Abraham Union High School. This study was undertaken as a compliment to the Bristol pilot, as explained in the Purpose section below.

While the scope of this study and the Vermont Eco-Wood Energy project is local, it is important to note that the idea of Community Wood Energy is gaining national attention through the 2007 Farm Bill, currently still under debate in the US House and Senate. Advocates such as the Northern Forest Alliance and Senator Patrick Leahy (D-VT) have been working to install funding in the energy section of the bill for Community Wood Energy projects that use low-grade biomass in community wood energy systems for state and locally owned businesses (Patrick Leahy, 2007). The funding, if included in the final version of the bill, will likely be administered through the USFS, and could play an important role in establishing various Community Wood Energy projects across the country.

These hardwood boles will be chipped and used as heating fuel.

II. Purpose

The purpose of this document is to examine the woodchip harvesting, delivery, and usage system at Mt. Mansfield Union High School in Jericho, Vermont to determine the opportunities and constraints around applying the Community Wood Energy model of sustainable production, efficient use, local sourcing, and fair access (SELF) to the school's woodchip system. While a pilot program of Community Wood Energy has been underway at Mt. Abraham Union High School in Bristol, Vermont, that project benefits by having two of the major woodchip producers in the area—Clare Lathrop's (which currently produces bole chips) and the A. Johnson Company (which currently produces mill residue chips)—located within 1 mile of the school itself. Mt. Mansfield Union High School, on the other hand, is more typical of many of the other woodchip heated schools in Vermont in that it does not currently have as much of the available infrastructure to employ the Community Wood Energy model as Mt. Abraham Union High School does.

Therefore, the broader goal of this case study is to add to the growing body of knowledge and experience that will help other woodchip heated schools to understand the challenges and opportunities that the Community Wood Energy model may present for their own situation.

III. Study Area

A. Mt. Mansfield Union High School

Mt. Mansfield Union High School (MMUHS) is housed in the Chittenden East Supervisory Unit and serves approximately 1,000 students from 5 towns in Chittenden County, Vermont: Jericho, Underhill, Richmond, Huntington, and Bolton. The school building is single-leveled and sits on a 150,000 square foot footprint. The current woodchip boiler was installed in 1997, replacing an electric heating system, and can burn bole chips in addition to mill residue chips. While no recent efforts to improve heating efficiency in the building have been undertaken, a heat efficiency test conducted in 2006 rated the building as highly efficient with leakage problems around some windows (Masson 2008). The school uses approximately 800 tons of woodchips per year and relies almost completely on woodchip heating from mid-October through Mid-May, using its back-up oil heating only when the woodchip heating system temporarily shuts down and for hot-water heating outside of the heating season.

The woodchip boiler at Mt. Mansfield Union High School uses 800 tons of woodchips during each heating season.

The 800 tons of woodchips that the school requires for heating each year is equivalent to approximately 320 cords of wood, or to the boles (main stems) of 1600 trees that are 10 inches in diameter at 4.5 feet off the ground.

Two other schools in the Chittenden East Supervisory Unit, Camel's Hump Middle School and Brown's River Middle School, are also heated with woodchips, but these schools require mill residue chips and are not able to utilize bole chips. Other schools within 20 miles of Mt. Mansfield Union High School that use woodchip heating (mill residue or bole chips) include Westford Elementary (12 miles), Champlain Valley Union High School (15 miles), and Burlington High School (20 miles). South Burlington High School and Frederick Tuttle Middle School (17 miles) and Milton Elementary, Middle, and High Schools (17 miles) are currently on a waiting list for state aid for woodchip boiler construction. Aid has been approved from the state for the South Burlington schools, although at the time of writing, a town debate ensues regarding whether or not to approve installation of the woodchip boiler.

B. MMUHS's Current Woodchip Supply System

- **Suppliers**

MMUHS currently purchases the approximately 800 tons of woodchips that it uses during each heating season from two woodchip suppliers: Claire Lathrop's and the A. Johnson Company. During the 2005-2006 heating season, 80% of the chips came from Clare Lathrop's, a land clearing and wood chipping company in Bristol, Vermont that supplies bole chips. 20% of the chips came as mill residue chips from the A. Johnson

Company, a sawmill also located in Bristol, Vermont. In the past, MMUHS has purchased chips from other companies, but the school now primarily deals with Lathrop's and the A. Johnson Company. Neither company signs more than a 1 year contract with the school at this point, based on the rising cost of chips and the fluctuating supply (Masson, 2007).

Doug Masson, the head of the MMUHS's maintenance department and their woodchip boiler operator, deals directly with these companies to secure a steady supply of chips. Doug prefers the quality of mill residue chips, which are cleaner and more uniform in size than bole chips, but he recognizes that nearby Brown's Trace Middle School and Camel's Hump Middle School, whose systems can't use bole chips, need the tight supply of mill residue chips more urgently (Masson, 2007).

During the 2005-2006 heating season, MMUHS paid $45/ton (or $112/cord) for woodchips delivered into the storage bin at the school. When the school originally started heating with woodchips 10 years ago, the price was $16/ton (or $40/cord) (Masson, 2007).

- **Clare Lathrop's**

Lathrop's had operated as a sawmill until 2003, when a fire caused significant damage to the mill. Rather than rebuild the mill, owners Jim and Claire Lathrop decided to convert their business to land clearing, wood chipping, and firewood processing using much of their remaining infrastructure. Lathrop's clears land for many purposes, including residential and commercial developments, pastures, orchards, vineyards, and wildlife habitat improvement. Roughly 50% of the wood that Lathrop's chips currently comes from his land clearing operations, while the other 50% come from timber stand improvement efforts (treatments to improve the growth and composition of forest stands), 5-15% of which is on his company-owned property (Lathrop, 2007).

Lathrop's is currently one of just two businesses in Vermont that produces bole chips and delivers them to schools. They now own 2 chippers (one 27 inch Morbark chipper and one 22 inch Morbark chipper) and 2 live-bottom tractor-trailers that can deliver chips to schools. Their previous mill site in Bristol includes yard space where they can store logs during the non-heating season and a covered space large enough to store 4-5 loads of chips at once. Lathrop's chippers are portable; Jim regularly transports his chipper to the International Paper pulp mill in New York to chip wood for their boiler (C. Lathrop, 2007). It costs Lathrop's $5/ton to chip, and they can chip a load (~22-26 tons) in approximately ½ hour (J. Lathrop, 2007).

This covered storage space, with concrete floors and an open front, allows Lathrop's to store 4-5 loads of chips, making the schedule for the transportable chipper more flexible.

Up until this point in time, Lathrop's has produced chips exclusively from logs harvested during its land-clearing operations and harvesting on the company's own land. Because of the growing demand for bole chips, however, the company is planning to begin purchasing logs from outside loggers for chip production in the near future, potentially in 2008 (J. Lathrop, 2007). Part of this increased demand for chips from Lathrop's comes from Middlebury College, which plans to convert to woodchip heating in 2008 and will purchase 1500 tons of chips from Lathrop's through mud season (J. Lathrop, 2007).

Lathrop's currently supplies chips to MMUHS, Mt. Abraham Union High School in Bristol, and Burlington High School in Burlington and serves as a back-up supplier for a number of other schools. The bole chips that Lathrop's producers are not debarked or screened but are fairly regularly sized (C. Lathrop, 2007).

- **The A. Johnson Company**

The A. Johnson Company operates as a full sawmill in Bristol, Vermont. The company produces mill residue chips as a byproduct of its lumber operations for International Paper (which receives 70% of A. Johnson's chips) and for the school woodchip heating market (which receives 30% of A. Johnson's chips) (Sayre, 2007). A. Johnson's does not own a transportable chipper capable of producing bole chips at this time, but rather owns a stationary chipper that can handle slabs and smaller pieces of waste wood from the lumber operation. The mill residue chips that A. Johnson's produces are debarked, screened, and very uniform at roughly the size of a matchbook each. It can take a full day to produce one load of mill chips, since they are a byproduct of the lumber operations (J. Lathrop, 2007).

Of the lumber that A. Johnson deals with, 15-20% comes from its own company land, 30-40% comes from purchased stumpage, and 40-60% comes from logs purchased on the open market (Sayre, 2007). The company is enrolled with the Sustainable Forestry Initiative (SFI), an organization that certifies enrolled landowners as practicing sustainable forestry.

The A. Johnson Company currently produces mill chips as a byproduct of its lumber operations.

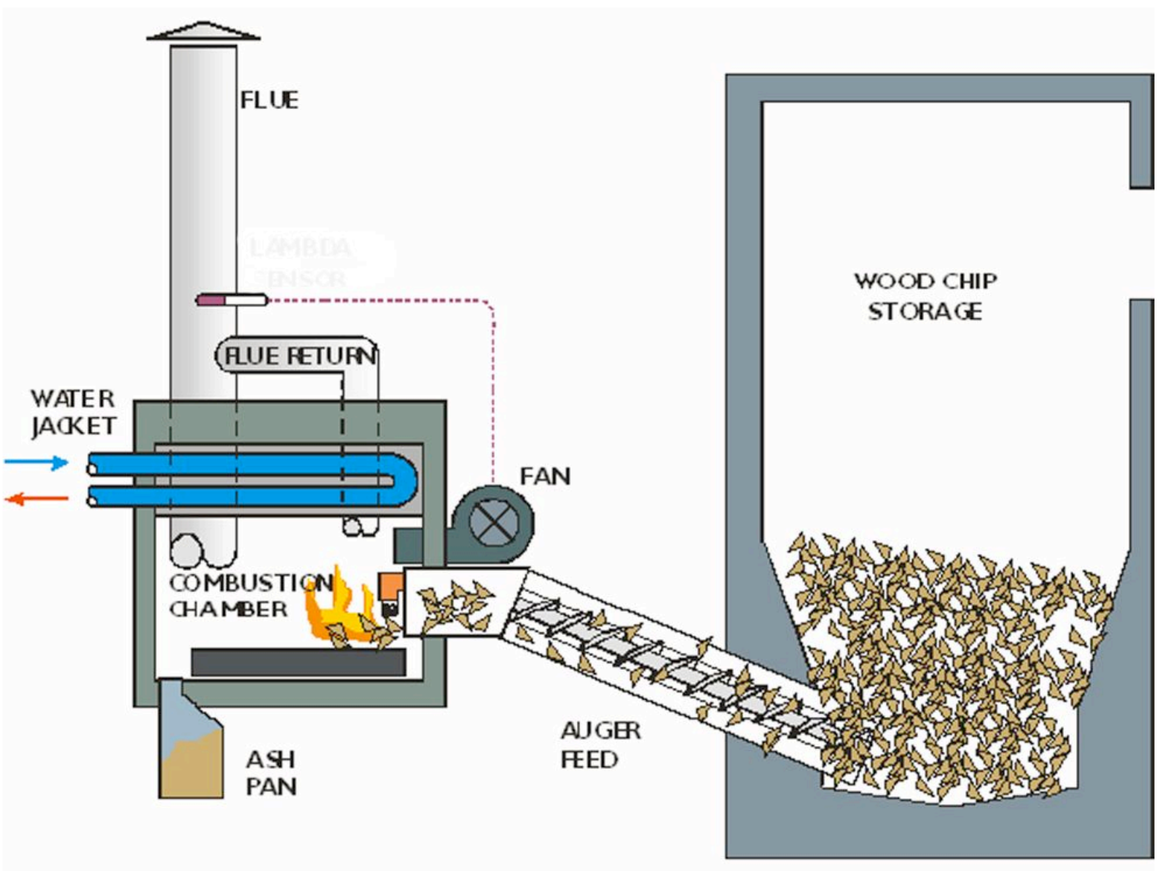
- **Delivery**

When MMUHS needs chips, Doug calls Lathrop's to request a delivery. The truck used to transport chips is a live-bottom tractor-trailer that automatically unloads the chips when the driver backs the truck up to the storage bin at the school. Each delivery of chips from the supplier weighs roughly 22-26 tons. The woodchip storage bin at the school can hold up to 2 loads of chips at a time. When it is over 0 degrees F, the school requires approximately 1 load of chips/week to be delivered. When the temperature drops below 0 degrees F, the school can require up to 4 loads/week (Masson, 2007). Lathrop's and A. Johnson are each approximately 30 miles from MMUHS. Drivers must consider limitations such as road weight restrictions and time of day that the school requires delivery (often early in the morning, before students arrive) when planning their delivery routes (Johnson, 2007). The round-trip delivery drive takes approximately 3 hours. The cost of trucking is approximately \$3/mile (Johnson, 2007).

A tractor-trailer holds approximately 22-26 tons of woodchips. Mt. Mansfield Union High School requires 1-4 truckloads of chips per week throughout the heating season.

- **The Boiler**

MMUHS uses a Messersmith industrial-sized woodchip boiler. The entire boiler system is automated, with a series of conveyer belts that move the chips from a storage bin and through the combustion process. The only manual components of the boiler system are the ash removal (6.25 pounds of ash per ton of woodchips) and occasional cleaning and maintenance. The boiler system rarely shuts down; it handles bole chips better than other models because of its use of conveyer belts instead of augers, which allow for more irregularly-sized chips to pass through without jamming the system (Messersmith, 2007). The heat created by the boiler is transferred to water, which circulates through radiators in the school to heat the building.



Generalized design of a wood chip boiler system showing primary components: storage bin, auger feed, combustion chamber, flu, and ash pan. Note that this figure is not an exact replication of Mt. Mansfield Union High School's boiler. (Sketch courtesy of Renew Project).

IV. Woodshed Analysis

A. Current Woodshed

The term "woodshed" refers to the area in which wood flows from the forest to its utilization point—in this case, as biomass fuel for heating MMUHS. Unlike watersheds, which are defined solely by the topography that determines where water flows, woodsheds are defined by ecological, social, and economic factors.

Currently, the woodshed for MMUHS extends far beyond the borders of the 5 towns that attend the school and even beyond the borders of Chittenden County. Because Lathrop's takes their land-clearing jobs up to 75 miles away from their Bristol location (C. Lathrop, 2007), woodchips going to MMUHS may be coming from forests of up to 100 miles away, many of which are not being managed as forests but rather are being cleared for conversion to other types of land use.

Two of the central strategies to the Community Wood Energy model are sustainable procurement and local sourcing. Toward that end, this study attempts to define a new woodshed for MMUHS that provides a suitable land base for sustainable procurement and local sourcing. Admittedly, "local" is a relative and somewhat ambiguous term; to limit the distance traveled from the school, this study will consider local in the context of 5 and 10 mile radius circles from MMUHS.

B. Methods for Analyzing the Potential Woodshed

An ecological woodshed analysis was conducted to identify the suitable forestland for providing sustainably procured wood for woodchip production within 5 and 10 mile radius circles around MMUHS. This analysis based its rationale and methods on those used by the Biomass Fuel Assessment for Middlebury College (Biomass Assessment Team of Vermont Family Forests, 2004). ArcGIS software at the University of Vermont was used to conduct the analysis. Layers used in the analysis are shown in Table 1.

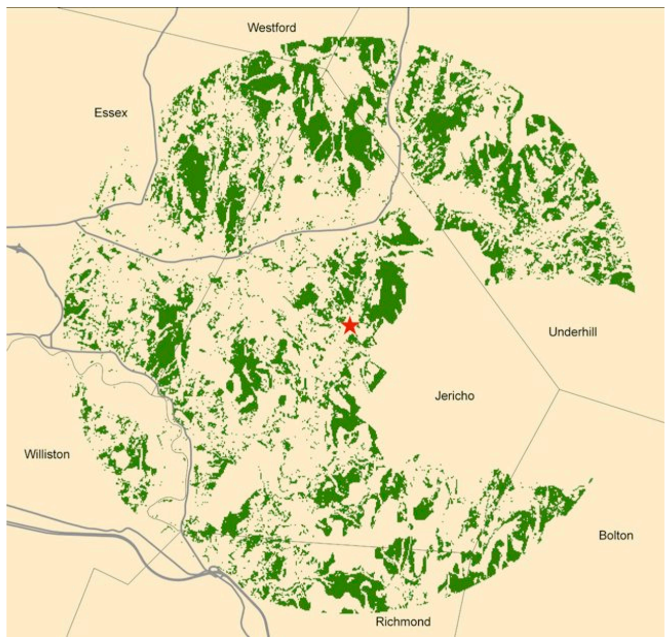
Table 1. GIS data layers used in the woodshed analysis.

Category	Layer Title	Data Source
Land cover	LandLandcov_LCLU2002	Vermont Center for Geographic Information (VCGI)
Boundaries	BoundaryOther_BNDHASH	VCGI
Slope and elevation	ElevationDEM_DEM24	VCGI
MMUHS location	EmergencyE911_ESITE_point	VCGI
Surface waters	WaterHydro_VHDCARTO	VCGI
Soils	GeologiSoils_SO	VCGI
Publically conserved lands	Cadastral_CONSPUB_poly	VCGI
Wetlands	WaterWetlands_VSWI	Agency of Natural Resources
Conservation status	cldshp_dec04	UVM Spatial Analysis Lab

Land suitability criteria were based on elevation, slope, soil type, distance from surface waters, land ownership, legal protection status of conserved lands, and forest cover type. The area of suitable land was calculated for circles of 5 and 10 mile radii from MMUHS. Land that was excluded through this analysis included slopes of greater than 60%, soil types 6 & 7 (considered to have limited forestry potential, while soil types of 1-5 were considered harvestable), elevations of over 2,500 feet, non-extractable conserved land, publicly owned lands, land within 75 feet of water bodies, and coniferous forests (although mixed coniferous and deciduous forest was included). Following the analysis, 10% of the total area of suitable forest within each circle was subtracted in order to account for sensitive features (such as seeps and vernal pools) and forest roads, which were not able to be extracted through the analysis itself.

C. Woodshed Ecological Analysis Results

Maps 1-3 in the Appendix show the results of the woodshed analysis. As shown in Table 2, the woodshed analysis suggests that a total of 11,451 acres of suitable forest exist in the 5 mile radius circle, while a total of 48,844 acres exist in the 10 mile radius circle. When 10% of the area is subtracted to account for sensitive features and forest roads not previously accounted for, the totals come to 10,306 acres in the 5 mile radius circle and 43,960 acres in the 10 mile radius circle.



The extent of suitable forest within a 5 mile radius of Mt. Mansfield Union High School (marked by the red star) is shown here in green. See the Appendix for the full set of maps.

Table 2. Acreage of suitable forest available for fuel wood harvesting in 5 and 10 mile radius circles from MMUHS.

Distance from MMUHS	**Total acres of suitable forest**	**Subtracting 10% for sensitive features and forest roads, total acres of suitable forest available**
Within 5 mile radius circle	11,451	10,306
Within 10 mile radius circle	48,884	43,960

D. How Much Wood Would the Woodshed Grow?

Knowing the total number of acres that would be suitable forest land for providing chips within 5 and 10 mile radius circles from MMUHS is one key piece of information for analyzing the school's woodshed. The second piece is to determine how many acres are necessary to produce enough wood to supply the school with 800 tons of woodchips per year over the long term. In this case, the following formula was used to calculate total acreage necessary to provide MMUHS with woodchips over the long term:

F/((((A/B)/C) x D) x E)) = total acres needed, where:

Symbol	Figure description	Value used
F	Volume of woodchips used by school per year	800 tons
A	Cubic feet of net annual growing stock on Vermont forest land	167,000,000 cubic feet/year
B	Cubic feet per cord	80 cubic feet
C	Acres of forest land in Vermont	4,600,000 acres
D	Tons of wood per cord	2.5 tons
E	Percentage of growing stock not currently being harvested	44%
Total acreage of suitable forest needed to heat MMUHS:		**1,602 acres**

Values for this calculation were drawn from the Vermont Forest Inventory and Analysis (FIA) 1997, which generalizes over the entire state of Vermont; specific county information for net annual growing stock may vary. Additionally, growth rates and forest acreage may have changed since the 1997 inventory (see footnote 2). It should also be noted that this calculation does not distinguish between low-grade wood, which typically goes to fuel wood markets, and high-grade wood, which typically goes to lumber markets. Because the calculation was based on net annual growth of growing stock, it only takes into account trees that are 5 inches in diameter or more at breast height (4.5

feet off the ground). Given these situations and assumptions, **the total acreage of 1,602 acres should be considered the best guess using available data.**

Combining the results from the ecological woodshed analysis and the woodshed growth calculation, it is clear that there is just over 6 times the needed suitable forest present within the 5 mile radius circle, while the 10 mile radius circle holds just over 27 times the amount of needed forest (Table 3).

Table 3. Suitable forest available and demanded in the woodshed to supply wood for MMUHS's woodchip boiler.

Suitable Forest	Acres
Supply	
Within 5 mile radius circle	10,306
Within 10 mile radius circle	43,960
Demand	
Needed to supply MMUHS with 800 green tons of woodchips/year	1,602

V. Applying the Community Wood Energy Model

The Community Wood Energy model presents a number of challenges and opportunities for MMUHS's woodchip supply system, many of which are not specific to MMUHS and will be applicable to other schools and facilities as well. Although they are significantly intertwined, the challenges and opportunities are presented below in three categories: economic, ecological, and social.

A. Economic Challenges and Opportunities

- **Lack of Local Chipping Facility**

As mentioned before, the two chip suppliers to MMUHS are currently located approximately 30 miles away in Bristol, Vermont, which means that chip deliveries travel 60 miles round-trip and take roughly 3 hours each. One chipping facility, Green Mountain Chipping, exists closer to MMUHS in Underhill. Green Mountain Chipping produces whole tree chips for Burlington Electric's McNeil Power Plant, but in previous conversations, Green Mountain Chipping has not shown interest in supplying chips to schools (Sherman, 2007a). The lack of a chipper within 10 miles of MMUHS poses one of the most significant challenges to the Community Wood Energy model. Without a local chipper or system for utilizing a portable chipper (see Alternatives section below), even locally harvested logs would have to be shipped elsewhere to be chipped and then shipped back to the school. Moving wood this way would use high amounts of fossil fuels and disconnect the local loop from forest to producer to customer.

➢ Infrastructure to Establish a Chipping Facility

At this time, it would be challenging to establish a chipping facility capable of producing high quality bole chips in the MMUHS woodshed in the near future due to high investment costs. A new bole chipper costs around $400,000-$480,000, while used ones are available at around $180,000. New live bottom trucks cost around $45,000, while used ones are available around $10,000-$15,000 (J. Lathrop, 2007). Other pieces of necessary equipment include bucket loaders, grapplers or other equipment for handling logs, and scales if logs are to be purchased from outside loggers. To make a bole chip akin to the quality of mill residue chips, additional equipment, including a debarker and a screener, would also be necessary. Infrastructure necessary for chip production includes a storage area for the chips, preferably off the ground and covered, and a storage area for round wood waiting to be chipped.

This Morbark chipper, owned by Lathrop's, can chip boles of up to 27 inches and can cost up to $480,000.

Even sawmills, which have some of the existing infrastructure necessary for handling wood, would need to invest a significant amount of capital to begin producing bole chips (Johnson, 2007). The A. Johnson Company estimates that it would cost their facility—which already has trucks and storage areas— nearly $1.5 million to establish the infrastructure for producing mill-quality bole chips, which they could sell to both the school and pulp mill markets. To make this investment worthwhile, the price of bole chips would need to rise from its current price of around $40-45/ton to $70-$80/ton, and the demand for chips would need to be less seasonal than it currently is (Johnson, 2007).

- **Scale and Seasonality**

In terms of scale, woodchip demand is widely dispersed across the state. Each public school uses only 500-1000 tons of chips per year, with the larger facilities, such as Middlebury College and the state office complex in Waterbury, using significantly more but also being dispersed. Within 20 miles of MMUHS, just 5 other schools use woodchips, with 4 more currently proposed. This dispersal, combined with the high cost of infrastructure, poses a challenge for establishing local chipping facilities.

Additionally, woodchip demand for the heating market is seasonal, from Mid-October to Mid-May, leaving 5 months of the year with no demand. Bole chips could also be sold to the paper industry for fueling their steam boilers or for pulpwood (if they were debarked and screened), but pulp mills tend to pay significantly less for chips than schools (Sayre, 2007). Additionally, like the lumber industry, the paper mill industry in New England is declining; in 2006, 2 of the region's 4 paper mills closed (Sherman, 2007b). Chips can also be used in combined heating and power facilities (CHPs), which offer a more year-round demand.

One large facility, Cousineau's of Henniker, New Hampshire, specializes in producing mill-quality bole chips for the heating and paper industries, but Cousineau's ships chips throughout New England in order to operate at a profitable scale.

- **Price**

As the price of chips rises (from $16/ton in 1997 to $45/ton in 2007) due to increasing demand and other factors, it may indeed reach the $70-$80/ton that A. Johnson's suggested would allow a company like theirs to produce bole chips. Under Community Wood Energy, it may be the case that the price of chips actually needs to rise in order to account for the cost of sustainable forestry, fair payment to loggers, and fair access. Our current economic system does not account for ecosystem services (see "Valuing Ecosystem Services" under Social Opportunities and Constraints section) or factors such as the value of local sourcing or external costs such as funding for the Iraq war to secure a fossil fuel supply. This situation makes it a challenge to price chips so that these factors are accounted for and so that they are still an attractive fuel choice for schools or other facilities compared with other options.

It should be at least recognized that the price of woodchips, or any type of fuel, impacts school budgets, which are measured against the cost of fuel from the previous year (Nassau, 2007). Schools without woodchip heating systems currently cannot consider converting to woodchip heating if the conversion does not pay itself off in fuel cost savings, because the state only offers financial aid for the conversion if it is economically feasible. Therefore, as long as the price of chips remains significantly below the price of fossil fuels, as it has done in the past, schools may continue to convert. This situation is likely, because even as the cost of chips rises, the cost of heating oil has been rising as well and will most likely continue to do so. But if the price of chips rises above the price of fossil fuels, conversion will not be economically feasible for schools, and they will not be permitted to convert to woodchip use. It should be noted that the feasibility study conducted for Middlebury College's woodchip plant put sustainably procured chips at a price higher than that of fossil fuels (Biomass Assessment Team of Vermont Family Forests, 2004).

The price of chips is rising, but may not yet be high enough to account for forest-based ecosystem services, sustainable forestry practices, and fair compensation.

- **Alternatives**

If it is not possible to establish a local chipping facility to shorten the forest to processor to customer loop near MMUHS in the near future, as the above economic challenges indicate may be the case, then the following alternative strategies may be useful:

1. **Establishing a log/chip storage yard** near the school to which a portable chipper periodically visits and processes chips. Being near to MMUHS and eager to

promote the Community Wood Energy model, the Jericho Research Forest and Conservation Center is an obvious option for this storage yard location. Although the idea of chipping off-site for schools has not been proposed to Jim Lathrop, his business does periodically transports its chippers to the International Paper facility in New York to chip there.

This option provides a positive way for Community Wood Energy to move forward in the absence of a local chipping facility, but it also poses a number of questions in itself that must be addressed before moving ahead. Some of these questions include:

The Jericho Research Forest could potentially serve as a storage yard for local fuel wood.

- Would it be an economically and ecologically feasible option to store logs on site and hire a chipper to periodically travel to the site and chip?
- Who would be in charge of managing the chip and log storage system?
- Who would be in charge of coordinating chipping dates, supply, and delivery to the schools?
- How would the chips be transported to the school when needed?
- How would the chips be stored in the interim to prevent rotting and freezing?

If a group did decide to move ahead with the idea of a log/chip storage yard, at the Jericho Research Forest and Conservation Center or elsewhere, they could also consider working with the Community Supported Forestry Firewood Program (Middlebury College Environmental Studies Senior Seminar, 2006), as both projects would share some of the same equipment and infrastructure needs.

2. **Clustering woodchip heated facilities and addressing seasonality issues** so that a larger demand exists in a concentrated area, providing a stronger market for potential chip producers. This is a long term option that depends on larger trends far beyond MMUHS and even beyond the school heating market. The small clustering of schools that currently exists within 20 miles of MMUHS could grow to include non-school buildings if the woodchip market continues to develop. Additionally, although none of the current schools do so, it is possible to use woodchips as a fuel for cooling systems and for combined heating and power systems (CHPs) (Johnson, 2007), thereby reducing the issue of seasonality for woodchip heating. Adjusting the woodchip demand schedule so that it ran throughout the year instead of from October to May would make it easier for chip providers to work with schools.

3. **Simply accepting the absence of a nearby chip producer and proceeding with the Community Wood Energy model otherwise.** In this case, loggers would

harvest sustainably from local forests and sell the fuel-wood quality logs to Lathrop's when that company begins to purchase logs from outside loggers. This option presents obvious drawbacks in that part of the woodchip system would be removed from the local woodshed, and that the carbon footprint of the woodchips would be higher than ideal due to transportation from local forests to Bristol and back to MMUHS. On the other hand, benefits of this option include that:

- It would allow for local, sustainable harvesting to begin occurring in the MMUHS woodshed, if local landowners could be found who were willing to participate in the program and if loggers could be found to do the work sustainably.
- Local, sustainable harvesting for woodchips would provide a means for people to connect with those local forests through the Community Wood Energy model, through educational activities with the schools and community as well as citizen-based forest monitoring.
- If/when it becomes feasible to establish a local chipping facility and/or storage and chipping yard, a system and support for local, sustainable harvesting will already be in place.

4. **Reducing fuel demand through efficiency and conservation**, so that the school requires less wood overall to heat the same building. Efficiency and conservation are essential to addressing our energy challenges, regardless of the facility type or the fuel used. Efficiency measures improve the ability of the building to use all of

the heat available in the wood and to retain that heat, such as good insulation, sealed windows and pipes, and running the boiler so that it extracts as much energy from the wood as possible. Conservation measures reduce energy demand through turning down the thermostat and encouraging people to wear warmer clothing while in the building. MMUHS rated highly on a heat efficiency test conducted in 2006 and maintains their woodchip boiler with care (Masson 2008), but further investigation into improving efficiency and conservation in the building would be beneficial.

B. Ecological Challenges and Opportunities

- **Amount of Local Suitable Forest**

As the woodshed analysis showed, an estimated 1,602 acres of forest are needed to provide MMUHS with woodchips over the long term, while an estimated 10,306 acres of suitable forest exist within 5 miles of the school and an estimated 43,960 acres of suitable forest exist within 10 miles of the school. The fact that the forest is there—over 6 times the needed forest within just 5 miles of the school and 27 times the needed forest with 10 miles of the school— provides an opportunity to harvest locally. It may even provide the opportunity to expand local sourcing to other schools within this area, such as Camel's Hump Middle School and Brown's Trace Middle School. (It should be noted, however, that these two schools currently require cleaner mill quality chips to burn, while MMUHS is capable of using less uniform bole chips). See "Identifying Landowners and

Forests for Harvesting" in Social Challenges and Opportunities section for more discussion on this point.

- **Long-term Ecological Monitoring for Forest Health**

In the woodshed analysis, estimates of how much fuel wood the forests around MMUHS can provide have been made using best guesses of forest growth rates and sustainable guidelines. These numbers have not been tested on the ground. Therefore, it will be important to conduct ecological monitoring in the forests that provide MMUHS's fuel wood to ensure that harvesting is not depleting forest health, and to correct that depletion if it does occur. A healthy forest is one that is capable of renewing itself after a disturbance, such as harvesting. In healthy forests, soil is not compacted or eroded, streams and water bodies are clean, species diversity is high, and resilience against exotic species and pests is high. Additionally, healthy forests sequester and store the same amount or more carbon than is being removed from them during harvests. Having data available to show that Community Wood Energy maintains or contributes to forest health, either at MMUHS or at other schools, may contribute to larger discussions about the impacts of increased harvesting for fuel wood across the state (Monastersky, 2006).

Engaging citizens in ecological monitoring can provide a strong connection between forests and the communities that use the forest. The challenge will be to establish a system for gathering meaningful data about forest health through citizen science, and then to ensure that such monitoring continues from year to year, through an on-going effort by a club, class, or organization.

Interest at Mt. Abraham Union High School in Bristol has already been shown by students and teachers in becoming involved in this type of monitoring, and Vermont Family Forests has started to create a simple system for training students to monitor forest health (Camara, 2007). While no students at MMUHS participated in monitoring this year, the Senior Environmental Seminar at the school (taught by Dan Tolle in 2007-2008) expressed interested in the idea, and it is likely that other groups or classes in the school would be interested given the opportunity. The School Partnership Program conducted at MMUHS by the Vermont Youth Conservation Corps is also a strong candidate for ecological monitoring, based on the ease with which they can travel off-site, their commitment to educating through meaningful, hands-on experiences, and their enthusiasm for the week-long woodchip education program conducted for them in the fall of 2007.

MMUHS students work through the Vermont Youth Conservation Corps School Partnership Program to complete hands-on, field-based projects that could include forest heath monitoring.

- **Carbon Budgeting**

It is probable that the carbon emissions related to woodchips vary based on which course the Community Wood Energy program takes at MMUHS and elsewhere. Knowing the carbon budget for procuring, processing, delivering, and using woodchips is an important piece to understanding the ecological sustainability of woodchips. How does this carbon budget compare to that of importing and using fossil fuels instead of woodchips? What is the carbon cost of shipping locally harvested wood to Bristol to have it chipped, as compared to bringing a chipper to a nearby log/chip storage yard for chipping? Carbon budgeting continues to be challenging task, due to our still-developing knowledge about carbon emissions, and it may be helpful to find a professor or graduate student with experience with carbon budgeting to assist with creating carbon budgets for woodchips. To my knowledge, no one has yet undertaken a carbon budget study on woodchips production, but one graduate student at the University of Vermont, working under Jen Jenkins, is currently conducting a carbon budget study on transportation-based biomass fuels in Vermont.

- **Harvesting Constraints**

According to the foresters and loggers consulted for this study, it is not possible to harvest fuel quality wood without harvesting higher-quality wood in the same job; the low-quality fuel wood simply does not pay its way out of the forest at this point (Anderson, 2007; Sayre 2007; Snyder 2007; Torrey 2007). In other words, landowners can currently make more money by taking less wood—but higher quality wood—out of their forests. In the future, the price of fuel wood may rise so that it is economically viable to harvest low grade wood alone, but until then, any harvesting for fuel wood will also mean harvesting higher quality logs as well. This situation presents an ecological restriction, in that forests selected as harvesting sites need to contain enough high quality logs to subsidize the low quality log harvest. This restriction was not able to be accounted for in the woodshed analysis.

- **Chain of Custody**

Following the chain of custody of wood harvesting through the Community Wood Energy model during chipping and delivery will initially present a challenge to MMUHS and other schools. Because no chipping facility currently exists exclusively for one school or one cluster of schools, it will be difficult to provide a school with 100% sustainably procured woodchips from their own local forests. Chipping facilities such as Lathrop's and A. Johnson's take in logs from many different sources and would find it difficult to separate out wood from one specific forest or logger (Johnson, 2007; J. Lathrop, 2007). Therefore, as long as logs are chipped at these types of facilities, it may be unreasonable for a school to guarantee that 100% of the woodchips actually entering its boiler come from its local forests through the Community Wood Energy model. Instead, it may be possible to say that the Community Wood Energy wood feeds a certain percentage of the chipping facility's overall chip production, or that local Community Wood Energy produces enough wood to cover the school's annual fuel consumption, even though those specific chips may not make it back to the school's boiler.

C. Social Challenges and Opportunities

➢ Identifying Landowners and Forests for Harvesting

Recruiting landowners who both own parcels of suitable forest and who are interested in working with the Community Wood Energy project will be an essential step in establishing the system. These landowners will need to be willing to manage their land sustainably and to experiment to a certain degree as the program works itself out. Additionally, the landowners will ideally be willing to have students and/or other citizens visit their property for educational and ecological monitoring purposes, although this is not a necessity.

In the case of identifying and enlisting private forests, it may be simplest to work through the existing infrastructures of the Use Value Appraisal program and of Vermont Family Forests. Through the Use Value Appraisal program, forested properties of over 25 acres with active forestry management plans can be identified on a town-by-town basis. Although there is not currently a map of these properties, Chittenden County Forester Mike Snyder has extensive knowledge about these properties and may be able to provide assistance in identifying leads. Through Vermont Family Forests' Certified Ecoforestry program, private forest owners can commit to sustainable forestry standards

Existing programs such as Vermont Family Forests' Certified Ecoforestry program or the state's Use Value Appraisal program provide pre-existing infrastructure for working with private landowners.

based on materials and standards that Vermont Family Forests has compiled, a process that may aid in more easily ensuring sustainable management.

The forests in the Community Wood Energy program do not need to be exclusively private, however. Another option would be to harvest some of the wood from local town forests; the Vermont Town Forest project through the Northern Forest Alliance has discussed integrating their program with Community Wood Energy projects (Turner, 2007). At this time, the Jericho Conservation Commission has expressed disinclination toward harvesting wood from Mobb's Farm, which is the nearest town-owned forest to the school, for woodchip production (Gray, 2007).

A third option would be to work with the Jericho Research Forest and Conservation Center to arrange for some of the wood to be harvested from this forest. This option would be particularly beneficial to the Jericho Research Forest and Conservation Center if it provided opportunities for UVM forestry students to gain experience in the process.

- **Finding the Right Loggers for the Job**

Logging is a dangerous and often difficult profession, and the declining number of new loggers entering the field while the current generation of loggers ages has caused concern for the profession (Torrey, 2007). Loggers often have a difficult time paying for their costly machinery and health insurance on the incomes that logging brings them. Among the dwindling number of loggers, only some have the equipment and skill to complete logging jobs to strict sustainability standards. The use of smaller machinery and

Using smaller machinery and forwarders, such as the one shown here, rather than skidders, can greatly reduce the impact of logging on a forest.

forwarders, as opposed to skidders, decreases impacts on forests, including soil compaction and erosion, water quality degradation, and residual stand damage, but not all loggers work with forwarders. Adherence to standards regarding what to harvest, when, and where improves forest health, but not all loggers will be familiar with or attentive to these standards.

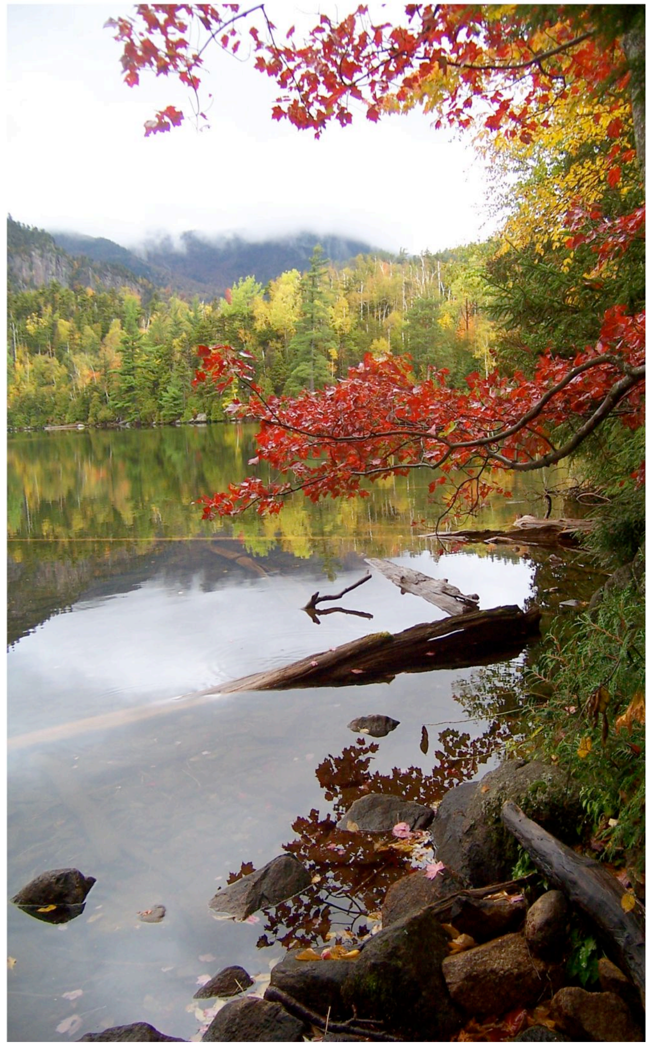
While Community Wood Energy may provide valuable work for loggers, it may also be challenging to find loggers willing and capable doing that work, at least initially. This may be true particularly if the number of Community Wood Energy projects grows beyond the capacity of the loggers who do currently work with forwarders and strict sustainable harvesting techniques. In the long run, though, it is possible that as Community Wood Energy projects and similar efforts offer more fair compensation to loggers for sustainable harvesting, the profession may become more attractive to a new generation of loggers.

- **MMUHS School Attitude**

The teachers, students, and administrators at MMUHS were all extremely receptive to the integration of woodchip education into lessons and activities at the school. The school offers environmental studies courses and encourages hands-on and placed-based learning opportunities wherever possible. Principal Jen Botzojorns was highly supportive of introducing woodchip education into the school's science classes (Botzojorns, 2007). Teachers Katy Meyers, Dan Tolle, Mark Keffer, and VYCC School Partnership Program teachers Sara Hays, Zac Gilhooley, and Lisa Passarello were all eager and willing to open their classrooms to woodchip education programs in the fall of 2007. Doug Masson, operator of the woodchip boiler at MMUHS, was also extremely helpful in educating students about their school's fuel supply. The openness and positive attitude toward woodchip educational activities was highly encouraging in terms of engaging students and teachers in the Community Wood Energy model.

- **Valuing Ecosystem Services**

A broader-scale social challenge arises in the way that people value the services that our forests provide, such as water and air filtration, soil development, biological diversity, carbon sequestration, and recreation. Currently, the price that people pay for fuel wood does not reflect these services. Through the transition from oil to biomass fuels, we must also make the transition to economic and social values that account for ecosystem services and allow us to tend forests sustainably and support local economies. At the same time, we must shift social trends to reduce our fuel consumption overall and increase the efficiency of the fuel that we do use (Brynn, 2006; Degeus, 2007). People cannot simply envision woodchip fuel—or any biomass fuel—as simply a substitution for oil or other fossil fuels. At its heart, the Community Wood Energy model is a model of social, economic, and ecological transformation, which is a sizable challenge for the Community Wood Energy model not just at MMUHS, but across Vermont and beyond.



Forests provide valuable ecosystem services, such as water and air filtration, that are not currently reflected in the prices of fuel wood.

VI. Conclusion

As a new model with no precedent to follow, Community Wood Energy faces challenges as it paves the way toward creating a sustainable, efficient, local, and fair system for producing fuel wood, as shown in the case of Mt. Mansfield Union High School. Some of the challenges arise at a local scale, such as the need for a way to locally chip wood and the need to find interested landowners to participate in the program. Other challenges, such as the need to change the way that people value ecosystem services and practice fuel efficiency and conservation, are wider societal changes that will only occur through the combined efforts of many groups and initiatives. The Community Wood Energy model can be an important piece of the effort to move that change forward.

At the same time, opportunities to progress with the Community Wood Energy model, or at least with pieces of it, presented themselves through this case study as well. The fact that Lathrop's intends to begin purchasing logs from other loggers for chip production is an opportunity in itself, allowing for local logs to be sold to and chipped by Lathrop's, the company that already delivers MMUHS's woodchips. The ample presence of suitable forest for sustainable fuel wood harvesting within 5 and 10 miles of the school opens the door for many different options for local harvesting sites, and even allows for consideration of drawing other local woodchip heated schools into the discussion. The openness of teachers, students, and administrators at MMUHS to bringing woodchip-related activities into the classrooms provides an opportunity to meaningfully engage citizens in the Community Wood Energy model.

Regardless, it seems that if Community Wood Energy is to move ahead at MMUHS at this point in time, compromises may need to be made, at least initially, given the significant obstacle of the lack of a local chipping facility. While the Community Wood Energy model would ideally have MMUHS keep the entire process local—from forest growth to fuel combustion—, the lack of a local chipping facility poses a challenge for keeping the system 100% local. Instead, wood may need to be shipped from local forests to Lathrop's in Bristol to be chipped and then delivered back to the school, at least until a system for chipping locally is devised (such as using a storage yard and portable chipper). Another compromise would be to think in terms of the wood procurement option that involves the lowest total carbon emissions, which may mean harvesting from forests close to Lathrop's rather than close to MMUHS. Such a compromise could reduce the amount of transportation needed between harvesting, processing, and delivery to MMUHS. Given that Mt. Abraham Union High School is already working to develop a Community Wood Energy program in Bristol near Lathrop's, MMUHS's Community Wood Energy program could be coupled with Mt. Abe's. On the other hand, though, this option would remove the local forest from near MMUHS, reducing the opportunities for local community engagement.

Given that many schools are likely to face the similar challenge of starting without local chipping infrastructure when considering Community Wood Energy for their site, figuring out which compromises are feasible and still remain most closely aligned with the Community Wood Energy model is a challenging but valuable task.

Additionally, moving forward with pieces of the model now allows may better prepare us to take advantage of future opportunities that arise to fulfill and/or improve the model.

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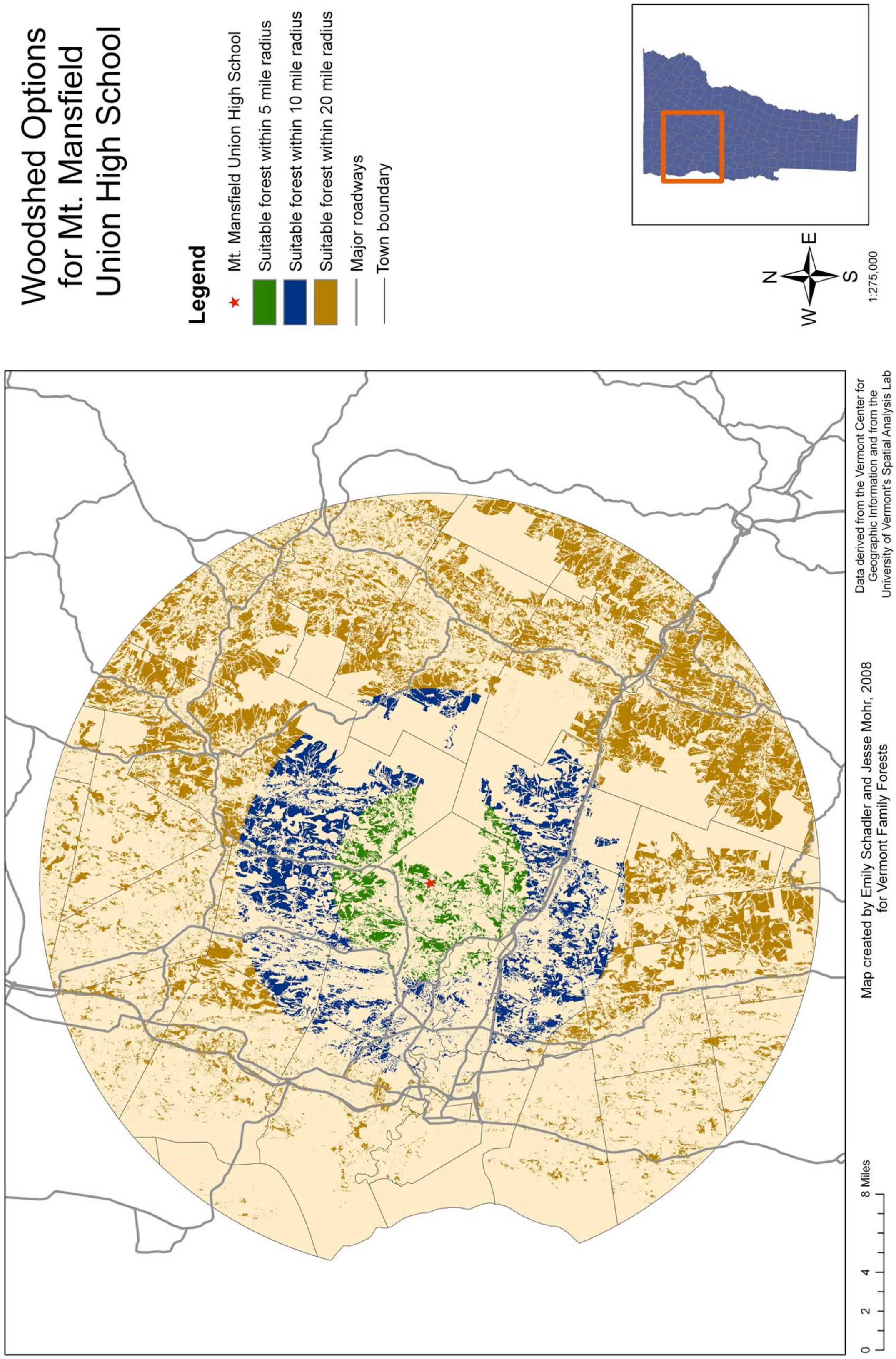
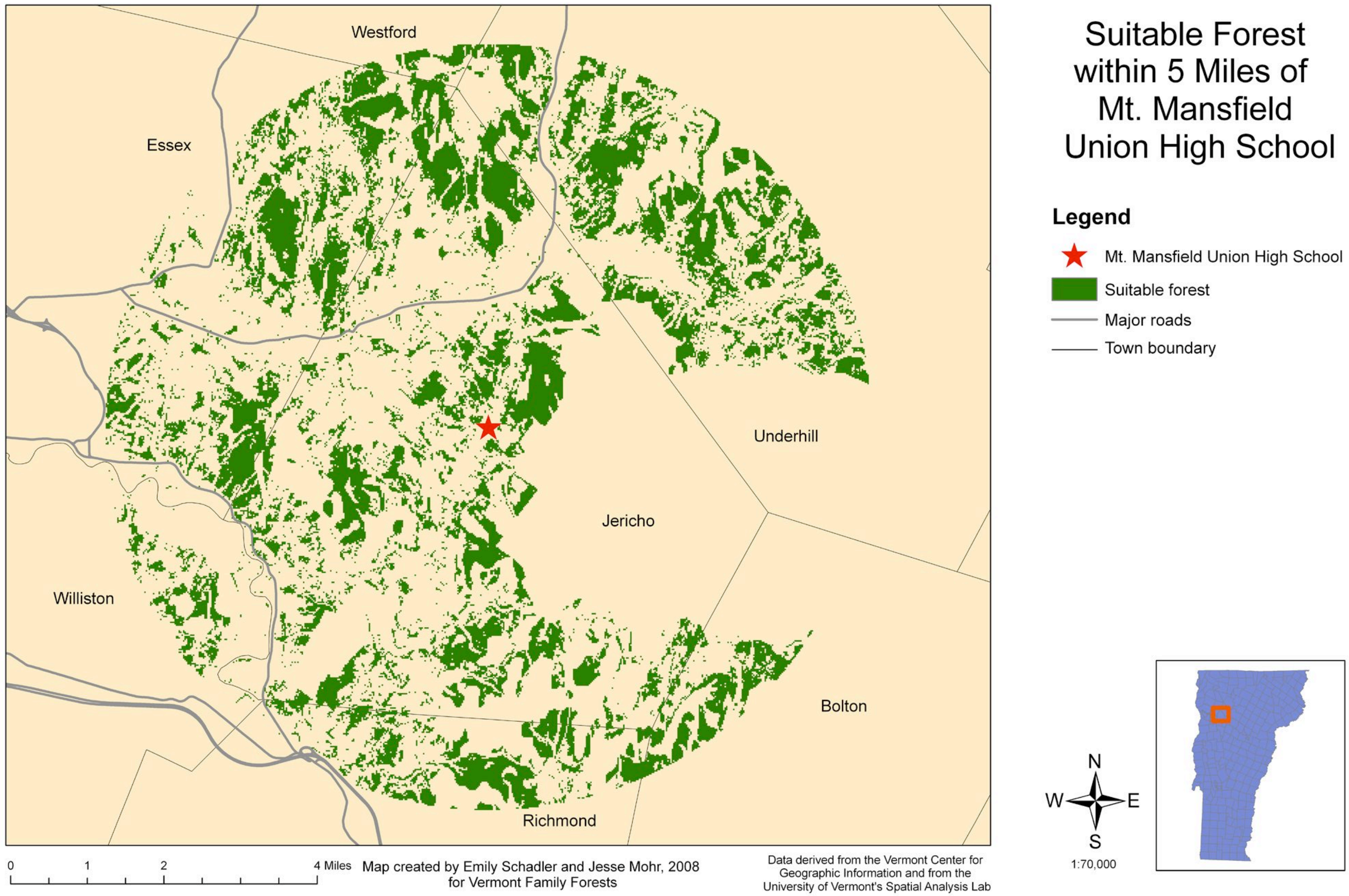
Appendix: Maps of the Potential Woodshed for MMUHS




Suitable Forest within 5 Miles of Mt. Mansfield Union High School
Legend
Mt. Mansfield Union High School
Suitable forest
Major roads
Town boundary
Westford
Essex
Underhill
Jericho
Williston
Bolton
Richmond
0
1
2
4 Miles
Map created by Emily Schadler and Jesse Mohr, 2008 for Vermont Family Forests
Data derived from the Vermont Center for Geographic Information and from the University of Vermont's Spatial Analysis Lab
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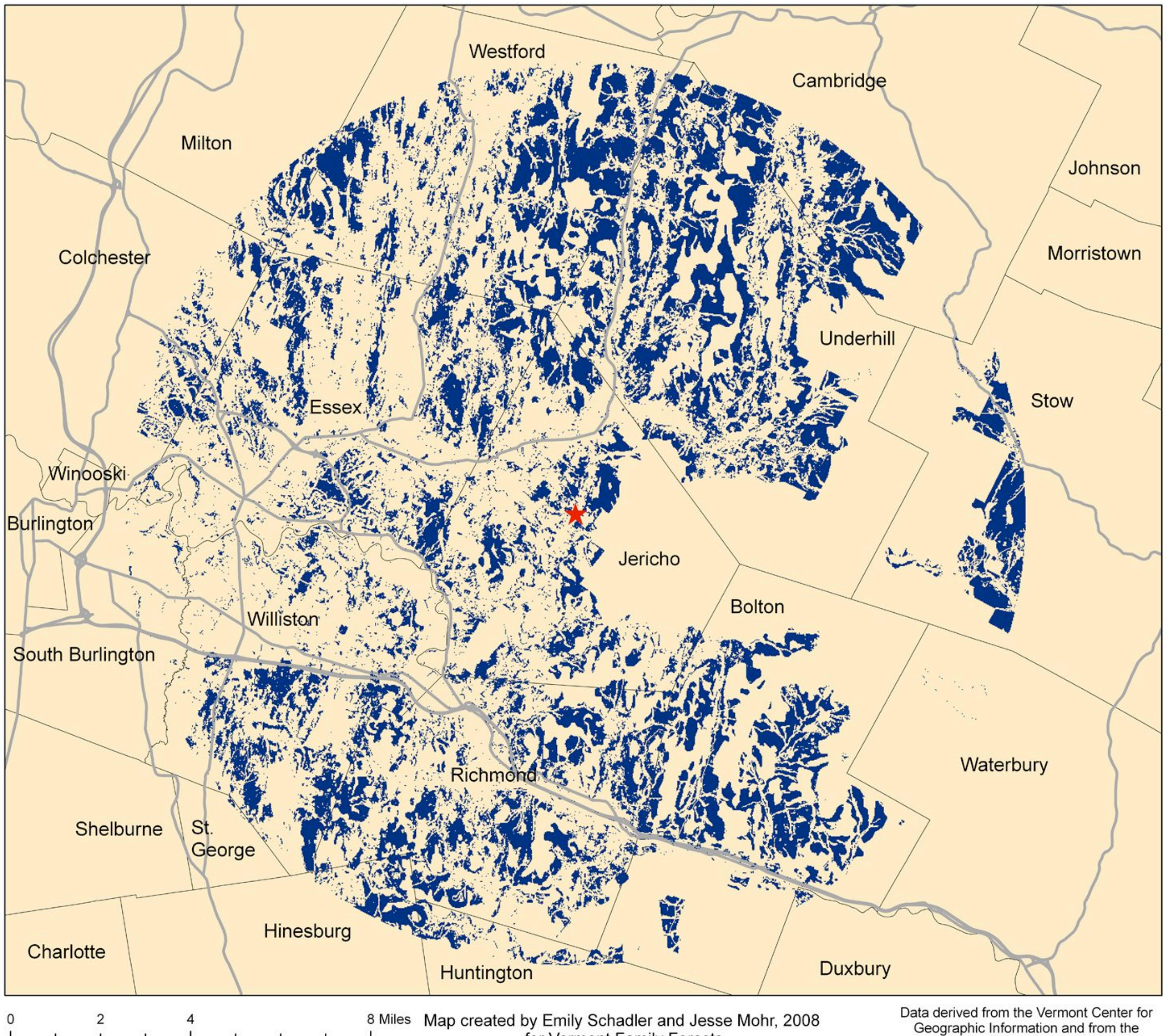
Suitable Forest within 10 Miles of Mt. Mansfield Union High School

Legend

★ Mt. Mansfield Union High School
Suitable forest
Major roads
Town boundary



Map created by Emily Schadler and Jesse Mohr, 2008
for Vermont Family Forests

Data derived from the Vermont Center for Geographic Information and from the University of Vermont's Spatial Analysis Lab