# FINAL TECHNICAL REPORT

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**Subcontractors:** Massachusetts Department of Conservation and Recreation

**Cost-Sharing Partners**: Massachusetts Clean Energy Center; formally Massachusetts Technology Collaborative / Renewable Energy Trust

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**Final Scientific/Technical Report**

**MASSACHUSETTS SUSTAINABLE FOREST BIOENERGY INITIATIVE**

**DE-FG36-06GO86019**

**Massachusetts Department of Energy Resources**
**September 2011**


**PROJECT TEAM**

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Team Collaborators: Robert Rizzo, Bioenergy Program Coordinator
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## EXECUTIVE SUMMARY


In the state's Electricity Restructuring Act of 1998, the Commonwealth of Massachusetts recognized the opportunity and strategic benefits to diversifying its electric generation capacity with renewable energy. Through this legislation, the Commonwealth established one of the nation's first Renewable Energy Portfolio Standard (RPS) programs, mandating the increasing use of renewable resources in its energy mix. Bioenergy, meeting low emissions and advanced technology standards, was recognized as an eligible renewable energy technology.

Stimulated by the state's RPS program, several project development groups have been looking seriously at building large woody biomass generation units in western Massachusetts to utilize the woody biomass resource. As a direct result of this development, numerous stakeholders have raised concerns and have prompted the state to take a leadership position in pursuing a science based analysis of biomass impacts on forest and carbon emissions, and proceed through a rulemaking process to establish prudent policy to support biomass development which can contribute to the state's carbon reduction commitments and maintain safeguards for forest sustainability.

The Massachusetts Sustainable Forest Bioenergy Initiative (SFBI) was funded by the Department of Energy and started by the Department of Energy Resources before these contentious biomass issues were fully raised in the state, and continued throughout the substantive periods of this policy development. Thereby, while SFBI maintained its focus on the initially proposed Scope of Work, some aspects of this scope were expanded or realigned to meet the needs for groundbreaking research and policy development being advanced by DOER.

SFBI provided DOER and the Commonwealth with a foundation of state specific information on biomass technology and the biomass industry and markets, the most comprehensive

biomass fuel supply assessment for the region, the economic development impact associated with biomass usage, an understanding of forest management trends including harvesting and fuel processing methods, and the carbon profile of utilizing forest based woody biomass for the emerging biomass markets. Each of the tasks and subtasks have provided an increased level of understanding to support new directives, policies and adaptation of existing regulations within Massachusetts.

The project has provided the essential information to allow state policymakers and regulators to address emerging markets, while ensuring forest sustainability and understanding the complex science on CO2 accounting and impacts as a result of biomass harvesting for power generation. The public at large and electricity ratepayers in Massachusetts will all benefit from the information garnered through this project. This is a result of the state's interest to provide financial incentives to only biomass projects that demonstrate an acceptable carbon profile, an efficient use of the constrained supply of fuel, and the harvest of biomass to ensure forest sustainability.

The goals of the Massachusetts Sustainable Forest Bioenergy Initiative as proposed in 2006 were identified as:

- increase the diversity of the Massachusetts energy mix through biomass;
- promote economic development in the rural economy through forest industry job creation;
- help fulfill the state's energy and climate commitments under the Renewable Energy Portfolio Standard and Climate Protection Plan;
- assist the development of a biomass fuel supply infrastructure to support energy project demands;
- provide education and outreach to the public on the benefits and impacts of bioenergy;
- improve the theory and practice of sustainable forestry in the Commonwealth.

Completed project activities summarized below will demonstrate the effectiveness of the project in meeting the above goals. In addition, as discussed above, Massachusetts DOER needed to make some modifications to its work plan and objectives during the term of this project due to changing public policy demands brought forth in the course of the public discourse on this topic.

We found that some tasks needed to be adjusted to meet changed conditions. Shortly after the start of SFBI, DOER recognized that establishing demonstration plots within state owned lands was not possible as the state enacted a temporary freeze on all timber harvesting on state lands, to allow for the completion of an assessment of current impacts of this activity and time to develop prudent policies on land conservation. Even more significantly, the state's energy and environmental Secretary asked DOER to place a "sustainability" criterion for biomass in the RPS regulations, and the passage of the landmark Global Warming Solutions Act in 2008 committed DOER to very carefully consider and assure that biomass energy supported by the RPS met carbon reduction thresholds aligned with the state's reduction commitments. These needs led to some adjustment of the SFBI scope and objectives to meet the policy challenges. Most notably was the funding and commissioning of the report by the Manomet Center for Conservation Sciences which provided the sustainability and carbon impact framework

necessary for DOER to move policy forward prudently. The "Manomet Study" has moved this emerging policy issue substantially forward, gained national and international significance, and provided a new look at how the forest sequesters carbon and the effect of the removal of growing stock for energy on future carbon sequestration and atmospheric flux. This activity provided information that supports the objectives of SFBI but to accommodate this work, several subtasks were combined and addressed within the framework of the Manomet research study.

The expected outcomes of the SFBI include the development of biomass energy systems that support sustainable forest management, new investment in forestry and fuel supply infrastructure, biomass energy generation that contributes to greenhouse gas mitigation, and job creation in project development and operation and in the rural forestry sector.

## PROJECT ACTIVITIES

The tasks included in the SFBI were identified to help Massachusetts understand and address the opportunity for increased use of forest based woody biomass. To prepare for and appropriately advance this development, the state needed to assess and quantify certain items including completing a comprehensive resource assessment, understand the supply infrastructure including establishing potential fuel processing methods that could be employed within the constraints of Massachusetts forest types and ownership patterns, and address the concerns that increased biomass harvesting may have on forest health and sustainability.

All publications identified in the summary are detailed in a list at the end of this report. The Initiative set out to accomplish several specific tasks, which are summarized below.

### Task 1.0 Forestry Infrastructure Development, Industry Education & Outreach

This task identified forestry technology available to process and deliver bioenergy fuel from the forest to energy facilities, and provided education and outreach regarding these methodologies to the forestry industry. Additionally, the task also completed a regional economic impact analysis of the bioenergy economy.

### Subtask 1.1 Research Harvesting and Fuel Processing/Aggregation Methods and Specify Optimal Practices

DOER completed this task as proposed. As provided in ***Publication 1***, a report was completed that investigated biomass fuel harvesting and processing equipment and methodologies and business structures. This study was conducted to provide insight into various approaches to convert forestry based biomass into suitable raw material for wood-energy facilities and to recommend specific approaches for operations located in the Commonwealth of Massachusetts. The report provides a framework for contractors to consider which harvesting and processing approach is most applicable for their operations, and makes recommendations for how the Massachusetts' public sector can promote and support in-woods biomass conversion operations. The report was made available to the biomass and forestry stakeholders on the DOER website.

### Subtask 1.2 Provide Technical Assistance to Forest Industry on Harvesting/Processing Methods

This subtask was completed as proposed. A biomass specialist was hired within the Marketing & Utilization program of MA DCR. This specialist provided technical assistance to the forestry industry for this and other subtasks. ***Publications 2 and 3*** were completed as part of this task and provide outreach both to potential new markets for the forest products industry of Massachusetts and to the general public on the energy and environmental attributes of biomass.

### Subtask 1.3 Perform Regional Economic Impact Analysis of Increased Bioenergy Development

This subtask was completed as proposed. The work was led by the University of Massachusetts and a regional economic modeling firm to complete the regional economic impact analysis. This analysis is documented in ***Publication 4*** and describes the economic impacts associated with a biomass economy consistent with the then current project development activity and the fuel supply resource assessment (Subtask 3.1). The research team developed models using the IMpact Analaysis for PLANning (IMPLAN) input-output model, to estimate economic impacts of building new biomass energy facilities in Massachusetts, compared to a business-as-usual scenario that assumes facilities contributing to the region's RPS demands are built elsewhere. The study demonstrates significant economic investment and the very real potential for all aspects of the forest products industry to benefit from increased biomass usage.

In addition to forest-based biomass, DOER recognized the potential of dedicated energy crops and analyzed the resource potential and economic impact associated with energy crops. In Massachusetts, biomass energy has typically meant wood chips derived from the region's extensive forest cover. One key feature of biomass energy crops is that they can have much higher energy yields per hectare than are available from the forest. Thus a relatively small amount of agricultural or marginal land might be used to produce a disproportionate amount of the Commonwealth's biomass energy. The attached study focused on perennial crops that can be used in solid-fuel applications, specifically willow as a short-rotation woody crop, and switchgrass as a perennial grass crop. This work is documented in ***Publication 5***. Apart from SFBI, the UMass researcher extended this analysis in his doctorate dissertation.

## Task 2.0 State Forests Resource Planning, Management and Infrastructure Improvements

This task shifted somewhat as the MA Dept. of Conservation & Recreation (DCR) initiated a Forest Visioning stakeholder initiative to evaluate potential models for forest sustainability. DCR also initiated a rulemaking process to update the MA Forest Cutting Practices Regulation to ensure forest sustainability. DOER actively participated in the above two processes but did not assume a lead role. The issue of biomass energy became a substantial topic of the stakeholder discussions and regulatory process.

This SFBI task had to be restructured due to the fact that during the project timeframe, and as part of the Visioning process, the Commonwealth placed a moratorium of timber harvesting on state owned properties until the state developed a comprehensive policy on the future

management of publically owned forestlands. This new suite of policies and directives includes set aside reserves, public parks and acreages where active forest management activities could be permitted.

### Subtask 2.1 Hire Management Forester to Assess and Target Biomass Production from State Lands

This subtask was not completed. The Governor enacted a hiring freeze for all executive agencies with the exception of essential personnel. DOER refocused efforts to address the growing concern from stakeholders and citizens of the Commonwealth to address concerns relating to public subsidies in the form of Renewable Energy Credits for biomass electrical generation. Funds were diverted from this task to expand others below to study biomass carbon accounting and forest sustainability for the purpose of establishing appropriate policy under the MA Renewable Portfolio Standard Program.

### Subtask 2.2 Establish Harvesting Areas (e.g. Quabbin) to Demonstrate Best Practices with Private Landowners

In June 2008, *A Summary of Potential Biomass Harvest Demonstration Areas* was completed and used internally to prepare for harvest areas, but never publically released because the administration enacted a freeze on all timber harvesting on state owned lands, which is still in place. The intent of the task was to address issues described earlier regarding forest sustainability with increased demand for biomass products. The concerns about forest sustainability, which surfaced in the Commonwealth while this project was underway, required DOER to re-assess this and other tasks. The restructuring of tasks led to the commissioning of an extensive study conducted by the Manomet Center for Conservation Sciences detailed in subtask 3.3 below and throughout this report. As in subtask 2.1, the balance of the originally budgets funds for this task were diverted to expand other tasks below.

## Task 3.0 Resource Assessment and Strategic Plan of Biomass Supply Infrastructure and Market

This task has met a critical need for project developers and policy makers in Massachusetts for a publicly available resource assessment of forestry biomass. The task has identified the current inventory and status of the biomass fuel harvesting equipment and supply infrastructure, and provided a vision and roadmap to achieve a supply infrastructure appropriate for the bioenergy project development potential.

### Subtask 3.1 Quantify Available Biomass Resource, Sustainable Removals, and Price

A resource assessment identified biomass fuel potentially available for the production of electricity, thermal energy or biomass-based liquid fuels. Biomass availability from a variety of sources was identified, including sustainable forestry, land clearing, sawmill residues, construction and demolition debris, agricultural residues and other sources. ***Publication 6*** provides a statewide comprehensive overview of available resources and ***Publications 7, 8, and 9*** are focused on specific regions within the state most likely to be the sites for biomass utilization.

### Subtask 3.2 Inventory Existing Fuel Harvesting/Supply-Chain Equipment and Specify Needs

DOER completed this task as proposed but merged with subtask 1.1 above due to considerable overlap in these two subtasks. ***Publication 1*** investigated biomass fuel harvesting and processing equipment and methodologies and business structures. The study was conducted to provide insight into various approaches to convert in-woods biomass into suitable raw material for wood-energy facilities and to recommend specific approaches for operations located in the Commonwealth of Massachusetts. This report also provides a framework for contractors to consider which approach is most applicable for their operations and makes recommendations for how the Massachusetts' public sector can promote and support in-woods biomass conversion operations. The report was made available to the biomass and forestry stakeholders on the DOER website.

**Subtask 3.3 Develop Strategic Plan to Establish Supply Infrastructure and Markets**

This subtask included facilitated discussions with stakeholders led by Raab Associates and a series of discussions across administrative agencies. The work resulted in an internal report entitled *Massachusetts Sustainable Bioenergy Strategic Plan*. DOER, with the Secretariat, utilized this document but never released it to the general public because of the then current need to further understand the carbon and forest sustainability impacts associated with increased utilization of forest based biomass and decision to enter into a rulemaking process.

**Task 4.0 Forest Impact Assessment with Increased Residue Removals**

The aim of this task was to compile scientific data which supports the sustainable use of our natural resource as a source of renewable energy, while at the same time improving the quality of that same resource, the forestlands of Massachusetts. Subtask 4.1 below details the completion of this task.

**Subtask 4.1 Research and Assess Impacts of Biomass Harvesting and Sustainable Removals on Forest Health**

The first part of this task assessed the levels of woody biomass fuels that exist in Massachusetts forests. At the level of the individual forest stand, the question became: what is the potential quantity of biomass fuels that can be harvested from typical sawtimber stands (70-100 years old) during a standard commercial harvest for sawlogs? At the state-wide level, the question became: what is the total annual sustainable biomass harvest from Massachusetts forests (that is, the total annual harvest level that would not exceed the total annual forest growth)?

The second part of this task reviewed key findings in the scientific research literature related to ecological impacts of increased harvesting for biomass, as is proposed for Massachusetts. The key findings from both components of this task including forest management recommendations are fully described in ***Publication 10*** and cover nutrient conservation, soil properties, streamwater and water quality, carbon cycling and storage, wildlife habitat and forest fire risk.

**Task 5.0 Forest Industry Training and Economic Development Programs**

Based on research done within this initiative on fuel harvesting, processing, and aggregation models DOER set out to train the industry on optimal equipment configurations and methodologies for biomass production.

**Subtask 5.1 Provide Industry Training Programs on Optimal Equipment Configurations for Biomass Production**

Subtasks 5.1 and 5.2 are both completed and reported out together due to the overlap in training programs developed and administered within this initiative.

A total of eleven workshops directed specifically to the forest products industry were conducted. The workshops provided a total of approximately 660 contact hours for industry to learn about specific topics to assist them in their decision making on biomass production for increased biomass utilization. The workshops provided are as follows:

- Workshop 1. *Understanding the Massachusetts Sustainable Forest Bioenergy Initiative.* This presented the findings of a number of reports generated from this project.
- Workshop 2. *Business Planning for Loggers.* Three workshops were offered throughout MA.
- Workshop 3. *Financing Workshop for Loggers*. Three workshops were offered throughout MA.
- Workshop 4. *Marketing Workshop for Loggers*. Three workshops were offered throughout MA.
- Workshop 5. *Caterpillar World Trading Corporation Financing*.

**Subtask 5.2 Identify and Disseminate Information on Economic Assistance Programs for Equipment Procurement**

See subtask 5.1 above.

**Task 6.0 Energy, Environment and Climate Integration - State Positions and Public Outreach**

The participating state agencies recognize the importance of providing sound technical information on biomass energy and the emerging project development. This task allowed the state to establish unified positions on biomass energy development and promote appropriate development through public outreach.

**Subtask 6.1 Establish State Biomass MOU on Biomass $CO_2$ Netting, State Forests Management, Emissions**

As this initiative developed it became clear that the state needed assistance in understanding the complex science of carbon accounting and the potential impacts associated with further biomass development. With this in mind, DOER contracted with the Manomet Center for conservation Sciences to lead an interdisciplinary team of researchers to undertake an analysis of currently available science and to develop modeling of increased biomass utilization from the forest. Coupled with a recent state directive to cease all timber harvesting on state owned forestlands, and increased stakeholder awareness of numerous developers seeking to install new large electrical generation only biomass facilities in the state, the development of a biomass MOU became impractical. Instead, directed by the Secretary of Energy and Environmental Affairs, DOER began a long, public input driven rulemaking process to add sustainability requirements to the state's RPS program and to establish a minimum efficiency standard and a requirement that all new biomass facilities must demonstrate a Greenhouse Gas

emission reduction within twenty years that would be 50% less than a combined cycle natural gas plant. As of the filing of this final report, this rulemaking process is not yet complete.

The report prepared by the Manomet Center and research team (***Publication 11***) provided the foundation for DOER to move forward on biomass policy development. The research delved into the potential impacts associated with increased utilization of forest woody biomass on the forest and investigated the carbon cycle associated with biomass extraction and combustion for energy. Some of the findings of the Manomet Study are contrary to traditional understanding that biomass combustion is carbon neutral. The modeling approach utilized by the team disputed the historic internationally accepted theory on the biomass carbon cycle and demonstrated that the removal of live trees from the growing Massachusetts forests for energy generation requires years to numerous decades to recover the carbon debt associated with the biomass combustion. The report illustrated that various woody biomass energy utilizations have different carbon cycles dependant on the source of the woody biomass, the relative conversion efficiency of the biomass for energy utilization, and the fossil fuel that is offset. In simple terms, the report established that woody biomass used for electrical generation only, has a potential carbon debt on the remaining forest lasting over 70 years and thus has negative impacts on reducing carbon from the atmosphere in a short timeframe. Whereas, woody biomass used for advanced thermal applications that demonstrate a very high efficiency rate may only have a carbon debt less than 7 years. Therefore, analyzing the Manomet Report and developing sound and prudent public policy on providing renewable energy incentives to those generation units that demonstrate a low carbon debt needed to be evaluated carefully. DOER has been in the rulemaking process for well over a year and has received hundreds of written comments, met with varying stakeholder groups and conferred with other state and federal agencies throughout the rulemaking process.

### Subtask 6.2 Produce Public Information Materials on Energy and Environmental Attributes of Biomass

***Publication 2*** was written as a public outreach document to demonstrate to facility managers, municipalities and others the development of a biomass energy system for facilities or as a district energy project.

In addition, a DVD video was produced: *Renewable Energy in Massachusetts: The Quabbin Reservoir Biomass Case Study*. The DVD is shown and hard copies are available to the general public at the Quabbin Reservoir Visitor Center. The video illustrates the development of the Center's biomass heating system, the importance of utilizing a locally available fuel, and the economics that led to the installation offsetting number two fuel oil.

***Publication 3*** is available on DOER's website and provides detailed information on pellet heating which is gaining in popularity throughout the northeast.

### Subtask 6.3 Facilitate Working Group to Address Biomass Issues

DOER commissioned Dr. Jonathan Raab, Raab Associates and Eric Kingsley, Innovative Natural Resource Solutions, LLC to facilitate an expert working group that was comprised of various stakeholders representing environmental organizations, non-governmental agencies, state personnel, foresters, and individuals from the forest products industry. Three meetings

were convened in March, April and June 2006. Each of the three meetings had 30 to 40 participants. The assembled groups discussed the development of a state strategic plan for biomass energy. Specific issues discussed included setting usage goals for biomass, clarifying emission standards for biomass electric and thermal projects, consideration of financial support for biomass thermal energy, the efficacy of convening a biomass consortium, replacement of heating systems with biomass, and promotion and support for the Massachusetts forest industry.

**Subtask 6.4 Systematic Public Outreach/Relations**

It became clear that MA DOER needed to better understand the carbon and forest sustainability implications of increased biomass usage. DOER determined that insufficient research was available to satisfactorily address these issues. As directed by the Secretary of Energy and Environmental Affairs, DOER commissioned a study to undertake this task. DOER contracted with the Manomet Center for Conservation to assist the state in understanding the complex science of carbon accounting, the effects of increased biomass on forest sustainability and the need to establish minimum efficiency standards for biomass generation facilities seeking public subsidies through the Massachusetts RPS program.

The findings of the Manomet Study have greatly influenced how Massachusetts will qualify electrical generation facilities for the RPS program mostly by requiring certification of sustainable forest management practices and mandating minimum efficiency standards. While controversial, MA has been recognized internationally through this work and has been in discussion with energy policy makers from several states, EPA, the US Congress, NGOs, and a few foreign countries. This important contribution of the Manomet Study to the science and policy discussion on biomass has raised the level of interest dramatically over the past year. Both DOER and the Manomet report authors have presented and discussed these results and policymaking process widely.

Throughout this initiative, the DOER and DCR engaged in a public outreach effort directed at government officials, local town governments, regional planning commissions, environmental organizations and forestry industry. To facilitate objective fact-based discourse regarding specific project development proposals, the state agencies have attempted to serve as an "honest broker" in addressing concerns and providing state policy positions and clarity on facts and risk assessment. Numerous meetings with municipal leaders have taken place leading to feasibility studies being completed. The state also conducted numerous public meetings/hearings on various topics associated with this initiative including conducting a very open and ongoing discussion on the results of the Manomet Study. DOER has spent considerable time over the last two years of this project hearing and understanding concerns from numerous stakeholders and initiating a sound and prudent rulemaking to address these concerns with science based policy. As detailed above, DOER contracted with the Manomet Center for Conservation to assist the state in understanding the complex science of carbon accounting, the effects of increased biomass on forest sustainability and the need to establish minimum efficiency standards for biomass generation facilities seeking public subsidies through the Massachusetts RPS program. It should be noted that DOER has shared all gained knowledge, stakeholder comments and various rulemaking documents on its public webpage to provide outreach. DOER has also conducted numerous public information sessions, public

hearings and met with numerous groups and individuals to solicit input and provide factual information on bioenergy.

**Task 7.0 Biomass Project and Market Development**

Although the focus of this initiative is on the development of the supply side of the biomass infrastructure, efforts were made in this task to identify, facilitate, and support new and on-going project development.

**Subtask 7.1 Low Emissions Support of RPS Eligibility Review**

Both subtasks 7.1 and 7.2 address key criteria (Low Emissions and Advanced Power Conversion Technology) statutorily required for the qualification of biomass units for the Massachusetts RPS program. At the outset of this initiative, DOER was preparing a rulemaking to revise the RPS regulations to clarify these criteria. Biomass power expertise commissioned under these subtasks provided the assistance DOER and MassDEP needed to establish and implement final guidelines to its regulation.

**Subtask 7.2 Advanced Technology Support of RPS Eligibility Review**

***Publication 12*** provides a review of the current commercially available technologies for biomass power conversion and for controlling emissions, and provides a report on the status of the marketplace, the technology advancements in the past 10-years, and potential for further advancement in each area. The work was divided into the following two tasks: Task 1 – Review of advanced biomass conversion technologies; and Task 2 – Review of conventional technologies with advanced design features.

**Subtask 7.3 Facilitate Biomass Generation Projects - Site Studies**

This task focused on biomass project applications at and for public facilities and on substantial development projects supported by the state's *Smart Growth* initiative. The task supported the completion of three feasibility studies integrating biomass thermal or combined heat and power for public facilities.

The following municipalities received feasibility studies: Pelham, Belchertown, and Ware. In addition to the financial support for municipal feasibility studies, DOER funded a feasibility study for seven DCR field offices. Two of the DCR facilities moved to project development and, though other funding sources, DOER funded the installation of two whole building automated pellet heating systems.

**Subtask 7.4 Initiate Market Development Activities**

This task was to facilitate the integration of biomass project development with the emerging forestry biomass supply infrastructure. DOER proposed to develop market outreach to project developers to connect with emerging supply chain entities (foresters supplying wood chips, aggregation facilities) to improve market conditions for improved development. It became apparent though initial research that a large gap existed in the permitting of advanced biomass thermal technologies developed throughout Europe which northeast based distributers were trying to import and install in the U.S. A major stumbling block was the lack of U.S. safety standards and certification requirements for European designed boilers. In 2009, in coordination with other northeast states, DOER commissioned a study, ***Publication 13***, to

examine the difference between European safety standards and U.S standards, and also to clarify how emission testing differs. Now with the knowledge provided in this study, DOER and numerous other northeast states are attempting to rectify these issues to assist in market development.

**Task 8.0 Project Management and Reporting**

Reports and other deliverables have been provided throughout the duration of this initiative in accordance with the Federal Assistance Reporting Checklist following the instructions included therein.

**Subtask 8.1 Project/Contract Administration and Reporting**

Reports and other deliverables have been provided throughout the duration of this initiative in accordance with the Federal Assistance Reporting Checklist following the instructions included therein.

**Subtask 8.2 Technical Management and Integration with DOE Biomass Program**

This task provided technical management of the project and attempted to seek opportunities to integrate the effort with the DOE Biomass Program. The task included travel to DOE meetings and to other venues to support the Massachusetts initiative

## PUBLICATIONS

The following list of publications and reports were developed within this project. All are electronically available through the DOER Massachusetts SFBI website cited below.

Publication 1:
RE Consulting and Innovative Natural Resource Solutions, LLC. 2007. *Forest Harvesting Systems for Biomass Production*.

Publication 2:
Massachusetts Department of Conservation and Recreation. 2008. *Wood Biomass Energy: Local Renewable Fuel for Commercial, Institutional and Commercial Facilities.*

Publication 3:
Massachusetts Department of Energy Resources. 2007. *Wood Pellet Heating; A Reference on Wood Pellet Fuels and Technology for Small Commercial and Institutional Systems.*

Publication 4:
Timmons, David, Damery, David, Allen, Geoff, University of Massachusetts, and Petraglia, Lisa, Economic Development Research Group, Inc., 2007. *Energy from Forest Biomass: Potential Economic Impacts in Massachusetts.*

Publication 5:
Timmons, David, Damery, David, Allen, Geoff. 2008. *Biomass Energy Crops: Massachusetts Potential*.

Publication 6:
Innovative Natural Resource Solutions, LLC. 2007. *Biomass Availability Analysis- five counties of western Massachusetts.*

Publication 7:
Innovative Natural Resource Solutions, LLC. 2007. *Biomass Availability Analysis- Worchester, Massachusetts.*

Publication 8:
Innovative Natural Resource Solutions, LLC. 2007. *Biomass Availability Analysis- Springfield, Massachusetts.*

Publication 9:
Innovative Natural Resource Solutions, LLC. 2007. *Biomass Availability Analysis- Pittsfield, Massachusetts.*

Publication 10:
Kelty, Mathew, D'Amato, Anthony, Barten, Paul. 2008. *Silvicultural and Ecological Considerations of Forest Biomass Harvesting in Massachusetts*.

Publication 11:
Manomet Center for Conservation Sciences et al. 2010. *Biomass Sustainability and Carbon Policy Study*

Publication 12:
Black and Veatch. 2008. *Advanced Biopower Technology Assessment*.

Publication 13:
CONEG Policy Research Center, Inc. 2009. *Biomass Boiler & Furnace Emissions and Safety Regulations in the Northeast States; Evaluation and Options for Regional Consistency.*

## MASSACHUSETTS SUSTAINABLE FOREST BIOENERGY INITIATIVE WEB SITE

http://www.mass.gov/?pageID=eoeeaterminal&L=4&L0=Home&L1=Energy%2c+Utilities+%26+Clean+Technologies&L2=Renewable+Energy&L3=Biomass&sid=Eoeea&b=terminalcontent&f=doer_renewables_biomass_bioenergy_initiative&csid=Eoeea