# GUIDANCE ON HARVESTING WOODY BIOMASS FOR ENERGY IN PENNSYLVANIA

**Pennsylvania Department of Conservation and Natural Resources**

## ABSTRACT

With 17 million acres of forestland, Pennsylvania has generated significant interest from policymakers, energy analysts, industry representatives and others looking for new sources of alternative energy. Woody biomass and cellulosic ethanol are emerging as options for producing fuel, heat, electricity and combinations of these while lowering greenhouse gas emissions and helping decelerate climate change. As stewards of the largest public forest in Pennsylvania and advocates for sustainable natural resource management, the Department of Conservation and Natural Resources (DCNR) undertook a review of the state's public and private forest resources to develop guidance on biomass harvesting that would balance the need for alternative energy sources with the need to protect forest resources for all citizens and future generations. Our review produced a number of conclusions. Current estimates of available low-grade wood for biomass harvest in Pennsylvania of 6 million tons are overly optimistic and do not adequately consider the many ecological, social, and practical concerns associated with procuring biomass. Biomass acquisition for energy production will have to compete with existing markets for pulpwood as well as overcome access, transportation, distribution, and other challenges. Responsible biomass harvesting may be best implemented opportunistically to take advantage of natural disturbances like wind damage, ice damage, pest invasions, invasive plants, and fire. Carefully planned and implemented biomass harvesting can emulate beneficial silvicultural practices like removal of competing vegetation, thinning, and reforestation of abandoned mined lands. Forest biomass use in Pennsylvania may be most appropriate on a small scale as feedstock for single-facility thermal combustion such as the "Pennsylvania Fuels for Schools and Beyond" program rather than to fuel large-scale ethanol production operations that require huge volumes of feedstock. Private forestlands will fare best under biomass harvesting scenarios if landowners carefully follow existing best management practices and get professional resource assistance. Finally, more study is needed at the state level to develop a reliable estimate of available biomass and to assess the impacts biomass harvesting will have on specific flora and fauna, nutrient availability, tree growth rates, soil, and other ecological processes.


**Best Management Practices tour at Michaux State Forest. Photo: S.Nicholas**

"The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and aesthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people." **Article I, section 27 of the Pennsylvania Constitution**

The mission of the Bureau of Forestry is to ensure the long-term health, viability, and productivity of the Commonwealth's forests and to conserve native wild plants by:

- Managing state forests under sound ecosystem management, to retain their wild character and maintain biological diversity while providing pure water, opportunities for low-density recreation, habitats for forest plants and animals, sustained yields of quality timber, and environmentally sound utilization of mineral resources.
- Protecting forestlands, public and private, from damage and/or destruction by fires, insects, diseases and other agents.
- Promoting forestry and the knowledge of forestry by advising and assisting other government agencies, communities, landowners, forest industry, and the general public in the wise stewardship and utilization of forest resources.
- Protecting and managing native wild flora resources by determining status, classifying, and conserving native wild plants.

**Acknowledgements:**

This report was developed and written by the following DCNR staff: Dan Devlin, State Forester; Jim Grace, Deputy Secretary for Forests and Parks; John Quigley, Chief of Staff; Paul Roth, Bureau of Forestry; John Hecker, Bureau of Forestry Chief of Silviculture; Sara Nicholas, Office of Policy and Planning; Seth Cassell, Bureau of Forestry; Jodie Gribik, Office of Parks and Forestry; Michael Palko, Bureau of Forestry; and Gene Odato, Chief of Rural and Community Forestry, Bureau of Forestry.

**Cover photo: S. Cassell/DCNR**

# TABLE OF CONTENTS

# INTRODUCTION

As policymakers look for a way to reduce the carbon emissions from fossil fuels and meet growing energy demands with alternative energy sources, there has been an escalating interest in Pennsylvania's forests – "Penn's Woods" - as raw material for the emerging bioenergy market. Investors and policymakers are looking at woody biomass as potential feedstock for everything from large-scale cellulosic biofuel plants to local wood-to-energy installations to heat school buildings.

Pennsylvania is both a forest-rich state and a leader in sustainably managing its forest resources. It was the first state to certify its 2.1 million acres of state forestland through the internationally recognized Forest Stewardship Council protocol. Several of the state's largest privately owned hardwoods forests are also certified. With the most diverse, most valuable temperate hardwood forest in North America, Pennsylvania has a stewardship responsibility to conserve its forest resources for multiple users and for current and future generations.

"Sustainability" can be an ambiguous term in the context of biomass because it has at least two definitions. When energy entrepreneurs speak of "sustainability," they are referring to the need for a reliable supply of cellulosic materials to fuel their bioenergy production operations. When foresters and conservationists speak of "sustainable" resources, they want to ensure that any existing and new uses of Pennsylvania's forests preserve its full range of benefits and functions, and its capacity to regenerate a healthy future forest. This guidance attempts to address both supply and conservation concerns.

DCNR undertook this project to help frame the issues surrounding the emerging biofuel industry, including existing markets, inventory, supply, demand, best practices, sustainable forest management, potential impacts, and opportunities. This document addresses biomass harvesting on both state and private forestlands. The two are treated distinctly because DCNR manages its state forestlands directly while providing management guidance for privately owned forestlands.

This document was written with two audiences in mind. The first half is a policy overview of issues, trends, concerns and opportunities designed for policymakers, potential investors and general audiences. The second half, written for forest products industry stakeholders and non-industrial forestland owners, summarizes existing harvest practices on state-owned forestlands and best management practices on private forestlands. While the guidance primarily addresses intact forestlands, it offers, where applicable, guidance for short-term rotational biofuel crops that are likely to convert open fields, Conservation Reserve Enhancement Program lands, poorly reclaimed or abandoned mine lands and others within a landscape mosaic of forested lands and agricultural fields.

**SUMMARY OF MAJOR REPORT RECOMMENDATIONS**:

Harvesting woody biomass from Pennsylvania's forests could help meet the demand for alternative sources of energy and reduce greenhouse gas (GHG) emissions, but should not compromise other important forest functions and values – including protecting water quality, critical natural areas and communities, biodiversity, recreational opportunities, and wildlife habitat.

Private forestland owners should follow accepted best management practices for timber harvests when implementing biomass harvesting on their lands, and involve resource professionals who can provide technical expertise.

Small-scale biofuel operations (requiring under 2,000 tons of biomass/year) such as the "Fuels for Schools and Beyond" program are more economically viable for Pennsylvania than large-scale operations that require larger volumes of feedstock (300,000 tons or more) annually and entail higher transportation costs.

The forest floor, including roots, stumps and below-ground biomass, should always be off-limits to biomass harvesting. This material provides too many irreplaceable functions to sustaining a healthy forest, including nutrients essential for tree growth and maintaining biodiversity.

Agroforestry operations should never replace existing natural forest. The state forest system in Pennsylvania has 98% of its land base in natural forest and thus would be off-limits to biomass plantations. Abandoned or poorly reclaimed mine sites on state forest land could be appropriate sites for plantation biofuel crops. Private lands will offer more potential for plantation biomass production but should not convert forestland or highly erodable lands.

A range of 15-30% of pre-harvest biomass – depending on soil type, forest composition and other factors – should always be left on site to buffer against nutrient depletion, erosion, loss of wildlife habitat and other factors. This would translate, for example, into leaving one out of every 3 to 6 harvested trees per acre on the forest floor.

Whole-tree harvesting may offer the potential to improve forest regeneration, aesthetics, and reduce fire hazards, but should be done with extreme care to avoid damage to the remaining forest during harvesting.

Studying Pennsylvania's existing forest products procurement stream and forest landownership patterns and preferences should be a prerequisite before initiating biomass energy operations to ensure that sustainable quantities of biomass exist to support them.

The best opportunities for biomass harvest in Pennsylvania may be natural-event driven. Disturbance from fire, wind, ice storms, insect damage and other events can create harvest opportunities that complement good silvicultural management. Biomass harvest should always include and advance practices that lead to healthy forest regeneration.

## CHAPTER 1:
## POLICY DISCUSSION

### Overview

Biomass is generally defined as any organic material that can be converted into energy. From rice hulls, corn, manure, switchgrass, wood, wood residues, algae, garbage, and many others, the list of potential feed stocks is extensive. This document will focus on woody biomass found in forests - wood material such as wood or bark, sawdust, timber slash, and mill scrap - and, to a lesser extent, on biomass from plantation crops.

The current national focus has been for corn-based ethanol production. There are, however, increasing concerns about corn and other agricultural biofuel crops impacting vulnerable ecosystems and creating competition for food resources. As a result, more attention and investment have shifted to woody biomass, and the ability to generate cellulosic ethanol from both natural forests and short rotation woody crops such as hybrid poplar or willow.

Most research to date on the potential of woody biomass as an energy and fuel source has been done on biomass from plantation crops. Unlike natural forests, biomass plantations require significant site preparation, inputs, and intensive management. While conversions of marginal agricultural land to agroforestry plantations require less capital cost and time than conversion of existing forestland, both scenarios entail environmental and economic costs.

Whether woody biomass will provide a more economically viable and environmentally sustainable means of addressing climate change and achieving energy independence depends on many things: how much of this material can we grow, access, sustainably harvest, acquire in a competitive field with other end-users, and do without compromising healthy and biodiverse future forests. To some extent, the answer comes down to an issue of scale. When confronted with the magnitude of the climate change issue, it is natural to focus on large-scale solutions such as large-scale liquid fuels production. Many of the current policy drivers for biofuel set ambitious goals of millions of gallons of cellulosic ethanol produced per year. There are, however, a whole suite of proven, affordable options for generating heat and electricity through the utilization of woody biomass at a smaller scale. There are local examples of significant cost savings when woody biomass systems replace fuel oil or natural gas. These systems are often locally supported, and provide myriad opportunities for sustainable rural economic development while providing opportunities to positively impact the regional forest resource. In the context of wood to energy, it may be the case that "small is beautiful."

## THE DEMAND FOR BIOMASS

Demand for biomass is being driven by a desire to strengthen national security through energy independence, by climate change, and by state-mandated alternative energy portfolio standards.

At the state level, interest in biomass harvest is fueled in large part by passage of Pennsylvania's Alternative Energy Portfolio Standards Act (Act 213 of 2004), which "requires all load-serving energy companies in the state to provide 18 percent of their electricity using alternative sources by the year 2020."

Higher energy prices, particularly for electricity, are also fueling the demand for new and renewable sources of energy. Most electricity consumers in Pennsylvania benefit from capped generation charges, which will be lifted by the end of 2010 in all electric service territories in the Commonwealth. The expiration of the cap on rates charged by Pike County Rate and Power resulted in a more than 70% increase in rates for customers in 2006, and similar increases have been documented in Delaware and Maryland in recent years. (Pennsylvania Public Utility Commission, 2006)[1]

At the federal level, the Energy Independence and Security Act of 2007 increased the Federal Renewable Fuels Standard (RFS) - which had called for production of 5.4 billion gallons of ethanol for 2008, rising to 7.5 billion by 2012 - to production of 9 billion gallons in 2008 rising to 36 billion gallons by 2022. Further, starting in 2016, all of the increase in the federal RFS target must be met with cellulosic ethanol and other biofuels derived from feedstock other than corn starch.

Concern over climate change has also created demand for more environmentally friendly fuel sources. Overwhelmingly, scientists agree that the principal reason for increases in average global temperatures is because of anthropogenic contributions of greenhouse gases (GHGs) into the atmosphere . GHGs inhibit the earth's ability to reflect heat away from itself, and include: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$). These gases all possess varying levels of heat-trapping capability and are expressed in carbon emission and offset discussions as emission reduction units or $CO_2$ equivalents, indicating their Global Warming Potential. For example, carbon dioxide represents a unit of one, whereas methane, on a per unit basis, has 23 times the heat trapping capability, would represent 23 units.

Pennsylvania ranks third, following Texas and California, in GHG emissions nationally. It is estimated that emissions in 2005 totaled 317 million metric tons of gross carbon dioxide equivalent, or equal to 4% of total gross US GHG emissions.[2] Pennsylvania produces 1% of total global GHG emissions.

## CARBON SEQUESTRATION

Reducing carbon emissions while maintaining economic activity and growth and avoiding the most catastrophic impacts of global warming is the essential challenge facing our society today. Although it would be convenient if there were a single solution to solve this challenge, there is widespread recognition that it will require a large number of small changes that, in the aggregate, will reduce emissions below the threshold at which the most severe consequences of global warming are expected to be triggered. Current estimates require an 80% reduction in carbon emissions by 2050 to avoid this threshold.[3]

Emissions can be reduced by energy efficiency improvements, the use of renewable energy sources like biomass, technological advances, substitution of non-fossil fuels for fossil fuel, and by capturing and storing emissions in "sinks" – the latter referred to as carbon sequestration. There are three basic types of carbon sequestration: terrestrial (storage in trees, plants, and soils), geological (storage in appropriate underground geologic formations), and chemical (combining CO2 emissions with certain substances to form other commodities – an approach that is in its infancy). Geologic sequestration, terrestrial sequestration and using biomass for energy instead of non-renewable energy sources, each can contribute significantly to reducing the Commonwealth's GHG contribution. This is described in more detail in the state's new Carbon Management Advisory Group report (2008) online at http://www.dcnr.state.pa.us/info/carbon/documents/final-report-050708.pdf.

Carbon sequestration refers to the capture of GHG. In terms of geologic sequestration, it generally refers to the capture of $CO_2$ at a point source location and the redirection of the GHG into long term storage in sub-surface geologic formations. Theoretically this process does not differ significantly from the energy industry practice of shipping natural gas via pipelines to known areas of natural gas reservoir depletion and pumping the natural gas into geologic formations for storage. Such practices are currently employed in Pennsylvania. In terms of terrestrial sequestration, plants sequester carbon as they consume CO2 during photosynthesis. Plants release carbon, however, during respiration. When plants sequester more carbon than they release, the process is a net gain for carbon sequestration.

Biomass both sequesters carbon and "offsets" nonrenewable carbon emissions. Consider a biomass plantation of willow trees. First, the trees will sequester carbon out of the atmosphere as they are growing. Secondly, their use as a fuel source will displace the use of non-renewable fuels such as coal. The willow-based fuel is renewable, since another tree can be planted in place of each willow consumed, producing a zero-sum carbon contribution to the atmosphere.

## SCALE OF OPPORTUNITIES AND OPERATIONS

The traditional approach to biomass utilization has been combustion. From a campfire to a residential woodstove to a commercial-size biomass boiler, combustion for heat has been the most common use. The range of opportunities for using woody biomass harvested in Pennsylvania varies significantly in size, scale, and product delivered. These include: straight thermal combustion, combined heat and power production, straight electricity production, co-firing with coal, wood pellet production, and the production of liquid transportation fuels. This section provides an overview of different energy production methods currently in use or on the near-horizon.

Thermal Combustion – generally referred to as biomass heating systems, thermal combustion is appropriate for schools, colleges, and medium to large scale institutions or commercial buildings. It is simply a biomass combustion/boiler system that replaces fossil fuel based boilers. These systems have higher initial costs but, with recent increases in traditional fuel prices, are averaging 5-10 year returns on investment horizons, expressed immediately in heating-cost savings annually. Systems falling within this range are the basis of a current statewide initiative within the Commonwealth, the Pennsylvania Fuels for School & Beyond working group. Consisting of over forty agencies and organizations, FFS&B is serving as an information clearing house to assist organizations considering these systems. The feedstock demands of these systems average in the range of 2,000 tons of green wood chips annually.

Straight Electricity Production – These facilities aim to deliver power to "the grid." Interest in these systems is being driven by PA Act 213, or the AEPS, in meeting the generation of 18% of the electricity load by alternative sources by 2020. Proposed systems are in the 2-8 mega-watt (MW) range. Feedstock demands vary and are related to moisture content. A system at the upper range would require an estimated 120,000 tons of green wood chips annually.

Combined Heat and Power (CHP) – These facilities are larger scale, and are often referred to as cogeneration facilities, meaning they are combustion systems that generate heat, but also generate steam which is used to power a turbine which generates electricity. A number of these facilities currently are in operation in varying locations nationwide, including Suez Energy's Northumberland Cogeneration Facility in Pennsylvania, the McNeil Station in Burlington, Vermont, and Boralex Stratton Energy, in Stratton, Maine. Feedstock demands for systems ranging from 20 - 40 MW vary from 200,000 to 400,000 green tons of wood chips per year.

Co-Firing Coal with Wood – This process involves burning coal with wood biomass in a coal fired power facility. This process achieves air quality emission reductions along with meeting the requirements of Act 213. The proportion of electricity generated from the biomass component is normally relatively small compared to the overall MW output of the facility, but the feedstock demands for accomplishing this are normally quite large, in the range of 200,000 to 400,000 green tons of wood chips annually.

Wood Pellet Production – This is a process that compacts sawdust residues into a small, concentrated fuel source. Residential pellet stoves gained popularity over the past two decades as an alternative to traditional wood stoves. There are also researchers examining the feasibility of pelletizing warm season grasses as a fuel source. Feedstock demands are dependant on the size of the operation, and such facilities are often an add-on to existing producers of saw dust.

Cellulosic Ethanol (Liquid Transportation Fuel) Production – This is a process of converting cellulose based materials into sugars and the fermentation of the sugars into ethanol. Simply stated, ethanol is 100% pure alcohol. Given the rising demands and associated costs of transportation fuels, there has been significant investment in and policy emphasis on the development of this technology to the commercial stage of production to blend with transportation fuels. The feedstock needs of these proposed facilities are at the largest end of the scale and are comparable to the demands of a traditional, large scale pulp and paper mill, with feedstock needs in the range of 325,000 to 750,000 tons for facilities that would produce 25-50 million gallons of cellulosic ethanol annually.

Polygeneration – This technology was recently developed in Austria. It employs a special fluidized bed steam gasification technology, consisting of two fluidized bed systems that are connected. Biomass is gasified with water vapor, rather than air, resulting in a nitrogen-free, low tar gas product with high calorific value. This product and its associated waste streams and effluent are fully utilized through varying conversion technologies to generate a number of energy products, including heating and cooling, electricity, synthetic natural gas, or transportation fuels. Overall efficiency (power and heat) is approximately 85%. The quantities produced of these various resources can be scaled to the needs and size of the respective region. Additional information is found at: http://www.nachhaltigwirtschaften.at/(en)/publikationen/forschungsforum/071/teil2.html

**SCALE FACTS**

One 25 million gallon cellulosic ethanol plant would need an estimated 325,000 tons of feedstock wood per year. This would require a woodshed comparable to that of a pulp mill – a 125 mile radius or more. To satisfy that demand from a hybrid poplar plantation alone, which has an estimated yield of 5 tons/acre/yr (PSU College of Agriculture), would require a 65,000 acre plantation. In terms of a natural forest, which produces between 1 and 2 tons/acre/year, it would require a forest of 162,000 to 325,000 acres to meet this need annually.

**SCALE FACTS**

A standard tractor trailer hauls twenty-tons per load. To estimate the number of tractor trailer loads needed annually to supply any of the above facilities, simply divide the average fuel needs by twenty. For example, to supply 200,000 tons a year would require 10,000 tractor trailer loads.

## WOODY BIOMASS SUPPLY

Statewide biomass estimates are periodically updated by the USDA U.S. Forest Service's Forest Inventory & Analysis (FIA). Low use wood (LUW) can be defined very generally as all trees, one inch in diameter or more, with low economic value. A more complete definition includes factors such as trees located on forestlands with a lower-than 40% slope and in stands with a density of more than 30 green tons per acre. Taking these and other factors into account, including "operability constraints," FIA states that almost 75% of LUW in Pennsylvania is found on private forest lands.

It is important to note that sustained yield estimates do not take into account the full range of factors that define a sustainably harvested resource, including social considerations, environmental protections, and future regeneration potential. As a result, a number of competing estimates for the supply of this annual LUW resource have been circulated.[1] A comprehensive, statewide, multi-variable assessment of LUW supply would be needed to more definitively answer this question, and to help current and future LUW users make business decisions based on the known level of available annual supply.

In addition, growing stock and growing conditions vary widely throughout the state. This directly influences annual biomass supply. The state average estimate of growing stock is 100 standard tons of biomass per forested acre, including all above ground material from stem to crown (limbs, branches, twigs and leaves). As a general rule, half the volume is in the stem and half is in the crown or topwood.

From a traditional forest management perspective [i.e. relying on natural regeneration instead of physically planting new seedlings], for biomass to be considered a renewable resource, the proportion of wood volume growing needs to be greater than the amount harvested in any given year. Vigorous regeneration is essential to maintain a sustainable supply of biomass, and in Penns Woods there are numerous factors that affect regeneration – from competing vegetation like striped maple and fern to deer browse to sunlight reaching the forest floor. These factors do, and will continue to have, a great impact on biomass supply.

### SCALE FACTS

If 1 million dry tons/year could sustainably supply a new cellulosic ethanol industry, it would produce 80 million gallons of ethanol. This could be used to replace a significant amount of the 90 million gallons of ethanol Pennsylvania imports to produce gasohol. It would also meet almost 10% of the Governor's proposed Penn Security Fuels Initiative that would require 900 million gallons of biofuels to be produced and consumed in the Commonwealth by 2017. However, if this production were used to entirely replace gasoline, it would supply only 6% of current consumption.

[1] One estimate has been completed by Penn State University's Dr. Charles Ray, who applied a 2.5% growth rate and then used a factor of .5 to convert to dry tons to develop an estimate of 6 million dry tons of LUW that could be harvested on a sustained yield in the state.

## .WOODY BIOMASS AVAILABILTY

How much woody biomass exists in Pennsylvania, and how much is actually physically available for harvest, are two distinct questions. It is important to recognize these realities: the wood is not free, and it is often not easy to get to.

Pennsylvania grows high-value hardwoods. Using a rough approximation, the proportion of high value trees, on a per-acre basis, are out-numbered 2:1 by less valuable trees. The cost of extracting harvested timber is normally justified by the value of 1/3 of the trees on a site. There are considerable costs associated with constructing forest haul roads, log landings and associated skid trails to get the trees out. To an operator, if sufficiently valuable timber is not available in a forested area, it does not make economic sense to enter a forested site and harvest it. The cost to harvest low use wood [LUW] is no less expensive. Standing LUW may be acquired for $2 to $3 per ton, but delivered LUW will cost, at June 2008 estimates, at least $24 to $30 per ton (2008 DCNR data) after harvesting and trucking costs are included. Given the rising cost of fuel and steel (products associated with timber harvests, i.e., gates, culverts, bulldozers, tri-axle log trucks) these costs are likely to rise incrementally into the future.

Since most forestland is privately owned, the greatest volume of woody biomass is located on private forestlands. Private landowners' willingness to harvest it will have a significant impact on biomass availability. Recent research by Penn State's School of Forest Resources estimates that approximately 70 percent of Pennsylvania's forestland is owned by 744,500 private forest landowners (PFLs)[4]. Private forest landowners include individuals, joint owners, clubs, associations, non-profits, and non-timber businesses. Collectively, these owners decide how Pennsylvania's private forests are managed.

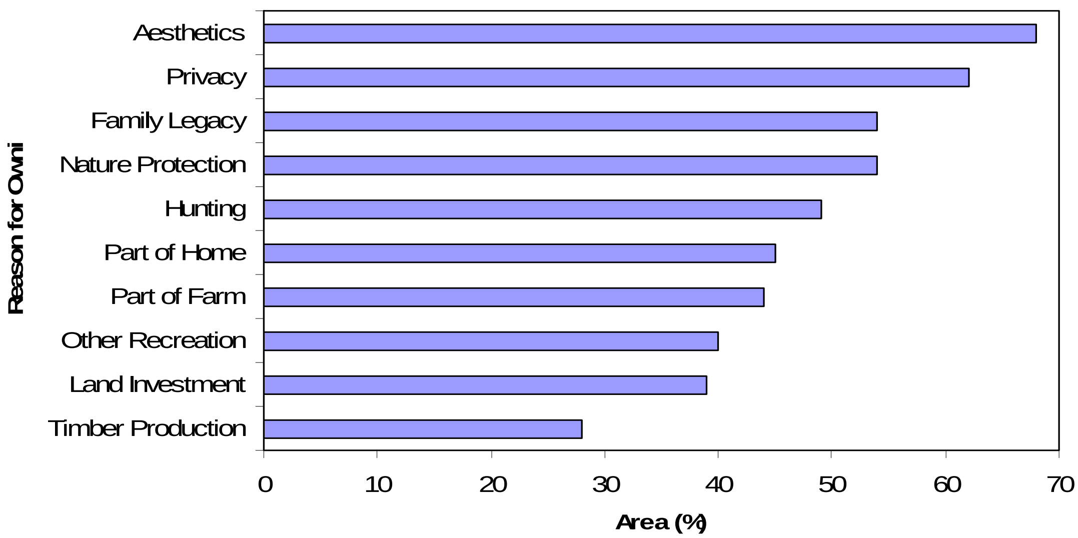
While the USFS estimates that timber volume has increased over the past several decades, recent anecdotal information from the timber industry suggests overall reduced access to private lands and general difficulty locating high volume, high quality stands. A recent statewide survey of PFLs conducted by the Penn State Human Dimensions Unit (Metcalf 2006)[5], along with a collaborative effort with Juniata College to explore forestland ownership patterns in Huntingdon and Berks Counties using GIS parcel ownership data (Metcalf et al. *pending*)[6], found that:

- Forestland ownership patterns and management of private forests differ geographically across Pennsylvania. For example, 58 percent of the forestland in Berks County is owned by PFLs with 20-acre or smaller properties, while 59 percent of the forestland in Huntingdon County is owned by PFLs with 100-acre or larger properties.
- Larger properties often afford more economical harvesting as economies of scale reduce costs. These properties also tend to be owned by PFLs more willing to conduct harvests and allow access.

As forestlands are further subdivided, there are likely to be more PFLs and less overall access. This trend is stronger in more developed areas of the state. In more rural counties, 57 percent of PFLs owning 20 acres of forestland or less are either "opposed" or "very opposed" to harvesting, while in more developed counties that number increases to 72 percent. [Metcalf et al, pending]

Scaling this up to the statewide level, the U.S. Forest Service's Forest Inventory and Analysis program's National Woodland Owner Survey, whose goal is to better understand family forest owners and their motivations and intentions, reports that "amenity values" are more important to these owners than financial objectives (Butler et al. 2005, see fig. 1 below)[7]. Timber production is last among the top ten reasons for owning forestland. Twenty-three percent of owners, who cumulatively own 50 percent of the family forest land, have commercially harvested trees one or more times since purchasing their land (FIA 2007)[8].

Fig. 1




Given these trends, many areas of the state will require new, innovative approaches if access is to be maintained. Harvesting operations for biomass must consider approaches appropriate for small properties and respect PFL preferences (i.e., most do not want to see clearcuts or unsustainable harvesting). PFLs, local policymakers, and the timber industry must work together to address access in the context of an increasingly parcelized forest.

## DEVELPMENT, GROWTH AND HARVESTING IN A TYPICAL PENNSYLVANIA FOREST STAND

This section aims to provide an overview of how forests within Pennsylvania grow, develop, and are harvested.

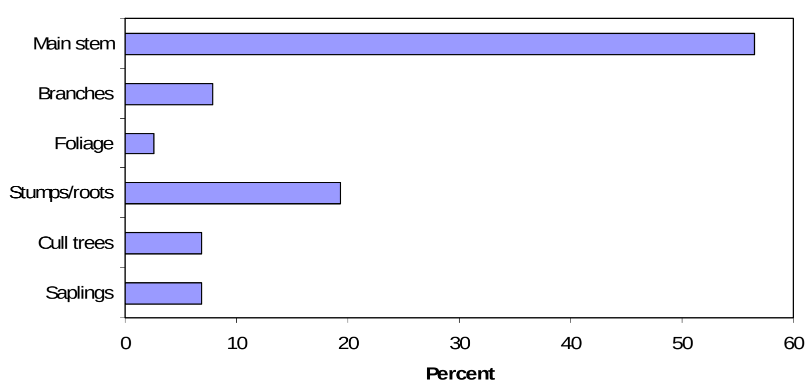
When forests are harvested in Pennsylvania, the great majority of forest managers rely on advanced natural "regeneration," which are young tree seedlings that will comprise the future forest. The term "advanced" implies that the seedlings are present prior to any harvesting activity. Most of our forests are "even-aged," where the majority of trees became established at roughly the same time and are the same age.

In early decades of development, seedlings and saplings grow closely together, competing for the limited resources of sunlight, moisture and space. Some trees begin to exert their dominance, while others die or begin to lag behind in growth. This dynamic continues for several decades. As trees grow taller and larger in diameter, the growing site can support fewer trees per acre.

Commercial timber harvests are generally not conducted until the stand is approximately 50 years old. A "stand" is a forestry term that refers to a defined area that allows managers to develop plans. It usually contains trees of a similar species mix and age class, or may be defined by topography. When a stand reaches 50 years or so, poorly formed trees can be harvested to concentrate the site's growing potential on the most dominant and desirable trees. Several light thinning harvests may occur until the stand reaches an approximate economic maturity age of 80 to 120.

Forests cannot be thinned or harvested indefinitely. They must be cut and regenerated at some point when stocking levels grow low or seed trees grow scarce. Establishing regeneration for the future forest can require considerable planning and effort. A common regeneration practice called a "shelterwood" harvest removes approximately one-third to one-half of the lower quality trees on the site to encourage the stand's highest quality trees to produce seed. By opening the forest canopy through the removal of poorer quality trees, more sunlight reaches the forest floor, providing the limiting resources of space and light to allow young trees or "regeneration" to become established for the next forest.

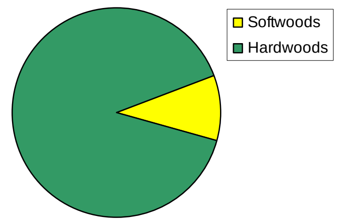
**Fig. 4: Distribution of tree biomass (green weight) on forest land by component, all species. [*Pennsylvania's Forest 2004*; Resource Bulletin NRS-20, October 2007]**



## PENNSYLVANIA'S WOOD PRODUCTS INDUSTRY

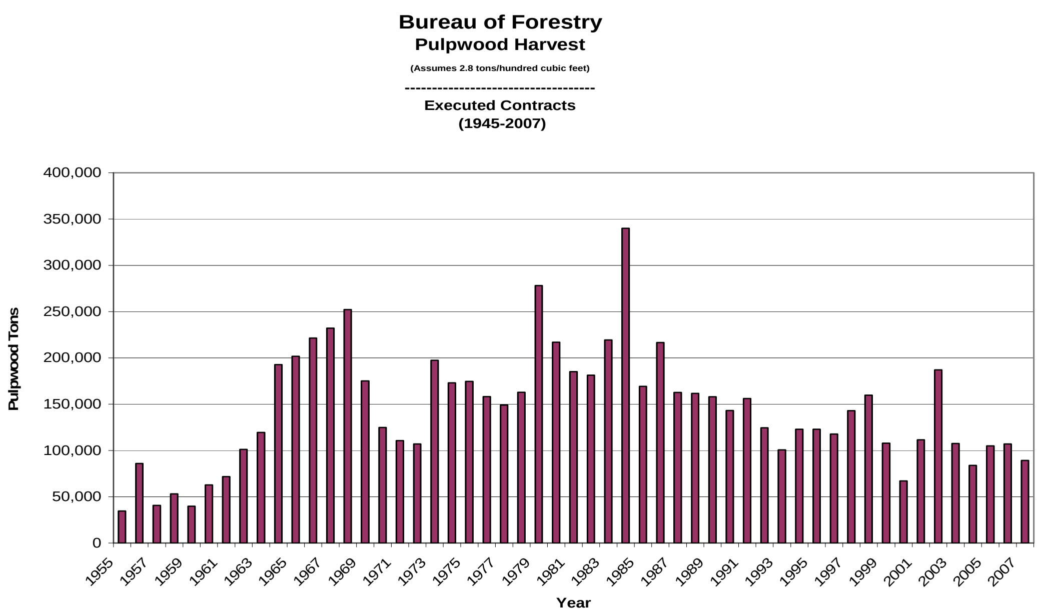
Pennsylvania's extensive forests support a robust forest products industry that is an integral part of the state's economy. The state prides itself in growing some of the highest quality hardwood timber in the world. Pennsylvania contains more hardwood growing stock than any other state. Ninety percent of Pennsylvania's biomass is in hardwood species (FIA 2004)[9]. Black cherry, oak, maple, ash, and other species are sought after in global markets for flooring, cabinetry, molding and millwork, furniture and veneer.

**Figure 5. Distribution of tree biomass on forest land**




The demand for high-quality hardwood sawtimber has historically been the principal driver of the state's wood products industry. In fact, no other state produces more hardwood sawlogs. About two-thirds of the state harvest is for high quality sawlogs and veener logs. While hardwood sawtimber provides the economic impetus for a timber harvest, large quantities of lower quality material are available and harvested where strong markets exist. Lower quality wood is used for a variety of products, such as pallets, boxes, pulpwood, landscape ties and various engineered wood products like particle board.

Harvests on private forestland often follow a pattern of removing only the highest quality sawtimber, leaving the lower value, less desirable species to occupy the "selectively harvested" site and provide the appearance of a mature forest for aesthetic reasons. While this practice, often referred to as "high-grading," offers quick economic returns, it undercuts the potential for these forests to regenerate into healthy, diverse future stands. Many of these "high-graded" stands would benefit from removal of the remaining trees through biomass harvesting. Convincing forest landowners to harvest these economically low value trees, however, will likely pose a significant challenge to biomass harvesters.



## BIOMASS HARVEST: OPPORTUNITIES AND POTENTIAL IMPACTS ON FOREST RESOURCES

Biomass harvesting on forested lands and harvesting of biomass as a short-rotation crop can be expanded and contribute to the Commonwealth's efforts to reduce carbon emissions and to provide renewable, home-grown energy. This expansion, however, needs to be done responsibly. These forests include many common as well as ecologically important and rare plant and animal communities. Old fields, meadows, barrens and other open spaces interspersed with forested lands provide valuable water quality protections, wildlife habitat, aquifer recharge, wildlife travel corridors, and help preserve the rural character of the state.

**25x25 Initiative**

A University of Tennessee study commissioned by the national 25x25 Initiative (whose goal is that 25% of all energy used come from alternative energy sources by the year 2025) predicts that Pennsylvania will see an increase in demand by 2025 of over 4 million dry tons of wood for the emerging biofuels industry[10]. Along with dedicated energy crops (estimated at 9.1 million dry tons by 2025), the study predicts these two biomass types will constitute the vast majority of biomass produced in Pennsylvania by 2025 (13.37 million tons out of a total 15.4 million tons). The 25x25 Initiative predicts that by 2025, Pennsylvania's 1.5 million acres of existing pastureland will be completely supplanted by 1.5 million acres of dedicated energy crops such as corn and switchgrass. While this represents an extreme case, significant loss of pasture is likely if a strong biomass market emerges. Given the expense and effort involved in converting existing forestland to plantation energy crops, however, it is more likely that agroforestry crops will displace marginal agricultural land than existing forestland.

### Potential Benefits to Wildlife and Forest Resources from Biomass Harvests

The primary short-term benefit from biomass harvest for wildlife in a forest is to create clearings that provide the early successional habitat needed by a wide variety of species. From wild turkey and woodcock that depend on these areas to find food and raise their young, to deer, black bear and many forest bird species that need forest openings, this practice would contribute to a varied landscape to meet their food and habitat requirements. In Pennsylvania, where even-aged stands of trees 80 to 120 years old dominate the landscape, there is a distinct shortage of these early successional habitats.

A longer-term benefit for wildlife habitat lies in the potential for biomass markets to provide economic incentives to cut low value wood, particularly in stands where high value wood has already been removed, and promote regeneration of a new and healthier, more diverse forest. In general, "high-graded" stands with few economically valuable trees left also provide comparatively less high-value habitat for wildlife, in part because the tree species most valued by sawmills – cherry and oak – provide some of the most nutritious food (berries and acorns) for wildlife.

## Adverse Impacts from Removing Woody Biomass from Forests

Several generalizations can be made from the scientific literature on probable impacts to forest resources from biomass removal over and above the levels of current timber harvest operations. These include:

1. Less course woody biomass will remain on the forest floor, which in turn can:
    - Expose forest soils to drying and erosion. Site preparation methods that remove significant woody debris from the forest floor, including windrowing and root raking, can also reduce nutrient availability and future stand productivity [Johnson and Curtis, 2001][11],
    - Reduce overall biodiversity, since coarse woody debris is an important indicator of species abundance [Carey and Johnson, 1995][12],
    - Reduce food supply for beneficial insects and substrates for mycorrhizal fungi that promote tree growth [DOE/Joint Genome Institute, 2008] [13] which states, in part: "Mycorrhizae are critical elements of the terrestrial ecosystems, since approximately 85 percent of all plant species, including trees, are dependant on such interactions to thrive. Mycorrhizae significantly improve photosynthetic carbon assimilation by plants,"
    - Reduce organic matter washing into streams to provide food and habitat for macroinvertibrates that support the aquatic food chain of streams, including trout [Sweeney et al, 2004][14], and
    - Limit populations of small mammals, and thereby limit food supplies for predators that depend on small mammals [Carey and Johnson, 1995].

2. Fewer standing dead trees, snags, and dead limbs left in the forest, which can:
    - Eliminate habitat for cavity-nesting species like kestrel, owls, bluebirds and wood duck [PSU Wildlife Fact Sheet 1, 2001] [15]
    - Reduce essential food sources for wood-boring species like woodpeckers [PSU Wildlife Fact Sheet No. 7, 2001][16], and
    - Eliminate dead trees that serve as denning sites for multiple species, including opossum, raccoon, black bear, and many others.

3. Removal of more fallen logs, slash piles and other brush from the forest, that can:
    - Eliminate important over-wintering habitat and year-round cover for rabbits, grouse, pheasants, and many forest generalist species [PSU Wildlife Fact Sheet No.1]
    - Reduce nutrients and growing substrates for wild mushrooms and other non-traditional forest products,
    - Shrink available habitat for salamanders and other forest –dwelling amphibian and reptile species [Butts and McComb, 2000][17], and
    - Make scarce hollow logs needed as drumming sites for ruffed grouse in their reproductive cycle, and similar impacts on highly specialized forest species.

4. Increased harvest of numerous woody shrub and vine species with low merchantable timber value, which can:

- Limit berries that numerous forest species rely on for survival, particularly in winter months when other foods are scarce [PSU Wildlife Fact Sheet No. 7, 2001], and
- Limit flowers that support declining species of pollinators like bees, butterflies, bats and humming birds [Robinson et al, 2006][18].

In addition to those impacts listed, biomass harvesting, if implemented without following recommended best management practices, may duplicate the environmental impacts of unsustainable timbering operations, including: soil erosion, siltation of streams, soil compaction, disturbance of wildlife during timbering operations, changes in vegetation habitat type and structure, collateral damage to remaining standing timber, and contamination from pollutants. A full discussion of these Best Management Practices for Pennsylvania Forests can be found in Chapter 3.

Studies of impacts to natural resources from biomass harvest to date have mainly focused on the forested habitat needs of mammals, birds, reptiles and amphibians. Additional research is needed to examine the potential impacts on forest soils, terrestrial [particularly saproxylic] insects, fungi, myccorhizal associations, and rare plants. Many of these less-studied species play key roles in regulating forest growth rates, nutrient availability, infestation spread and prevention, overall biodiversity rates and other functions.

### Recommendations for Minimizing Adverse Impacts on Forest Ecosystems

The State Forest Resource Management Plan (SFRMP) that governs forest management practices on state forestlands provides an excellent set of recommendations that, when applied to biomass harvests, would help mitigate many of the potential impacts described above.

**Operators Harvesting Biomass Should**:

- **Retain slash on areas treated by conventional timber operations.**
- **Limit whole tree harvests.**
- **If doing a whole tree harvest, retain slash on 10% of the site.**
- **Retain 2-5 non-merchantable logs per acre on timber operations. Cull trees can be felled and left to accomplish this.**
- **Retain an average of 5 trees with cavities per acre.**
- **Retain 1 to 5 snags per acre.**
- **In streamside buffer areas, retain dead and downed woody material. Reduce the amount of biomass available for removal by 5 to 20% from inventory data in order to retain an average basal area of 10-20 square feet over the entire treatment area.**

## IMPACTS FROM CONVERTING OPEN LANDS TO WOODY CROP PRODUCTION

There can also be ecological impacts when converting existing pastureland, meadows, highly erodable lands, and other fallow areas, to short-rotation woody crops (SRWC). With SRWCs, trees are harvested on two to five year intervals and require significant inputs (site preparation, irrigation, fertilization) to reach their full economic potential. Most of these impacts will result from mechanical planting and harvesting on vulnerable soils, and the removal of biomass from the site.

<u>Impacts of conversion may include</u>:

1) Accelerated decline of grassland species:
    - Grassland nesting bird species are one of the fastest-declining cohort of bird species in the U.S. [NRCS, 1999] [19] Warm-season grasslands, in particular, as well as some cool-season grasslands provide food and habitat for small mammals that support larger predatory species. [PSU Fact Sheet No. 12, 2001] [20].
    - As a monoculture, SRWCs would have lower biodiversity and lower habitat value. One exception would be switchgrass, which is used by grassland nesting birds, but growers would have to implement delayed-mowing schedules to avoid hen and nestling mortality.

2) Increased soil erosion, stream sedimentation and topsoil loss by replacing established rooted vegetation and protective canopy cover with short-rotation plantation crops:
    - Excess sediment is one of the leading causes of stream degradation in Pennsylvania.
    - Sediment and sediment-borne nutrient contamination that reaches the Chesapeake Bay has negative impacts on commercial fisheries, shell-fish and water quality;

3) Loss of meadows, riparian buffers, and other fallow areas currently providing a multitude of environmental benefits, including wildlife habitat, water quality protection, sediment trapping, heavy metals trapping through plant uptake, carbon sequestration, aquifer recharge and flood abatement.

4) Loss of flowering trees, shrubs and grassy vegetation found in pastures, meadows, and riparian zones support pollinators important to commercial agriculture and represent another rapidly declining cohort of species [Robinson et al, NRC, 2006].

## Recommendations for Minimizing Adverse Impacts from Short Rotation Woody Crop Production

While future federal and state legislative and regulatory efforts may include some safeguards to prevent widespread conversion of erodable lands, wildlife-enrolled Conservation Reserve Enhancement Program lands and other areas to biomass production, it is reasonable to assume some proportion of these lands will be converted to woody short-term rotational crops for biomass production.

**Key protections for areas that *do* experience conversion should include**:

- **retention of forested buffer areas along streams and rivers,**
- **prohibitions on converting highly erodable lands (HELs),**
- **protection of wetlands, seeps, vernal pools and other features critical to supporting many endangered and special-concern species,**
- **retention of tree rows or grassed wildlife corridors to help wildlife travel safely and avoid isolated "island" effects, and**
- **delayed harvest of biofuel crops and other management practices to protect nesting birds and other wildlife.**

### A Snapshot of Short Rotation Woody Crop Research

Researchers at the State University of New York College of Environmental Science and Forestry (SUNY - ESF) have been developing a willow biomass production system over the past three decades, ranging from trials with hybrid poplar at relatively wide spacing and anticipated 10 to 12 year rotations, to willow trials at extremely high densities and 1-year rotations (Kopp et al. 1993)[21]. SUNY researchers and industry partners are working to demonstrate that willow energy crops can compete economically as a feedstock for bioenergy and bioproducts in a restructured industry. In their published research findings, however, (White et al. 1995)[22] researchers found that their price for delivered fuel from hybrid plantation willow was still more expensive than coal under long-term contracts in New York state. To compete in the current energy and bioproducts market, willow biomass production may require tax incentives, emission credits, and other approaches. One route researchers are exploring to help justify costs is to make willow crops do double-duty as snow fences, windbreaks, phytoremediation for contaminated sites, and alternative landfill covers before they are harvested. Rising fuel and energy costs will also influence the viability of these crops.

**Earth star fungus growing on forest biomass**
**Photo: J.Hassinger**

## BIOMASS ON STATE FOREST LANDS

While DCNR is the largest owner of public forest land in Pennsylvania, two other agencies also own and manage significant acreage. The Pennsylvania Game Commission administers 1.5 million acres of public lands, and the Allegheny National Forest in northwestern PA another 611,000 acres. Each of these agencies manages its forests independently.

DCNR's State Forest Resource Management Plan (SFRMP) has guidelines that directly impact biomass availability. The entire SFRMP can be found online at: http://www.dcnr.state.pa.us/forestry/sfrmp/update.aspx. The plan is updated periodically since first written in 1955, with input sought from the public, the forest products industry, environmental communities, and academia.

Under the SFRMP, state forestland is partitioned into various management zones. Each zone has distinct goals that influence the availability of biomass. For example, the Natural Area Zone is set aside to provide locations for scientific observation of natural systems, to protect examples of typical and unique plant and animal communities, and to protect outstanding examples of natural interest and beauty. Harvesting trees in any manner in this zone is not permitted. Wild Areas are another zone set aside and no harvesting is allowed without special approval from the State Forester. This approval is seldom given in practice, so Wild Areas will yield little biomass. There are also Limited Resource Zones that are too steep (>40% slope), too wet, or too rocky to be practical for typical forest management activities and have limited biomass potential. The Multiple Resource Zone and Aesthetic/Buffer Zone are the areas where active timber management occurs and would be available for biomass production. In all, 60% of the state forestland is zoned available for biomass harvesting, and 40% is simply unavailable.

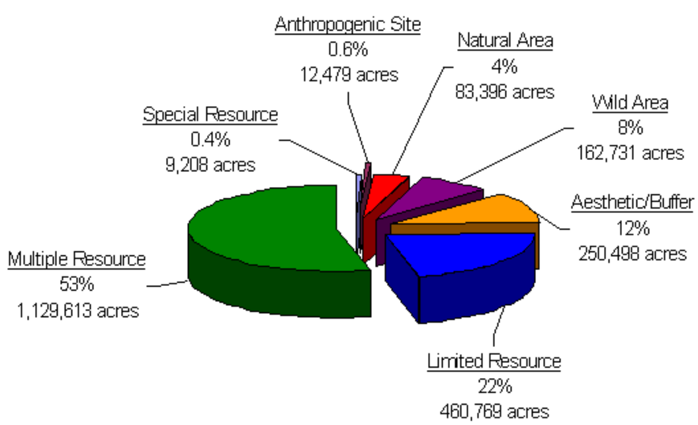



Fig. 2: State Forest Zones

State forestland consists of a largely even-aged forest. Tree harvesting on the state forest land base available for woody biomass production is regulated by a scientifically developed harvest allocation model which includes constraints designed to produce a sustainable harvest of timber and biomass while generating a variety of age classes and habitat types. These are explained in detail in the SFRMP.

The SFRMP calls for harvesting 14,337 acres of the 2.1 million-acre state forest annually. Of these acres, 5,932 acres are high-yielding regeneration harvests. The remainder are generally timber stand improvement thinnings or salvage harvests. The sawtimber and low value wood products from these harvests are currently around 70 million board feet equivalents annually, (not including topwood) or about 400,000 tons of potential biomass. The current users of these products pay approximately $35 million per year for the rights to this resource.

Ecosystem Management

State forestland management, and therefore biomass supply and accessibility on state forestland, is also guided by the concept of ecosystem management. This approach strives to conserve and maintain all the functions of a forest by maintaining its many inter-related parts; plants, wildlife, soil, water and people, that contribute to a healthy forest. Forests provide many benefits to society: clean air, clean water, recreational opportunities, wildlife habitat, and timber. A more detailed discussion of ecosystem management in Pennsylvania's forests can be found in *Penn's Woods, Sustaining Our Forest*: http://www.dcnr.state.pa.us/forestry/sfrmp/docs/Penns%20Woods%20Stategic%20Plan.pdf .

Third Party Certification

Third-party certification of state forestland also affects biomass harvest on state forestlands. The third-party Forest Stewardship Council's Appalachia Standard, adopted by Pennsylvania in 1998, verifies – among other things - that the Commonwealth's forestlands produce a diversity of forest products, and that harvest rates cannot "exceed levels which can be permanently sustained." The entire standard is found on the web at: http://www.fscus.org/images/documents/2006_standards/app_4.2_NTC.pdf

FSC ©

The FSC Appalachia Standard is expressed as 10 broad principles of sustainable forest management. Forest management activities are evaluated on a set of criteria under each principle. Of the ten principles, there are a number that directly impact the availability of biomass from state forest land. They are listed below.

*PRINCIPLE #5: BENEFITS FROM THE FOREST*

Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.

5.2. Forest management and marketing operations should encourage the optimal use and local processing of the forest's diversity of products.

5.3. Forest management should minimize waste associated with harvesting and onsite processing operations and avoid damage to other forest resources.

5.3.c. Woody debris is retained on site to provide biological capital for the cycling of nutrients and the maintenance of habitat (see indicator 6.3.c.). Woody debris in excess of this amount is sold when markets exist, and is distributed throughout the forest when they do not.

5.4. Forest management should strive to strengthen and diversify the local economy, avoiding dependence on a single forest product.

5.6. The rate of harvest of forest products shall not exceed levels which can be permanently sustained.

5.6.a. The sustainability of harvest levels is based on documented data on growth and regeneration, site index models, and classification of soils, appropriate to the scale and intensity of the operation.

*PRINCIPLE #6: ENVIRONMENTAL IMPACT*

Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and the integrity of the forest.

6.3. Ecological functions and values shall be maintained intact, enhanced, or restored, including:

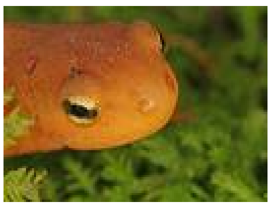
- forest regeneration and succession.
- genetic, species, and ecosystem diversity.
- natural cycles that affect the productivity of the forest ecosystem.

6.3.a.4. Natural regeneration is used unless artificial regeneration is required for establishing extirpated species or enhancing naturally occurring species.

6.3.b.2. A diversity of habitats for native species is protected, maintained, and/or enhanced. For example:

- declining trees and snags
- vertical and horizontal structural complexity
- Diversity of understory species
- well-distributed, large woody debris
- habitats and refugia for sedentary species and those with special habitat
- requirements

6.3.c. Natural cycles that affect the productivity of the forest ecosystem



6.3.c.1. Coarse woody debris is maintained in the form of large fallen trees, large logs, and snags of various sizes.

6.3.c.2. Post-harvest management activities maintain soil fertility, structures, and functions.

6.3.c.5. Whole-tree harvesting and the burning of slash and stumps are used only where it is ecologically justified, e.g., for pest control.

6.5.i. Measures to protect streams (including perennial, intermittent, and ephemeral streams and other waters) from degradation of water quality and/or their associated aquatic habitat are used in all operations.

6.5.u. Harvesting in outer stream management zones (SMZs) is limited to single-tree and group selection (see Glossary), while maintaining at least 50 percent of the overstory

6.9. The use of exotic species shall be carefully controlled and actively monitored to avoid adverse ecological impacts.

6.10. Forest conversion to plantations or non-forest land uses shall not occur, except in circumstances where conversion:

- entails a very limited portion of the forest management unit; and
- does not occur on high conservation value forest areas; and
- will enable clear, substantial, additional, secure, long term conservation benefits across the forest management unit.

*PRINCIPLE #7: MANAGEMENT PLAN*

A management plan -- appropriate to the scale and intensity of the operations -- shall be written, implemented, and kept up to date. The long-term objectives of management, and the means of achieving them, shall be clearly stated.

7.1. The management plan and supporting documents shall provide:

- Rationale for rate of annual harvest and species selection.
- Provisions for monitoring of forest growth and dynamics.
- Environmental safeguards based on environmental assessments.
- Plans for the identification and protection of rare, threatened and endangered species.

*PRINCIPLE #10: PLANTATIONS*

Plantations shall be planned and managed in accordance with Principles and Criteria 1 - 9, and Principle 10 and its Criteria. While plantations can provide an array of social and economic benefits, and can contribute to satisfying the world's needs for forest products, they should complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests.

Applicability Note to Principle 10: Plantations are not prevalent in the Appalachian Region and do not represent the preferred method of managing a typical Appalachian forest. While adjoining regions may contain ecosystems that have been historically managed with plantations and landowners may have land in more than one region, plantation management in the Appalachian region is only appropriate where they already exist, and for restoration purposes.

**Cook Forest understory  Photo: S. Cassell/DCNR**

## CHAPTER 2:
## SITUATIONS AND SETTINGS FOR BIOMASS HARVESTING

The considerations below are based on the best management practices and silvicultural policies adopted by DCNR to ensure good stewardship of Pennsylvania's natural resources. All ecological factors must be considered when deciding when and where it is environmentally acceptable to remove biomass. Economic factors also influence where and when biomass harvesting should be conducted, and should also be considered. The following list is intended as a first-stop tool in determining when and where biomass harvesting is environmentally acceptable (beneficial) or unacceptable (harmful).

### Situations and settings in which biomass harvesting may be beneficial/acceptable:

1. In forested areas that have been "high-graded" in the past, leaving understocked conditions or otherwise undesirable tree species or trees of poor growth and form.

2. To remove competing low-growing plants or brush that interfere with the growth and regeneration of desirable trees and plants and will not eliminate existing wildlife habitat.

3. On any site in which the vegetation has undergone damage by wind, ice or other weather factors. Priority should be given to populated areas in which downed or damaged trees may present a significant safety hazard.

4. On poorly reclaimed sites from past mining activities, particularly where the primary purpose is to provide early successional habitat.

5. To remove trees, brush and/or woody debris in urban areas or along trails, median strips, roads and road shoulders for safety purposes, aesthetics, and for site clearance.

6. Salvage harvests on forested sites where pests or disease have damaged vegetation. EXCEPTION: If the pest or disease can be further disseminated by moving of wood products, no removal should take place.

7. Sanitation cutting to prevent the spread of pests and disease.

8. To remove invasive species which DO NOT readily propagate from cutting.

9. To reduce wildfire fuels and wildfire risk around communities, especially regarding forest edge-communities to create openings by removing fuel around structures in forested communities. EXCEPTION: Do not clear biomass from heavily cut areas or areas without much canopy cover as desiccation of the soil can be a greater fire risk factor.

10. In park-like settings where grounds are normally populated, any harvesting should include total tree removal for aesthetic and safety purposes.

11. To clear undesirable overgrown vegetation and brush on marginal or abandoned agricultural land or industrial brownfields for proper reclamation to productive land.

12. To provide early successional habitat for wildlife.

**Situations and settings in which biomass harvesting may be harmful/unacceptable:**

1. It is unacceptable to convert native forest land into high-yield biomass crops. The only sites that may be acceptable for growing high-yield biomass crops are marginal agricultural lands, abandoned or poorly reclaimed mine sites and brown fields.

2. Downed woody debris and leaf litter on the forest floor under a healthy stand of trees should not be removed because it provides important nutrient cycling, wildlife habitat and other benefits.

3. In most cases, native shrubbery should not be harvested for biomass as it is necessary for wildlife forage and shelter, protection of the forest floor and biodiversity. Native brush can also prevent a site from being overtaken by shade intolerant invasive species.

4. After silvicultural removals of timber, woody debris should be left on site to protect the advanced, natural regeneration of native tree species from weather related factors, competition from shade intolerant and/or non-native vegetation, and from wildlife foraging.

5. After harvesting of any site which exposes the forest floor, biomass should be retained. Woody debris and brush/shrubbery are important factors in decelerating the rate of run-off from rain or ice and snow melt and in preventing rain-splash erosion.

6. Biomass must not be removed in any area which is afflicted with a disease or pest problem which can be spread by moving the woody materials.

7. Biomass harvesting of any materials along stream and river banks or along bodies of water is unacceptable. Riparian vegetation is necessary for a host of biotic factors, including wildlife habitat, biodiversity, bank stabilization and protection of water temperatures.

8. Sensitive ecosystems, protected areas and those that support rare, threatened or endangered species of flora or fauna should be protected from biomass harvest.

9. To remove biomass for the purpose of decreasing wildfire risk and fuels in areas where soil desiccation is possible should be avoided. Removal of biomass will expose soils and cause excessive drying. This can lead to a greater threat of wildfire.

10. Biomass harvesting is unacceptable in peat bogs or other such areas where geologic factors and rock weathering cannot act as an alternate source of available soil nutrients.

## Whole Tree Harvesting Situations

Whole tree harvesting can present practical problems for a forest manager. To harvest the whole tree, including the topwood, the tree must be dragged full-length through the forest to an on-site processing area (log landing) where the main stem is cut into logs and the topwood chipped. Whole tree harvesting is often very mechanized, involving feller bunchers and large grapple skidders that work very efficiently on large regeneration harvests.

Because of the damage that can be caused to young seedlings by this large equipment, foresters should exclude feller bunchers on certain types of harvests. This machinery's damage to seedlings can be highest on steep slopes and with tracked equipment. The willingness and skill of the operator to limit site disturbance as well as the season of the year can also significantly affect the amount of damage to young seedlings. In partial harvests, shelterwoods and thinnings, regeneration is not as important. However, harvesting and skidding long whole trees with broad tops is difficult without damaging the large residual trees. Foresters should limit whole tree harvesting in some partial cuts to prevent damage to the residual timber. Harvesting topwood is currently prohibited on state forest land unless a waiver is approved by the State Forester. Less than 10% of all harvests receive a whole tree harvesting waiver.

Whole tree harvesting is not always detrimental. If there is dense brush competing with the establishment of new seedlings, mechanized whole tree logging operations can be used to efficiently crush and control this layer. Whole tree harvesting also leaves a very clean forest floor which helps when planting additional trees is sometimes necessary. A clean forest floor can be useful in reducing fire hazards near buildings.

**Feller buncher used in whole-tree harvest. Photo: M. Palko/DCNR**

## CHAPTER 3
## BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) are universally accepted activities that have positive effects or minimize negative effects on the forest ecosystem. The BMPs discussed below are adapted for this guidance from the publication, *Best Management Practices for Pennsylvania's Forests* (1997), the product of the Forest Issues Working Group formed in 1991 as a joint effort of the Penn State School of Forest Resources, the Pennsylvania Hardwood Development Council, and the Susquehanna Economic Development Authority – Council of Governments.

As forest land managers strive to manage healthy, sustainable forest ecosystems, harvesting woody biomass presents itself as one of their greater challenges. Good biomass harvesting practices can enhance and improve forest land; poor practices can damage and devalue it. Following the BMPs in this section prior to and during biomass harvesting can result in:

- **improved forest regeneration through removal of low value, low use wood and/or competing vegetation,**
- **reduced amounts of fuel for wildfires,**
- **improved wildlife habitat,**
- **reductions in invasive exotic plant and insect species,**
- **reduced reliance on fossil fuels, and**
- **increased economic benefits especially at local community levels.**

The new and increased markets for this low value, low use woody biomass may provide opportunities for increased timber improvement operations. These opportunities would have benefits for future stands and could provide revenues to help pay for increased reforestation, site preparation, and restoration activities elsewhere in the forest, which, in turn, would allow for more treatment acres.

These BMPs reflect what is known today about using forest resources wisely and well. They provide the basic, minimal acceptable standards of good forest management. They are a set of recognized tools and methods designed to help landowners, loggers and resource management professionals practice good forest management operations. Their impacts can be limited to individual stands or spread over multiple ownerships. Some BMPs are multipurpose. For example, buffer strips along streams designed to control sedimentation can also serve as wildlife travel corridors, result in habitat diversity, and maintain stream water temperature and nutrient levels.

### ***BMPs for Planning Considerations***

Like any silvicultural operations, biomass harvest operations should consider similar practices of good forest management that emphasize the future of the forest. As nd trade-offs among the alternatives, weighing immediate financial gain against long-term financial and environmental benefits and costs. That evaluation takes planning.

Harvesting biomass without planning can produce undesirable environmental, economic, and aesthetic consequences. One concern with some landowners is their lack of awareness of the values available from their forestland. Many do not define what they want from their forestland nor do they involve resource professionals in forest management planning. Forest management activities, particularly biomass harvesting, are often undertaken for short-term gain, without thought for the forest's future.

There are other trade-offs that landowners, resource professionals, and harvesters must consider when planning biomass harvesting strategies. Improving appearance by removing snags and cavity trees may lower wildlife values. On the other hand, retaining snags, dead trees, and cavity trees, while improving wildlife values, may provide operation hazards for the harvester and make it more difficult to operate safely. Familiarity with BMPs can help us recognize the trade-off and make intelligent decisions about these activities.

**Landowners, foresters, and loggers should follow these basic planning BMPs prior to undertaking any biomass harvesting:**

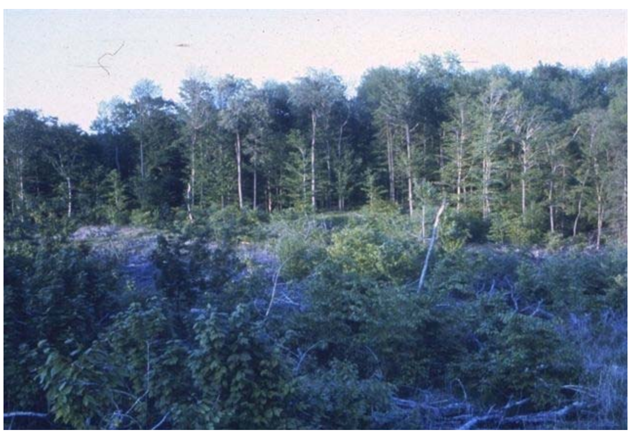
- **Inventory resources on the property, including general plant/tree communities, water resources (streams, spring seeps, wetlands, and vernal ponds), soils, and unique areas (endangered, threatened, or rare species habitat, rock outcroppings, and notable views).**
    - **Initially inventory at a level of detail necessary to address preliminary goals and objectives.**
    - **Later conduct a more detailed analysis to meet specific landowner operational needs, such as harvesting.**
    - **Be aware of how the resources on the property fit in with the surrounding landscape.**
- **Landowners, working with a natural resource professional should identify preliminary goals and objectives.**
- **Mark and maintain property boundary lines.**
- **Develop realistic goals and objectives based on the resource inventory and available landowner time and finances. Be as specific as possible when enumerating objectives (e.g. does "managing for wildfire" mean creating habitat for a wide variety of wildlife or concentrating habitat requirements for one or two species).**
- **Consider the effects of planned activities on surrounding properties.**
- **Create a written management plan based on the resource inventory and landowner objectives. Include a map showing stands or management units, and a timetable for completion of recommended activities.**

***BMPs for Forest Regeneration and Renewal –***

In Pennsylvania, there is a lack of abundant, advanced regeneration of desirable species. Once seed sources of desirable species are gone, it is difficult to reproduce a productive forest. Without successful regeneration, the future of the forest is jeopardized. Furthermore, deer continue to have a major impact on forest regeneration. Pre-harvest assessments of advanced regeneration and potential problems will minimize the possibility of regeneration failure.

**To promote the regeneration and renewal of our Commonwealth's forests, landowners, foresters and loggers should follow these BMPs:**

- **Assess advanced regeneration, seed sources for post-harvest regeneration, and stump and root sprouting potential.**
- **Assess and, if necessary, control competing vegetation such as ferns, grasses, and other undesirable understory trees and shrub species.**
- **Assess and, if necessary, control the potential loss of seed, seedlings, and sprouts to deer and other wildlife.**
- **Provide for regeneration each time harvests are made under the uneven-aged system.**
- **Consider the biological requirements of the species wanted to regenerate, whether by natural reproduction or planting.**



**Regeneration following a clear-cut. Photo: G. Odato/DCNR**

***BMPs for Residual Stand Protection***

Silvicultural treatments under even-aged or uneven-aged management schemes should leave the forest in better condition than it was before the activity was undertaken. Careless operation of equipment results in damaged trees; however, proper planning can minimize the chances of damaging or degrading the residual stand.

**To protect the residual stand, landowners, foresters, and loggers should adhere to the following BMPs:**

- **Focus on protection of the residual stand rather than on the trees being removed.**
- **During intermediate operations, retain seed sources of species needed to achieve long-term management objectives.**
- **Avoid intermediate cutting that may increase interfering plant communities, such as grasses and ferns, or be prepared to treat interfering vegetation before the regeneration cut.**
- **Design and lay-out skid trails and skid roads to minimize damage by avoiding residual trees and using bumper trees to protect them from skidding damages.**
- **Exercise special care when harvesting trees during the growing season (usually between April and August), when residual trees are most susceptible to felling and skidding damage.**
- **Identify and mark unique vegetation to be protected.**
- **Ensure that a stand compatible with long-term management objectives remains after any intermediate treatments. Instead of selecting for cutting, select for retention**
  - **species adapted to the site**
  - **trees not likely to develop epicormic branching from exposure to increased sunlight**
  - **properly spaced trees.**
- **Avoid high-grading.**

***BMPs for Biomass Harvesting Operations in Stands Damaged by Insects, Diseases, and Wildfires***

Insects, diseases, and wildland fires can make it difficult to accomplish forest management goals and objectives. Landowners and some resource professionals fail to recognize the impacts these damages have on their forests. Landowner objectives may have to be modified to deal with them. Biomass harvesting operations may provide the incentive to treat damaged stands, thereby minimizing the adverse impacts these factors have on forest resources

**Landowners, foresters, and loggers should adhere to the following BMPs when treating stands damaged by insects, diseases, and wildland fires:**

- **Monitor insect and disease populations throughout the year.**
- **Take appropriate control measures when insects or diseases are likely to prevent the accomplishment of management goals and objectives.**

- **Consider increasing species diversity, changing species composition, or changing stand structure to minimize susceptibility to insect and disease attack.**
- **Maintain access roads to facilitate wildfire control.**
- **Consider a biomass harvest to salvage dead and dying trees and to eliminate nuisance fuels.**

***BMPs for Soil Protection***

Any biomass harvesting operation at the wrong location and during inappropriate weather can damage soil structure and lower site quality. Current equipment makes it possible to move large volumes of biomass in all kinds of weather and soil conditions. Soil compaction inhibits regeneration. Deep ruts can damage roots, which can lead to decay, stain, reduced growth, and mortality. Careful removal of forest products can be the key to having a productive forest in the future.

**To protect forest soils, desired plant and animal communities, and future regeneration potential, landowners, foresters, and loggers should observe the following BMPs:**

- **Minimize soil compaction and rutting by matching operating techniques, season of operation, and equipment to soil types and moisture levels.**
- **Use soil surveys, topographic maps, and on-site evaluations as guides when planning log landing, skid road, and haul road locations.**
- **Modify landing and road locations to reflect actual soil, parent material, and topographic conditions.**
- **Keep landing and road network at the minimum size necessary to remove harvested biomass efficiently.**
- **Do not contaminate soils with equipment fuels, lubricants, and other chemicals.**

**Red grapple skidder with load of logs. Photo: G. Odato/DCNR**

**Forested Riparian Buffer. Photo: G.Odato/DCNR**.

***<u>BMPs for Water Resources</u>***

Erosion and sedimentation from biomass harvesting activities can adversely affect water quality. When management plans call for a harvesting operation, special attention to water resources is essential. Water resources are most susceptible to off-site impacts. Heavy sediment loads can travel for miles and adversely affect fish habitat, stream vegetation, and human uses far downstream. Changes in forest cover near streams can cause changes in water temperature, which may result in changes in aquatic plant and animal habitat. Also, forested wetlands are often difficult to identify, especially during dry seasons.

**To minimize the movement of soil into water resources during biomass harvesting operations, landowners, foresters, and loggers should observe the following BMPs:**

- **Comply with all provisions of Chapter 102 and Chapter 105 of the Clean Streams law and the Dam Safety and Encroachments Act, respectively.**
- **Design roads to shed surface water quickly.**
- **Design roads and landings to prevent or divert surface water flow.**
- **Avoid locating roads and landings on seasonally wet soils.**
- **Consider slope when laying out roads and landings.**
- **Provide adequate riparian buffers between disturbed areas, such as roads or landings, and streams or wetlands.**
- **When fords are used for truck crossings, stabilize the bottom with clean rock. Bridges and culverts are the preferred methods of crossing intermittent and perennial streams.**
- **Cross wetlands only when absolutely necessary**

- **If biomass harvesting necessitates taking heavy equipment into wetlands, conduct those operations, whenever possible, during the driest periods or when the wet area is solidly frozen.**
- **Do not skid through water courses or spring seeps.**
- **Do not contaminate water bodies and soil with forest management chemicals and petroleum products.**
- **Retire the road network properly at the completion of operations.**

## ***BMPs for Wildlife Habitats***

Accommodating a variety of wildlife and plant species requires providing them with the food, shelter, water and habitats they need. In many cases, biomass left in a forest provides critical food and habitat requirements for wildlife, so removing any biomass should be done carefully and with a full knowledge of what wildlife species are using the site, both year-round and for short-term or migratory periods.

**To limit the impacts of biomass harvesting activities on wildlife resources, landowners, foresters, and loggers should follow these BMPs:**

- **Inventory habitat features on the property, and be aware of their relationship to surrounding lands.**
- **Protect sensitive habitats such as spring seeps, vernal ponds, riparian zones, cliffs, caves, and rubble lands.**
- **Develop missing special habitats, such as herbaceous openings for grouse and other species, through planting, cutting, or other manipulations.**
- **Protect cavity trees, snags, and food-producing shrubs and vines.**
- **Maintain overhead shade along cold-water streams.**

**And most importantly:**

- **Leave up 15 to 30% of harvestable biomass as course woody debris. While harvesting as much biomass as possible increases profits and satisfies some management objectives, minimizing course woody debris might reduce habitat for small mammals, reptiles, amphibians, and beneficial insects.**

## ***BMPs for Plants of Special Concern and Unique Habitats***

Unique areas and plant and animal species of special concern need to receive specific attention during and after biomass harvesting activities. Forest managers are often unaware of the existence of species of special concern or unique areas. The loss of additional endangered, threatened, or rare species will diminish the biological wealth of our Commonwealth.

**To protect unique or special resources to the ecological integrity of the forest ecosystem, and to limit how biomass harvesting activities may impact them, observe following BMPs:**

- **Become aware of the presence of endangered, threatened, and rare species habitats and unique habitat features and take steps to protect them.**
- **Know the habitat requirements of endangered, threatened, and rare species on the property so that activities can be planned either to avoid disturbing or to enhance these habitats.**
- **Keep in mind that plant habitats can be very small and specific. Learn to recognize these special micro sites.**
- **Develop specific management plans for unique areas and habitat with the help of a resource professional.**

**For more on how to facilitate these BMPs, check out <u>Pennsylvania's Natural Diversity Index and Pennsylvania Natural Heritage Program at http://www.naturalheritage.state.pa.us/</u> .**

***<u>BMPs for Aesthetic Considerations</u>***

Biomass harvesting can result in a major change to the appearance of the harvested area. Frequently this change, especially in areas highly visible to neighbors or the general public, creates opposition to biomass harvesting. Landowners, foresters, and loggers can modify the operation to minimize the impact of harvesting on the physical appearance of the area. All parties involved need to understand that lower stumpage values or lower return to the harvester may result from the modification. Regardless, most landowners are concerned about the appearance of their property, and acceptance of biomass harvesting activities by the general public will likely increase if a site is left with a good appearance.

**Landowners, foresters, and loggers should observe the following BMPs to minimize the adverse visual effects from biomass harvesting operations:**

- **Cut all broken trees, leaners, and badly scarred trees except where they are being retained for a specific purpose.**
- **Locate landings away from public view.**
- **Design cutting areas to take advantage of natural contours; avoid straight lines when possible.**
- **Lop tops of harvested trees near a public road, frequently used trails, recreational areas, and residential sites.**
- **Clean up all refuse daily.**
- **Regrade and seed landings, using native grasses wherever possible.**
- **Keep mud off public roads and out of streams.**
- **Consider leaving a visual buffer along traveled roads.**

**BMPs for Forest Protection during Re-entry and Restoration of Previously Harvested Stands**

Harvesting biomass for energy projects involves the removal of woody biomass that is of low value and low use. Of course, the preference is to remove biomass at the time of the initial harvest; however, there may be some benefits to re-entering high-graded stands that still retain slower-growing and poor-quality trees. High-graded stands may contain residue in the form of roundwood and tops left behind after the previous harvest. Other forest management activities may have piles of biomass left on site after those harvests were completed.

**Landowners, foresters, and loggers should adhere to the following BMPs when considering re-entering a previously harvested site to retrieve biomass. These BMPs are adapted from guidelines provided by the Minnesota Forest Resources Council (Biomass Harvesting on Forest Management Sites in Minnesota, 2007)[23].**

- **Avoid re-entry for the purpose of harvesting remaining biomass once regeneration has begun or planting has been completed.**
- **Limit re-entry onto a site to accessing existing infrastructure once regeneration has begun or planting has been completed.**
- **Re-establish erosion control measures on roads and landings, including water diversion devices, to help stabilize soil prior to establishing vegetative cover.**
- **Encourage native seed mixes and avoid invasive species seed sources when seeding roads and trails to stabilize exposed soils.**
- **Avoid re-entry of sites across non-frozen wetlands.**
- **Retain slash piles that show evidence of use as wildlife habitat, especially by that wildlife known to den in slash piles. In addition, consider retaining for wildlife habitat slash piles that are difficult to access.**
- **Do not remove the forest floor, litter layer and/or root systems for utilization as biomass. Retain all stumps and uprooted stumps.**
- **Avoid re-entering for biomass harvesting those sites prone to erosion.**
- **Ensure that after use, landings or on-site areas used to store biomass are in a condition that favors regeneration and growth of native vegetation and trees.**
- **Avoid harvesting biomass from within leave-tree clumps left previously for biodiversity purposes.**
- **Leave all snags possible standing in harvest areas. Snags cut for safety reasons should be left where they fall.**

.

**Additional Guidance Sources Relevant to Biomass Harvest**

***Best Management Practices for Pennsylvania Forests*; 1999. 48p.**
**http://pubs.cas.psu.edu/FreePubs/pdfs/uh102.pdf**
**http://www.hlma.org/pennswoods/overview/practices.htm**
**http://conserveland.org/lpr/library?parent_id=15356**

***Biomass Harvesting on Forest Management Sites in Minnesota;* Minnesota Forest Resources Council; 2007, 23p.**

***Woody Biomass Harvesting for Managing Brushlands and Open Lands in Minnesota;* Minnesota Forest Resources Council; 2007, 28p.**

**http://www.frc.state.mn.us/**
**http://www.frc.state.mn.us/Info/MFRCdocs/forest%20biomass%20harvesting.pdf**
**http://www.frc.state.mn.us/Info/MFRCdocs/brushland%20biomass%20harvesting.pdf**

**Appalachia (USA) Regional Forest Stewardship Standard – Version 4.2.**
**Look to sections -**
**http://www.fscus.org/images/documents/2006_standards/app_4.2_NTC.pdf**

- **5.3 Harvesting and Onsite Processing & 6.3c Natural Cycles affecting Productivity**
- **6.9b – Invasive Species**

***Aquatic Habitat Buffer Guidelines,* DCNR – Bureau of Forestry.**
**http://www.dcnr.state.pa.us/forestry/sfrmp/documents/Water_Aquatic_Buffer_Guidelines.pdf**

**Regs – found in BMP doc –**
**Chapter 102 – Erosion Control Rules & Regs**
**Chapter 105 – Dam Safety and Waterway Management Rules & Regulations**
**Fish & Boat Code – Act 175**
**Chapter 441 – Access to and Occupancy of Highways by Driveways & Local Roads**
**Chapter 189 – Road Bonding Regulations**
**Municipal notification of DEP Permit Application Submittal**

*Woody Biomass Utilization Strategy*, USDA Forest Service, FS-899, February 2008, 17p.
http://www.fs.fed.us/woodybiomass

*Woody Biomass Utilization Desk Guide*, USDA Forest Service, National Technology & Development Program, 2400 Forest Management, September 2007. 83p.
http://www.fs.fed.us/forestmanagement/WoodyBiomassUtilization/index.shtml

Fuels for Schools: http://www.fuelsforscools.org/

## GLOSSARY

Anthropogenic: Of human origin.

Biomass: The organic materials produced by plants, such as leaves, roots, seeds, and stalks. In some cases, microbial and animal metabolic wastes are also considered foods or consumer products but may have alternative industrial uses. Common sources of biomass are (1) agricultural wastes, such as corn stalks, straw, seed hulls, sugarcane leavings, bagasse, nutshells, and manure from cattle, poultry, and hogs: (2) wood material, such as wood or bark, sawdust, timber slash, and mill scrap: (3) municipal waste, such as waste paper and yard clippings: and (4) energy crops, such as poplars, willows, switchgrass, alfalfa, prairie bluestem, corn (starch), and soybean (oil).

Cellulose: Cellulose is the structural component of the primary cell wall of green plants.

Coarse Wood Debris (CWD): Stumps and fallen trunks or limbs of more than 6-inches in diameter at the large end.

Conservation Reserve Enhancement Program: CREP is a USDA program that provides financial and technical assistance to landowners for the installation of conservation practices.

Epicormic: Growing from a dormant bud.

Ethanol: A flammable, colorless, chemical compound.

Fine Woody Debris (FWD): Tops, limbs and woody debris less than 6-inches at the large end.

Forest: An ecosystem characterized by a more or less dense and extensive tree cover.

Forest Stand: A contiguous group of trees sufficiently uniform in age-class distribution, composition, and structure, and growing on a site of sufficiently uniform quality to be a distinguishable unit.

Mycorrhiza: The usually symbiotic association between higher plant roots (host) and mycelia of specific fungi that aid plants in the uptake of water and certain nutrients and may offer protection against other soil-borne organisms.

Regeneration: The act of renewing tree cover by establishing young trees naturally or artificially

Phytoremediation: Treating environmental contamination through the use of plants.

Pulpwood: refers to timber grown with the principal purpose of making wood pulp for paper production. However, pulpwood is also used as the raw material for some wood products, such as oriented strand board, and there is an increasing demand for pulpwood as a source of 'green energy' by the bio-energy sector.

Roundwood: The main stem or trunk of the tree.

Sequestration: A technique for the permanent storage of Carbon Dioxide or other active compounds so they will not be released into the atmosphere where they would contribute to the greenhouse gas effect.

Silviculture: the practice of controlling the establishment, growth, composition, health, and quality of forests to meet diverse needs and values.

Short rotation woody crops: Intensively managed forestry crops such as poplar or willow grown for 1-4 years, increasingly for the alternative energy market.

Sound Ecosystem Management: Management guided by explicit goals, executed by policies, protocols, and practices and made adaptable by monitoring and research based on the best understanding of ecological interactions and processes necessary to sustain ecosystem composition, structure, and function over the long term.

Sustainably Managed Woody Biomass: Trees, brush and other biomass harvested from lands in accordance with the Best Management Practices for Pennsylvania Forests.

Topwood: The upper portion of a tree above the merchantable portion of trunk.

Vernal Pond: Vernal ponds are temporary pools of water created by snow melt and spring rains.

Whole Tree Harvesting: The act of cutting and removing an entire tree consisting of trunk, branches, and leaves.

## APPENDIX A
## CONVERSION FACTORS

**Conversion Factors for Woody Biomass Utilization**

Here are some woody biomass conversion factors that are commonly used by natural resource managers in the Pacific Northwest:

1. The gasoline market in the U.S. is about 118 billion gallons per year. That means about 323 million gallons per day.

2. The theoretical limit of conversion of ethanol from wood is 120 gallons per ton. A high but achievable figure is about 80 gallons per ton.

3. With 370 million tons of biomass available (dry weight), if it were all converted to ethanol, it would yield 29.6 billion gallons of ethanol.

4. Ethanol is less "energy dense" than gasoline. It takes 1.6 gallons of ethanol to produce the same energy as a gallon of gasoline. (29.6 / 1.6 = 18.5 billion gallons of "equivalent" gasoline)

5. So it works out that 370 million tons of biomass could be converted to 57 days worth of transportation fuel for the U.S. (18.5/.323 = 57.28)

To put 370 million tons of biomass into perspective, the U.S. currently consumes about 300 million tons of wood per year.

From: *Woody Biomass Utilization Desk Guide*, USDA Forest Service, National Technology & Development Program, 2400 Forest Management, September 2007. 83p. http://www.fs.fed.us/forestmanagement/WoodyBiomassUtilization/index.shtml

**Red bellied turtle**

**APPENDIX B**
**BIOMASS UTILIZATION**

**Biomass Conversion Factors**

| | |
|---|---|
| 1 green ton (GT) of chips | = 2,000 pounds (not adjusted for moisture) |
| 1 bone-dry ton (BDT) of chips | = 2,000 dry pounds (assumes no moisture content) |
| 1 bone-dry unit (BDU) of chips | = 2,400 dry pounds (assumes no moisture content) |
| 1 unit of chips | = 200 cubic feet |
| 1 BDT chips | = 2.0 GT (assuming 50-percent moisture content) |
| 1 unit of chips | = 1.0 BDT chips |
| 1 CCF (hundred cubic feet) roundwood | = 1.0 BDU chips |
| 1 CCF roundwood (logs) | = 1.2 BDT chips |
| 1 CCF roundwood (logs) | = 1.2 units of chips |
| 1 CCF roundwood (logs) | = 1.2 cords roundwood @ 85 cu. Ft. wood/cord |
| 1 Board Foot (BF) | = 1 board foot of lumber measures 12-in by 12-in by 1-inch thick |

| | |
|---|---|
| 1 MBF (thousand board feet) | = 1,000 BF |
| 1 GT (green ton) of logs | = 160 BF of lumber |
| 6 GT (green ton) of logs | = 1 MBF |

1 Standard chip van carries 25 green tons, or approximately 12.5 bone dry tons (BDT) assuming 50-percent moisture content.

When woody biomass is utilized in a commercial-scale (10+ megawatt (MW) electrical output) power generation facility, the following energy output rules of thumb apply:

1 BDT fuel will produce 10,000 pounds of steam.

10,000 pounds of steam will generate 1 megawatt hour (MWH) of electricity

1 MW = 1,000 Horsepower

1 MW = Power For Approximately 750 To 1,000 Homes.

Source: Woody Biomass Utilization Desk Guide, USDA Forest Service, National Technology & Development Program, 2400 – Forest Management, September 2007.

APPENDIX C
Treatment Unit Sustainability Form

# PENNSYLVANIA SFI® IMPLEMENTATION COMMITTEE

TREATMENT UNIT SUSTAINABILITY ASSESSMENT FORM

**Harvests may include multiple treatment units. For example, the harvest might include a 10-acre unit to release regeneration and a 40-acre stand improvement unit. A separate Treatment Unit Sustainability Assessment Forms (TUSAF) should be completed for each treatment unit. Attach all TUSAF forms to the single Timber Harvesting Assessment form for the area.** *(All detailed landowner, location and contractor information provided on the (TUSAF) form will be kept confidential by the PA SFI office. Forms tallied for analytical purposes will be identified numerically and will not contain specific names or locations.)*

**This form is for Unit #** _______ **of** _______
**Township of Harvest** ______________________
**County of Harvest** ______________________
**Total Harvest Acres** ______________________
______________________
**Treatment Unit Acres** ______________________
**% of Unit Harvested** ______________________
**Dates of Harvest** ______________________
**Assessment Date** ______________________
**Product Destination** ____________________

**Harvesting Company** _________________________
**TUSAF Assessor(s)** _________________________
**Landowner** ________________________________
Person to contact for follow-up information or to schedule a site visit:
**Name:** ____________________________________
**Address:** __________________________________
**City, State, Zip:** ____________________________
**Phone:** ___________________________________
**E-mail:** ___________________________________

**Signature:** ____________________ **Date** _______

**1. Who developed the harvest recommendation and prescription?**
__ **Landowner or Landowners family** __ **Landowner's Forester** __ **Buyer's Forester**
__ **Timber Harvester / Logger** __ **Timber Buyer** __ **Other** ___________________

**2. What ownership category best describes the current owner?**
__ **Private forest landowner owning** ______ **acres in PA.**
__ **Industrial forest landowner**
__ **Forest investment owner**
__ **Municipal**
__ **State**
__ **Federal**

**3. Is this harvest associated with conversion to non-forest use?**
__ **Yes** __ **No** **If yes, what?** ____________________________________

***Please refer to the diagram below when answering questions 4 and 5 for trees 6 inches DBH and larger.***

| | |
|---|---|
| **4. Estimate the percent <u>summer</u> canopy closure that best describes the unit prior to harvest?**<br><br>**__ Greater than 80% __ 61 to 80%**<br>**__ 41 to 60% __ 21 to 40%**<br>**__ Less than 20%** | ☐ |
| **5. Estimate the percent <u>summer</u> canopy closure that best describes the unit after harvest?**<br><br>**__ Greater than 80% __ 61 to 80%**<br>**__ 41 to 60% __ 21 to 40%**<br>**__ Less than 20%** | |

| |
|---|
| **6. How did the harvest affect the average tree diameter?**<br><br>**__ The average diameter increased (many to most of the trees cut were smaller than the average tree size before harvest)**<br>**__ The average diameter remained the same**<br>**__ The average diameter decreased (many to most of the trees cut were larger than the average tree size before harvest)**<br>**__ N/A overstory removed** |
| **7. Did the harvest result in a change of timber quality in the residual stand?**<br><br>**__ Timber quality improved (most of the trees cut were of below-average quality)**<br><br>**__ Timber quality remained the same**<br><br>**__ Timber quality decreased (a majority of the high-quality stems were removed or damaged during the harvest and lesser quality stems predominate in the remaining stand)**<br><br>**__ N/A (overstory removal)** |
| **8. How has the harvest affected the species composition of the overstory?**<br><br>**__ The percent of medium to low value species decreased**<br><br>**__The percent of medium to high value species decreased**<br><br>**__ The percent species composition remained relatively unchanged.**<br><br>**__ N/A (overstory removal)** |
| **Answer questions 9 – 14 if the residual overstory canopy closure after harvest will be less than 60% (see question 5).** |

| |
|---|
| **9. Estimate the percent of the area stocked with advanced desirable seedlings (rooted in mineral soil) and vigorous saplings.**<br><br>**__ Less than 10% _ 10 to 30% __ 31 to 50% __ 51 to 70% __ Greater than 70%** |
| **10. Estimate the percent of the area covered with interfering plants including woody non-commercial species (such as beech, black locust, fire cherry, striped maple, rhododendron, mountain laurel), ferns, and/or grass.**<br><br>**__ Less than 10% __ 10 to 30% __ 31 to 50% __ 51 to 70% __ Greater than 70%** |
| **11. Are the seedlings/saplings in question 9 overtopped by the interfering vegetation?**<br><br>**__ On less than 10% of the area __ On 10 to 30% __ On 31 to 50% __ 51 to 70% __ On greater than 70%** |
| **12. Is an interfering plant treatment planned in association with this harvest?**<br><br>**__ Yes – Describe treatment and schedule ____________________________________________ __ No** |
| **13. What is the expected deer impact on regeneration in this treatment unit?**<br><br>**__ High __Medium __ Low** |
| **14. Is there a plan to mitigate deer impact? __ Yes __ No If yes, mark all that apply:**<br>**__ Fence __ Fertilization __ DMAP (Additional Hunting) __ Other _______________________** |

**Return to***:* Pennsylvania SFI® Implementation Committee
315 South Allen Street, #418, State College, PA 16801

**TUSAF Sustainability Key – A Work-in-Progress**

| | Item | Description | Go to: |
|---|---|---|---|
| | 1 | Residual overstory canopy > 60 (Thinning) | Go to 10 |
| | | Residual overstory canopy ≤ 60% (Regeneration Cut) | Go to 2 |
| | | | |
| | 2 | Advance regeneration < 70% | Go to 6 |
| | | Regeneration ≥ 70% | Go to 3 |
| Regen harvest - Advance Regen Present, Abundant | | | |
| | 3 | Interfering plants overtopping desirable regen ≥ 70% | Go to 4 |
| | | Interfering plants overtopping desirable regen on < 70% | Go to 5 |
| | | | |
| | 4 | Interference treatment planned in conjunction with harvest. | Go to 5 |
| | | Interference treatment not planned | Delay harvest. Seek assistance. |
| | | | |
| | 5 | Deer impact low or deer impact reduction planned (fencing or very aggressive hunting) | Treat and harvest. Follow up stand development. **Probably sustainable.** |
| | | Deer impact high and no deer impact treatment planned. | Seek assistance. Will seedlings overwhelm deer? |
| | | | |
| Regen Harvest - Advance Regen Scarce or Absent | 6 | One or more desirable seed source species lost or reduced in overstory to < 15 large/30 small sawlog trees per acre | Delay harvest. Seek assistance. |
| | | All desirable seed source species retained | Go to 7 |
| | | | |
| | 7 | Interfering plants abundant on < 30% | Go to 9 |
| | | Interfering plants abundant on ≥ 30% | Go to 8 |
| | | | |
| | 8 | Interference treatment planned in conjunction with harvest. | Go to 9 |
| | | Interference treatment not planned | Delay harvest. Desirable seedlings not likely competitive after harvest. Seek assistance |
| | | | |
| | 9 | Deer impact low or deer impact reduction planned (fencing or aggressive hunting) | Treat and harvest. Follow up stand development. |

| | | | |
|---|---|---|---|
| | | | **Probably sustainable.** |
| | | Deer impact high and no deer impact treatment planned. | Delay harvest. Scarce seedlings likely to disappear after harvest. Seek assistance. |
| | | | |
| Partial cut – Check seed source | 10 | One or more desirable seed source species lost or reduced in overstory to < 15 large/30 small sawlog trees per acre | Delay harvest. Seek assistance. |
| | | All desirable seed source species retained | Go to 11 |
| | | | |
| Partial cut – Check residual stand | 11 | Average DBH retained or increased (≤ 10% reduction) | Rate of growth likely sustained or improved. Go to 12. |
| | | Average DBH reduced | Rate of growth likely slowed. Go to 12. |
| | | | |
| | 12 | Timber quality sustained or improved by harvest, average DBH retained or increased (≤ 10% reduction) | Future valuable harvest probable. **Probably sustainable.** |
| | | Timber quality sustained or improved by harvest, average DBH reduced. | Future valuable harvest probable, though later than with diameter improvement. **Probably sustainable**. |
| | | Timber quality reduced by best trees removed and/or damage to residual, average DBH sustained or increased. | Future valuable harvest at risk. Seek assistance, consider regenerating. |
| | | Timber quality reduced by best trees removed and/or damage to residual, average DBH reduced. | Future valuable harvest at risk, rate of growth likely slowed. Seek assistance, consider regenerating. |
| **END** | | | |

## End Notes

[1] Investigation Order, Public Meeting of May 19, 2006; docket No. M-00061957.Pennsylvania Public Utility Commission.
[2] *Pennsylvania Climate Change Roadmap*. Pennsylvania Environmental Council; http://www.pecpa.org/files/downloads/FINAL_PEC_Roadmap_Complete_Report.pdf.
[3] The IPCC was established jointly by the World Meteorological Organization and the United Nations Environment Programme. More than 2500 scientific experts from 130 countries – including the United States – participate in this effort to provide the world with a clear and objective view of the present scientific understanding of climate change. See www.ipcc.ch and http://dels.nas.edu/globalchange/
[4] *Private Forestlands of Pennsylvania Study*. J. Finley et al. Pennsylvania State University – college of Agricultural Sciences: School of Forest Resources; 2008.
[5] Metcalf, Penn State University; 2006
[6] Melcalf et al, Penn State University, pending
[7] Butler, B.J., Leatherberry, E.C.; Williams, M.S. 2005. Design, implementation and analysis methods for the National Woodland Owner Survey. Gen. Tech. Rep. NE-GTR-336. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station.
[8] *Forest Inventory and Analysis*, Northern Research Station, U.S. Department of Agriculture, U.S. Forest Service, 2007
[9] *Forest Inventory and Analysis*, Northern Research Station, U.S. Department of Agriculture, U.S. Forest Service,2004
[10] U. Tennessee, “25% Renewable Energy for the United States By 2025: Agricultural and Economic Impacts.” Available at www.25x25.org.
[11] Johnson, D.W. and P.S. Curtis, *Effects of forest management on soil C and N storage*. Ecol. Mgmt 140:227-238, 2001]
[12] Carey, A.B., and M.L. Johnson, *Small mammals in managed, naturally young, and old-growth forests.* Ecol. Applications 5(2): 336-352, 1995]
[13] D.O.E./Joint Genome Institute, *Laccaria Bicolor*, Nature, March 2008]
[14] B.W. Sweeney et al, *Riparian deforestation, stream narrowing and loss of stream ecosystem services*, National Academy of Sciences, 2004]
[15] Pennsylvania Wildlife Fact Sheet No.1, *Wildlife-Habitat Relationships*, Penn State U., 2001],
[16] Pennsylvania Wildlife Fact Sheet No.7, *Landscaping for Wildlife: Trees, Shrubs and Vines,* Penn StateU., 2001]
[17] Butts, S.R., and W.C. McComb, *Associations of forest floor vertebrates with coarse woody debris in managed forests of W. Oregon*, J. Wildlife Management 64(1): 95-104, 2000]
[18] G. Robinson et al, National Research Council, October 2006]
[19] Natural Resource Conservation Service, *Fish and Wildlife Habitat Mgmt leaflet No. 8*, Grassland Birds, 1999]

[20] Pennsylvania Wildlife Fact Sheet No. 12, PSU, 2001
[21] Kopp et all, State University of New York, Syracuse, School of Forest Resources, 1993
[22] White et al, State University of New York, Syracuse, School of Forest Resources, 1995
[23] *Biomass Harvesting on Forest Management Sites in Minnesota;* Minnesota Forest Resources Council; 2007, 23p