Energy from Woody Biomass:
A Review of Harvesting Guidelines and a Discussion of Related Challenges

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Introduction

Current estimates are that biomass from forestry and agriculture provides about 14 percent of the world's primary energy supplies, principally in the form of wood used for cooking and home heating. With effective planning, strategic development, and a focus on the latest technologies for converting wood to useful energy, the International Energy Agency (IEA) believes the potential exists for biomass resources to meet 50 percent of world energy demands during the next century while still reducing carbon emissions from fossil fuels.

Despite general enthusiasm for the prospects of bioenergy development, there are significant concerns about the potential role of forests in bioenergy production. Some see great opportunity, viewing new markets for forest biomass as a source of income to more effectively respond to ecological challenges including insect and disease threats, wildfire and fuel loading concerns, storm events and natural disasters. There are, in addition, perceived benefits of achieving more effective management of young forests to support longer-lived species and higher valued products. Biomass harvesting and resulting energy, fuel and chemical products are also widely viewed as offering significant opportunities for economic development, fossil fuel independence, community self-reliance and job creation. It is a concept that has gained the attention of governments worldwide. Others envision problems. For example, in Africa and other developing regions of the world, most of the wood harvested is currently used for home heating and cooking. With such use already a major driver of deforestation, in these regions there is great concern over expanded exploitation of forests for such things as liquid fuels production. In developed regions of the world there are concerns regarding forests as a source of biomass for energy production, including possible negative impacts on esthetics, biodiversity, soil productivity and ecosystem health. It is worth noting that environmental concerns are not unique to biomass energy or woody biomass harvesting; there are serious questions about potential environmental impacts associated with the full range of alternative energy options.

A cornerstone of responsible biomass energy development is the establishment of guidelines for biomass harvesting and utilization that fully consider short- and long-term impacts on the local and regional environment and communities. The potential for significant impacts from biomass harvesting and collection suggests an important public policy and planning role – particularly when forests are involved – as a large number of communities, existing biomass-dependent industries, and a broad swath of the landscape will likely be engaged. Thus, broad and proactive stakeholder input that considers ecological, social, and economic impacts will be important to help ensure that unintended consequences of biomass energy development can be avoided. Periodic updating of guidelines, based upon the results of monitoring and improved scientific knowledge, will also be important.

In some regions, including several U.S. states, guidelines have been developed for removal of woody biomass from forested areas; similarly, guidelines for removal of agricultural residues, in anticipation of commercialization of cellulosic ethanol and other fuels, have been developed. This report provides a brief overview of forest biomass harvesting guidelines and their importance in the United States and other regions of the world.

Current Biomass Harvesting, Bio-Energy Initiatives and Practices

Biomass is growing in importance and is projected to supply a growing share of our energy supply for transportation fuels, industrial and chemical feedstocks, and production of electrical energy. [1] Today, biomass provides about 14 percent of energy globally, with biomass energy production concentrated in the developing countries. A large portion of biomass energy is used for home heating and cooking, and wood provides most of this. More than one-half the global harvest of wood in 2006 was used as fuel wood. In the United States biomass currently provides less than 3 percent of energy needs.[2] Since about 2000, woody biomass use for energy has been estimated to be relatively constant in residential, commercial and industrial uses, but increasing from a relatively low level in producing electricity.

Current technology provides a number of options for conversion of biomass and other biomaterials to energy. The technologies include direct firing for electrical generation, repackaging of biomass in the form of fuel pellets for use in home and institutional heating, and use as a fuel in steam generation for either large-scale district heating or for powering manufacturing operations. Emerging technologies are also stimulating interest in production of ethanol, bio-gas, and bio-diesel from wood. Current interest in bio-energy is driven primarily by near and longer-term concerns vis-à-vis petroleum supplies and the impact of energy imports on the U.S. trade balance.

A recent report suggests the annual availability of over 1.3 billion dry tons beyond that needed for food, livestock feed, fiber, and soil conservation (Perlack et al. 2005). In the continental U.S. some 55 million acres have been identified as available and having high potential for production of energy crops such as switchgrass, reed canary grass, poplar, eucalyptus, and other species.

Goals for bio-energy production, as set forth in the Perlack report, indicate that by 2030 biomass could supply 5 percent of the nation's power, 20 percent of its transportation fuels, and 25 percent of its industrial chemicals and chemical feedstocks. This goal is equivalent to 30 percent of current petroleum consumption.

The energy production potential from biomass is substantial, and the combustion of such material is close to carbon neutral. The growth of replacement crops following harvest sequesters atmospheric carbon in a quantity equivalent to that released when the harvested crop is burned; the result is that little net CO_2 is produced in the cycle. This represents a substantial advantage over the combustion of fossil fuels.

[1] Since 2004, Dovetail Partners has issued a number of reports related to biomass energy opportunities. Previous reports have addressed opportunities for community-based bioenergy and district heating development, an assessment of bioenergy and biochemical potentials for Minnesota, and the biomass potentials for farms and forests of rural America. Dovetail Reports are available at: http://www.dovetailinc.org

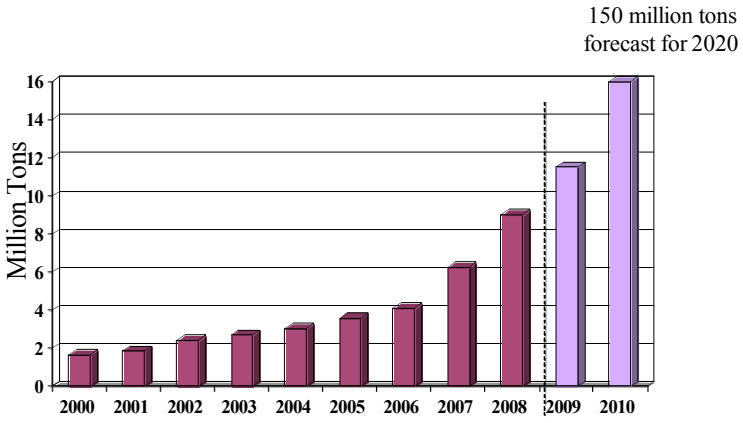
[2] Wood energy consumption in the U.S. has declined steadily as a share of all *renewable* energy consumption, from 45% in 1981 to 32% in 2007 as a result of rapid growth of wind energy production.

Global Interest in Woody Biomass

The global trade of woody biomass, primarily for energy production purposes, totaled just over 11 million metric tons in 2007. This level represents a near doubling of the 5.6 million metric ton market of 2003.[3] The major trade flows associated with the global woody biomass market are within Europe and between Canada and Western Europe. Increasing volumes are also shipped from the U.S. to Europe.

Wood pellets account for a large share of the biomass trade. Total global wood pellet production was approximately 6 million tons in 2007, rising to 9 million tons in 2008. Production of wood pellets is forecast to grow by more than 70% by 2010 and to include 150 million tons of production in 2020 (Figure 1).

Figure 1
Global Production of Fuel Pellets, 2000 -2010



Source: Various sources as reported by Hillring et al. 2007; Hillring et al.2008.

Biomass Harvesting Guidelines

Guidelines for biomass harvesting have been established in various countries as well as in a number of U.S. states. Such guidelines are generally included within best management practices for conducting harvests, with objectives for maintaining biodiversity, coarse woody debris, and soil productivity. In other instances, specific issues associated with biomass harvesting are addressed, including site re-entry following the harvest of traditional forest products and the removal of stumps.

[3] UNECE/FAO Forest Products Annual Market Review, 2007-2008 Available at: http://www.unece.org/timber/docs/fpama/2008/FPAMR2008.pdf

International Guidelines

Finland has had guidelines addressing "Energy Wood Harvest from Clear Cuts" since 2005. These guidelines specifically address the intensified harvesting of biomass for energy production following traditional clear-cut treatments and include guidelines for stump and harvest residue collection and storage. The guidelines and associated emphasis on utilization of woody biomass are part of that nation's efforts to reach goals for renewable energy and reduced carbon emissions.

Specific guidelines applicable to energy wood harvests from clear cuts in Finland include:

- Large dead wood (standing or on the ground) is not to be collected and should not be damaged (exceptions are made for harvests being conducted in response to storm events and for insect or disease concerns)
- Stumps must not be removed from riparian areas[4]
- Stumps should not be removed on steep slopes or must be planned so that erosion is avoided
- A filtering zone of 2 to 10 meters (6 to 30 feet) must be left along riparian zones, with width dependent upon the slope and other watershed characteristics. Equipment may not operate, and no stumps may be pulled in this area.
- Rocky, dry, poor soils, open swamps and other types of sites are not recommended for stump or residue harvest.[5]
- 30% of residues must be left on harvest sites.
- Stumps are not to be lifted if they are decayed, less than 15cm (6 inches) in diameter, on steep slopes, on a site with bedrock near the surface, in riparian zones or nature areas, or near saved trees and snags.
- All stumps larger than 15 cm (6 inches) in diameter should be left (20 such stumps per hectare). Fifty stumps per hectare must be left in clay and silt soils. Stumps from diverse tree species should be left.

A similar approach to forest biomass harvesting is employed in Sweden. Other European countries, Canada, and the U.S. have also been active in development of guidelines for forest biomass harvesting and collection (see below). There is no evidence in the literature that guidelines have been developed for biomass harvesting in the developing regions of Asia, Africa or South America. Within these regions wood is already a primary source of energy and nations are generally seeking ways to increase the efficiency of biomass-to-energy conversion. In most cases, these nations are not looking to forests as sources of new raw materials for energy production. Rather, agricultural energy crops and crop residues, and tree and shrub plantations - especially plantations of oil-producing plants - are the focus of current attention in bioenergy development in these regions. As a result, development of guidelines for harvesting of forest biomass is not viewed as a priority.

In North America and much of the E.U. the use of forests as an important energy source represents a "new" use of forests, with a century or more having passed since forests were last exploited for supplying primary energy. It is these countries that are most active in considering

[4] Riparian areas include aquatic and terrestrial ecosystems along streams, lakes, and open water wetlands.

[5] The guidelines also provide a listing of the types of sites that are suitable for harvest.

how much biomass can be removed from forests without endangering ecological sustainability or the economic well-being of established forest products industries.

In 2008, a workshop held in Toronto, Canada brought together scientists from throughout Canada, the United States and Sweden to review current science supporting biomass utilization and the development of guidelines and policies for harvesting.[6] Biomass harvesting guidelines are already being used in several Canadian provinces, including Ontario and British Columbia. Given the fact that in 2007, Canada exported 1.3 million tons of woody biomass, including 600,000 tons of wood pellets targeted for the European market, developing a country-wide approach to managing the impacts of this growth is viewed as strategically important.

NY biomass plant first to achieve FSC standards certification
By Lisa Gibson

Posted June 23, 2009, at 3:39 p.m. CST

Curran Renewable Energy LLC in Massena, N.Y., is the first biomass mill in the nation to receive Forest Stewardship Council chain-of-custody certification from the Rainforest Alliance's SmartWood program.

Chain-of-custody certification guarantees that wood used in Curran Renewable Energy's pellets comes from certified, responsibly managed forestlands and is tracked throughout the supply chain from the forest to the consumer. Consumers can look for the FSC label on wood products to know they are supporting forest management that protects biodiversity.

Source: http://www.biomassmagazine.com/article.jsp?article_id=2821

Forest Certification Standards

International forest certification programs, such as the Programme for the Endorsement of Forest Certification schemes (PEFC) and the Forest Stewardship Council (FSC) forest certification program, may have important roles to play in supporting the development of biomass harvesting guidelines. Although neither of these programs has developed biomass specific guidelines, each program's existing standards already provide some guidance related to the responsible management of site productivity, diversified product utilization, and other considerations. The certification programs are also reacting to potential impacts of biofuels development on forest management. The PEFC acknowledges the potential role of wood fuels within their position paper addressing climate change[7], and the first FSC chain-of-custody certificate was recently issued for a wood pellet mill in the U.S. (see sidebar).

Recent forest certification standards review processes have included consideration of biomass harvesting within the context of responsible forest management. The Sustainable Forestry Initiative (SFI) hosted meetings with stakeholders in 2008 to gather feedback on how biomass related issues might be addressed within the SFI standard. The FSC-US is currently completing a standards review process that includes consideration of biomass harvesting operations.

Although any actions taken by forest certification programs will be limited to directly impacting only those lands that are voluntarily enrolled, the approaches taken by these programs, especially at an international scale, may influence actions by other decision-making bodies.

[6] http://www.sfmnetwork.ca/html/biomass_workshop_e.html
[7] http://www.pefc.org/internet/resources/5_1177_1784_file.2256.pdf

Guidelines for Biomass Harvesting in the United States

In January 2009, the Forest Guild released a report assessing biomass harvesting guidelines that have been established in Maine, Minnesota, Missouri, Pennsylvania and Wisconsin (Evans 2009). This report concluded that biomass harvesting guidelines should address six areas of potential biomass harvesting impacts, including:

- Dead wood (coarse woody material, fine woody material and snags).
- Wildlife and biodiversity (including sensitive plants, animals and natural communities).
- Water quality and riparian zones (including wetlands, erosion and non-point source pollution).
- Soil productivity.
- Silviculture (including regeneration, aesthetics, re-entry, roads and skid trail layout).
- Disturbance (insects, disease, fire and fuels, pesticides, invasive species and conversion of native forests to non-forest uses or plantations).

The assessment found that existing state guidelines comprehensively address the impacts associated with dead wood, wildlife and biodiversity, water quality and riparian zones. However, existing guidelines were found to be lacking in effectively addressing disturbance considerations such as fuel reduction, needs for pesticide use, invasive species and conversion threats. It was also noted that more work is needed to address soil protection and site re-entry for the purposes of biomass harvesting.

Additional recommendations from the Forest Guild report on biomass harvesting guidelines include:

- Use the best available eco-regional science in determining biomass harvesting guidelines;
- Include public input and stakeholder collaboration in the guidelines development process;
- Include clear definitions for biomass related terminology; and
- Provide specific recommendations to address the retention of snags (e.g., standing dead trees), coarse woody debris, fine woody debris and protection of the forest floor and litter layer;

The Forest Guild has compiled a collection of woody biomass removal case studies from throughout the United States. The case studies provide information about lessons learned and recommended strategies that can help support successful biomass harvesting efforts. The case studies are available online and in a published project report[8].

[8] http://biomass.forestguild.org/

Forest Guild Woody Biomass Removal Case Study:
Thinning Mixed Conifer Stands, Lakeview, Oregon

This project was designed to utilize material from what would previously have been considered a pre-commercial thinning. The stands were thinned in order to improve tree vigor, growth, and resiliency to insects and fire. About 50% of the trees were removed, and the Bureau of Land Management (BLM) used a ten-year stewardship contract to treat the area. This was the first time that the BLM thinned a young plantation outside of its normal timber sale contract stipulations and utilized the material in lieu of letting it remain on site. The contractor agreed to utilize the material as clean chips. Project design minimized soil impacts by ensuring that the skid trails and landing affected less than 20% of the area. All trees were cut and moved to designated skid trails with mechanical harvesters. The costs of cutting and yarding were about $345 per acre (cutting was $265 per acre and yarding was $80 per acre). Hauling costs were an additional $2 per mile. The BLM received $8 per ton for the chip material. This relatively high price for chips reflected a percentage of small sawlogs (5 to 6 inch diameter and 16 feet long). The BLM and contractor negotiated a price, approximately $15 to $30 per MBF, for these small sawlogs that were also chipped due to available markets. The value of the clean chips removed was approximately $39,000 or $89 per acre, leaving a net cost of cutting, yarding and removing the biomass of $256 per acre; this total, is $10 per acre less than the standard treatment cost of $266 per acre. The BLM chose to apply the positive value that the clean chips generated to help pay for approximately 270 acres of pruning on residual trees (approximate cost rate of $143 per acre). So far approximately 600 acres have been treated as part of this biomass removal project, and another 1,500 acres have been tasked out.

Source: http://biomass.forestguild.org/Case-Studies/1009.html

Biomass Harvesting Guidelines in the Lake States

In Minnesota, *Biomass Harvesting Guidelines for Forestlands, Brushlands and Open Lands* were finalized in 2007. These state guidelines consider the wildlife and biodiversity, water quality and soil productivity interactions associated with woody biomass harvesting. Guidelines address the planning, design and operation of biomass harvesting activities. These biomass harvesting guidelines are intended to be applied in conjunction with site-level guidelines that have been developed to address other forest management operation considerations, including road layout and riparian area protection.

The guidelines specify that 20% of fine woody debris[9] (tops and limbs) be intentionally retained on site. Based upon standard forestry practices, it is estimated that an additional 10-15% retention occurs due to incidental breakage of branches during the harvesting operation and tree removal activities.

Specific guidelines applicable to biomass harvesting in Minnesota include:

- Avoid biomass harvesting in specific sensitive native plant communities (e.g., rare forest, woodland and savanna communities) or within specific sites where endangered or threatened plant or animal species are known to exist.

[9] The Minnesota guidelines define fine woody debris as: Tops, limbs and woody debris of less than 6-inch diameter at the large end.

- Avoid biomass harvesting within Riparian Management Zones (RMZs) and in leave-tree clumps.
- Avoid biomass harvesting from erosion-prone sites (e.g., sites on steep slopes of 35% or more) or within 25 feet of a dry wash bank (a specific sensitive site type found in southeastern Minnesota).
- Avoid biomass harvesting on organic soils deeper than 24 inches that are ombrotrophic[10] (e.g., black spruce bogs and conifer swamps).
- Avoid biomass harvesting on aspen or hardwood cover types located on shallow soils (8 inches or less) over bedrock.
- Do not remove any part of the forest floor, litter layer and/or root system.
- For soils with 8-20 inches of soil over bedrock and droughty sands, one-third or more of the fine woody debris should be retained on site.
- Retained woody debris should be distributed relatively evenly throughout the site rather than piled.
- Re-entry to a previously harvested site to retrieve biomass is not recommended but where re-entry occurs this should be done with caution to avoid negatively impacting forest regeneration.
- Retain snags, stumps and uprooted stumps, and retain and limit disturbance to pre-existing coarse woody debris.[11]
- Retain and scatter tops and limbs from 20% of trees harvested (e.g., one "average sized" tree out of every five trees harvested).
- If harvesting brush and small trees for biomass, leave 20% of this material on site.
- When harvesting understory vegetation for fuel reduction purposes, retain understory vegetation in 20% of the harvest area and retain snags greater than 12 inches in diameter as well as downed logs.

The Wisconsin Council on Forestry approved woody biomass harvesting guidelines for the state in December 2008.[12] These basic guidelines include:

- Retain and limit disturbance to down coarse woody debris (CWD) already present, except on skid trails and landings.
- Retain down fine woody debris (FWD) on site following harvest.
- Do not remove the forest litter layer, stumps, and/or root systems.
- Do not harvest fine woody material on shallow soils where bedrock is within 20 inches of the surface.
- Do not harvest fine woody material on dry nutrient-poor sandy soils.
- Do not harvest fine woody material on soils classified as dysic Histosols. (These are wetland soils with at least 16 inches of organic material that are nutrient-poor with a low pH.)
- Protect and sustainably manage species of greatest conservation need and sensitive ecosystems.

[10] The Minnesota guidelines define "ombrotrophic" as: A condition where minerals and nutrients are received solely from precipitation and dust fall, not from runoff or ground water; characteristic of bogs.

[11] The Minnesota guidelines define coarse woody debris (CWD) as: stumps and fallen trunks or limbs of more than 6-inch diameter at the large end.

[12] http://council.wisconsinforestry.org/biomass/pdf/BHG-FinalizedGuidelines12-16-08.pdf

In comparison to the Minnesota guidelines, Wisconsin advises operators to "retain and scatter tops and limbs (<4" diameter) from *10% of trees* in the general harvest area (e.g. one average-sized tree out of every 10 trees harvested)" as compared to the Minnesota guideline to retaining 20% (one out of every five trees). Additional, the Wisconsin guidelines specifically address salvage operations in the following way:

> For complete salvage operations, following severe disturbance (e.g. crown fire or complete blowdown), implemented on areas >10 acres under one ownership, and that include the harvest of fine woody material: *Retain at least 5% of area in unsalvaged (no harvest) patches at least 0.1 acres in size. These should include large diameter reserve trees, mast trees, cavity trees, snags, and down coarse woody debris if present.*

The Michigan Department of Natural Resources is currently developing guidelines, to be finalized in October 2009.

Challenges and Opportunities

At the same time that there is growing interest in woody biomass as a source of fuel, energy and chemicals there is also growing debate about the potential negative impacts to existing forest industries, the environment and human populations. Clearly, many areas of debate are not unique to woody biomass, as there is ongoing discussion about potential environmental, economic and social impacts of virtually all forms of alternative energy development. The development of biomass harvesting guidelines is one constructive response to this debate, but there are several other challenges to consider in the development of woody biomass opportunities.

Supply and Demand

Recently established renewable energy goals for the United States would require harvesting woody biomass at an annual rate and volume that far exceeds current total forest sector harvests to supply the existing industry. This potentially expanded level of harvest presents technical challenges to existing infrastructures, social challenges in terms of public acceptance, and competition with existing forest-dependent industries and communities. As policy makers have become aware of the potential magnitude of impact that could result from biomass-related renewable energy goals, there is discussion of adjusting these goals. In the E.U, the goal of 10% liquid biofuels is being re-assessed and additional funds have been requested to support research that would expand biofuel alternatives and include identification of energy saving and efficiency improvement opportunities.

Environmental Protections

Expanded biofuels development, and associated increases in biomass harvesting activity, has the potential to negatively impact ecosystem services and functions, including air and water filtration, wildlife habitat, carbon storage and sequestration, and biodiversity. Addressing these concerns is critical for gaining public support for biomass harvesting and to ensure that developments provide long-term environmental, economic and social benefit to the communities directly and indirectly affected. The development of biomass harvesting guidelines and the application of third-party certification programs for verifying responsible management and

harvesting practices can help address these concerns. To be most effective, voluntary efforts will need to integrate with policy and regulation in some manner and collaboration across sectors (e.g., forestry and agriculture) is needed to address the development of dedicated energy crops (see sidebar). To the extent that environmental concerns apply to other sources of biomass and competing energy sources, these alternatives should also be evaluated and guidelines developed. The impacts of forest-derived biomass should be assessed within the spectrum of alternatives.

Policy Arenas to Mitigate the Impact of Biofuel Production on Biodiversity

- Protect native ecosystems and indigenous lands.
- Make sustainability a priority for all biofuel production
- Moderate environmental damage that could result from dramatic price volatility in agricultural commodities.
- Redesign the agricultural and energy sectors.

Source: *Biofuel and Global Biodiversity*, 2008, Institute for Agriculture and Trade Policy

Land Use Choices

As biomass utilization expands there will be growing pressure to maximize the efficiency at which these raw materials are harvested, transported and converted to fuel, energy, chemicals, and other products. This pressure could result in increased intensification of natural forest management as well as conversion of native forests to plantations or short-rotation dedicated energy crops. Current biomass harvesting guidelines focus almost exclusively on environmental implications of utilizing biomass as a byproduct from harvesting of traditional timber products or agricultural residues from traditional crops. These guidelines should be expanded to include recommendations regarding plantation establishment and management, and situations where biomass is the primary product being grown and harvested. In ecoregions where aforestation or the introduction of energy crops could have negative impacts on biodiversity, there may need to be guidelines addressing where bio-energy plantations are established and/or which plant and tree species are used. Similar guidelines are needed for non-woody biomass and the harvesting of agricultural residues. The development of guidelines for the collection of agricultural residues and other cropping systems for biomass, including current work by the University of Minnesota's West Central Research and Outreach Center, is essential to evaluating alternative approaches to bioenergy development. The rapid rate of biomass development has outpaced policy, and action is needed at the federal, state and local level to get back in front of the challenge.

Jobs, Training and Infrastructure

Infrastructure change and development is needed to support biomass harvesting, transportation, and storage as well as production of biomass derived fuels, energy and chemicals. Additional training programs and job creation incentives may be needed to create necessary service capacity. To maximize potential gains and minimize potential problems associated with bioenergy development, coordinated state and regional action may be needed. Absent such coordination, redundancies as well as inefficiencies are likely. In some cases, regions with the strongest biomass potentials may lack necessary resources for efficient development without facilitated regional collaboration.

Climate Change

One of the reasons biomass harvesting is so appealing is that the resulting fuel, energy and chemicals provide an alternative to fossil fuel-derived products, thereby offering the possibility of dramatic reduction in carbon dioxide emissions and other greenhouse gases. The opportunity for forest-derived biomass to be part of the carbon solution is an important consideration in the planning and development of biomass projects. Without careful planning, projects may include inefficiencies that greatly undermine opportunities to replace fossil fuels and minimize greenhouse gas emissions. Ideally, biomass development will occur in a manner that maximizes efficiencies in energy production (e.g., by combining heat and power production) and that minimizes energy consumption associated with transportation, storage and raw material processing. Linking energy development projects to full carbon accounting and reporting will increase financial incentives for efficient development.

The Bottom Line

Biomass harvesting and associated energy, fuel and chemical products offer significant opportunities for economic development, fossil fuel independence, community self-reliance, and job creation. Biomass harvesting could also help in responding to ecological challenges including insect and disease threats, storm events and natural disasters, wildfire and fuel loading concerns, and goals of achieving more effective management of young forests to support longer-lived species and higher valued products. However, biomass harvesting raises significant social concerns about esthetics and potential conflicts with other forest values and benefits. The development of biomass harvesting guidelines is one response to these concerns, but there are several other challenges to consider in the development of woody biomass opportunities. Careful monitoring and precautionary guidelines as well other policy and planning actions are needed to ensure that energy investments, including bio-energy initiatives, do not negatively impact biodiversity, soil productivity and ecosystem health in the United States and other parts of the world.

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