Reconciling Renewable Energy Goals with Forest Sustainability

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Introduction

Recent and proposed national policies aimed at increasing renewable energy production to mitigate climate change and increase energy security could have major implications for forests in all regions of the United States. Careful planning will be needed at the national policy level and in decisions by local communities to fully capture the environmental and economic benefits that new markets for woody biomass represent, while also ensuring that the local siting of new or expanded bioenergy or biofuels facilities does not create cumulative new demands on local forests that cannot be supported.

State and local governments today are facing decisions about what approaches to renewable energy are best suited to their particular needs and circumstances, and to the level of woody biomass production their local forests can supply sustainably. The useful life of a power plant may be 30 years or more, so the decisions made today will affect the region's communities and forests, and potentially limit other options, for many decades into the future. Once these decisions are made, and the resources committed, this may also limit the flexibility to consider other options in the future. So it is important for state and local governments to have access to information that is the most complete, accurate, and up-to-date as possible.

The single most critical set of information is a realistic estimate of woody biomass availability within a feasible transportation distance. Overestimates of local supply will mislead energy companies into decisions to site facilities that are of the wrong type or scale, and the resulting boom and bust will work in no one's best interest. There will be pressure to overharvest the available resources in the short term, and then disruptions in local employment as the facility is forced to downsize or close. For energy companies and their investors, this will result in a financial setback, and a reluctance to invest in other renewable energy facilities in the future.

A realistic estimate has to entail much more than just an examination of standard forest inventory information. There are both public and private forest lands that will be off limits due to statutory constraints or landowner preferences. Terrain, transportation distance, truck weight limits, and other factors will further constrain the proportion of the woody biomass supply that is economically recoverable. All of these constraints that take some portion of the local forest resource "off the table" shift a greater burden to the remaining forest lands to meet supply expectations, thereby increasing the likelihood of overharvesting and its associated impacts.

Adequacy of potential woody biomass supplies

It is the combination of new and expanding demands on forests for energy that makes it so challenging to assess the adequacy of woody biomass supplies, and to anticipate how best to meet renewable energy needs while sustaining forest productivity and the host of other environmental, economic, and cultural values of forests. Thinking about only one use at a time when considering the capacity of forests to absorb and accommodate additional demands has gotten us in trouble before, and simultaneously balancing the multiple uses and demands on forests has become one of the central challenges of forest policy and sustainable forest management.

Large-scale demands on forests for energy production are for the most part new to 21st century America, and are additive to the existing challenging set of competing uses and needs from forests. Because of somewhat different motivations and policy drivers, the energy sector itself is fragmented in its approach to forest resources. The pressing need to find substitutes for transportation fuels derived from imported petroleum was the motivation behind the goal of producing enough biofuels to supply 30 percent of the nation’s transportation fuel needs by 2030, which was the basis for the US Department of Energy’s 2005 study on the supply of biomass to meet this need (Perlack et al. 2005). The results of the study found over 1.3 billion dry tons per year of biomass potential, including 368 million tons from woody biomass, as available for producing enough biofuels to substitute for a third of the current demand for transportation fuels (see Figure 1). But the biomass that is necessary to meet the 25x’25 goal for renewable electricity production must come from this same resource. What will be the combined effect on forests from achieving both these goals?

A 2007 study by the Department of Energy attempted to address this very question—it examined the environmental and economic impacts of implementing both a 25x’25 renewable electricity standard and a 25 percent renewable fuel standard by 2025 (EIA 2007b). The demand this would place on US forests for increased biofuels production, together with the even greater demand for biomass for power generation, could be more than the nation’s forest can sustain. It could price most of the US wood products industry out of existence, and have impacts on soil and water resources, biodiversity, and other values that the American public would almost certainly find unacceptable.

Biofuels

To meet these twin goals by 2025 would require the production of 61 billion gallons of ethanol, 28 billion gallons of which would be cellulosic ethanol (EIA 2007b). These goals are significantly higher than those in the Renewable Fuels Standard established by 2007 Energy Independence and Security Act (EISA), which called for 36 billion gallons of ethanol production by 2022, with 21 billion gallons of this coming from advanced biofuels such as cellulosic ethanol.

Increased competition for feedstocks is expected to push up the price of energy from all sources. With an increase from the current $1.70 per million Btu to about $4.00 per million Btu, the US will be operating near the estimated maximum level of biomass availability (EIA 2006). Based on supply curves developed by DOE using the National Energy Modeling System, there would be a strong supply response from other forms of biomass for energy at this price, resulting in an additional 173 million dry tons of biomass from energy crops, 162 million dry tons from forest residues, 127 million dry tons from agricultural residues, and 29 million dry tons from urban wood waste (EIA 2006), for a total of 491 million dry tons.

It takes roughly 1 dry ton, or 2 greens ton of wood to produce 86 gallons of cellulosic ethanol. A cellulosic ethanol plant producing 50 million gallon/year, such as the Range Fuels plant currently nearing completion in central Georgia, will require about 600,000 dry tons of woody biomass annually. In the near term, a significant portion of the supply for this plant is expected to come from wood waste and residues, but as the plant gradually scales up to full capacity, an increasing proportion of its woody biomass will

come from roundwood harvested for this purpose (Barmore 2009). At stocking rates typical of forests in the Southeast, this will require the equivalent of harvesting an average of 28,000 acres of forest each year.

Producing 28 billion gallons of cellulosic ethanol will require approximately 325 million dry tons of biomass.[1] If 275 million dry tons can be supplied by energy crops, urban wood waste, and forest and agricultural residues, this would leave 50 million dry tons to be supplied from roundwood (see Figure __). Meeting these production goals would require constructing the equivalent of more than 83 biofuels facilities of the size and capacity of the Range Fuels plant described above. Wood consumption would be approximately 3.0 billion cubic feet annually. At timberland stocking levels typical of forests in the US South, this translates to the equivalent of harvesting roughly 2.3 million acres annually.

Wood bioenergy

Electric power generation from woody biomass is expected to have a far greater demand on forests. In the DOE study, both wind and biomass power capacity are expected to increase ten-fold from current levels. Electric power generation from biomass is projected to rise to 495 billion kilowatthours from the current 55 billion kilowatthours (EIA 2007b).

In 2007, renewable energy from all sources accounted for 8.4 percent (351 billion kilowatthours) of total electricity production nationally (EIA 2008a). Of this, electricity from wood accounted for 38.5 billion kilowatthours or 11 percent. Most of the electricity currently generated from woody biomass, about 76 percent, is from industrial cogeneration, and most of that (94 percent) is generated and used by the pulp and paper industry (EIA 2008b) (see Table __). Since this power is generated as a byproduct, the woody biomass that is utilized results in no significant increase in wood harvested. Much of the remaining 24 percent of electricity generated from woody biomass is generated from wood residues and waste products, so the area of forest land currently harvested specifically to provide wood for energy is negligible.

This picture is expected to be the reverse under a mandatory 25x'25 goal. As the amount of electricity generated from renewables increases toward this goal, an increasing proportion is expected to be generated from wood and other biomass (See Figure __) (EIA 2001). More importantly, although the amount of electricity produced through cogeneration by 2020 is expected to increase by 66 percent, from 29 billion kilowatthours to 49 billion kilowatthours, the proportion generated from additional harvesting of biomass is projected to increase from 8 billion kilowatt hours to more than 475 billion kilowatthours (see Figure __) (EIA 2003).

Harvesting roundwood is not the lowest cost source of woody biomass for energy production, but it is the most plentiful. There are lower-cost sources such as urban wood waste that are currently underutilized (see Figure __), but as the demand for renewable fuels increases this will reach its limit. Mill residuals and logging residues are another lower-cost source, but like co-generation they depend on the production of existing wood-based industries. After the limits are reached for woody biomass supply from residuals, energy producers will shift to roundwood harvesting from existing forests, where they will compete directly with wood-based industries for feedstock. As prices for roundwood increase, marginal existing wood-based industries will be displaced, further

[1] 1 bone dry ton (bdT) of wood is equivalent to 2 green tons (gT) and produces approximately 86 gallons of cellulosic ethanol.

reducing the supply of residuals and accelerating the price increase for roundwood (Galik et al. 2009).

If under a 25x’25 Renewable Electricity Standard power generation from woody biomass rises to 495 billion kilowatt hours as projected (EIA 2007b), the area of forest land harvested annually would increase sharply when the limits of residuals is reached, possibly around 2012 (Galik et al. 2009), and continue to rise quickly in subsequent years. Assuming that a combination of energy crops, urban wood waste, and agricultural and forest residues would be able to supply 219 million dry tons of biomass annually (see Figure __), an additional 329 million dry tons would have to be supplied by roundwood. Using accepted conversion rates of 1.1 bdT (2.2 gT) of wood required per thousand kilowatthours, and 30 cubic feet of wood per green ton, generating this amount of electricity will require 19.7 billion cubic feet of wood. Growing stock volume on timberland in the US South averages 1,322 cubic feet per acre (Smith 2002), which means that the equivalent of 14.9 million acres of timberland would have to be harvested annually to supply this volume of wood.

Meeting combined goals for wood bioenergy and biofuels

So for forests, the combined effect of simultaneously implementing a 25x’25 renewable electricity standard and a 25-percent renewable fuels standard would require 379 million dry tons of roundwood, in addition to 162 million dry tons from forestry residues (see Figure 5). This translates to a harvest of 22.7 billion cubic feet of roundwood annually. At average stocking levels in the US South, this would require harvesting the equivalent of all of the growing stock on 17.2 million acres—an area more than 14 times the size of Delaware--each year.

The current net growth of growing stock on all 504 million acres of timberland in the US is 23.7 billion cubic feet annually (Smith et al. 2004) so just meeting these energy requirements would utilize the equivalent of more than 95 percent of growth. The average annual harvest of wood for all wood products over the past two decades is roughly 15.5 billion cubic feet (Smith et al. 2004), so the combination would represent over 39 billion cubic feet per year, more than double recent harvest levels. Even allowing for some displacement of existing wood products manufacturers due to increased wood prices, the demand on forests for a combination of energy and wood products could exceed 150 percent of current net growth.

All the competitive jostling for this forest resource presumes that, in the end, all of the accessible and practically available woody biomass will get harvested and go into one bioenergy or biofuels application or another. Such intensive harvesting may not be possible in some areas due to the potential for soil nutrient depletion and loss of productivity (Scott and Dean 2006). This would place even greater pressure on those forest areas where harvesting is feasible. In all the excitement it is also easy to forget that some of these resources are serving other important purposes—conserving biological diversity, protecting water quality, providing wildlife habitat, and perhaps sequestering more carbon where it is than will be saved by substituting it for a gallon of oil.

Can wood bioenergy and biofuels goals be met?

Is it likely that every acre of the nation’s forests will be cut down to feed electric power plants or to keep filling the gas tanks of America’s persistent fleet of SUVs? Hardly. Do large categories of public and private forest lands need to be placed off-limits to harvesting for biomass energy in order to prevent overharvesting or other environmental degradation? No. In fact, taking large areas of US forest land out of the total potential supply base would concentrate demand on an

even smaller area of forest land, and increase the likelihood of unsustainable management on the remaining forests.

Two-thirds of US forest land is in the hands of ten million private woodland owners, many of them families, and survey after survey has shown that the objectives for which these forests are managed are as diverse as the owners themselves. A majority of them consistently report that income from wood production is not their primary objective (Butler 2008). Nevertheless, if there is a major rise in wood prices because of increased competition for wood supplies as projected, there undoubtedly would be a significant number of forest landowners who would sell their timber. In some states, forest practices laws provide a safety net to ensure that wood harvesting is done in a sustainable manner, and some states have taken additional steps to ensure that woody biomass harvesting is done sustainably (Evans and Perschel 2009). Other states have very few such safeguards.

The one-third of the nation's forests that are in public ownership also have a variety of safeguards in place to prevent overharvesting or unsustainable management, and most of them are monitored as closely by local citizens as they are by the public officials responsible for their management. A provision in the Energy Independence and Security Act of 2007 essentially placed all federal forest lands off-limits to harvesting for biofuels to satisfy the national Renewable Fuels Standard. As of this writing, a more flexible approach is being considered in proposed federal legislation to create a national 25x'25 Renewable Electricity Standard. While wilderness areas, old-growth forests, and other high conservation-value areas would continue to be off-limits, there would be flexibility to utilize woody biomass from hazardous fuels reduction and other kinds of ecosystem restoration activities. In parts of the western US where these fuel buildups pose a significant risk of catastrophic wildfires (and major additions to atmospheric carbon), the amount of woody biomass that could be utilized on a sustainable basis is substantial—up to 60 million tons per year (Perlack 2005).

After an initial surge in new capacity for wood bioenergy and biofuels production, investments in additional capacity may slow considerably. Energy companies that are unable to secure multi-year supply contracts to guarantee a significant portion of woody biomass feedstocks may determine that the risk is unacceptable, and either delay or cancel plans for new or expanded facilities. In most regions of the US, there is a limited number of large private forest ownerships well-suited to enter into long-term biomass supply agreements. A few federal and state forest management agencies have statutory authority to enter into multi-year supply agreements, but thus far only a small number of such contracts have been approved. Each new wood bioenergy or biofuels facility will find it more difficult than the last to secure adequate feedstocks, and the opportunities to build additional capacity is likely to diminish over time.

It may simply take longer than expected to reach the established goals for renewable biofuels and bioenergy, and the goals themselves may have to be extended. The Annual Energy Outlook for 2009 projects that the US will fall short of the Renewable Fuels Standard goals for biofuels production by about 6 billion gallons by 2022 (EIA 2008c). It is predicted that this goal can be met by 2030, however, assuming a further doubling of biofuels production from biomass between 2022 and 2030, and a quadrupling of net ethanol imports (see Figure 6).

A Department of Energy study of alternative goals for renewable energy production describes enormously different implications for biomass energy in going from a 10 percent renewable energy requirement to a 20 percent requirement. To reach a 10 percent goal by 2020 would require an increase in biomass-fired generating capacity to approximately 15 gigawatts, whereas the 20 percent goal would require this to increase to approximately 70 gigawatts (EIA 2003) (see

Figure 8). At the 10-percent goal, much of the demand for renewable bioenergy could be supplied by wind power, which is more economical than biomass. Shifting to a 20-percent goal translates to a much larger demand for biomass feedstocks—70 gigawatts of additional electrical generation capacity from biomass translates to 700 new 100MW power plants, each of them consuming an average of 1.2 million green tons of wood annually. The DOE analysis raises the question of whether there would be sufficient land to sustain the required level of biomass production, estimating that 9.6-14.4 million acres of land would have to be devoted to energy crops, including up to 37 percent of all land currently in the Conservation Reserve Program (CRP) (EIA 2003).

Incentivizing efficient uses of wood for energy

Wood will continue to be a scarce resource in economic terms, and mandatory goals such as those being considered for the 25x'25 Renewable Electricity Standard will make demand for wood and woody biomass increasingly inelastic. In the crafting of tax subsidies and other kinds of financial incentives aimed at supporting the growth of the domestic renewable energy industry, it will be important to ensure that there are adequate incentives for the most efficient technologies.

A combined-heat-and-power facility operating at a typical 80 percent efficiency will get much more energy out of a ton of wood than an electricity-only power plant operating at a typical 20 percent efficiency (see Figure 9). A community that is considering a 50MW power plant, but is concerned about sustainably supplying 650,000 tons of wood annually, may be best served by facilitating the construction of three 20MW power plants in the general vicinity, each of them located in conjunction with an existing wood products manufacturing facility that can provide wood waste as fuel, and utilize the thermal energy and electricity. Other process-related factors may need to be considered as well. For example, biofuels plants typically use large volumes of water, so the critical questions may be as much about water consumption or effects on local water supply as they are about woody biomass supply.

Communities in Europe have installed more than a thousand small-scale (10 MW or less) power plants using advanced wood combustion technologies (AWC) that are remarkably efficient (up to 90%), produce minimal amounts of greenhouse gases or other air pollutants, and are linked to the sustainable management of local forests (Richter et al. 2009). More than 100 of these plants combine heat and electric power to serve towns, portions of cities, industrial complexes, and public institutions. It is estimated that if one state, North Carolina, were to construct one facility of this type each year in each of its 100 counties over a 5-year period, the $100 million annual investment costs would soon be offset by fuel savings of up to $180 million each year, and fossil emissions of greenhouse gases would be reduced by up to a million tons annually (Richter et al. 2009). Policy initiatives that would facilitate this kind of development in the US include: (1) carbon management policies that encourage the substitution of carbon-neutral fuels such as wood for fossil fuels, (2) make AWC then energy system of choice for new construction and renovations in communities with adequate local wood supplies, (3) make more efficient use of urban wood waste from tree removals and construction, and (4) expand construction of AWC-powered district-energy systems in which heat is supplied from a central source to complexes of commercial/institutional buildings.

Conclusion

When the US last relied upon wood as its primary source of energy, up through the end of the 19th century, the nation's forests were down to their smallest area in history and were being rapidly

depleted (Starr 1865). In many ways, the shift to fossil fuels in transportation, heating, electricity, and industrial processes in the late 1800s came just in time, and gave America's forests a century to recover (Williams 1989). Will our reliance upon forests for energy in the 21st century return them to the conditions of the 19th century? Presumably we will not let that happen, but there is no guarantee.

Mitigating global climate change by reducing greenhouse gas emissions is perhaps the most urgent challenge facing humanity in our era. It is not simply an environmental issue. It is an economic and social issue of enormous proportions here in the US, in other industrialized nations, and especially in developing nations around the world. Energy conservation and the expansion of zero-carbon energy sources like wind, solar, and geothermal will get us part of the way there, but renewable, carbon-neutral energy sources like wood and other biomass must inevitably play a large and essential role.

Finding a substitute for petroleum-based transportation fuels will become an increasingly urgent priority as well. More than almost any nation, the basic physical infrastructure of the US—the layout of our cities, suburbs, highways, and transit systems—developed after the near-total shift to fossil fuels. The functioning of this infrastructure, and on society itself, is premised on the continuation of abundant, cheap energy. The Department of Energy points out that achieving the 25-percent renewable fuel target in both the electricity generation and transportation fuel markets will lead to higher energy prices, as producers substitute more expensive renewable fuels for less expensive fossil fuels, and that these higher energy prices will have an impact on economic activity (EIA 2007a). There are multiple alternative energy sources for electricity and heat, but for domestic, renewable transportation fuels there are few significant alternatives to biomass. Our physical infrastructure of suburbs and highways cannot be changed overnight. If Americans are faced with the choice of enduring the economic and social impacts of higher energy costs, or accepting greater environmental impacts on the nation's forests, it will not be an easy decision and the outcome is far from certain.

This kind of information is essential for state and local government officials deciding how to best meet their constituents' needs for energy while protecting and sustainably managing natural resources that meet those same constituents' needs for clean water and the other essential ecosystem services that forests provide. It is essential to the energy industry and community leaders as they decide the type, scale, and location of a biofuels or bioenergy facility that will be best suited to the locally available and sustainable supply of biomass, and that will be financially viable as competition for feedstocks increases. It is essential for natural resource managers charged with the responsibility of ensuring that forests continue to be managed in accordance with accepted standards of sustainability, but who also recognize that even the best standards are of little value if too many wood-dependent facilities get placed in too close a proximity to one another and wood demand simply overwhelms local supply.

Perhaps most importantly this information is essential to national and state policymakers who are considering ambitious mandatory goals for renewable energy production, and who will design the subsidies, tax credits, trade tariffs, and other incentives that they think will best support the development of a biofuels and bioenergy industry that will meet those goals.

It is clear that forests will play a major role in the nation's energy future. This can be an enormously positive development from the standpoint of mitigating climate change through a shift to more carbon-neutral energy sources, making the transition to renewable energy, and even improving the health and productivity of US forests. But it is essential that policymakers, energy producers, and all of us as energy consumers do not lose sight of the fact that US forests,

extensive though they may seem, are a scarce resource relative to what they are expected to provide. Almost too late did we comprehend that forests were not an inexhaustible resource during an earlier era in which we depended on forests as our primary energy source. Their utilization must be guided, by informed, insightful policies that encourage innovation in the efficient use of this limited resource; that facilitate a diversity of different types, scales, and locations of biofuels and bioenergy facilities that are well matched to local circumstances; and that are grounded in a continued commitment to the conservation and sustainable management of forests for the full range of values and services they represent.

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