Inherent Sustainability & Carbon Benefits of the US Wood Pellet Industry

Executive Summary

Sustainably produced wood pellets and other solid biomass fuels are renewable, low-carbon[1] fuels that are essential for utilities seeking to reduce their environmental impact. Biomass-fired electricity generation has demonstrated greenhouse gas emissions reductions between 74 percent and 90 percent as compared to equivalent energy produced using coal.[2] In addition to the environmental benefits, biomass generation provides both firm and peaking capabilities and dispatchable generation, meaning it can be quickly mobilized to fill a gap in energy or electricity supply. It is low in sulfur, low in chlorine and low in nitrogen. Of the various forms of biomass, the high calorific value, low moisture content, high density and uniform geometric shape (enabling efficient transport over significant distance), make wood pellets a particularly compelling fuel for use in utility-scale renewable energy generation applications.

Enviva is one of the largest wood-pellet manufacturers in the world. As a company which uses woody biomass, a natural resource, as its only raw material, Enviva is not only committed to, but also obliged to ensure that sourcing, production, and transport operations are sustainable and promote a clean and healthy environment. Our business model is founded on sound, sustainable forestry practices. With operations in the southeastern United States, a region where there are extraordinary commercial forests, strong environmental protections, and continuously growing carbon stocks, Enviva is well positioned to meet the rapidly growing demand for sustainable, renewable biomass fuel to supply the world's energy generating needs. This is because:

US Forests Are Robust and Growing

The US is home to approximately 751 million acres of forest area. The net volume of live trees per acre[3] has increased in all regions of the US for more than 50 years. In the Southeast US, where Enviva

1 Fuels derived from plant matter such as woody biomass are often referred to as carbon-neutral because only the atmospheric carbon that was recently absorbed during the plant's growth is emitted during combustion. When used as a renewable energy source for power generation, emissions generated from the upstream production processes and transportation to the power plant are carefully tracked and calculated. Life-cycle carbon emissions values of biomass compared to fossil fuels can be found on page 5, 6 and Appendix IV.

2 UK Environment Agency. (2009). *Minimising greenhouse gas emissions from biomass energy generation.* Bristol, UK: UK Environment Agency.

3 Also referred to as growing stock inventory on timberland by the USDA Forest Service.

About this White Paper

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has its manufacturing operations[4], the net volume per acre has increased 94 percent since 1953.[5] This increase is due in part to strong forest industry commercial activity. Markets ensure that landowners have an incentive to keep their land forested and sustainably managed. It is partly for this reason that forests have thrived and increased even when harvesting pressure was at its greatest. For example, during the period from 1997–2007, when the forest products and paper and pulp industries harvested an average of 187 million tons of wood per year,[6] the growth-to-drain ratio (the amount of new forest growth in excess of removals) continued to increase.

Sustainable Forestry Practices Ensure Forest Growth and Promote Increased Carbon Sequestration

Young trees absorb carbon at a faster rate than older, mature trees.[7] The practice of sustainable, rotational harvesting means that there is a continuous cycle of new growth in the forest. Managed forests, which have trees of various ages and species, absorb more carbon than older growth stands and maintain stable carbon stocks.[8] In the most recent version of the US Environmental Protection Agency's "Inventory of US greenhouse gas emissions and sinks," forest carbon sequestration has increased 31 percent since 1990.[9]

Healthy Markets Ensure Healthy Forests for the Long Term

The positive trend of increasing forests and forest carbon stocks is potentially threatened by an economic downturn that has decreased demand for forest products (e.g. furniture, construction materials, paper products, etc.), and depressed timberland values relative to other potential uses for commercial land. The majority of forestland in the Southeast US is owned by small forest owners.[10] Many of these people have owned their land for generations and benefit from the revenue it generates. Decreased demand for the products produced on their lands may lead them to look for higher and better returns from alternative land uses, such as development. Strong timber markets with new demand created by biomass-to-energy provide the economic incentives to ensure that land owners maintain their land as forests and do not sell or convert these resources to other uses. In practice, when forest landowners benefit from new markets (e.g. bioenergy), they respond by growing more trees and increasing forest management.

The Combination of Forests and Energy Avoids the Perceived Tradeoff Between Jobs and the Environment

The wood pellet industry is one of the few growing forest-product industries in today's challenged economy. In the US it provides direct manufacturing jobs and indirect supply chain jobs in rural areas, and an economic incentive for forest owners to continue to invest in their forest land. In the

4 Enviva operates wood pellet manufacturing facilities in Bumpass VA, Ahoskie NC, Wiggins MS and Amory MS. Enviva has announced two additional facilities in Northampton County NC and Southampton County VA.

5 USDA Forest Service. (2009). US Forest Resource Facts and Historical Trends. USDA Forest Service, p.17

6 Source: Proprietary inventory and demand data supplied by RISI. Figures are in US short tons.

7 Bowyer, J., Bratkovich, S., Frank, M., Howe, J., Stai, S., & Fernholz, K. (2012). *Carbon 101: Understanding the Carbon Cycle and the Forest Carbon Debate.* Minneapolis MN: Dovetail Partners Inc., p.4.

8 Malmsheimer, R. W., Heffernan, P., Brink, S., Crandall, D., Deneke, F., Galik, C., et al. (2009). Forest Management Solutions for Mitigating Climate Change in the United States. Washington, DC: Society of American Foresters, p.71.

9 US Environmental Protection Agency. (2012). Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2010. Washington, DC: US Environmental Protection Agency, Section 2, p.14.

10 USDA Forest Service. (2009). US Forest Resource Facts and Historical Trends. USDA Forest Service, p.10.

countries where wood pellets fuel renewable energy generation, existing power plants can be utilized and jobs both at these facilities and along the supply chain are maintained. At a time when the US and many other countries are concerned about both jobs and climate change, biomass-to-energy industries like wood pellets create win-win solutions for the economy and the environment.

This paper highlights the carbon-reduction benefits of biomass combustion, the inherent and proven sustainability of sourcing woody biomass from US forests, and the positive impact that bioenergy has made as a new export market for the US.

Introduction

Global demand for sustainable, renewable energy sources continues to grow, and countries committed to reducing their use of fossil fuels both for carbon mitigation and fuel independence look for reliable and cost effective means to do so. Solid biomass[11] fuel has emerged as one of the three leading renewable energy sources.

Demand projections for this form of low-carbon[12] fuel have increased significantly over the past several years. Pelletized woody biomass, due to its high calorific value, low moisture content, high density and uniform geometric shape (enabling efficient transport over significant distance), is in particular demand for use in industrial-scale energy generation applications. It also perfectly complements other forms of renewable fuel sources that are weather dependent and intermittent in nature. Capable of providing both firm capacity and peaking generation (meaning it can be quickly mobilized to fill a gap in energy or electricity supply), biomass is an attractive renewable fuel source. As one of the few renewable energy sources that can be adjusted to meet daily fluctuations in energy demand, biomass is flexible, controllable and reliable, and ideally suited to help fulfill today's energy demands.

Biomass, broadly defined, is any organic plant material that stores energy from the sun. Through the process of photosynthesis, plants convert carbon dioxide from the air and water from the ground into carbohydrates, which are complex compounds composed of carbon, hydrogen, and oxygen. When these carbohydrates are burned (e.g. for energy), they turn back into carbon dioxide and water, releasing the solar energy they contain in the process, resulting in no net effect on atmospheric CO_2. In contrast, combusting a fossil fuel like natural gas or coal adds to overall levels of CO_2 in the atmosphere because the geologic carbon it releases would have remained trapped underground if not for human activity.

Because wood pellets can be used in the same furnaces that currently fire coal, biomass can be deployed with a relatively low capital cost. In these "co-firing" applications, biomass is not just a renewable resource built alongside fossil fuel sources, it actively displaces the use of fossil fuel in energy generation. This concept is often referred to as the "Substitution Effect." When sustainably produced wood pellets are used to generate electricity instead of

11 For the purposes of this paper, solid biomass will henceforth refer to pelletized woody biomass.

12 According to the United Kingdom Environment Agency, *Minimising greenhouse gas emissions from biomass energy generation*, wood pellets can reduce carbon emissions relative to coal between 74 and 90 percent. Enviva's own internal calculations indicate a GHG emission savings from between 82 percent and 92 percent when compared to the US coal average with plants at steady state capacity. Variances depend on location, feedstock, utility efficiency and other variables (See Appendix III).

fossil fuels (e.g. natural gas or coal), then that quantity of fossil fuel, along with its embedded carbon, remains deep underground. Biomass prevents geologic CO_2 from fossil fuel combustion from entering the atmosphere.

The US, with its robust and highly developed commercial forests, strong environmental protections, and continuously growing carbon stocks, plays an important role in meeting the rapidly growing demand for sustainable, renewable biomass fuel to supply the world's energy resource needs. US Federal laws and regulations such as the Environmental Protection Agency's Clean Water Act (CWA),[13] the Endangered Species Act (ESA)[14] and the Lacey Act lay out measures to protect US forestlands, wetlands and other sensitive ecosystems. The Endangered Species Act (ESA) provides a program for the protection and conservation of threatened and endangered plants and animals and the habitats in which they are found. The Lacey Act, which was originally passed in 1900 to protect wildlife, has been expanded recently to prevent the illegal extraction of trees, the removal of trees from protected areas, and the laundering of illegal logs.[15]

Along with these comprehensive government regulations, the US forest industry has established what are known as "Best Management Practices" or "BMPs" that are widely respected and followed throughout the forest industry. These BMPs are driven by the knowledge that sustainable forest management practices result in healthier, more productive forests. Links to some southeastern state BMPs can be found in Appendix I.

In addition to BMPs, well established, third party forest certification programs in the U.S. help to ensure that sustainable forest practices are upheld throughout the supply chain. Independent forest certification programs provide a consistent and transparent framework for evaluating the sustainability of a company's operations, from forest to product. Enviva maintains a number of certifications to leading programs that verify the certified content in our supply chain and also ensure that non-certified fiber comes from responsible sources. Appendix II provides detailed information on Enviva's various certifications.

Enviva's biomass resources include residues from the forest products industries and commercial forests.[16] As with any bioenergy company, sourcing biomass comes with the obligation to make certain that the resource is sustainable. Enviva sources from a variety of wood resources, including commercial forests that have long been an economic backbone of the US economy and have been sustainably managed for generations. Sustainability is non-negotiable from both an environmental and an economic standpoint. As a company which uses a natural resource as its only raw material, Enviva is not only committed to but also obliged to ensure that sourcing, production and transport operations are sustainable and promote a clean and

13 California Wetlands Information System (2007). "Federal Clean Water Act, Section 404." http://ceres.ca.gov/wetlands/permitting/sec_404.html. More information on the CWA can be found at http://www.epa.gov/lawsregs/laws/cwa.html.

14 More information on the ESA can be found at http://www.epa.gov/lawsregs/laws/esa.html.

15 Elias, P. (2012). Logging and the Law: How the US Lacey Act Helps Reduce Illegal Logging in the Tropics. Cambridge, MA: Union of Concerned Scientists. More information on the Lacey Act can be found at http://www.aphis.usda.gov/plant_health/lacey_act/.

16 Currently, Enviva's biomass sources include processed residues such as chips, bark and sawdust; unprocessed residues such as tree tops, branches, and other forestry debris remaining after the primary biomass (tree trunk) has been processed and shipped from the forest; and low-grade round wood fiber and commercial thinnings.

healthy environment. Furthermore, our manufacturing facilities must ensure a reliable supply of biomass, sourced within 50 to 75 miles, for continuous operation. Our business model is founded on sound, sustainable forestry practices and sustainable biomass sourcing, without which we could neither succeed nor survive.

Cleaner Emissions: Biomass vs. Coal, Oil & Natural Gas

While CO_2 released by energy production from wood pellets is part of the earth's natural carbon cycle, there are some CO_2 (or GHG) emissions associated with manufacturing wood pellets. Coal and natural gas also have GHG emissions associated with their harvesting and preparation. However, even if one excludes the "production" emissions for coal and natural gas, the production emissions from wood pellets are far less than the combustion emissions alone of these fossil fuels. The average life cycle GHG emissions of pelletized woody biomass are between 100 and 200 $kgCO_2$/MWhe of energy produced, compared to between 506 and 582 for natural gas and between 896 and 1104 for coal.[17] Variances depend on plant efficiencies, transport methods and distances, and feedstock resources, among other factors. It is worth noting that most of the emissions from sustainably produced wood pellets come from the upstream production process and transportation to the power plant, as the CO_2 emissions from burning sustainably produced biomass are part of the earth's natural carbon cycle.

The potential to reduce these emissions even further is therefore significant, as transport methods become more efficient and an increasing amount of process energy is sourced from renewable sources.[18] Coal, in contrast, produces most of its emissions during the combustion process, and as previously noted, the geologic carbon released is a net addition to existing atmospheric carbon. In Appendix III, we provide a table from the United Kingdom's Environment Agency that shows the relative emissions savings of different types of biomass compared to coal and natural gas. Appendix IV provides a table from Enviva's internal data input into the UK Office of Gas & Electricity Markets (OFGEM) carbon calculator which shows the average emissions of different facilities based in Mississippi, North Carolina and Virginia, relative to US coal plants, US natural gas plants, and the current UK reference emissions standard.

Studies at the National Renewable Energy Lab (NREL), the US Environmental Protection Agency (EPA) and the National Council for Air and Stream Improvement (NCASI) among others have shown that co-firing biomass alongside coal at utility power plants reduces the emissions of air pollutants, such as mercury, smog-forming NO_X, and acid rain-forming SO_X. Additionally, clean, untreated woody biomass has lower concentrations of trace metals relative to coal including arsenic, beryllium, cadmium and lead.[19]

17 Fulton, M., & Mellquist, N. (2011). Comparing life cycle greenhouse gas emissions from natural gas and coal. Frankfurt Germany: Deutsche Bank AG, Worldwatch Institute, p.27. Wood pellet life cycle emissions calculated with Enviva proprietary GHG calculator tool.

18 The Southeast US is particularly well-suited to low carbon footprint wood pellet production. The major producers located in the Southeast are located close to the robust woodbaskets from which they source and close to major export ports from which they ship their product, thereby minimizing the use of diesel and other fossil fuels. Additionally, companies like Enviva strive to minimize emissions throughout the supply chain, for example by using biomass in their facilities' boilers and using barge and rail transportation wherever possible.

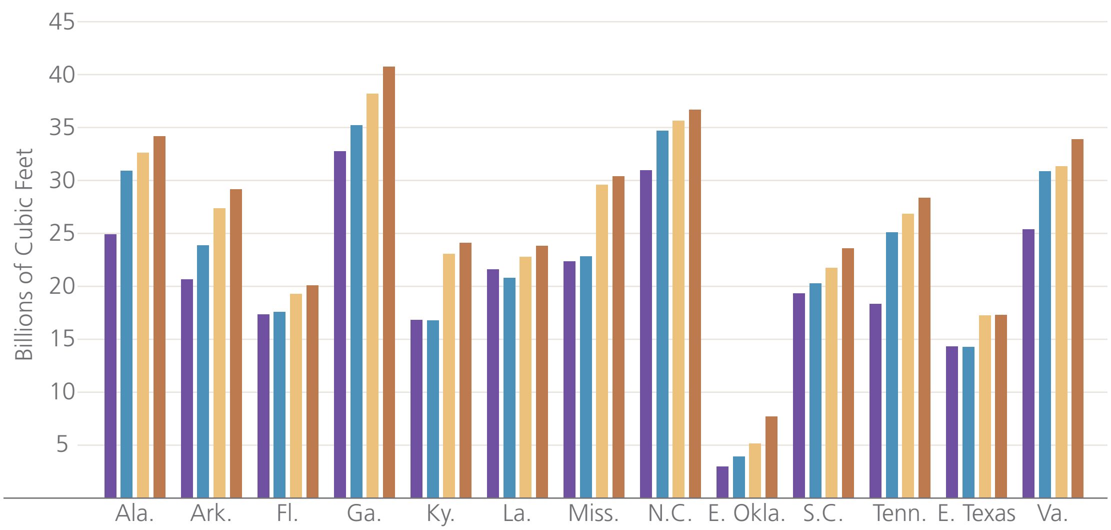
19 Mann, M., & Spath, P. (2003). The Environmental Benefits of Cofiring Biomass and Coal. Golden, CO: National Renewable Energy Laboratory, p.8.

Research by NREL outlines emissions of the five criteria pollutants designated by the EPA for electricity generation from several configurations of fossil and biomass fuels: Carbon, particulates, SO_X, NO_X and non-methane hydrocarbons (NMHC's or Volatile Organic Compounds). In all cases except carbon monoxide and NMHCs, where emissions are relatively low for both coal and biomass, replacing coal with biomass reduces emissions.[20]

US Forests Are Robust & Growing

According to the USDA Forest Service, the net volume of live trees per acre, or growing stock inventory, has increased in all regions of the US for more than 50 years. This means that net growth has exceeded removals on a consistent and long-term basis. During this time, net growth has consistently been approximately three percent of total growing stock inventory while removals have been two percent (see Appendix V).[21] Further data from RISI, an information provider for the global forest products industry (http://www.risiinfo.com/), also indicates that historical demand back to the mid-1970's consistently hovers around 2 percent of operable inventory.[22] At the time of the last Forest Service report, published in 2009, average net growth from 1952 to 2006 was 35 percent higher than the average volume of annual removals.

US forests have been and continue to be a stable and sustainable resource. Consistently, more trees are grown than harvested, during some of the most active periods of timber harvesting, heavy industry growth and population growth. The



Volume of All-Live Hardwood & Softwood Trees on Southern Timberlands by State & Survey Year (billions of cubic feet)

This graph from the USDA Forestry Service shows state level tree volume growth in billions of cubic feet across the south.

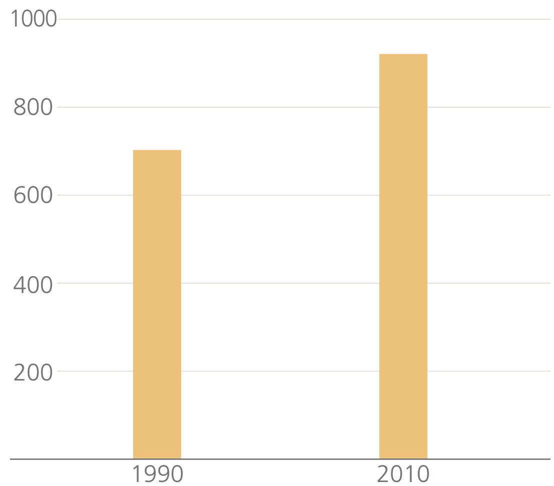
- 1985
- 1995
- 2005
- 2010

Source: USDA Forest Service, Economic Dynamics of Forests and Forest Industries in the Southern United States, 2012

20 Mann, M., & Spath, P. (2003). A Comparison of the Environmental Consequences of Power from Biomass, Coal, and Natural Gas. Golden, CO: National Renewable Energy Laboratory, p.11.

21 USDA Forest Service. (2009). US Forest Resource Facts and Historical Trends. USDA Forest Service. See Appendix V for actual values for total inventory, growth and removals.

22 Inventory and demand according to RISI are as follows: "Operable Inventory" excludes timberlands unavailable or uneconomic for industrial use, lands in public ownership and, in the South, excludes non-pine softwoods. Inventory is a broad measure of timber supply, encompassing both saw timber and pulpwood grade logs. "Demand" includes all logs used for the production of pulp, OSB and biomass, and a small portion of pulpwood grade material used to produce lumber. Demand does not include residual wood fiber consumption (forest industry by-products).



Carbon Sequestration of US Forests (millions of metric tons of CO_2 equivalent)

The chart depicts the increase of forest-related CO_2 sequestration in 1990 and 2010.

Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2010, 2012, Table 7-1

total acreage of forestland is within one percent of what it was one hundred years ago.[23] In the US South, where Enviva's facilities are located, and where the forest products industry has a long history, net volume per acre has increased 94 percent since 1953.[24] The graph on the previous page shows that, on a state level, the volume of trees in southern timberlands increased between 1985 and 2010 during a particularly active commercial period.

Enviva's policy is to locate its facilities in regions where, once Enviva's full capacity demand is calculated and incorporated, growth-to-drain ratios remain greater than one. Enviva's woodsheds cover a radius of approximately 50 to 75 miles from each facility. Across these operating areas, forest growth consistently exceeds harvests by up to 130 percent per year. [25]

Sustainable Forestry Practices Ensure Forest Growth & Promote Increased Carbon Sequestration

As US forest inventories have steadily increased due to responsible forestry practices, so has the overall CO_2 sequestration of US forests.[26] **Healthy, sustainably managed forests result in increased forest volumes and increased carbon capture.**

According to the EPA, net CO_2 sequestration from forests was 922 million metric tons of CO_2 equivalent in 2010 vs. 701 million metric tons of CO_2 equivalent in 1990.[27] Due to careful focus on forestry management and reforestation, U.S. forests can capture more carbon than the annual emissions produced by the United Kingdom and Spain combined.[28] Increased intensive forest management has resulted in higher growth rates and higher biomass density. Sustainable forest management practices, net forest growth and increasing forest volume over the same time period has also translated to an increase in biomass carbon stocks per hectare (2.47 acres) from 55 Mg C/ha to 62 MgC/ha.[29]

In addition to the increase in forest volume and carbon sequestration, it is important to note that trees in their growth phase absorb carbon at a faster

23 Bratkovich, S., Bowyer, J., Bratkovich, J., Fernholz, K., Stai, S., & Frank, M. (March 2012). Forests of the United States, Understanding Trends and Challenges. Dovetail Partners Inc., p.7.

24 USDA Forest Service. (2009). US Forest Resource Facts and Historical Trends. USDA Forest Service, p.17.

25 Source: Proprietary forest diligence data supplied by Forest2Market.

26 US Environmental Protection Agency. (2012). Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2010. Washington, DC: US Environmental Protection Agency, Section 2, p.14.

27 US Environmental Protection Agency. (2012). Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2010. Washington, DC: US Environmental Protection Agency, Section 2, p.14.

28 U.S. Energy Information Administration. (2012). International Energy Statistics: 2006-2010. Washington, DC: US Department of Energy.

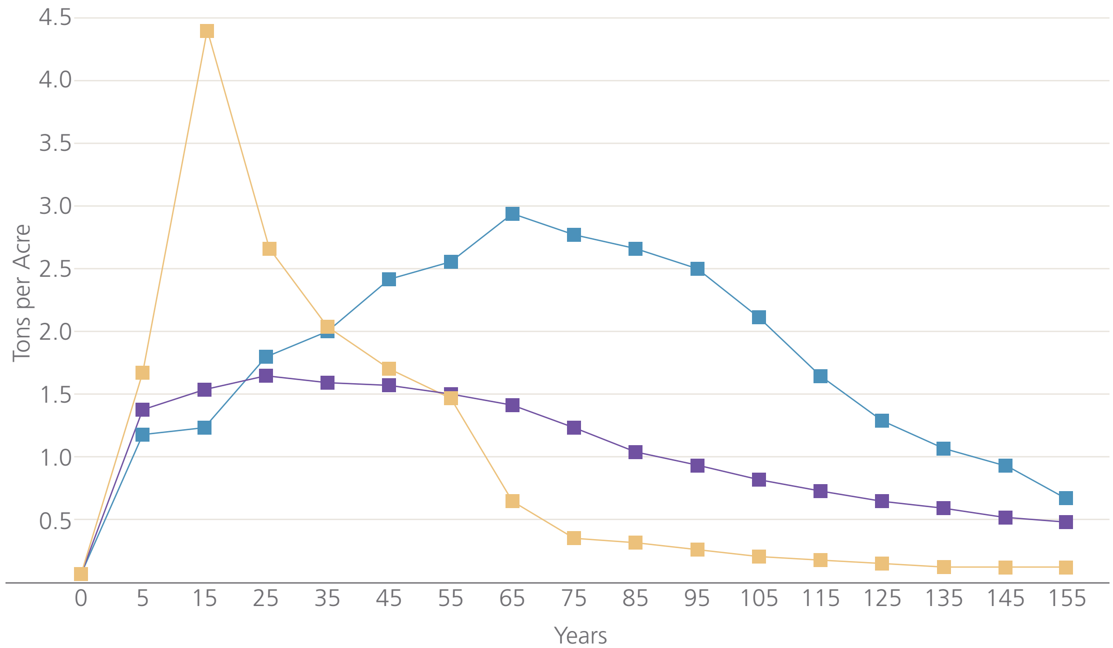
29 US Environmental Protection Agency. (2012). Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2010. Washington, DC: US Environmental Protection Agency, Section 7, p.14.

Annual Carbon Absorption (tons per acre per year)

"Young trees, and fully stocked stands of young trees, have high rates of net carbon uptake that culminate earlier for rapidly growing shade intolerant pines than for less rapidly growing, more shade tolerant trees..."

- Loblolly Pine, Southern Plains States
- Ponderosa Pine, Mountain States
- Black Walnut, Northern Plains States

Malmsheimer, R. W., Heffernan, P., Brink, S., Crandall, D., Deneke, F., Galik, C., et al. (2009). Forest Management Solutions for Mitigating Climate Change in the United States. Washington, DC: Society of American Foresters, page 68.



rate than older, mature trees. As trees age, their rates of carbon capture slow.[30] Maximum carbon storage (or saturation) in a forested landscape is attained when all stands in that landscape have reached maturity and are no longer in a vigorous growth stage. In some cases, mature forest stands may even become net carbon emitters, should over saturation cause disease, infestation or wildfire.[31]

The graph on page eight compares the annual carbon uptake in tons per acre per year of loblolly pine (which is found in the southern plains states) with ponderosa pine (found in the mountain states) and black walnut (found mainly in the northern plain states). **It clearly shows that the carbon absorption rate of the quick growing loblolly pine tree prevalent in the south peaks at around year 15, which is frequently the first harvest in a typical forest management program. This demonstrates how fast newly growing trees can re-absorb carbon emitted during combustion and complete the earth's natural carbon cycle.**

Active forest management can help increase rates of carbon absorption by ensuring that the forest comprises trees at various growth stages.

> "In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained [carbon] mitigation benefit."
>
> — *Intergovernmental Panel on Climate Change*[32]

30 Bowyer, J., Bratkovich, S., Frank, M., Howe, J., Stai, S., & Fernholz, K. (2012). *Carbon 101: Understanding the Carbon Cycle and the Forest Carbon Debate.* Minneapolis MN: Dovetail Partners Inc., p.4.

31 Malmsheimer, R. W., Heffernan, P., Brink, S., Crandall, D., Deneke, F., Galik, C., et al. (2009). Forest Management Solutions for Mitigating Climate Change in the United States. Washington, DC: Society of American Foresters, p.68.

32 Nabuurs, G. J., & Masera, O. (2007). Intergovernmental Panel on Climate Change, Chapter 9: Forestry. Cambridge, UK: Intergovernmental Panel on Climate Change.

The common forest management practices of thinning and sustainable rotational harvesting means that there will be a continuous cycle of new growth in the forest. Managed forests, which have trees of various ages and species, not only absorb more carbon more quickly than older trees, they continually accumulate carbon and maintain stable carbon stocks.[33]

Forestscapes, Regional Differences, Tree Growth Rates & Climate Conditions are Crucial to Understanding Woody Biomass Life-Cycle

When considering the carbon capture of forests, it is important to look at **forests at the landscape level,** which includes a wide swath of forests, tree species, and tree ages, to get a macro-level understanding of the forest carbon dynamic. The graphic to the right depicts forest carbon cycles at the forest stand, parcel and landscape levels. Forest stands range in size from one acre (.41 hectare) to 25 acres and usually share some common characteristics (e.g. species, age, etc.). Forest parcels correspond to ownership and vary greatly in size. Forest landscapes include multiple parcels and cover a large area of continuous forests where harvesting, mortality, natural regrowth and replanting simultaneously occur. **Measured at the "landscape" level, the amount of carbon stored in the forest essentially remains the same with tree removals and mortality balanced by reforestation.** When considering a forest landscape, carbon storage and cycles are quite stable, despite 2 percent of timber being harvested on a regular basis.

When considering forest volume growth in the South, it is also essential to note that the majority of reforestation is accomplished through natural (un-planted) regeneration and that natural and planted regeneration strategies co-exist in the Southeast US. This is especially important when applying sustainability criteria in policies and regulations, where the distinction must be made between (artificial) replanting and reforestation which includes both manual planting and natural regeneration. In 2010, approximately 78 percent of the south's 208 million acres of timberland acres were from natural regeneration rather than artificial regeneration.[34] Furthermore, due to the warm, moist climate enjoyed by the southeastern US, trees grow quickly. As a result, commercial timber rotation ages in the US South are short as compared to other regions. Pine harvest thinnings occur as early as eight to 15 years, with final removals occurring within 20 to 30 years. **In the southern region, almost 75 percent of all planted forest stands are between one and 20 years old, and only 3 percent of these stands are more than 40 years old.** [35]

33 Malmsheimer, R. W., Heffernan, P., Brink, S., Crandall, D., Deneke, F., Galik, C., et al. (2009). Forest Management Solutions for Mitigating Climate Change in the United States. Washington, DC: Society of American Foresters, p. 71.

34 Brandeis, T., Hartsell, A., Bentley, J., & Brandeis, C. (2012). Economic Dynamics of Forests and Forest Industries in the Southern United States. Knoxville, TN: USDA Forest Service, p.16.

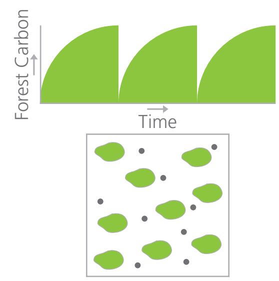
35 Bowyer, J., Howe, J., Bratkovich, J., Fernholz, K., Stai, S., & Frank, M. (2012). Forests of the United States, Understanding Trends and Challenges. Minneapolis MN: Dovetail Partners Inc., p.7.

Forest Carbon in a Sustainably Managed Forest at Stand, Parcel, & Landscape Levels

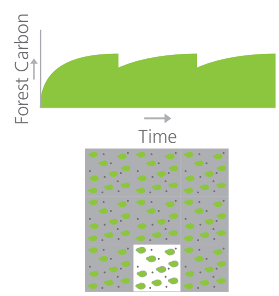
The graphic below depicts forest carbon cycles at the Forest Stand, Forest Parcel, and Forest Landscape levels.

The stability of carbon stocks is attributable to growth of trees across the landscape which offsets the small portion of trees harvested in any given year.

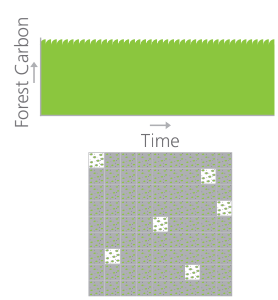
Forest Stand



Forest Parcel



Forest Landscape

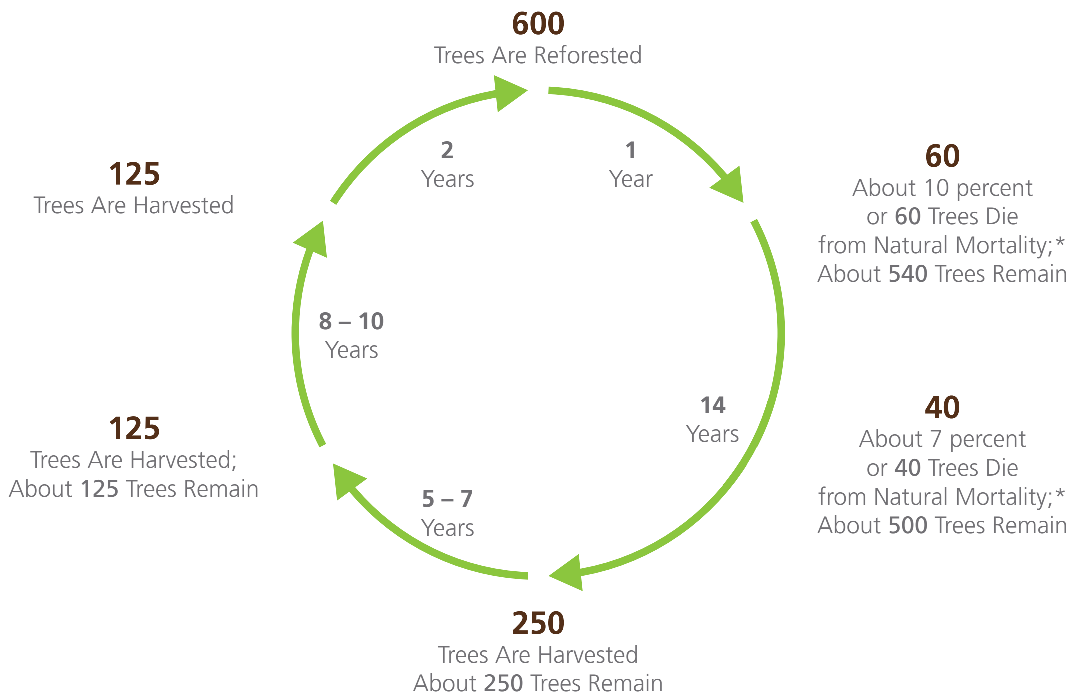


Source: Carbon 101: Understanding the Carbon Cycle and the Forest Carbon Debate, 5 January 2012 (Dovetail Partners Inc.)

Rotational Harvesting

This graph is an example of traditional rotational harvesting where a well-managed stand of trees is planted and harvested over an extended period of time. About 80 percent of the forest regrows naturally on its own. The remaining 20 percent is replanted by the forest landowner.

* Natural mortality results from tree competition (for nutrients and sun), weather related events, disease and infestation.



Healthy Markets Reduce Forest Vulnerability and Ensure Healthy Forests for the Long Term

The woody biomass market has the potential to revitalize an otherwise depressed forest products industry, providing incentive to commercial landowners to keep their forestlands as forests and to keep those forests healthy and productive. In recent years, the economic downturn has decreased demand for forest products (e.g. furniture, construction materials, paper products, etc.), which has had ripple effects on the entire supply chain.

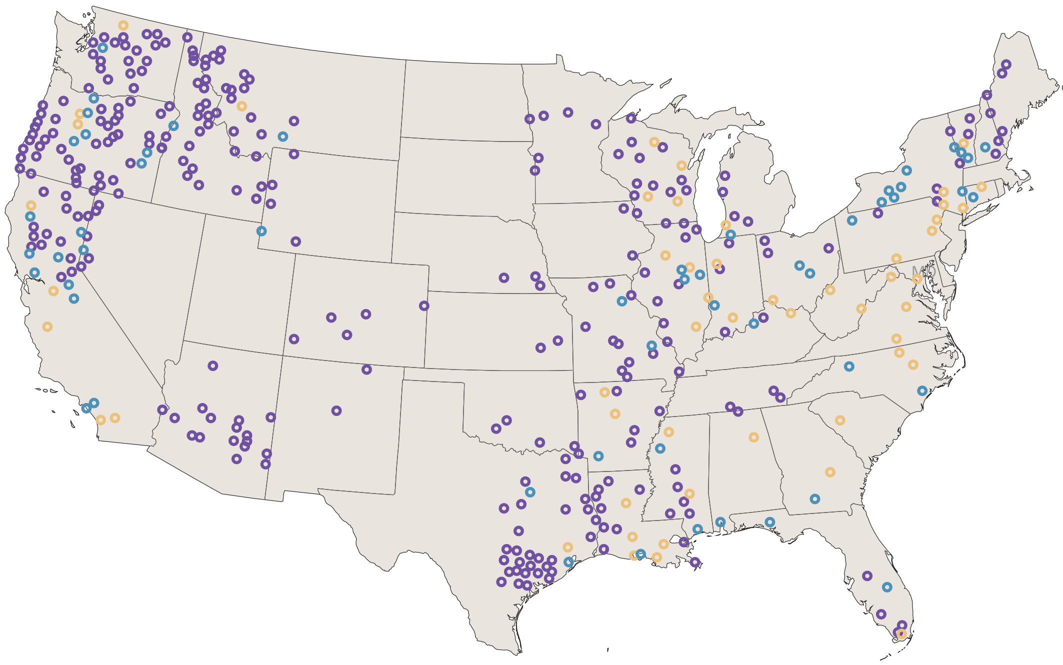
According to the US Forest Service, 25 percent of all forest sector mills in the South have closed since 2005, including more than 450 sawmills. Mill closures both directly and indirectly impact employment, and the mill's supply chain, from landowners to loggers to timber supply companies. As an example, assuming one supply chain job for every 10,000 short tons of green fiber demand, a mill such as International Paper's (IP) Franklin, Virginia operations, which closed in 2010, would have eliminated approximately 300 supply chain jobs, in addition to the more than 1,000 IP employees laid off when the mill closed.[36]

With decreased demand, there is risk of forest saturation. As forest density grows, competition for space increases and trees are not able to get the light and nourishment they need to thrive. Tree mortality rises[37] and the remaining stand is left vulnerable, less able to resist potential threats.[38] As trees grow, their canopies become denser, which reduces the light reaching the forest floor. **Periodic**

36 Source: http://hamptonroads.com/2011/05/international-paper-reopen-franklin-mill-hire-213-workers

37 As an example, national forests where harvesting is restricted have a much higher rate of tree mortality ((0.33 in the East and 0.36 in the West) as on timberlands outside the national forests (0.19 in the East and 0.22 in the West). Malmsheimer, R. W., Bowyer, J. L., Fried, J. S., Gee, E., Izlar, R. L., Miner, R. A., et al. (2011). Managing Forests because Carbon Matters: Integrating Energy, Products and Land Management Policy. Journal of Forestry , 109 (7S): S17.

38 Lippke, B., O'Neil, E., Harrison, R., Skog, K., Gustavsson, L., & Sathre, R. (2011). Life cycle impacts of forest management and wood utilization on carbon mitigation: knowns and unknowns. Carbon Management , 303–333, p.309.



Pulp & Paper Mill Closures

The map depicts closures of sawmill and paper mill closures from 1989 to 2010.

- Closed Saw Mills and Paper Mills, 1989–2003
- Closed Saw Mills and Paper Mills, 2004–2007
- Closed Paper Mills, 2007–2010

Source: Pulp and Paperworkers Resource Council, 2011

commercial thinning of forests clears out the smaller, and often less healthy, low grade trees to ensure the remaining trees get the necessary sunlight and soil nutrients. Just as a garden needs to be tended and weeded to thrive, so does a forest. Unmanaged forests tend to have an increased amount of dead fuel near the ground surface and combustible fuel in the forest canopy. The US has seen increased frequency of severe wildfires in recent years.[39] Severe wildfires are costly, result in the loss of forests and habitats, threaten populations, scorch forest lands and in some cases leave forest floors sterile and unable to reforest for long periods of time.[40]

During the period between 1997 and 2006, approximately six million acres were consumed by wildfire per year. In the years 2004 through 2006, that rose to more than eight million acres per year.[41] In 2011, 45 percent of the total acres burned by wildfire were in the Southeast, a region that has also seen increased levels of wildfire incidence and acres burned in the past five years.[42]

Strong timber markets help ensure that landowners can maintain their forests as such and do not need to convert their land to another use to make up for poor economic returns. Over the past century, demand for forest products has ensured robust forest growth and good forest management. Sustainable forest management systems help to maintain a forest's health and vitality. For the most part, biomass compliments, rather than competes with, other forest industries, for example, taking residues from the sawmill and furniture industries, and harvesting the trees that are typically thinned to make way for higher value lumber-grade timber.

39 USDA Forest Service. (2009). US Forest Resource Facts and Historical Trends. USDA Forest Service, p.31.

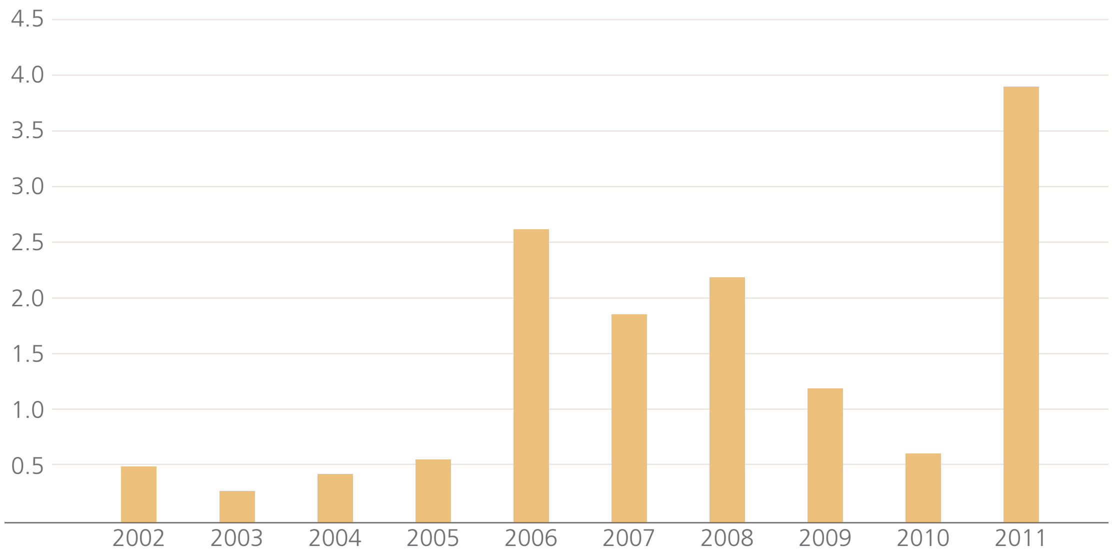
40 Reynolds, K., Hessburg, P., Miller, R., & Meurisse, R. (2011). Evaluating Soil Risks Associated With Severe Wildfire and Ground-Based Logging. USDA Forest Service, p.1–3.

41 Smith, B., Miles, P., Perry, C., & Pugh, S. (2009). Forest Resources of the United States, 2007. Washington, DC: USDA Forest Service, p.51.

42 National Interagency Coordination Center. (2011). Wildland Fire Summary and Statistics Annual Report. National Interagency Coordination Center, p.15 & p.23.

Acres Burned by Wildfires in the Southern US from 2002 through 2011 (millions)

Source: National Interagency Fire Center



Not only does biomass energy harvesting provide landowners with additional revenue sources ensuring they can keep their forestlands as forests, but also indirectly supports other forest related industries as well and the sustainable management of commercial forests.

The majority of the 751 million acres of forest land (56 percent) in the US is owned by private land owners,[43] many of whom have owned their land for generations and benefit from the revenue it generates. In the Southeast US, that percentage is 87 percent.[44] Most of these landowners manage their forestland sustainably to ensure they can enjoy it today and that it will be part of their family's legacy for generations to come.

Following is an excerpt from the testimony of the late Robert W. Slocum, Jr., Executive Vice President of the NC Forestry Association, before the NC Utilities Commission on June 21, 2010, that describes the economic driver behind forest continuity in the US:

> "Many landowners have a need to thin existing stands but often have very limited or even no markets for the material. Including that wood as a biomass resource simply creates a market for what would otherwise have little or no economic value. The reason we have as much forestland as we do today is because wood has economic value to the people who own it. We have seen time and again through history that forest landowners will respond to economic signals. If they see new markets for what they are growing they will respond by growing more of it. The biomass for fuel market will provide an expanded economic incentive for landowners to grow more trees in NC and will improve utilization of timber on existing harvest sites."
>
> *— Bob Slocum, the late Executive Vice President of the NC Forestry Association*

43 Smith, B., Miles, P., Perry, C., & Pugh, S. (2009). Forest Resources of the United States, 2007. Washington, DC: USDA Forest Service, p.19.

44 USDA Forest Service. (2009). US Forest Resource Facts and Historical Trends. USDA Forest Service, p.10.

Positive Economics: In the US & Abroad, Biomass Provides Jobs, Economic Stimulation & a Cost-Effective Way to Keep the Lights On

The wood pellet industry is one of the few growing industries in today's challenged economy. In the US, the wood pellet industry provides tens of thousands of new employment opportunities, both direct manufacturing jobs and indirect supply chain jobs in rural areas. The Bioenergy industry also provides revenue for forestland owners, helping them earn a living from their wood resources and giving them the incentive and the means to reinvest in the forest.

Biomass used as a renewable fuel source for energy generation offers multiple economic benefits in addition to its positive environmental profile. Biomass is a low-cost, renewable and sustainable alternative to coal. Biomass enables utilities to use existing assets and infrastructure rather than invest heavily into new grid infrastructure. It liberates utilities and their customers from volatile fossil fuel markets without the expensive conversion technologies or operational tradeoffs often associated with renewable energy. When utilities convert to biomass as a fuel source, jobs at the facilities are maintained and increased all along the supply chain. These advantages, along with the significant carbon savings forest biomass energy provides, have led numerous authorities including AEA Technology, the International Panel on Climate Change, Imperial College's UK Energy Research Council and the UK Forestry Commission's Biomass Energy Centre, to support biomass as a viable renewable energy source.[45]

Conclusion

As the world looks to renewable and sustainable alternatives to fossil fuels for energy, woody biomass, and wood pellets in particular, offer an unparalleled advantage for economic, base-load renewable fuel supply. **With one of the most extensive commercial forestscapes in the world, increasing timber volumes, and a culture of sound forest management practices, the US forest industry is well-equipped and well-positioned to be a reliable, professional major supplier into the wood biomass market.** Its strong environmental laws and mature forest management, fast-growing native species, and natural synergies with higher value timber markets, mean that customers can be confident in the net carbon benefit and sustainability of wood from the US. Domestically, the US wood pellet industry offers a new economic channel for forest owners and suppliers, provides security that forests will remain forests and creates a market driver for continued sustainable forest management. Sustainable commercial forests have long been a pillar of the US economy and the emerging bioenergy market ensures they will continue to be for generations to come.

45 www.theecologist.org/blogs_and_comments/commentators/other_comments/1267624/response_biomass_needs_to_be_part_of_our_lowcarbon_future.html

Appendix I

"Best Management Practices" or "BMPs" are widely respected and followed throughout the US forest industry. BMPs are driven by the knowledge that sustainable forest management practices result in healthier, more productive forests. Links to several southeastern state BMPs can be found below.

State	Web Site
Alabama	http://www.forestry.state.al.us/Publications/BMPs/2007_BMP_Manual.pdf
Louisiana	http://www.ldaf.state.la.us/portal/Portals/0/FOR/for%20mgmt/BMP.pdf
Mississippi	http://www.mfc.ms.gov/water-quality.php
North Carolina	http://ncforestservice.gov/water_quality/bmp_manual.htm
Virginia	http://www.dof.virginia.gov/wq/index-BMP-Guide.htm

Appendix II

Independent forest certification programs provide a consistent and transparent framework for evaluating the sustainability of a company's operations, from forest to product. Enviva maintains a number of certifications to leading programs that verify the certified content in our supply chain and also ensure that non-certified fiber comes from responsible sources.

Chain of Custody Certifications
Chain-of-Custody (CoC) certification tracks the percentage of fiber from certified forests through the supply chain and into final products. Enviva-owned plants have achieved CoC certifications from the Forest Stewardship Council (FSC), the Programme for Endorsement of Forest Certification (PEFC) Programs and Sustainable Forestry Initiative (SFI®).

Forest Stewardship Council
FSC is an international forest certification program. Founded in 1993, FSC improves forest management around the world by implementing national certification standards based on ten core principles. FSC CoC tracks the amount of FSC certified and recycled fiber throughout the supply chain.

FSC CoC certification addresses non-certified fiber through Controlled Wood requirements. FSC Controlled Wood requires companies to avoid controversial sources of supply which includes fiber that is harvested in the following ways:

- illegally
- in violation of traditional and civil rights
- where high conservation values are abandoned
- in natural forests undergoing significant conversion to plantations or non-forest uses
- from forests where genetically modified trees are introduced
- in violation of International Labor Organization Core Conventions

For more information, visit www.fscus.org.

Programme for Endorsement of Forest Certification
PEFC is the world's largest forest certification system. Founded in 1999, PEFC expands responsible forestry by endorsing national forest certification initiatives that meet minimum requirements for governance, standard setting processes and standard requirements. PEFC CoC tracks the amount of fiber from PEFC-endorsed standards, along with recycled content in the supply chain. In the US, SFI and the American Tree Farm System (ATFS) are national programs endorsed by PEFC. For more information, visit www.pefc.org.

Sustainable Forestry Initiative
SFI, founded in 1994, is a North American based forest certification program which maintains a single standard for all of US and Canada. SFI CoC tracks the amount of SFI and ATFS fiber, along with recycled content, in the supply chain. For more information, visit www.sfiprogram.org.

The American Tree Farm System
ATFS, founded in 1941, is the largest and oldest sustainable family woodland system in the US, and is internationally recognized, with strong requirements and independent verification. While the majority of industrial-sized landowners in the US have achieved certification, most family forest landowners

do not have the resources to achieve certification to large-scale programs like SFI or FSC. ATFS provides a certification framework at a scale that is manageable for family forest owners, while still providing the assurance of responsible forest management. Because SFI CoC recognizes ATFS fiber as certified, Enviva actively encourages landowners to explore the benefits of achieving certification under the ATFS program. For more information, visit www.treefarmsystem.org.

SFI Fiber Sourcing Certification

All Enviva-owned and partner pellet plants are now certified to the Sustainable Forestry Initiative® (SFI) Fiber Sourcing Standard. SFI Fiber Sourcing is a program for companies like Enviva that source fiber directly from forests, but do not own forest land. Through SFI Fiber Sourcing certification we promote responsible forestry on non-certified lands by sharing management and stewardship knowledge with our suppliers.

While large tracts of public and industrial forest lands are certified in the US, many family forests are not certified because timber harvesting is not often the primary management activity. Given that only about 20% of all forests are certified to any program in the US (Sustainable Forestry Initiative), SFI Fiber Sourcing certification is extremely important in addressing the non-certified fiber in our supply chain. SFI Fiber Sourcing Certification requirements include:

- the use of trained loggers during harvest
- contracts require the use of best management practices to protect water quality
- landowner outreach and education on important issues such as reforestation, endangered species protection, sensitive and/or protected sites and invasive species

Thus, Enviva proactively works with all of its suppliers to promote responsible forest management on all lands, not just those that are already certified.

Certification Process

To become certified and to maintain certification, Enviva must complete an independent, third-party audit on an annual basis which verifies that it meets the criteria in each of the certification programs. Auditors verify that activities related to standard implementation and landowner outreach are adequately addressed through supplier interviews, on-site visits and other activities. Enviva must complete on-going surveillance and re-certification audits on a regular basis to verify ongoing compliance with our certification programs.

Appendix III

The following table from the United Kingdom's Environment Agency shows the relative emissions savings of different types of biomass compared to coal and natural gas when producing electricity, assuming good, but not best, combustion practices. Even the least effective biomass options yield significant reductions in carbon emissions.

Carbon Emissions Reductions Relative to Coal and Natural Gas

Feedstock	Percentage Savings Compared to Coal	Percentage Savings Compared to Gas
Chips		
Local Forestry Residues	97%	95%
Imported Forestry Residues	94%	90%
Waste Wood	98%	97%
Short Rotation Coppice	96%	93%
Miscanthus	95%	92%
Pellets		
Chips	90%	83%
Local Forestry Residues	87%	78%
Imported Forestry Residues	87%	77%
Waste Wood	83%	71%
Short Rotation Coppice	74%	56%
Miscanthus	83%	71%

Source: UK Environment Agency. (2009). Minimising greenhouse gas emissions from biomass energy generation. Bristol, UK: UK Environment Agency, p. 5.

Appendix IV

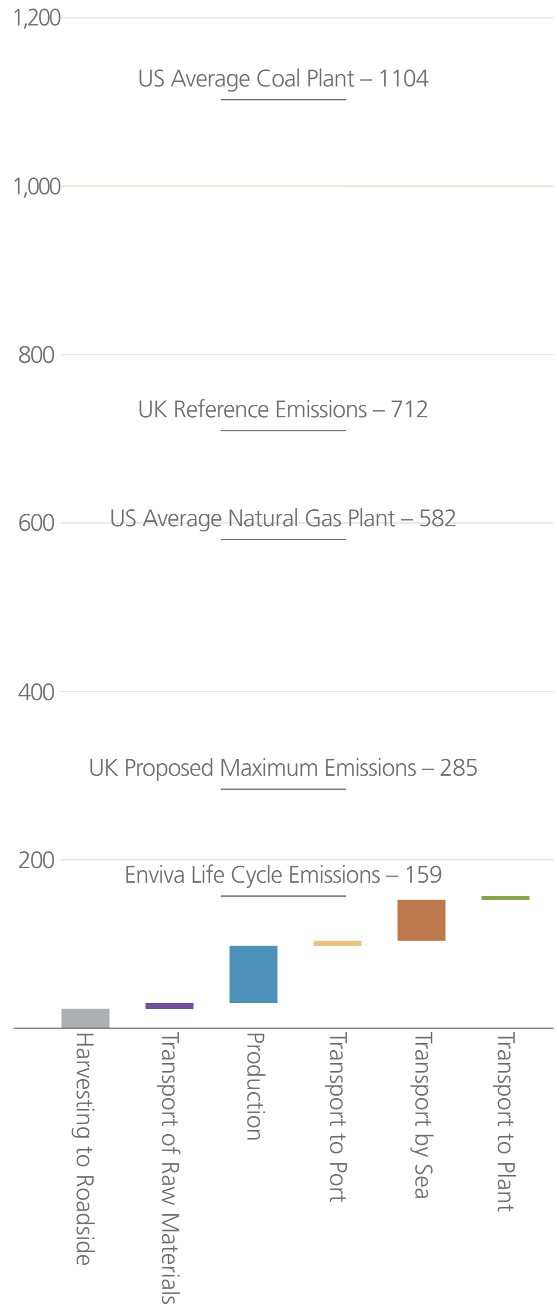
Enviva Life Cycle Emissions vs Coal and NG (KgCO_2e/MWhe)

- Harvesting to Roadside
- Transport of Raw Materials
- Production
- Transport to Port
- Transport by Sea
- Transport to Plant

Assumes NCV of 17.4 GJ/mt for pellets and 35 percent power plant efficiency.

Source for coal and natural gas emissions: Deutche Bank Climate Change Advisors Report

The following table from Enviva's internal data input into the UK Office of Gas & Electricity Markets (OFGEM) carbon calculator shows the average emissions of different facilities based in Mississippi, North Carolina and Virginia, relative to US coal plants, US natural gas plants, and the UK reference emissions standard.



Appendix V

Total growing stock inventory, growth and removal trends on timberland in the United States, 1952–2007 (in million cubic feet).

Source: USDA. Forest Service. (2009). *U.S. Forest Resource Facts and Historical Trends.* USDA. Forest Service.

Year	Total (milions of cubic feet)	Percentage of Inventory
Inventory		
2007	932,082	
1997	835,663	
1987	781,662	
1977	733,042	
1963	665,591	
1953	615,895	
Growth		
2006	26,731	2.9%
1996	23,871	2.9%
1986	23,616	3.0%
1976	21,493	2.9%
1962	16,707	2.5%
1952	20,048	3.3%
Removals		
2006	15,546	1.7%
1996	16,027	1.9%
1986	16,452	2.1%
1976	14,215	1.9%
1962	11,950	1.8%
1952	11,440	1.9%

Works Cited

Bowyer, J., Bratkovich, S., Frank, M., Howe, J., Stai, S., & Fernholz, K. (2012). *Carbon 101: Understanding the Carbon Cycle and the Forest Carbon Debate.* Minneapolis MN: Dovetail Partners Inc.

Bowyer, J., Howe, J., Bratkovich, J., Fernholz, K., Stai, S., & Frank, M. (2012). *Forests of the United States, Understanding Trends and Challenges.* Minneapolis MN: Dovetail Partners Inc.

Brandeis, T., Hartsell, A., Bentley, J., & Brandeis, C. (2012). *Economic Dynamics of Forests and Forest Industries in the Southern United States.* Knoxville, TN: USDA. Forest Service.

Bratkovich, S., Bowyer, J., Bratkovich, J., Fernholz, K., Stai, S., & Frank, M. (2012). Forests of the United States, Understanding Trends and Challenges. *Dovetail Partners Inc.* , 5.

Elias, P. (2012). *Logging and the Law: How the U.S. Lacey Act Helps Reduce Illegal Logging in the Tropics.* Cambridge, MA: Union of Concerned Scientists.

Fulton, M., & Mellquist, N. (2011). *Comparing life cycle greenhouse gas emissions from natural gas and coal.* Frankfurt Germany: Deutsche Bank AG, Worldwatch Institute.

Lippke, B., O'Neil, E., Harrison, R., Skog, K., Gustavsson, L., & Sathre, R. (2011). Life cycle impacts of forest management and wood utilization on carbon mitigation: knowns and unknowns. *Carbon Management* , 303–333.

Malmsheimer, R. W., Bowyer, J. L., Fried, J. S., Gee, E., Izlar, R. L., Miner, R. A., et al. (2011). Managing Forests because Carbon Matters: Integrating Energy, Products and Land Management Policy. *Journal of Forestry* , 109 (7S): S7–S50.

Malmsheimer, R. W., Heffernan, P., Brink, S., Crandall, D., Deneke, F., Galik, C., et al. (2009). *Forest Management Solutions for Mitigating Climate Change in the United States.* Washington, DC: Society of American Foresters.

Mann, M., & Spath, P. (2003). *A Comparison of the Environmental Consequences of Power from Biomass, Coal, and Natural Gas.* Golden, CO: National Renewable Energy Laboratory.

Mann, M., & Spath, P. (2003). *The Environmental Benefits of Cofiring Biomass and Coal.* Golden, CO: National Renewable Energy Laboratory.

Nabuurs, G. J., & Masera, O. (2007). *Intergovernmental Panel on Climate Change, Chapter 9: Forestry.* Cambridge, UK: Intergovernmental Panel on Climate Change.

National Interagency Coordination Center. (2011). *Wildland Fire Summary and Statistics Annual Report.* National Interagency Coordination Center.

Reynolds, K., Hessburg, P., Miller, R., & Meurisse, R. (2011). *Evaluating Soil Risks Associated With Severe Wildfire and Ground-Based Logging.* USDA. Forest Service.

RISI. (2012). United States forest sector still reeling, future is uncertain. *International Wood Fiber Report , 18* (3), 6.

RISI. (2012). United States forest sector still reeling, future is uncertain. *International Woodfiber Report* , p. 6.

Smith, B., Miles, P., Perry, C., & Pugh, S. (2009). *Forest Resources of the United States, 2007.* Washington, DC: USDA. Forest Service.

Someshwar, A. V., Wnwin, J. P., Thacker, W., Eppstein, L., & Malmberg, B. (2011). Environmental Aspects of Wood Residue Combustion in Forest Products Industry Boilers. *Tappi Journal* , 27–29.

The Environmental Paper Network. (2011). *The State of the Paper Industry.* The Environmental Paper Network.

UK Environment Agency. (2009). *Minimising greenhouse gas emissions from biomass energy generation.* Bristol, UK: UK Environment Agency.

UK Environment Agency. (2009). *Minimising greenhouse gas emissions from biomass energy generation.* Bristol, UK: UK Environment Agency.

U.S. Environmental Protection Agency. (2012). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2010.* Washington, DC: U.S. Environmental Protection Agency.

USDA. Forest Service. (2009). *U.S. Forest Resource Facts and Historical Trends.* USDA. Forest Service.

Our Mission

By connecting biomass sources to energy consumers, Enviva will reliably provide customers throughout the world with sustainably generated, clean biomass to improve the environmental profile of energy generation.

Our Facilities

Enviva operates manufacturing and shipping facilities in the Southeast United States and overseas.

U.S. Facilities
Amory, Miss.
Wiggins, Miss.
Ahoskie, N.C.
Northampton, N.C. *(startup in early 2013)*
Bumpass, Va. *(partnership with Biomass Energy)*
Chesapeake, Va. *(deep water port)*
Southampton, Va. *(startup in early 2013)*
Mobile, Ala.

European Facilities
Thimister-Clermont, Belgium

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