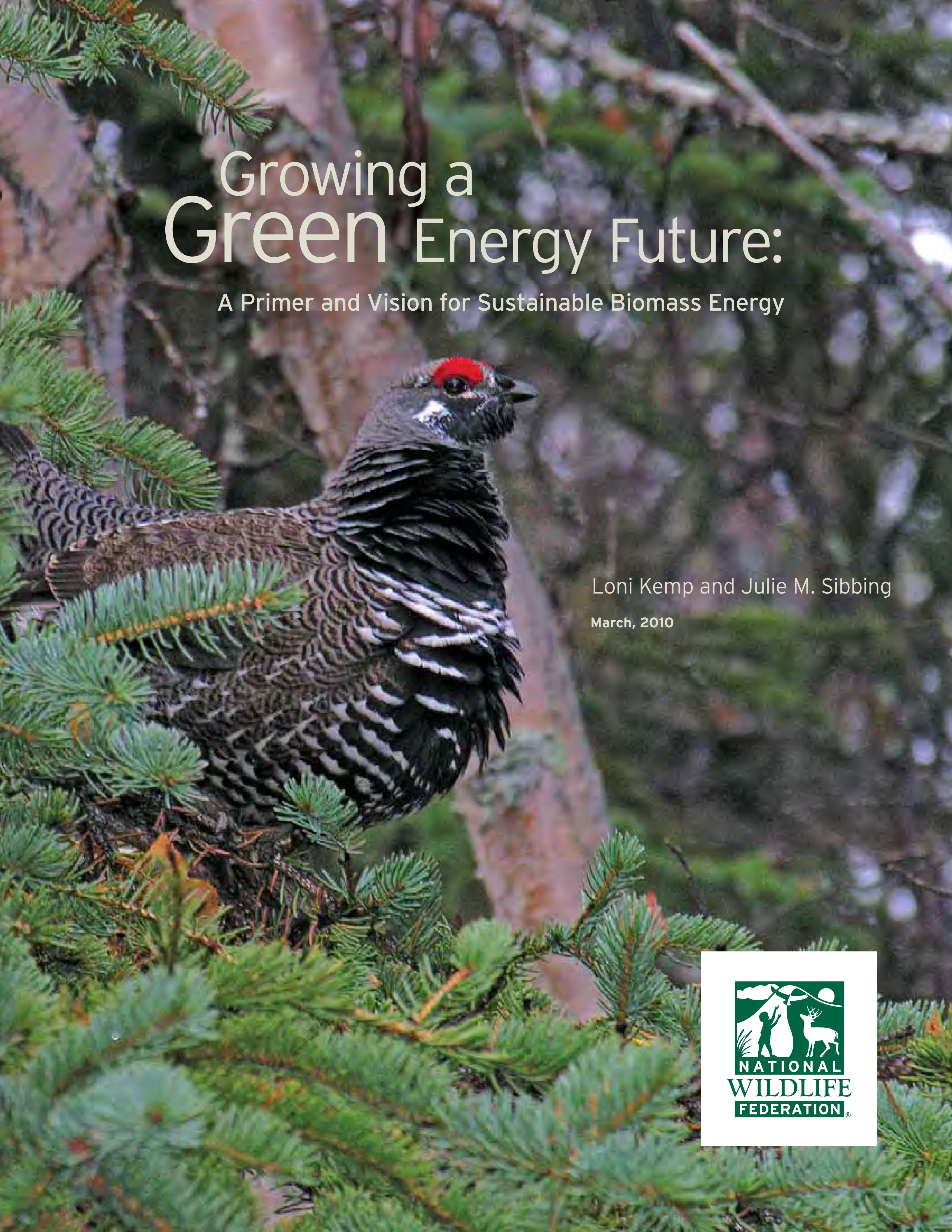
Growing a Green Energy Future:

A Primer and Vision for Sustainable Biomass Energy

Loni Kemp and Julie M. Sibbing

March, 2010



NATIONAL WILDLIFE FEDERATION®

LEARN MORE ABOUT SUSTAINABLE BIOMASS

The Forest Stewardship Council maintains a certification system for sustainable forest management:

http://www.fscus.org/

The Council for Sustainable Biomass Production is working to establish a certification program for sustainably grown biomass in North America:

http://www.csbp.org/

The international Roundtable on Sustainable Biofuels is developing a certification system for sustainable biofuels:

http://cgse.epfl.ch/page65660.html

Learn more about Bioenergy at:

http://www.bioenergywiki.net/Main_Page

Cover photo by Julie Sibbing

Steven Katovich, USDA Forest Service

INTRODUCTION: Biofuels at the Crossroads

Alternative energy and building a "green economy" have become hot topics in recent years. This attention to green alternatives springs from a growing realization of the critical need to address global warming. According to the Intergovernmental Panel on Climate Change, we must reduce our global warming pollution by a minimum of two percent per year over the next several decades if we are to avoid the worst effects of global warming. Recent findings suggest that even greater reductions may be needed. To accomplish such reductions, we must reduce our overall energy use, transition away from our reliance on fossil fuels, and increase our major stocks of carbon stored in forests, wetlands, and grasslands.

Ken Hammond

The idea of growing plants that can be used to fuel our vehicles and power our homes is a concept that has captured the imagination of many. While using plant material for energy is not new—wood has been burned for fuel since the early days of human history—the scale of today's energy needs, combined with the increasing competition for land, brings new and heightened challenges.

Can bioenergy be done in a truly sustainable fashion and in ways that significantly contribute to addressing greenhouse gas emissions in the United States? While this report shows that such a future is indeed possible, it also makes clear that we will not get there under current policies that do not require or reward sustainability.

The majority of government support to date for development of bio-based alternative energy has been directed to use of grain crops—ethanol from corn and biodiesel from soybeans. This "first generation" of biofuels promised renewable transportation fuels that would displace foreign oil, improve national energy security, create jobs, reinvigorate rural areas, and improve air quality. While we have met some of those early goals, and ethanol now makes up seven percent of our gasoline equivalent fuel, other goals have gone unmet and serious, unintended consequences have resulted from the industry. The hope that such fuels could be a significant factor in addressing global warming has now largely faded, and impacts to soil, water, and natural landscapes continue to mount.

Topsoil has been lost from the top of this hill in central Iowa after years of wind and water erosion with continuous rowcropping.

Gene Alexander

While first generation biofuels created a technical foundation on which to build a plant-based domestic alternative energy industry, the dominant methods of growing grain-based feedstocks for energy are widely recognized to be unsustainable. From scientists to agriculture policy-makers, critics have reviewed the consequences of ramped up production of crops used as first-generation feedstocks. The result is that on too many farm fields there is:

- Too much soil erosion
- Too much pesticide and fertilizer runoff
- Too much fossil high-carbon energy used for inputs and tractors
- Too little soil organic matter retained in soils
- Too little habitat for wildlife and beneficial insects
- Too much of an incentive for farmers in other countries to clear their forests (leading to massive releases of carbon that exacerbates global warming) to make up for the deficit of commodities created by the diversion of crops from food and animal feed.

Relying on the same policies that have been used to advance corn ethanol and soy biodiesel, will not be sufficient to ensure a sustainable future for biomass energy.

In short, the natural ecosystem cannot continue to regenerate and grow such crops into the future without serious environmental degradation and massive fossil fuel injections—not a good scenario for a sustainable source of renewable energy.

However, the next generation of biofuels—from biomass—has the potential to deliver much higher levels of benefits than those derived from grain crops. Plus, biomass can be used to generate electricity. Biomass is basically organic matter derived from recently grown plants. It can be grown specifically for energy or collected as byproducts and waste from other activities. Biomass energy has the potential to be much kinder to the environment—potentially requiring less fertilizer, pesticides, and water, and providing greater protection to soils.

As the nation turns to biomass crops for energy, the capacity to reduce global warming pollution and the ability of the landscape to continue rengenerating biomass must be the foremost consideration.

These improvements, however, are by no means guaranteed. Biomass energy systems can be done right, but they can also be done very wrong. As the nation turns to biomass crops for energy, the capacity to reduce global warming pollution and the ability of the landscape to continue regenerating biomass must be the foremost consideration. The potential for eliminating or greatly reducing pesticides and fertilizers, irrigation and tillage could produce great environmental outcomes. Even wildlife could benefit from replacement of annual row crops with perennial biomass crops. Scale is important however—attempting to force the land to carry too large a burden for our energy needs, while also providing for food, feed and fiber, simply cannot be done in a sustainable fashion. A balance must be found between what the land can support sustainably long term, in a manner that helps address global warming, while also maintaining food and fiber production, soil productivity, water quantity and quality, air quality, wildlife, and biodiversity.

Relying on the same policies that have been used to advance corn ethanol and soy biodiesel, will not be sufficient to ensure a sustainable future for biomass energy. The potential benefits of biomass energy will only materialize if policies are adjusted to ensure better results for natural resources and net greenhouse gas benefits.

We also must level the playing field with fossil fuels. Currently fossil fuels receive more than twice the level of subsidies as renewable energy sources—totaling $72 billion versus $29 billion over the past seven years[1]. World leaders in the Group of 20 recently made a commitment to phase out fossil fuel subsidies over time.

Steven Vaughn DOE

Corn Ethanol Plant

Biomass Basics

Plants use energy from the sun, water and nutrients from the soil, and carbon dioxide from the air to grow. When biomass—material derived from living, or recently living organisms—is used for energy, the carbon stored in the plant is released into the atmosphere as carbon dioxide. Some or all of the carbon dioxide that is released is offset by uptake of carbon dioxide by the new crop of biomass plants. While fossil fuels also started as plants millions of years ago, that carbon has been stored underground over eons, thus reducing atmospheric carbon concentrations to the low level that has allowed life as we know it evolve and survive for millions of years. Recently, the world has been extracting and burning so much oil, natural gas and coal that the enormous amount of carbon dioxide being released cannot be offset by plant growth. The gas instead is accumulating in the atmosphere and is contributing heavily to the "greenhouse effect" that causes global warming.

When done right, biomass for energy achieves a balance or even a net gain of carbon dioxide taken in by plants, versus the carbon dioxide and other greenhouse gasses released in production and combustion. When biomass energy is done wrong, it can release more greenhouse gases than are absorbed by subsequent biomass crops, just as with corn and soy.

New biomass feedstocks from agriculture, wastes and algae are just now making the transition from research into commercial scale production.

Mixed plantings of native species can produce biomass as well as provide benefits to wildlife

Lynn Betts

Perennial grasses such as switchgrass have great potential as energy crops

Todd Johnson

The ways that biomass feedstocks can be converted to energy are diverse. A variety of pathways are under development for creating liquid transportation fuels from biomass. Breaking down plant material to make ethanol can be done by use of enzymes, heat, chemicals, aneorobic digestion, and other processes. Oils can be extracted from plants, algae and other microorganisms that are grown specifically to make diesel or jet fuels. There is also much research into producing fuels other than ethanol, such as green gasoline and biobutenol, which could be used in existing gasoline pipelines and theoretically, used in unlimited quantities in current gasoline engines (neither of which is true for ethanol). It is expected that such new fuels will be produced much more efficiently than ethanol.

Biomass is already used extensively in boilers to produce heat, steam, and electricity (often called biopower). Our nation's transportation will increasingly be fueled by electricity in the future. A recent study found that bioelectricity produces an average of 81 percent more transportation mileage and 108 percent more emissions offsets per unit area of cropland than cellulosic ethanol[2], making electricity a better choice to fuel our vehicles.

New biomass feedstocks from agriculture, wastes and algae are just now making the transition from research and demonstration into commercial scale production. Yet a thousand-fold increase in scale of these next generation fuels over the next few years will be needed to meet the goal of the Renewable Fuel Standard passed by Congress in 2007—21 million gallons a year from cellulose by 2022. Which biomass pathways will be chosen? How can we transition away from grain-based biofuels as next generation, biomass technologies come on line? Because the land, climate, environment, and human community are highly varied, biomass answers must be localized, and will differ dramatically throughout the country. Each region, and even each landowner, must consider which biomass options can work sustainably, under what type of management, in each particular location.

What is Biomass?

Biomass is basically recently grown plant material used to produce energy. Cellulose, lignin and hemicellulose are the components of biomass. Biomass comes from fields,

Perennial grasses such as switchgrass have great potential as energy crops

Todd Johnson

forests, industry and food processing, as well as garbage, sewage and animal manure. Cellulosic biomass consists of the leaves, stems, woody, and generally inedible parts that make up 75% of all plant material. Also being explored are small living sources of biomass such as algae, diatoms, and seaweed.

Grasses

Many species of grasses are being investigated for energy crops, including switchgrass, reed canarygrass, fiber cane, and Miscanthus. Sugarcane is also a perennial grass grown in tropical areas. Alfalfa is technically not a grass, but is a legume that fixes its own nitrogen fertilizer in the soil and is now widely grown for hay but someday may be used for its biomass energy.

The vast prairies of the past are now being looked to for biomass feedstock species—thin-stemmed perennial grasses that were completely adapted to local climate and soil conditions. Switchgrass, big bluestem, and other native varieties grow quickly in many parts of the country, and can be harvested for up to 10 years before replanting. The perennial roots are deep and contain most of the carbon in the plant, sequestering carbon and holding soil in place year round. When mixed with other prairie species, especially legumes that fix nitrogen naturally, productivity and resilience increase.

The vast prairies of the past are now being looked to for biomass feedstock species—thin-stemmed perennial grasses that were completely adapted to local climate and soil conditions.

Much attention has been paid to Switchgrass , a perennial grass that grows throughout the Great Plains region of the United States. It is hardy, showing resistance to floods, droughts, nutrient poor soils, and pests while producing consistently high yields. Another species, Miscanthus, is a non-native species from Asia that is used in Europe for biomass. It has been shown to potentially double the yields of switchgrass with significantly less fertilizer, but with much greater costs to establish, since it is propagated not by seeds, but by root stock.

Mixing several grasses along with flowering plants and legumes can virtually eliminate the need for crop inputs, and increase resilience to weather and pests by the diversity of species present. It has been found that mixed prairie species can maximize added environmental and wildlife benefits. Nitrogen-fixing species benefit the grass species and

CLEANING UP WITH BIOMASS

Forest pests

Large forested areas of the Rocky Mountains in Canada and the US have been devastated by pine beetles, leaving behind thousands of acres of dead trees with few uses. A one-time harvest of dead trees may supply fuel for biomass power plants or other energy uses for 25 years. New crops of trees could be planted in the meantime for future supplies.

Natural disasters

Hurricane Katrina led to the demolition of 300,000 homes plus the disposal of debris from other buildings and forested lands. Over one hundred million cubic yards of waste was buried in landfills. If emergency plans had been in place, clean vegetative debris could have been collected from disaster areas, processed and transported to biomass energy refineries. In fact, millions of tons of trees and forest debris from Hurricane Rita were shredded the same year, and shipped from Texas and nearby states to Europe and the Northeast US for biomass fuel.

Invasive Species

Many areas are facing the negative impacts of invasive trees on their natural forests. Where large scale removal operations are recommended, recycling the biomass for energy may generate revenues instead of disposal costs.

potentially eliminate the need for fertilizer. The forbs also create variation in size and height in the stand, provide food for insects and pollinators, and open spaces for wildlife to perch and nest.

Mixtures of native prairie grasses and forbs have drawn much interest as bioenergy feedstocks. Dr. David Tilman at the University of Minnesota has found that biomass yields on degraded soils increase with the number of plant species planted. High diversity plots were on average 238 percent more productive than monoculture plots, including plots of switchgrass which had significantly impaired yields on these degraded soils[4].

Few farmers have yet to begin planting grasses strictly for biomass, and establishment may take two to three years before harvests can begin. The establishment of mixed prairie is more complex than establishing a monoculture crop; however the benefits of establishing mixed native plantings go well beyond high yield. Sustainability, along with a host of ecosystem and habitat benefits will be maximized through such plantings. The ideal time to harvest is in late fall or early spring, after the nutrients and moisture have returned to the roots. The beauty of biomass perennials is that carbon is being stored while crops are being harvested from grass, shrubs and trees.

Perennial energy crops may be very suitable for marginal croplands that are underproductive due to poor soils, wet or dry conditions, subject to erosion, or otherwise depleted by poor cropping practices. In most places, millennia of prairies were responsible for making the soils productive for cropping, and perennial energy cropping could help heal the land.

Forest Biomass

When trees are planted for the purpose of harvesting the biomass for energy, the resulting system is referred to as short rotation woody biomass. Willows, poplars, black locusts, hazelnuts and eucalyptus can all be cut on a 3-8 year rotation, and will grow back from the roots for 20-30 years without any root disturbance or replanting. Fast growing hybrid poplars have been developed and planted on 23,000 acres in Minnesota, with yields expected to nearly double that of current commercial hybrids. New York biomass development has focused on willows. However, such intensive agroforestry systems will need fertilizer inputs to maintain productivity.

Warren Gretz

Short-rotation woody crops such as these hybrid cottonwood trees ar e being studied for their potential use as biomass

Forestry residues are already a major source of energy used at lumber and paper mills as well as residential firewood usage. Biomass from thinning operations, logging and wood processing may have huge potential for bioenergy production, but it must be harvested sustainably to preserve the regenerative capacity of the forest. Some states have developed biomass harvesting guidelines to ensure sustainable residue removal from forests.

Pulpwood (softwood species often grown in plantations), which once fetched good prices for paper production, has suffered from the overall contraction of the U.S. paper industry, especially in the southeastern United States. In the eyes of many landowners and biomass investors, the southeast with its high tree growth rates and underutilized pulp market is fast becoming the biomass wood basket of the country, as well as to expanding offshore markets for wood pellets. This raises concerns about the sustainability of the land base, especially if market demand for biomass leads to widespread conversion of natural forests for energy crops or inhibits forest restoration efforts.

Annual Crops and Residues

Annual crops require significantly more inputs than perennial crops because they have to be planted anew every year, creating greater potential for soil erosion and water pollution from fertilizer and other farm chemicals carried in run-off. However, interest remains high in biomass from annual crops and their field residues because they tend to fit better into the current agricultural system.

While the seeds of annual crops like corn and soybeans are plant materials and they are used for energy in the form of ethanol and biodiesel, they are not usually referred to as biomass because the leaves and stems are not the part that is used.

Some annual crops could be raised specifically for their biomass, like hemp. Sorghum is an annual plant that looks like corn, but it yields more biomass and also has high sugar content in the stalks, indicating that it could bridge from first to second generation biofuels by fermenting both sugars and cellulose. It requires less water than corn, and could fit into current cropping systems.

Cover crops and double crops may be a promising way to harvest annual biomass as well as a regular crop, while improving environmental benefits. Early studies suggest that winter cover crops could produce between 2 and 5 tons per acres of biomass. If only a tenth of the nation's croplands were cover cropped for biomass, 3-12 billion gallons a year of ethanol would be produced, with little impact on food production[6]. These crop pairings must be carefully selected to fit local conditions, but it is possible to underseed a main crop with a fast growing second crop that will grow in the fall after harvest, and again in the spring. The biomass could then be harvested prior to planting a fast growing main crop in the second year. An alternative might be to harvest the first crop's residues, while relying on the cover crop to provide necessary soil protection. These double-cropping systems could be a win-win scenario for farmers with the right growing conditions by bringing the incentive of additional revenue from sale of a second crop into the picture. Specific crop pairings and management practices must be carefully matched to each farm and region, and tradeoffs are inevitable.

USDA photo

Canola can be used to make biodiesel

Residues from food crops are also being considered as a feedstock. However, a certain amount of leaves and stems leftover after harvest are needed to maintain organic matter in the soil and to protect against water and wind erosion. Scientists are still researching whether limited removal on some level fields could be done without compromising

While some corn stalks could be harvested for biomass, care must be taken to leave enough behind to protect the soil

sustainability, and how sustainable removal could be regulated. Some scientists say that about a fourth of corn residue could be sustainably removed from flat fields where no tillage is used, but none from conventionally tilled or sloped fields. Corn cobs have emerged as a promising crop residue, because removing the cobs has little impact on the soil.[7]

Garbage

Much of what is currently thrown in landfills could be used to generate energy. Technology to produce energy from mixed, post recycled, waste streams in ways that protect the environment would help solve both our energy, and waste disposal problems. An easier short-term supply of waste for energy could be found in clean, urban wood and yard waste. Expansion of technologies to capture and use the methane released from decaying wastes in landfills could help to both reduce global warming (methane is a potent greenhouse gas), and produce energy.

Manure and Sewage

Large quantities of liquid waste from livestock feeding operations and city sewage plants could be harnessed to produce energy. These wastes can be processed to capture methane gas, which can then be burned for heat and power, or the wastes could be processed at extremely high temperatures to produce both energy and bio-char, a valuable soil amendment that stores carbon in a decay resistant form. Currently, livestock-related emissions of carbon and methane account for 18 percent of total greenhouse gas emissions worldwide[8], more than from transportation. Capturing the methane from manure is one way to both reduce emissions as well as provide a renewable substitute for natural gas and a high value soil amendment.

Todd Spink

The Hornsby Bend sewage treatment plant in Austin Texas uses a method to draw methane or "bio" gas from the decomposing solids to generate electricity

Industrial Waste

When is a waste not a waste? When it becomes a resource—many food processing and other industries produce biomass byproducts that could be matched to appropriate technologies to turn them into energy. For example, meat and oil processing wastes can be made into biodiesel, or liquid wastes can be digested into methane gas.

Capturing the methane from manure is one way to both reduce emissions as well as provide a renewable substitute for natural gas.

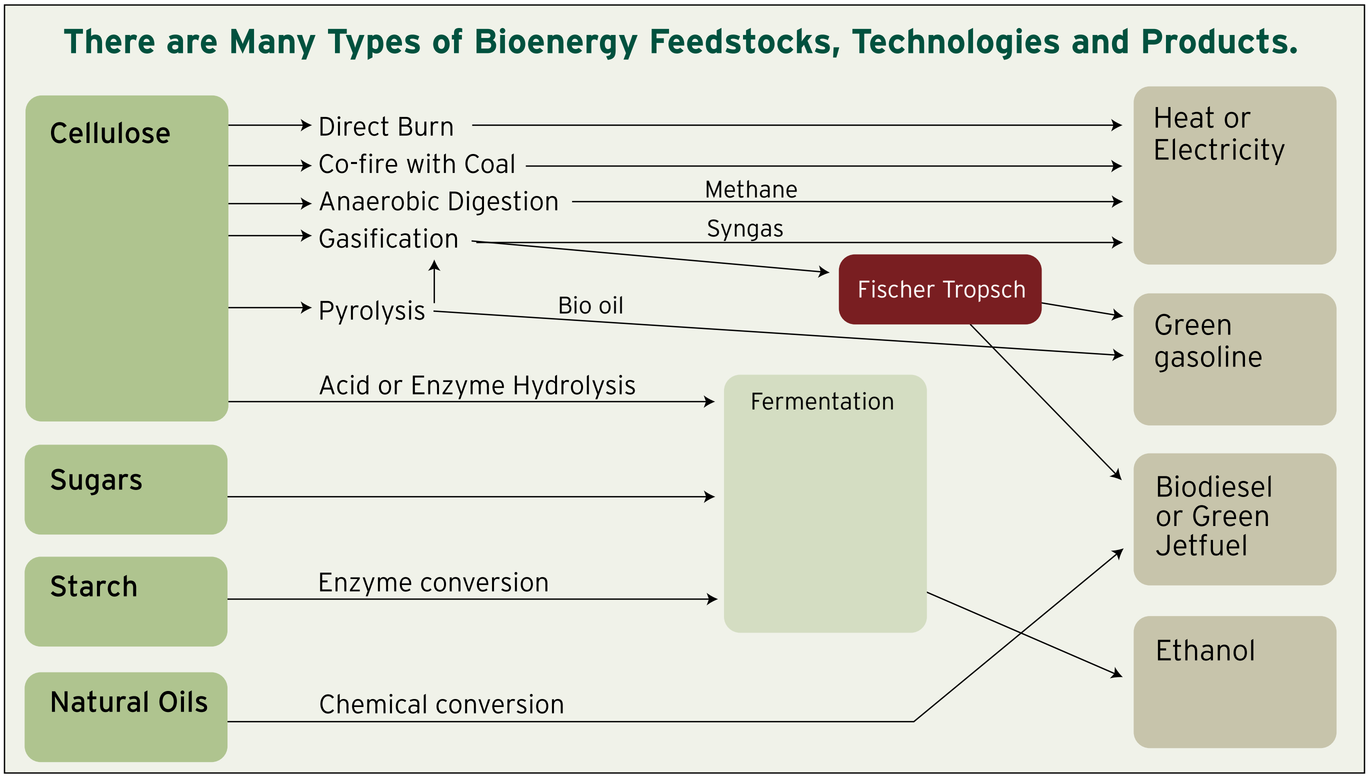
Micro Crops

Scientists are hard at work growing microorganisms such as algae, diatoms, microangiosperms and seaweed in ponds or closed tanks in order to produce fuels such as biodiesel, ethanol or pump-ready green gasoline, as well as high value proteins for animal feed, from the processed material. Using wastewater and a fraction of the space of biomass, microcrops have generated intense interest due to the potential for high-yielding, low-cost renewable energy. While the technology is proliferating in China, several U.S. companies have pilot facilities.

Conversion Technologies—It's not just ethanol....

It is a very exciting time for biomass development, with scientists and companies racing to invent new technologies to process every form of biomass into energy—with end products ranging from biofuels to biopower (electricity) to heat. To further complicate matters, it seems that nearly every form of energy that is produced can be further processed into other forms of energy. This cornucopia of possibilities is a good thing, because the right feedstock, the right conversion technology, and the right final energy product can be designed for every local market and cost situation.

Fermentation Just like in making wine or beer, ethanol is made by fermentation. Yeasts consume the sugars in corn or other feedstocks and convert them to alcohol, otherwise known as ethanol. Much research is going into the pathway that pre-treats cellulose with enzymes, microbes or acids to break it down so that the resulting sugar can be fermented into ethanol. There are many projects under research, development, and pilot scale production, but no commercial scale biorefineries for cellulosic ethanol operate at this point. While cellulose-to-ethanol has captured most of the public attention so far, it is not at all certain that ethanol or even liquid biofuels are necessarily the most effective or efficient uses of biomass for energy. Because of its corrosive properties, ethanol requires separate tanks and trucks, and as of this writing, is only approved for



The largest wood fired CHP plant is District Energy of St. Paul, MN, which burns urban wood waste to generate electricity for the grid and uses the hot water to heat and cool most of the downtown buildings.

blending into gasoline for most vehicles at a maximum of 10 percent, though ethanol proponents are currently pushing to raise this limit to 15 percent. Blends of 85 percent ethanol, called E85 can be burned in special, dual-fuel vehicles, but few of these special pumps exist to sell E85.

Direct Burning The simplest way to use biomass is to simply burn it in a boiler, producing heat for space heating and industrial uses, or hot water and steam to create electricity. First generation thermal technologies—widely deployed with subsidized power contracts following the first oil price shocks of the late 1970s—use a conventional grate or fluidized bed boiler to drive steam turbines. A uniform feedstock of wood chips or pellets is required to ensure optimum combustion. However, the efficiencies of these early plants that were built mostly in the 1980s are quite low, typically no more than 30-35 percent, which meant they did not run very often and came to be seen as expensive power in the eyes of utilities.

However, the efficiency of biomass power can now be quite high, e.g. in the 90 percent range, with the advance of "second generation" biomass gasification systems that create a much cleaner burn and conversion of heat, along with co-generation systems that capture excess heat. So called Combined Heat and Power (CHP) plants can utilize biomass to drive electricity generation and capture the previously "waste" heat for space heating and cooling, and industrial process heat. These applications are especially well proven at the institutional and small commercial scale, such as in schools, hospitals, housing developments or local district heating. The largest wood fired CHP plant is District Energy of St. Paul, MN, which burns urban wood waste to generate electricity for the grid and uses the hot water to heat and cool most of the downtown buildings. But many smaller systems exist throughout the country as well.

Co-firing Adding biomass to coal combustion is a commonly used process in Europe where biomass is pretreated by milling or pelletizing to some extent, then up to ten percent is injected into the boiler with coal, producing heat as well as electrical power with lower carbon and sulphur dioxide air emissions than coal alone. While boiler modifications and monitoring must be attended to, an advantage is that ash can be returned to the land to replace important soil components and air pollution is lessened when burning biomass instead of coal.

Gasification Gasification is a technology that is currently available to create synthetic gas in an enclosed process using high temperatures. As indicated above, gasification represents a big leap in performance over conventional direct fired systems, The "syngas" is equivalent to natural gas, and can be directly burned, or by using a chemical process, called "Fischer-Tropsch," can be made into green gasoline, biodiesel and jet fuel. Gasification of biomass is seen by many as the logical first step for ethanol plants to begin to step into the next generation of energy. Gasified biomass is used to replace the coal or natural gas used in the ethanol heating and evaporation process, and dramatically reduce the carbon footprint of the facility as well as improve air quality. One ethanol plant near Benson, MN, has already put this system in place.


DOE Photo

Biomass gasifier

Pyrolysis The process of burning biomass under heat and pressure has been around for a long time. Pyrolysis is an older technology which could be scaled down to the level of the farm, township, or local elevator. Biomass could therefore be processed into bio-oil very close to where it is harvested, and that product could easily be transported to a wide variety of markets for further conversion into biofuel, biopower, or heat. It makes good sense to transport a small quantity of high value bio-oil from rural communities, rather than to transport enormous quantities of biomass to faraway energy facilities. The resulting bio-oil (light crude oil), can be turned into ethanol, green gasoline, biodiesel, jet fuel, or it can be directly burned. This old technology was used to create gas for vehicles during World War II. Currently one ADM plant in Carthage Missouri converts turkey and egg production byproducts into bio oil using pyrolysis. Pyrolysis also produces biochar, a stable carbon material that can be returned to the soil to keep half the carbon of the biomass out of the atmosphere and provide excellent soil conditioning properties.

Anaerobic digestion Anaerobic digestion uses bacteria in an enclosed tank in the absence of oxygen to break biomass down into methane, which can be used to drive a turbine for electricity or create heat. Digestion is generally used for sewage sludge and livestock waste, retaining important residues that can be returned to the soil.

Direct conversion to green fuels Natural oils from plants, such as soy oil, used cooking oil, and algal oil, can be chemically converted to biodiesel, green gasoline or green jet fuel, all liquids functionally identical to fossil fuels.

WHAT IS BIO-CHAR?

What if we could take agricultural wastes, including manures, and turn them into a high value soil amendment that stored carbon for thousands of years and produced biofuels or biopower in the process? This process is already beginning to be a reality and the product is called bio-char.

Bio-char is created by pyrolosis or gasification—where the wastes are heated at high temperatures in an airless vacuum. The process produces a fine-grained, porous charcoal that is extremely resistant to decomposition. Unlike typical organic matter in soils, bio-char doesn't release its carbon to the atmosphere for hundreds of thousands of years. Yet when mixed in soils, biochar increases nutrient and water retention properties.

Making biochar also generates biproducts that can be used to make biofuels or biopower. According to the International Biochar Initiative, *"It's one of the few technologies that is relatively inexpensive, widely applicable, and quickly scalable. We really can't afford not to pursue it."*

Sustainable biomass done right

When a forest is cut down, a wetland drained, or a grassland plowed for crop production, large amounts of the carbon stored in these systems is released into the atmosphere.

As our nation seeks to promote alternative sources of energy in order to address global warming, decisions must be made about what role bioenergy will play in that future. What is truly sustainable over the long term? Like wind, solar, geothermal, and hydropower—biomass has pros and cons from an environmental standpoint. However, the landscape footprint needed to produce biomass at the scale needed to substitute for significant amounts of fossil energy dwarfs that of other alternative energy sources, creating some unique challenges. There are already many competing needs on land for which biomass must vie—food, feed, fiber, carbon storage, wildlife and biodiversity, as well as human communities and infrastructure. Balancing these competing needs poses one of the biggest challenges to sustainability of biomass.

Sustainable Biomass Must Help Address Global Warming

When many of the current incentives and mandates were created for corn ethanol and soy biodiesel, it was mostly assumed, despite some debate, that such biofuels would help address global warming pollution. The debate that did occur chiefly focused on whether more fossil fuels were needed to make a gallon of ethanol than the resulting fuel displaced. Using a simple calculation, corn ethanol appeared to achieve modest reductions in net carbon emissions over the use of fossil fuels.

Native grasslands, and the vast amounts of carbon they store, are being lost to the plow at an alarming rate to meet the demand for corn ethanol

Jim Ringelman

Rainforest is cleared in the Amazon basin to make way for farming

Rachel Kramer

Yet, two major, overlooked factors in the overall global warming impact of these fuels were left out of the early calculations entirely—the amount of global warming pollution created when land is converted from forests, wetlands or grasslands, to row crop production and the impact of displaced food production commodities into forests and grasslands in other parts of the world.

When a forest is cut down, a wetland drained, or a grassland plowed for crop production, large amounts of the carbon stored in these systems is released into the atmosphere. As government policies and subsidies began to drive expansion of corn for ethanol, the price of corn increased greatly, as did the competition for land on which to grow corn. Some other crops were deemed less profitable and corn was planted instead. In addition, millions of acres of Conservation Reserve Program-restored lands were removed from the program and newly cultivated and cropped, as were vast areas of grazing lands that had never been plowed before. The conversion of these lands to crop production not only destroyed wildlife habitat and increased soil erosion and water pollution, but also resulted in what is called a "carbon burp" as the carbon stored in soils and vegetation is released to the atmosphere. This carbon burp must be factored into the equation of whether the ethanol produced is good or bad for global warming.

KEY FEATURES OF SUSTAINABLE BIOMASS

- Helps Address Global Warming
- Economically viable
- Protects Native Habitats and Biodiversity
- Harvests are Sustainable
- Crops do not Become Invasive
- Protects Our Waterways
- Does not Impact Water Supplies
- Does not Deplete Soils

Further, to ensure a truly accurate accounting of the overall greenhouse gas implications of biofuels, another significant "carbon burp" must be considered: the "indirect emissions." This occurs when farmers in other countries seek to make up for the crop production displaced by corn expansion for ethanol in the United States by clearing carbon-rich land, such as rain forests, to produce the amount of corn that is no longer exported by the U.S. or the soybeans not grown in the U.S. Such emissions, while difficult to measure exactly, are significant and likely render nearly all conventional biofuels a source of global warming pollution rather than a solution.

These direct and indirect land use change emissions must also be considered for biomass energy. For example, if productive cropland were shifted into biomass production, then the food no longer produced on that land would need to be produced elsewhere, likely resulting in the release of large amounts of carbon, and the destruction of habitats in the U.S. or in other countries. A further complicating factor is that even if a forest is cut for biomass and re-grown, the re-growth will not occur overnight, thus there may be a serious lag in the uptake of carbon dioxide.

To ensure wise public policy, it is critical that the overall global warming impact of a bioenergy source—often called the "life cycle greenhouse gas balance"—is calculated as accurately as possible. Only those sources of bioenergy that have a life cycle greenhouse gas balance significantly better than fossil fuels should be promoted.

There are five general sources of biomass that minimize the contribution of land use change to the life cycle greenhouse gas emissions of the fuel or energy, while also minimizing impacts to habitats and biodiversity:

- **Wastes**—wood and food wastes, such as wood from cleanly separated municipal solid waste or construction and demolition debris, forest industry residues, food product wastes, and sewage and animal manures
- **Algae, and other micro-crops**—grown in contained structures
- **Sustainable harvesting of existing systems**—low intensity, managed harvest of forests and grasslands that does not degrade habitat, deplete carbon stocks or damage biodiversity, and residues from conventional harvesting systems that do not deplete soil carbon and productivity
- **Improved use of existing crop land that does not displace food**—improving the carbon balance on existing cropland, for example, shifting to cellulosic feedstocks that get more energy per acre on land currently in corn ethanol production (not those in food or feed production), or planting winter cover crops for biomass on existing cropland
- **Biomass crops grown on degraded lands**—improving the carbon storage on highly depleted, or degraded lands, such as establishing perennial crops on abandoned agricultural lands or abandoned mine lands that have little carbon storage

Julie Sibbing

Native pollinators are in decline across the United States

In addition to ensuring that more carbon is stored in the growing of biomass crops than is released when the biomass is used as an energy source, other sources of carbon and other greenhouse gases must be minimized in the production of bioenergy. Fuel use can be minimized by growing the biomass in a close proximity to the energy facility and end user. A 50-60 mile radius around the facility may be the maximum viable distance across which to transport the material, except in cases where the biomass is grown near waterways, where barges can transport the material longer distances efficiently. Other emissions can be avoided by minimizing the use of agricultural chemicals, fertilizers and the use of irrigation, and developing efficient cultivation techniques and processing technologies.

Other Factors Needed to Ensure Sustainable Biomass

While these goals necessarily include competing priorities and tradeoffs, many, or all can be optimized if biomass choices are carefully matched to particular landscapes and ecosystems.

Measuring Greenhouse Gas Performance from Direct Emissions

It was once thought that calculating the greenhouse gas balance of biofuels involved a simple equation weighing the carbon taken in by the biomass feedstock against the total of all the carbon and other greenhouse gases released in producing, distributing and burning the fuel. Most biofuels showed at least modest improvements over fossil fuels using this approach.

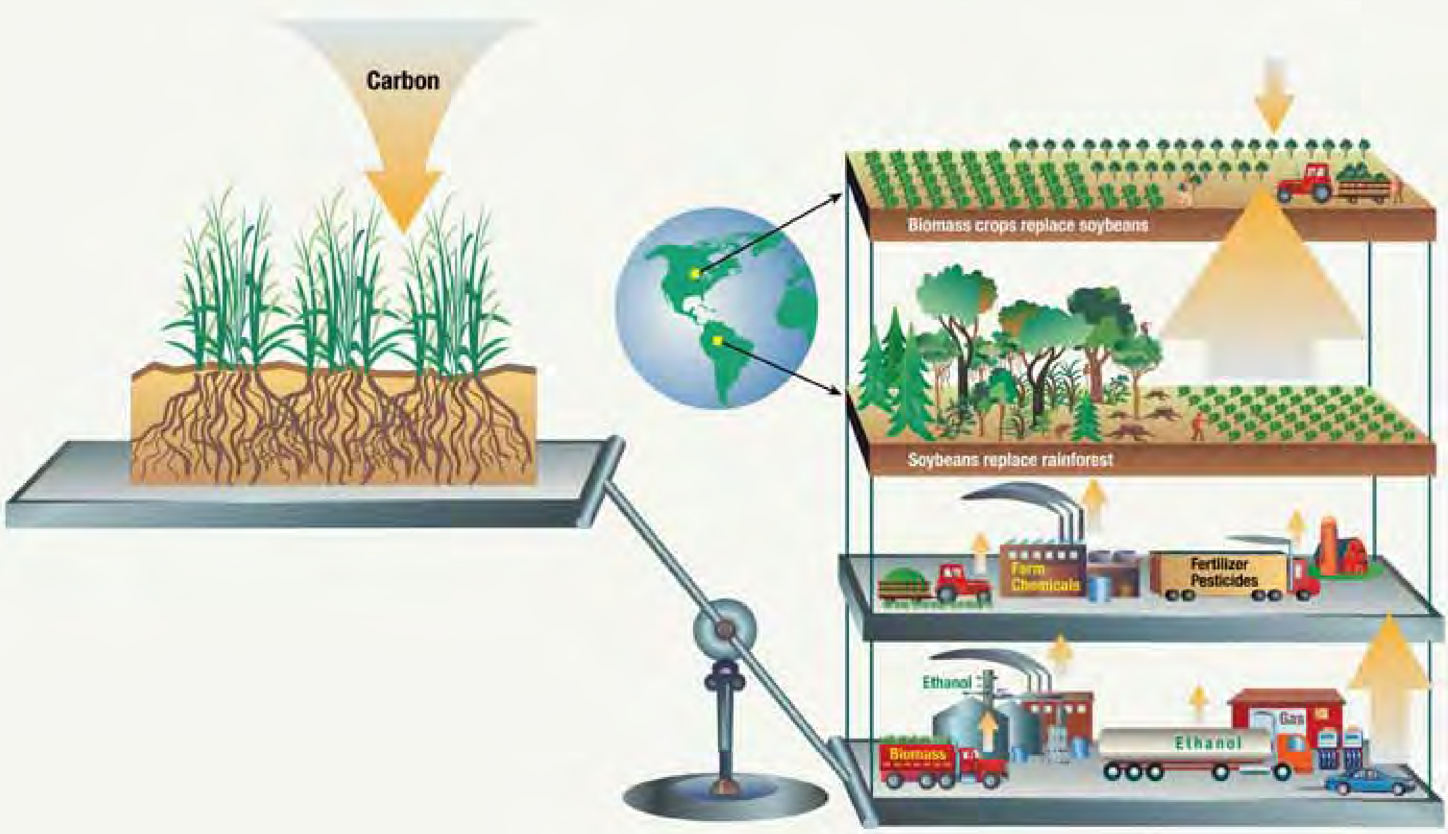
Maintains Economic Viability

For bioenergy to succeed, it must be both environmentally and economically sustainable over the long term. A secure market for biomass for fuels and/or power must be developed for the long term in order to drive the investments needed to develop the industry. The Renewable Fuels Standard creates a secure, long-term market for biofuels, but a federal Renewable Electricity Standard is needed to create a secure market for biomass for power and heat.

While subsidies and incentives can bridge the gap in the short term in making certain technologies profitable and in underwriting the risk to investors, all biomass pathways will have to become more efficient and cost effective in order to succeed long term. While the price of oil currently drives the price at which liquid biofuels are profitable, laws putting a price on carbon emissions would makebiofuels and biopower much more profitable.

Measuring full Greenhouse Gas Performance, Including Indirect Emissions

It is now known that to fully calculate the greenhouse gas performance of biofuels, both the direct emissions and the indirect emissions from land use change must be taken into account. If energy crops are grown on lands that formerly produced food or feed, the enormous emissions associated with clearing new land to grow more food and feed—often in the Amazon rainforest—must be taken into account, tipping the scale such that the bioenergy contributes to global warming rather than helping to solve the problem.



Protects Native Habitats and Biodiversity

The demand for corn for rapidly expanding corn ethanol production has already driven significant conversion of grasslands to crop lands, either to grow more corn, or to grow the crops that corn has displaced elsewhere. If lands with perennial vegetation are plowed up and tilled repeatedly, soil carbon plummets and water pollution increases. Of particular concern is the loss of habitats and biodiversity. Native grasslands are among the most endangered ecosystems in the world and grassland birds are the fastest declining species group in North America. What little remains of our untouched grassland ecosystems is extremely vulnerable to biofuels expansion.

Laws putting a price on carbon emissions would make biofuels and biopower much more profitable.

David Cappaert, Michigan State University

Giving new economic value to our forests, through sustainable biomass harvesting could help keep them from being destroyed

While USDA does not keep track of this critical information on a national level, the Farm Service Agency counted over 475,000 acres of newly broken land in North and South Dakota alone between 2002 and 2007 [9]. Perhaps the most vulnerable of lands are those enrolled in the Conservation Reserve Program (CRP), a program that pays farmers to take marginal lands out of production and re-establish native vegetation to protect soil, water and wildlife resources for contract terms of 10-15 years. As ethanol helped drive corn prices and thus land prices higher, it made CRP payments less appealing for farmers. Nearly seven million CRP acres exited the program between 2007 and 2010, and much of that grassland is being plowed up.

Lynn Betts

Mixed native plantings provide habitat for quail in Iowa

CRP AND BIOMASS PRODUCTION—NOT A GOOD MATCH

A variety of voices, including a National Research Council panel[10] and the Chesapeake Bay Commission[11], have assumed that the Conservation Reserve Program should become a biomass production program. Currently, the CRP program has a maximum enrollment of 32 million acres and its purpose is to conserve soil, water and wildlife resources. On all these counts, the CRP has been wildly successful, removing marginal and highly erodible lands from crop production, thus reducing runoff of farm chemicals and sediment into surface waters, while providing critical wildlife habitat in heavily managed landscapes where little natural habitat remains.

In calling for CRP to become a biomass production program, it has been argued that many potential biomass crops are native species, some of which already occur on CRP lands, thus the purposes of the CRP would not be undermined. Such arguments fail to consider that CRP lands provide critical habitat because they have been planted with mixtures of native plants and are left undisturbed for sufficient periods of time to regain some of the characteristics of native habitats. Single species monocultures, even of native species, provide little in the way of habitat for wildlife and could hurt native populations of pollinators, especially when the need for fertilizers, herbicides and pesticides to maintain such monocultures are taken into account.

Even the idea of simply harvesting the native mixtures that make CRP such great habitat for wildlife, is not as simple as it seems. Annual harvests would reduce the value of these areas for wildlife by keeping them from developing the diversity and structure of native systems. In an era of expanding and intensifying agricultural production, CRP is literally the “finger in the dike” for many species of wildlife. Reducing its habitat value would have serious consequences.

A BETTER SOLUTION

The 2008 Farm Bill included a new program to help launch biomass cropping, without imposing upon the critical functions delivered by the CRP. The National Wildlife Federation played a key role in designing the Biomass Crop Assistance Program (BCAP). When this program is fully implemented in 2010, it will help pay the costs of establishing and growing biomass crops in areas near energy facilities. Participants are required to have forest stewardship or conservation plans to protect soil, water and related resources to help ensure sustainability. While some CRP lands will surely be taken out of the program to enroll in the BCAP in areas near energy facilities, the acres freed up from the CRP acreage cap can then be made available for landowners elsewhere to enroll to ensure adequate habitat for wildlife.

Assures Sustainable Harvests

Forests: Harvesting biomass from forests, if overdone, can expose soil to drying and erosion, reduce biodiversity, reduce organic matter, reduce stored carbon, eliminate habitats, pollute water and harm pollinators. Removal must be done carefully and retain sufficient residues to help regenerate the forests. By working with the Forest Stewardship Council, forest managers can assure that their biomass harvesting operations meet standards for well-managed forests.

With careful attention to local ecosystems, biomass crops can be managed to maximize habitat.

Crops: With careful attention to local ecosystems, biomass crops can be managed to maximize habitat. For example, mowing could be timed to avoid nesting periods. For other species, cover in the form of higher stubble at critical times of the year is necessary. Still other species require edges between trees and grasslands, or corridors between their prime habitats. Researchers have found that perennial grasses are usually best mowed after frost, when the nutrients return to the roots. The best timing might be early spring, so wildlife can enjoy the cover during the winter, and return to nest in the new growth. Conversely, poor management can create wildlife sinks, where biomass practices actually cause increased mortality. Mowing at a highly vulnerable stage of life for a particular species can negate the habitat provided all the rest of the year.

Harvest timing is critical in grassland plantings in order to protect birds during the nesting season.

Breeding and genetic modification efforts are attempting to increase the yields of switchgrass

Genetic modification and traditional breeding of native species have the potential to unintentionally create invasives.

Prevents Crops from Becoming Invasive

A major concern with new biomass crops is that non-native species could become invasive[12]. Ironically, the very traits that can make for a productive, resilient, low input energy crop are the traits that may make it invasive. Additionally, the very agronomic features sought in modification of biomass plants—hardiness, perenniality, drought tolerance, fast growth, resistance to pests and weeds—are the known features of highly invasive species. For example, Miscanthus is a fast growing grass native to Asia that usually reproduces from underground roots. However seeds of the garden variety are viable and the grass is invading areas of the Northeast. Varieties being developed for biomass are sterile and are reproduced by labor intensive cuttings of the rhizome, which so far has prevented seeds from escaping. Will the roots remain in place in case of a flood? Will seeds remain sterile? Invasive species can wipe out natural ecosystems and even become fire hazards unless they also have traits or management systems that prevent them from surviving outside the intended field environment.

Genetic modification and traditional breeding of native species have the potential to unintentionally create invasives. For example, a grass that is bred to be more drought-tolerant may move into a drier part of the landscape where it never grew before. Another concern is that pollen could cross breed and destroy the native species that have adapted locally over millennia. Detailed evaluations should be performed for every non-native or modified species to determine whether the risks of invasion are low enough, and whether the species is likely to survive outside of cultivation.

A very different approach is being considered as one state develops a new biomass industry. Minnesota officials are considering offering incentives only for planting native prairie species for which seeds must be procured within a certain distance from the planting site, to ensure local adaptations by the species planted[13].

Lynn Betts

Does not Impact Water Supplies

Because irrigation is already the nation's largest consumptive user of water[14], it is important to select biofuel feedstocks that do not require irrigation. Corn is now widely irrigated in the West, but only sometimes in the East, depending on soil types. Native grasses could be expected to grow well without irrigation, but there may be pressure to irrigate as species are planted in new areas and high yields become the focus. Water consumption by ethanol refineries can also deplete groundwater. Ethanol plants used about four gallons of water to produce a gallon of ethanol in 2006, but many are successfully reducing water usage as they recycle more and improve conversion techniques.

Protects Our Waterways

Polluted runoff from agriculture is the nation's largest source of water pollution today[15]. In particular, nutrient runoff from corn and other Midwestern commodity crops is blamed for hypoxia in the Gulf of Mexico. It will be important for biomass crops to be selected for low nutrient and pesticide inputs. A recent analysis of nitrate pollution from biofuels and the Dead Zone in the Gulf of Mexico predicted that moving from corn ethanol to cellulose biofuels—including switchgrass and corn stover—will result in a 20 percent decrease in nitrate pollution in the Mississippi River watershed[16].

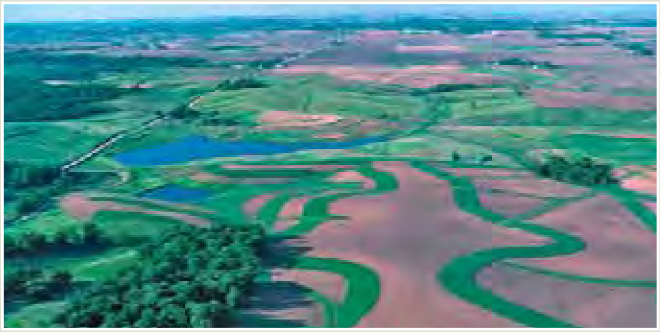
While the entire watershed contributes to watershed health, it has been found that if year-round vegetative cover is maintained in strategic areas, such as buffer strips along riparian and drainage areas, most watershed functions will be maintained even while the rest of the land is heavily used. Perennial biomass of grasslands, shrubs or trees could support watershed health and in addition produce a crop for energy.

Does not Deplete Soils

Various biomass crops and the ways in which they are managed can have very different effects on soils. In general, perennial crops and annuals managed with continuous cover crops prevent erosion, increase soil organic matter, and improve soil quality. Annual crops that leave bare land exposed for long periods of time—including those crops from which the residues (stems and leaves) are harvested for biomass—tend to have increased erosion from wind and water, decreased soil carbon, and degraded soil quality. Recent studies conclude that even no-till corn can sustain only about 25 percent of residues being removed without harming soils[17]. Conservation and conventional tillage systems, the dominant corn systems in the U.S., cannot tolerate any residue removal[18]. On the other hand, corn cob removal is thought to have an insignificant effect on soils, and will be the first large scale residue-to-ethanol project, at an ethanol plant in Iowa.

WHAT SUSTAINABLE BIOMASS MIGHT LOOK LIKE:

1. The Cornbelt—Weaving biomass crops around productive croplands



Tim McCabe

Plantings for biomass, food, feed and fiber need to fit sustainably on the landscape

Imagine the diverse and productive Midwestern farm country of tomorrow, transformed by the integration of resource-protecting biomass crops grown for energy alongside commodity and food crop production. Previously, monoculture agriculture dominated the landscape, with corn and soybeans taking turns in filling every field, nook and cranny during the summer. Yet from harvest time until well into the next summer, soils were mostly bare and prone to polluted runoff during rains. Now, farmers carefully analyze every nuance of their particular land. Food crops are still grown on the flat, productive fields, and yields continue to inch up every year as varieties are improved and fertilizer and pest management become ever more site specific. However, what a transformation has taken place as these farmers realized that biomass became a profitable crop as well as a valuable component of the conservation of neighboring croplands. And what a variety of crops and management systems have arisen, each matched to the best location.

The highly erodible fields with steep slopes or depleted and windblown soils are now planted to perennial grasses or mixed prairie species to hold the soil. Every stream, lake, drainage ditch and wetland is now buffered by a wide swath of perennial biomass vegetation. Roadsides are seeded with appropriate biomass varieties. Dry fields that used to be irrigated with precious ancient groundwater supplies are now planted to drought tolerant grasses and prairie mixtures. Pastures and grasslands have expanded as farmers learned to manage them for both livestock grazing as well as biomass production, depending on markets and their own chosen options.

Low yielding croplands that were designated disaster areas as often as not because of all too predictable floods, late snows, or droughts, are now planted to hardy and tolerant perennial grasses and fast growing trees which yield reliably every year. Even cereal croplands have integrated biomass production into the cropping system while improving the soil and water quality. The majority of field crops are either followed by a fall cover crop that keeps the soil protected over the winter and may be harvested in the spring for biomass, and/or are not tilled at all—each spring's seed is directly planted into the previous year's leaves and stems. Some farmers carefully harvest a limited portion of the main crop residue, but follow up with a cover crop to protect and build the soil. Other farmers accomplish the same thing with a resource conserving crop rotation, growing alfalfa hay for several years with the stems utilized for biomass and the leaves processed for animal feed, followed by several years of commodity crops.

Biomass harvests are often conducted in the fall, after the first frost, or in the very early spring, when grasses have taken their nutrients into the roots, leaving dry biomass to harvest as soon as the snow melts, and before birds return for their spring nesting. Crop residues and alfalfa are harvested in fall and midsummer, respectively, and woody biomass collected in the winter. Special care is taken to leave stubble for wildlife habitat, and unharvested areas for cover.

While food, feed and fiber are still produced off the land, energy is now an equally important commodity. Marginal lands that once produced corn for ethanol are now producing 2-3 times as many gallons per acre of biofuels from perennial grass systems, with many fewer expensive inputs, leading to improved farmer income. In addition to biofuels, local energy producers are using pyrolysis, gasification, and direct burning to create a wide array of energy forms to meet the specific energy needs of local institutions, communities and businesses.

This highly diverse system is not only beautiful, it has resulted in clear streams, clean groundwater, and a resurgence of wildlife that lives in the biomass covered lands. Soils have improved, reducing the need for fertilizers and pesticides. Organic matter levels are rising, improving soil productivity and helping to mitigate climate change. Many farmers are collecting additional payments for their contributions to soil carbon. Best of all, there is a resurgence of farming families able to make a living with diverse production that can be responsive to market changes.

WHAT SUSTAINABLE BIOMASS MIGHT LOOK LIKE:

2. Northeastern forests—Local wood waste provides local energy

Steven Katovich, USDA Forest Service

Sustainable harvesting of northern hardwood forests can be used to fuel small-scale combined heat and power plants

Picture a vast network of wood waste collection activities, all feeding into a matching network of local wood energy facilities, providing heat and power to community facilities and businesses. Visualize the vast forests of the northeastern part of the U.S. and the industries that use the forests to harvest lumber. Whereas logging used to leave half the biomass behind when the tree trunk was harvested, special equipment is now used to chip, shred and make pellets out of a portion of the waste wood, being careful to leave enough residue both on the forest floor and in the form of standing deadwood or "snags" to protect the forest soils and benefit wildlife.

Large private, investor-owned, and remaining industrial forest owners have become certified by the Forest Stewardship Council, and are managing forestlands to protect sensitive sites and watersheds and create more resilient forests (with structural diversity) given the expected effects of climate change on forest systems. They are conducting low impact harvesting operations and managing for wildlife corridors where landscape level considerations are important. Smaller, private forest landowners have pursued group certification to ensure sustainable forest management at a reasonable cost and to ensure their lands fit in a landscape matrix of other woodland owners. At the lumber mill, sawdust and bark residues continue to be utilized as a biomass feedstock but with newer, cleaner combustion technologies. Secondary processors and factories making products from wood also collect biomass left from the machining process to be used as an energy resource.

Throughout the region, cities and towns are collecting yard and storm waste, and recycled wood products like pallets because the wastes are now a resource. Construction and demolition debris is carefully and reliably sorted so the clean wood waste can be diverted from the landfill and used for clean energy production. Areas long ago-deforested, used for agriculture and recently abandoned have naturally re-generated or have been replanted with fast-growing willow or poplar plantations that are cut to the ground every three to eight years for continuing biomass harvests without having to replant.

Warren Gretz

McNeil Generating Station at Burlington, VT—a biomass gasifier which operates on wood chips

This wood biomass is going to the nearest biomass energy producer, which includes many hundreds of relatively small scale wood energy facilities. Institutions, including schools, colleges, hospitals and prisons have converted their boilers to cleaner, more efficient wood gasification systems. The result is heat, steam, and sometimes even electricity that can be used on site or sold to the power grid. Wood industries, who typically use their wood waste for their own energy needs, can now sell their excess energy to the power grid due to favorable net metering policies. Combined heat and power plants are using wood waste to sell electricity to local utilities and steam to nearby industries, doubling the efficiency of energy production. Some utilities are retrofitting their coal power plants to co-fire with wood waste biomass. Many residents continue to cut firewood for winter home heating, but now they have incentives to retrofit to take advantage of the latest wood stove designs to reduce air emissions and increase efficiency.

State, regional and federal forestry agencies continue to carefully monitor the forests to be sure that biomass removal is at sustainable levels, biodiversity is not impaired, and to make sure that biomass energy does not develop at a rate or size that exceeds the carrying capacity of the land. Over all, citizens are proud of their region's contribution to energy security and protecting the climate, as regional fossil fuel use is substantially replaced with woody biomass for energy.

3. Southern woodlands—Restoration of two native forest ecosystems


W. Robert Maple, USDA Forest Service, www.forestryimages.org

A healthy longleaf pine forest in Alabama

Envision how biomass harvested for energy could be the key to unlocking a set of programs that stimulate restoration of long-lost southern forests, including longleaf pine forests and southern alluvial bottomwood forests.

The legendary southern longleaf pine forest once covered approximately 90 million acres of the coastal plain, crossing nine states from east Texas to southeastern Virginia in the southeastern U.S.[3] This unique ecosystem of tall pines had an open, park-like structure with an understory dominated by many species of grasses and forbes and containing many unique species. After 200 years of logging and agricultural pressure, only about three million acres remain, making it among the most endangered ecosystems on the continent. Much of what remains suffers from a lack of fire, which historically maintained the open forest-grassland ecosystem structure by periodically burning off understory brush without harming the longleaf pines or the grass and ground vegetation.

Today, most of the historic longleaf range has been planted to annual crops (e.g. cotton, corn, soybeans) or to short-rotation loblolly and slash pine plantations to serve the pulp or pole markets. Given the decline in demand for pulp and the rising demand for biomass for pellets and ethanol production in the southeast, it is quite possible that many pine plantations will move into short rotation biomass energy crops. On the one hand this may be good if such plantations are managed and scaled appropriately using native species with ecologically sensitive management techniques (such as those described in NWF's publication "The Possibility of Plantations"). However, there is also a very high risk that such energy plantations could thwart the needed restoration of longleaf even worse, further endanger this threatened ecosystem.

Envision a carefully implemented policy that takes a three-pronged approach to driving sustainable biomass production in the southeast that complements the needed

"This is not the work of rich men but those rich in spirit whose belief that the resurrection of the native ecosystem delivers a dividend far greater than the monetary value of carbon."

—Chandler Van Voorhis, Managing Partner, C2I

restoration and protection of longleaf and its biodiversity treasures. Under one initiative, forest owners are now using mechanical removal of biomass from existing or potential longleaf stands, where the understory is too thick to prevent the use of prescribed fire. This technique removes the hardwood scrub that often invades longleaf stands where fire management has been absent and diverts the wood to energy facilities. Under another initiative, land use policy incentives have been established to steer energy crop production to areas less suitable for longleaf restoration because of their previous cropping history, their sensitivity to the use of fire management, or their fragmented nature. A third initiative has expanded experimentation into new forest management techniques known as "inter-cropping," that allow for energy crops and longleaf to co-exist side by side and represent both short and long terms sources of income. Experimentation is occurring on different types of intercropping systems to better understand the tradeoffs between the loss of the historic grassland component of longleaf systems and these new energy interplantings.

Each of these policy initiatives have contributed to a southern forest landscape that consists of both restored longleaf pine ecosystems and sustainably managed energy crop plantations. Local and regional private landowner associations are working together to share information and resources and now profit from an investment in both energy and native forest restoration.

A bit farther west is the vast Mississippi River delta region, once home to 25 million acres of flood-adapted mixed hardwood forests called bottomwoods. Only 4 million acres remain today from Louisiana north to Missouri and east to Kentucky, a result of vast forest clearing for agriculture, even though the resulting farm fields are often subject to frequent river floods, destroyed crops, and debris-strewn fields.

Picture how a "perfect storm" of supportive policies have enabled private landowners to restore disaster-prone fields to mixed hardwoods that can naturally withstand floods and provide income, recreation and wildlife habitat to the owners and to visitors. A new method of interplanting fast-growing eastern cottonwoods with slower-growing hardwood trees is helping to transform the Delta. Private landowners, tired of frequent flooding, now realize they can grow a new, flood-tolerant crop, with markets for biomass, for future timber, and for the environmental benefits these trees produce.

Courtesy of Chandler Van Voorhis

Working through regional suppliers of afforestation carbon credits like GreenTrees® in Mississippi, they get an up-front payment to help plant trees, in return for their long-term legal commitment to grow trees to address climate change, all paid for by companies that need to meet their greenhouse goals. Farm conservation programs like the Conservation Stewardship Program also help farmers to establish trees on flood-prone cropland. Alternating rows of cottonwood and hardwood seedlings, it only takes a few years to have harvestable cottonwood biomass, which will regrow directly from the stump for multiple cuttings. Selling the biomass to local energy markets makes the whole system work, by providing income in the decades it takes to grow a restored bottomwood forest. In addition to local electric and power generation buyers, the biomass is also processed into dry pellets and sent to energy facilities up the Mississippi river in empty barges that are returning from hauling farm commodities downriver. Meanwhile the hardwood seedlings become well-established in their sheltered rows, ready to put on fast grown when they overtop the cottonwoods.

Biomass markets for early cuttings of fast growing trees, carbon markets for the greenhouse gases stored in long-growing hardwood trees, and long term value in the standing restored forests (including hunting leases)—these three opportunities working together have helped private landowners find a better alternative to earn income, restore the land, and build an ecosystem that their children and grandchildren will continue to value.

WHAT SUSTAINABLE BIOMASS MIGHT LOOK LIKE:

4. The South blooms with algae for energy

Research is currently underway across the country as companies and scientists race to make growing algae and other "micro-crops" such as diatoms, micro angiosperms, and cyanobactor, for energy profitable. Requiring sunlight, water, carbon dioxide, and a bit of nutrients, the microorganisms produce vegetable oil and carbohydrates, which could feed a wide array of energy possibilities, as well as proteins that can be sold as a high-value nutritional supplement for animals and humans. Green versions of petroleum fuels that could be made from algae include biodiesel, ethanol, green gasoline, and jet fuel. Also being explored are gasification and pyrolysis of algae for heat and power. Algae can theoretically produce one hundred times the yield per acre of biodiesel compared to soybeans or other agricultural crops[5].

PetroAlgae grows micro crops at this Fellesmere, Florida facility

Picture the future of sustainable algae biomass. After several years of major public investment in research and development, the Southwest and Southeast have become epicenters of a whole new, scaled-up energy industry. In the Southwest, new companies have taken advantage of reliable sunshine, warmer temperatures, cheap land and abundant brackish groundwater, private industry has developed extensive enclosed pond systems. The covered ponds allow better temperature and environmental control, and minimize water evaporation. The added expense is worth it to keep contaminating microorganisms out. Highly efficient and productive algae biofuel production has largely displaced the use of farm crops like soybeans and canola in energy production, freeing farmers to grow food. A robust and diverse biorefining industry is producing a variety of biofuels that replace their petroleum equivalents. In the Southeast, rows of concrete ponds grow thick, floating mats of diatoms, producing high quality proteins for animal feed and a residue that can be processed into fuel in a conventional petroleum refinery.

Other parts of the country have developed smaller scale micro-crop energy systems matched to local resources. Fully enclosed bioreactors are used by large wastewater treatment plants that treat nutrient rich water supplies with algae, which cleans up the water before releasing it. Coal power plants are diverting their warm water and carbon dioxide emissions to algae facilities for faster algae growth, and a second energy use before the carbon is ultimately emitted by vehicles running on biofuels.

Local microcrop producers have garnered public support for choosing to use native species of micro-organisms and have developed closed loop systems to prevent releases of microorganisms into local waters and to conserve precious water supplies. Due to a much smaller footprint on the land, and careful siting to avoid impacts to natural ecosystems, micro crop businesses help address global warming by avoiding the land use change emissions problematic for other biofuels. Adding to the economic viability of the industry, high-value co-products such as fertilizers and nutritional supplements are sold.

WHAT SUSTAINABLE BIOMASS MIGHT LOOK LIKE:

5. Urban Biomass Wastes—Rubbish to Energy

Imagine a day not too long from now when the renewable energy value of wastes is recognized, and the result is that the very idea of waste is transformed. Picture a metropolitan area and its surrounding suburbs and communities. Of course trash and sewage are being continually generated, but with careful processing, valuable biomass energy resources are recovered alongside landfill methane and organic compost materials.

Biosolids—treated sewage sludge—are created at every sewage treatment plant and they use to be largely landfilled or applied as fertilizer to nearby lands at some expense. Now biosolids are being converted to energy that is replacing fossil energy used in the treatment plant, or is sold to nearby users. Some cities are gasifying biosolids to create syngas. Others are using anaerobic digestion to collect methane to create electricity or heat. Others are converting biosolids into solid renewable fuel that is replacing coal in nearby industries.

Garbage has been dramatically reduced by reuse and recycling efforts, but as technologies have improved to make gasification of trash both economical and safe for the environment and human health, post-recycled trash is being sorted even further to divert a large portion of the remaining waste to gasification plants to produce energy. Where such facilities do not exist, state of the art landfills are now collecting methane gas—a natural part of the breakdown of buried garbage. Not only is methane a valuable feedstock for renewable electricity, but capturing it keeps this most potent greenhouse gas from escaping and contributing to global warming.

Urban wood and yard wastes are created in huge volumes, but now they are kept clean and systematically collected for a wide variety of renewable energy production systems. Woody wastes, including storm debris, prunings, used pallets, construction debris, and carefully sorted demolition debris have become a valuable feedstock for various energy needs. Education, training, and equipment are provided so that solid waste collection and processing facilities are segregating clean woody biomass from painted, treated, or otherwise undesirable feedstocks. Downtown district heating systems, co-fired power plants, and local space heating facilities are using locally generated wood wastes for their feedstock, while everyone benefits from climate-friendly energy produced from urban wood waste. Organic wastes from food processing facilities and orchards are also collected and used for energy production.

Andrew Carlin

This 21 MW power plant uses fuel from wood residue

WHAT SUSTAINABLE BIOMASS MIGHT LOOK LIKE:

6. Diverse rural landscapes—Mixed biomass feedstocks

Show Me Energy Cooperative in Missouri

Whether due to hilly topography, variable soils, or an ecosystem at the edge between forest and prairie, many regions of the United States enjoy a highly variable landscape, where agriculture is done at a smaller scale that alternates pastures and croplands, and most farms preserve woodlands, wetlands and waterways. Biomass for energy can really thrive in these areas if technology creates markets that encourage many different kinds of feedstocks.

Imagine a sustainable biomass system in the near future which evolves from the model that already exists in Missouri. The farmer-owned Show Me Energy Cooperative processes and sells biomass pellets, made from a wide variety of biomass sources, to a wide variety of energy users. Show Me Energy started in 2004 by developing a pelletizing process to make better use of grass seed hulls that were a waste problem to grass seed producers. Other producer members wanted to sell non-food biomass materials for pelletizing as well, including hay, switchgrass, corn crop residues, and stubble from milo, wheat and oats. The nearby government mint wanted to get rid of old, shredded money removed from circulation.

Show Me Energy partnered with local experts to develop an adjustable process that uses no water or natural gas, yet can turn any of 21 non-food local feedstocks into consistent and transportable pellets with high-energy content. Useful minerals are extracted for return to the soil.

Because the 420 farmer shareholders share a concern about their landscape and wildlife, the cooperative has set harvest limits that preserve fifty-foot buffers along all streams, conservation structures and fence lines. No cutting is done during nesting season in April and May. Cutting heights are also limited, depending on the crop, to ensure 30 percent coverage of the soil after harvest. Wildlife thrive in the permanent vegetation and stubble, ensuring food, cover and habitat. Future plans include mixing in other plants with the grasses, to take advantage of nitrogen fixation and eliminate fertilizer applications.

"If we can put a man on the moon—there's no reason why we as a nation cannot do this—let's get on with it!"

—Steve Flick, President—Show Me Energy Cooperative

Because a diversity of feedstocks is welcomed, farmers can preserve a diverse landscape with multiple enterprises. Cattle are produced on pastures, while harvests of switchgrass for biomass on other acres of the farm bring in revenues that can be partially invested in improving pastures. Corn or miscanthus grass is grown in the river bottoms, allowing profits from different market sectors. Grass seed is a major cash crop, but after harvest of the seeds, the biomass can also be harvested after fall frosts send the nutrients down into the grass roots. Biomass is a valued addition to the rural economy, but it is at a scale that does not transform the land into a high-risk biomass monoculture, and the cooperative hopes to keep the same number of livestock in the area.

The cooperative model allows farmers to be the owners of the value added to their product. Each farmer's modest investment in shares guarantees delivery rights for their biomass, and a share of the company's annual profits.

The diversity model applies not only to biomass; it also applies to the renewable energy end uses. The pellets produced from all of these materials have excellent renewable energy value, and markets were developed for multiple energy users, including pellet heating stoves for homes and barns, and electricity generation by co-firing pellets with coal in an existing power plant. The power company also benefits from meeting renewable energy requirements. Future plans of the cooperative include building their own power plant combined with use of the waste heat, as well as a cellulosic biodiesel facility, and new processes to make pellets with even higher energy value and less air emissions.

Envision a future where this model catches on, with dozens of similar farmer cooperatives all over the country learning from the model and buying the licensed conversion technology, each pelletizing the biomass materials that can be sustainably harvested in their particular local landscapes and selling energy in forms suitable for local needs.

Many farmers are growing energy crops, including native grasses and mixed native perennials, as well as fast growing woody plants. Hay is processed to pelletize the leaves for livestock feed, and the stems for energy use, doubling the value of the crop. Local food processing and other industries are bringing in clean biomass for conversion to energy pellets. A number of producer cooperatives have built the new wave of cellulosic biofuel and biopower facilities, using locally available materials to produce low carbon fuels that benefit from government incentives and tax credits.

Not only are local economies thriving and retaining value-added dollars in the community, but local ecosystems are thriving as well. In contrast to monoculture agriculture, where much of the landscape is managed in exactly the same way, these communities have a diverse patchwork of perennials, crops and natural areas that provide habitat for wildlife and excellent recreation opportunities for residents. By focusing on diverse local feedstocks, diverse local energy needs, and local ownership of the businesses, Show Me Energy has shown the way to a sustainable biomass future.

Biomass being unloaded at Show Me Energy Cooperative in Missouri

WHAT SUSTAINABLE BIOMASS MIGHT LOOK LIKE:

7. Grasslands—Restoring perennials to the prairies

Lynn Betts

Envision the vast northern Great Plains, once a prairie of waving grasses that was plowed under to grow crops, now healed in large tracts, with a blanket of biomass grasses grown to produce renewable energy.

Picture a landscape that has carefully protected the remaining remnants of native prairie. Those twelve million acres are cherished for the intact ecosystem that functions as it always has. Of all the land once in crops, only the best soils and most productive lands are still growing food on some of the best farmland in the world. But a huge change has taken place. Farmers have planted a new crop on the lands that never were well-suited for corn or wheat. Perennial grasses and mixtures of native prairie species have been established to produce a new crop, one that need not be replanted but that will produce an annual biomass harvest whatever the weather throws at it.

Previously converted grasslands have been restored around the vast network of wetlands called the prairie pothole region, helping wildlife and ducks while bringing a profit to the landowners. Huge areas with low rainfall, poor, sandy or rocky soils, or erosion-prone slopes—fields that never bore a good yield but were subsidized by crop insurance, frequent disaster payments, and government crop supports—have now been planted to a mixture of native grasses well suited to the soils and climate. With few input costs and high diversity for crop resilience, farmers get a good biomass crop because the policies that drove prior poor cropping choices have been changed. Now a biomass assistance program helps farmers restore grass cover to the land, with all of the environmental benefits that brings, but encourages them to make careful biomass harvests that bring income without harming wildlife or the environment.

Because farmers now: 1) harvest their grasses after birds have finished raising their young, 2) leave sufficient stubble to provide nesting structure for waterfowl the following spring, and 3) leave some parts of their fields unharvested each year to serve as winter cover, wildlife are thriving. Local communities are also thriving from the seasonal influx of hunters.

A Truly Sustainable Bioenergy Future—You Can't Get There With Current Policies

There can be a sustainable future for biomass energy and biofuels—one that not only helps to address global warming, but also protects, or even enhances the natural environment. Several examples of what a sustainable biomass future might look like are included in this report. Yet this sustainable future for bioenergy will not happen without a serious reexamination and adjustment of our federal policies. Instead of learning from the experience of corn ethanol expansion, we are simply using the same policies to promote biomass, hoping this time for a better result. To get this better result, we must either require or reward the practices that lead to sustainability.

Simply creating subsidies, mandates and incentives for certain quantities of fuel or energy will not result in a sustainable biomass industry. Industry proponents argue that sustainability considerations should come later, after the industry is up and running. Yet for those who have watched the powerful ethanol lobby oppose any limitations on their industry, this suggestion is a non-starter. We need to begin immediately to ensure that our policies:

1. Promote a transition to next generation, more sustainable bioenergy sources.
2. Establish minimum standards for all bioenergy sources to ensure sustainability and greenhouse gas performance.
3. Establish graduated incentives that offer the greatest rewards to the best performers.

BIOMASS IS NOT A SILVER BULLET

There is no silver bullet to America's energy future. While biomass will never meet all of our nation's transportation fuel needs, there is theoretically enough under the most aggressive scenarios to substitute for up to a third of U.S. transportation fuel use[19]. The U.S. consumes 14 million barrels of oil a day for transportation and less than five could come from biomass. Biomass is just one important part of the solution, which must also include energy efficiency, mass transit, and renewable electricity. Vehicle electrification will likely become the best and most sustainable solution to meeting our transportation fuels needs. Biomass already produces fifteen times more renewable energy for the U.S. than wind and solar combined, mostly from wood waste used at paper mills. It also holds promise for creating heat and electricity through a wide variety of conversion pathways.

Scott Bauer

Policy Changes Needed to Promote Sustainable Biomass

1. Promoting a transition to next generation, more sustainable bioenergy sources

The first generation of ethanol has been underway for some 25 years. Over 10 billion gallons of corn ethanol were produced in 2009. This amounted to nearly seven percent of U.S. gasoline equivalent energy. The recent explosion in corn ethanol was aided by multiple public policy incentives, mandates and subsidies. The Federal Renewable Fuel Standard (RFS) mandates the use of 15 billion gallons of corn ethanol per year by 2015, while a "blenders credit" gives a $.45 a gallon tax credit for every gallon of ethanol blended into gasoline.

Unfortunately, most of the 15 billion gallons of corn ethanol mandated by the RFS come from existing facilities, which are not required to meet any greenhouse gas standards. Even without considering the greenhouse gases released through land use changes driven by corn ethanol expansion, the net energy gain of corn ethanol is modest because of the significant investment of fossil fuel it takes to grow corn and process ethanol. When land use change effects are taken into account, most corn ethanol actually contributes to global warming, rather than serving as a solution[20, 21]. The impacts to soil, water, wildlife and biodiversity are also severe, rendering corn an unsustainable source of fuel.

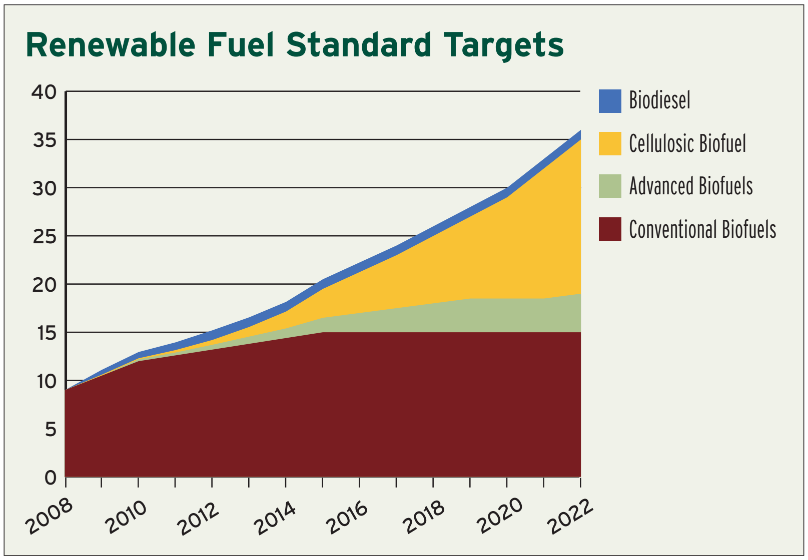
Biodiesel is a smaller industry that currently transforms vegetable oils—mainly from soybeans—and animal fats into biodiesel (plus the byproduct glycerine.) Biodiesel from soybeans, like corn ethanol, is not a good choice for reducing greenhouse gases, or for long term sustainability. Other possible feedstocks include camelina, palm oil, algae, other vegetable oils and used fats. Biodiesel can be blended with petroleum diesel or used alone in diesel engines. Today the industry is in a severe economic slump due to high soybean prices and low petroleum prices. While the tax credit of $1 per gallon has temporarily expired, it is expected to be reinstated soon.

When the mandates and incentives for corn ethanol and soy biodiesel first began to show great success in increasing production, many thought that this first generation of biofuels was simply a bridge to a more efficient and sustainable next generation of bioenergy. It was argued that the success of this first generation of biofuels was necessary to pave the way for the next generation. However, it has become increasingly clear that the success of the first generation has spawned a powerful, well-funded lobby that is bent on self perpetuation. While next generation bioenergy is also supported by this lobby, and in fact some businesses have hedged their bets by investing in both, next generation is definitely seen as additional to corn ethanol, not as a replacement.

The RFS is evidence of this approach, carving out a permanent place for corn ethanol, although leveling it out eventually at 15 billion gallons per year. Yet in order to grow

Soybeans are currently the major source for biodiesel in the U.S.

the corn needed to produce 15 billion gallons of corn ethanol, biomass will be forced into the most marginal of lands, making it even more difficult to advance the industry and make it economical.



New biomass based biofuels are at a distinct disadvantage in competing with corn ethanol. While they also have an RFS mandate and a tax credit, they are still going through the expensive research and commercialization stage. Non-crop biomass also lacks the underlying foundation of commodity subsidies which minimize risk and pay farmers if prices are low or disaster strikes. The Biomass Crop Assistance Program should eventually help biomass growers get started, but delays in launching the program have hampered the development of the industry. Finally, the greater sustainability of biomass crops is not currently recognized by either policy or the market.

The following specific legislative and policy changes are needed in order to ensure a transition to next generation bioenergy sources:

- Congress should eliminate the so-called "blenders' credit" of $.45 per gallon for corn ethanol and $ 1.00 per gallon for biodiesel. Because there is already a mandate in the Renewable Fuels Standard that requires these companies to use biofuels, tax credits are duplicative and cost taxpayers billions.
- Congress should rework the Renewable Fuels Standard targets when next generation fuels are fully deployed, such that mandates for first generation biofuels are phased out to make room for more sustainable biofuels.
- Congress should make first generation biofuels ineligible for Department of Energy and Department of Agriculture assistance programs, such as loan guarantees, grants, etc., except for projects focused on retrofitting existing refineries to run on biomass or wind instead of fossil fuels, or to convert these refineries to process biomass instead of corn or soybeans.
- Congress should increase funding for agriculture conservation programs and impose new conservation requirements on recipients of farm subsidy and benefit programs during reauthorization of the next Farm Bill to prevent continued habitat losses, water pollution and soil losses.
- Congress should eliminate the grandfathering provision for corn ethanol in the Renewable Fuels Standard so that all ethanol refineries are forced to improve their greenhouse gas performance in order to qualify for the mandate.
- EPA should work to improve their modeling of life cycle greenhouse gas emissions of biofuels to make them reflect the most realistic projections of these levels, rather than the most optimistic projections, which enable poorly performing biofuels to continue to meet the RFS.

Harvest timing is critical in grassland plantings in order to protect birds during the nesting season. John Mosesso

2. Establish minimum standards for all bioenergy sources to ensure sustainability and greenhouse gas performance.

Each and every publicly-funded benefit or mandate designed to promote bioenergy should also be designed to promote the public good.

There are many federal, state, and even local subsidies, incentives, and mandates for biofuels. These range from the federal "blenders' credit," to loan guarantees and grants for construction of processing facilities, to mandates requiring the use of certain quantities of biofuels. Several states also have renewable electricity standards that require that power companies obtain a certain percentage of their power generation through use of renewables, including biomass. Several bills are working their way through Congress that would establish a Federal Renewable Electricity Standard. Each and every publicly-funded benefit or mandate designed to promote bioenergy should also be designed to promote the public good. Minimum greenhouse gas performance and sustainability standards attached to these benefits will ensure that bioenegy does not have unacceptable environmental impacts or contribute to global warming. The following should be required of all sources of bioenergy that receive government assistance or benefit from legal mandates:

Helps Address Global Warming

The biofuel or bioenergy produced should be compared to its fossil fuel equivalent, with a fair and complete accounting of greenhouse gas emissions over the entire life cycle of the fuel, including land use change. Acceptable biofuels and bioenergy would produce significantly less greenhouse gas emissions per unit of usable energy than their fossil fuel equivalent. (By contrast, the Environmental Protection Agency's efforts to establish accounting procedures have taken the most optimistic of assumptions in order to err on the side of conventional biofuels production, at least in the short term.)

A portion of the woody debris from forestry operations can be harvested for biomass

Chris Schnepf, University of Idaho

- Congress must maintain full and complete life cycle accounting requirements and aggressive performance targets for biofuels in Federal law.
- EPA should work to improve their modeling of life cycle greenhouse gas emissions of biofuels and bioenergy to make them reflect the most realistic possible projections so that existing and new laws can rely on these assessments to ensure incentives and mandates for bioenergy do not support sources that do not address global warming.
- Congress must ensure that passage of a Renewable Electricity Standard includes requirements to ensure that biomass energy sources have positive greenhouse gas benefits and does not reward energy produced from biomass systems that release more carbon than is replaced through re-growth.

Protects Native Habitats and Biodiversity

While addressing land use change issues to achieve a positive effect on greenhouse gases will go a long way toward protecting habitats, there also need to be strict requirements governing where biomass and biofuel crops are produced. This issue has been quite contentious in recent years, with a strong land restriction provision in the Renewable Fuel Standard attacked as being too restrictive, and efforts in Congress to take away all restrictions on what lands can be converted to biomass production.

- Congress must ensure that any incentive or mandate for "renewable biomass" for either fuels or energy include safeguards to ensure that valuable natural ecosystems are not converted to energy cropping; that some high value areas—including certain public lands—are placed off limits to biomass harvesting; and that all biomass harvesting is accomplished in a sustainable fashion.

Ensures Sustainable Harvests, Protects Our Waterways, Does not Impact Water Supplies, and Does not Deplete Soils

Sustainability must become a goal of our biomass policies. Yet, these goals will not be met without some minimum requirements attached to incentives and mandates for biomass production.

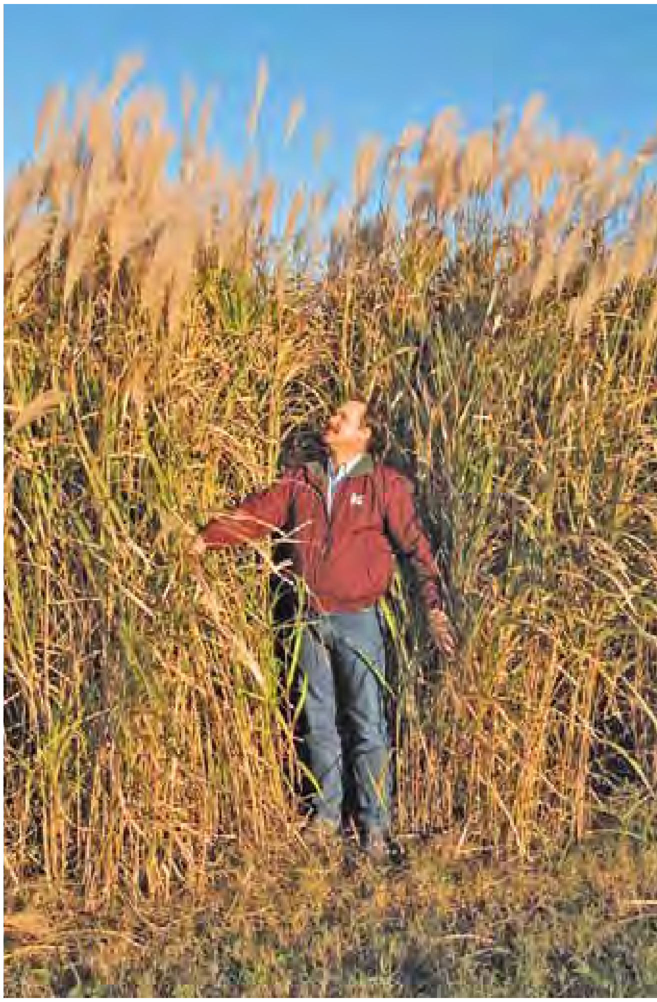
- Congress must enact requirements on those receiving subsidies and incentives for biomass production to ensure that they develop and implement comprehensive conservation or forest stewardship plans to ensure against degradation to soils, water or wildlife.
- Congress and the states should consider incentives for combined heat and power projects which utilize sustainable feedstocks through explicit fuel procurement policies or closed loop energy crops on appropriate lands.

Less than one percent of our native tallgrass prairies still remain in the U.S. The potential for these last few remnants to be degraded by exotic or genetically manipulated species is of great concern.

Crops do not Become Invasive

As discussed earlier in this report, if biomass crops are not carefully screened and field tested, many species could be used that would spread and become invasive. Drift of pollen from genetically modified native plants could also mix with native species. These invasions are of great concern, especially with regard to prairie plants since native prairies have declined so dramatically. Less than one percent of our native tallgrass prairies still remain in the U.S. The potential for these last few remnants to be degraded by exotic or genetically manipulated species is of great concern. Yet existing laws are weak and poorly enforced.

Liability for control of escaped invasive plants is rarely assigned to those responsible. In the case



The exotic grass, Giant Miscanthus, has a high biomass potential, but could it become invasive?

of genetically modified species, patent laws skew liability such that those whose lands have been invaded by such species could actually be subject to lawsuits from the seed producers if they make any economic use from the invading plants that they had no role in introducing to their fields. Congress must include provisions in all laws to promote biomass that:

- Prohibit the use of invasive or noxious species or those with significant potential to become invasive or noxious.
- Require all plant varieties to be fully tested and screened prior to being approved for commercial deployment.
- Assign clear liability for control and remediation of plant spread beyond the target properties to the seed or stock producer unless label directions were not followed, in which case liability would be assigned to whoever planted the material.

3. Establish graduated incentives that offer the greatest rewards to the best performers.

In addition to setting a bar to ensure that all biofuels and bioenergy are produced sustainably, incentives, mandates and subsidies should also recognize and reward greater levels of performance with regard to greenhouse gas reductions and environmental benefits. The current Renewable Fuels Standard, as implemented by EPA assigns greenhouse gas values to specific biofuel production system types to determine whether they meet the greenhouse gas reduction targets in law. The rules do not reward or punish individual operators for doing better or worse. There is, therefore, no incentive to improve greenhouse gas performance. There are also no incentives in the RFS mandates to produce biofuels in ways that are environmentally sustainable.

- Congress should replace the current "Blenders' Credit" with an incentive payment for growers of biomass that rewards them on a sliding scale, depending on their performance in reducing greenhouse gases, and protecting soil, water and wildlife resources.

Lynn Betts

Conclusion

The United States is currently at a crossroads with regard to the future of bioenergy. This year, Congress will consider legislation that includes:

- A Renewable Electricity Standard that would create a long term market and greatly increased demand for biomass.
- Reauthorization of the "blender's credits" for corn ethanol and biodiesel, the largest of the economic subsidies for first generation biofuels.
- Changes in the definition of "renewable biomass" that would make all private lands—no matter how ecologically valuable or vulnerable—eligible for biomass production for purposes of meeting both the RFS and any future Renewable Electricity Standard.
- A prohibition on including the carbon emissions associated with international indirect land use change in calculating the greenhouse gas performance of biofuels—obscuring the true effect of biofuels on global warming.

As the country moves to promote additional biomass production for fuels and power, it is disappointing that legislative efforts are focusing on how to further weaken the few sustainability considerations currently in place rather than ways to make bioenergy more sustainable. This approach will not create the sustainable, green energy future our country needs. Will we go for the win-win-win-win for climate, clean energy, a healthy environment, and economic development? We owe it to future generations to at least try.

"We should work toward a future where we restore America's great grassland ecosystems and all the benefits they can provide, including biomass as a source of sustainable energy to power our nation."

—Jason Hill, Resident Fellow, Institute on the Environment, University of Minnesota

Endnotes

[1] Adenike Adeyeye, James Barrett, Jordan Diamond, Lisa Goldman, John Pendergrass, and Daniel Schramm, *Estimating U.S. Government Subsidies to Energy Sources: 2002-2008,* Environmental law Institute, September 2009.

[2] Campbell, J.E., et. al., 2009. Greater Transportation Energy and GHG Offsets from Bioelectricity Than Ethanol. Science Express, May 7, 2009

[3] Tilman, Hil, and Lehman, Carbon-negative Biofuels from Low-Input High-Diversity Grassland Biomass, Science, December 8, 2006.

[4] Second Harvest, Biomass from Cover Crops, NRDC. Pending publication.

[5] Blanco-Canqui, H., R. Lal. 2009. Corn stover removal for expanded uses reduces soil fertility and structural stability. Soil Science Society of America Journal 73, no. 2: 418–426. <https://www.crops.org/story/2009/mar/tue/corn-stover-removal-reduces-soil-fertility>

[6] Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales and C. de Haan (2006) Livestock's long shadow—environmental issues and options. Food and Agricultural Organization, Rome, Italy. Available online at: <http://www.virtualcentre.org/en/library/key_pub/longshad/A0701E00.pdf>

[7] New breakings data provided by the Farm Service Agency to Ducks Unlimited.

[8] Ramage, M.P. 2009. Liquid Transportation Fuels from Coal and Biomass: Technological Status, Costs and Environmental Impacts. National Academies Press.

[9] Chesapeake Bay Commission. 2010. Chesapeake Biofuel Policies: Balancing Energy, Economy and Environment. Report of the Chesapeake Bay Commission and the Commonwealth of Pennsylvania.

[10] DiTomaso et. Al.Biofuel Feedstocks: The Risk of Future Invasions, CAST, November 2007. <http://www.cast-science.org/websiteUploads/publicationPDFs/Biofuels%20Commentary%20Web%20version%20with%20color%20%207927146.pdf>

[11] Reinvest in Minnesota-Clean Energy. February 2008. <http://www.bwsr.state.mn.us/RIM-CE.html>

[12] U.S. Geological Survey. Water Use in the United States. <http://www.nationalatlas.gov/articles/water/a_wateruse.html>

[13] U.S. EPA. Nonpoint Source Pollution. <http://www.epa.gov/reg3wapd/nps/>

[14] Costello, et.al. Impact of Biofuel Crop Production on the Formation of Hypoxia in the Gulf of Mexico, August 2009 <http://pubs.acs.org/doi/full/10.1021/es9011433>

[15] Blanco-Canqui, H., R. Lal. 2009. Corn stover removal for expanded uses reduces soil fertility and structural stability. Soil Science Society of America Journal 73, no. 2: 418–426. <https://www.crops.org/story/2009/mar/tue/corn-stover-removal-reduces-soil-fertility>

[16] IBID

[17] D. Brockaway, et al., Restoration of Longleaf Pine Ecosystems, USDA Forest Service, July 2005. <http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs083.pdf>

[18] Is the Future of Biofuels in Algae?, Environment and Study Institute, Renewable Energy World, June 12, 2009. <http://www.renewableenergyworld.com/rea/news/article/2009/06/is-the-future-of-biofuels-in-algae>

[19] Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply, USDA and USDOE, April, 2005 <http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf>

[20] Searchinger, T. et.al. 2008, Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change. Science Express. February 7, 2008.

[21] Hertel, T.W., A.A. Golub, et. al. 2010. Effects of US Maize Ethanol on Global Land Use and Greenhouse Gas Emissions: Estimating Market-mediated Responses. BioScience, Vol. 60 No. 3. pp. 223-231.

National Wildlife Federation
National Advocacy Center
901 E St. NW, Suite 400
Washington, DC 20004

www.nwf.org

FSC Info/logo