GENETICALLY ENGINEERED TREES

THE NEW FRONTIER OF BIOTECHNOLOGY

CENTER FOR FOOD SAFETY

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ABOUT US

THE CENTER FOR FOOD SAFETY (CFS) is a national non-profit organization working to protect human health and the environment by challenging the use of harmful food production technologies and by promoting organic and other forms of sustainable agriculture. CFS uses groundbreaking legal and policy initiatives, market pressure, and grassroots campaigns to protect our food, our farms, and our environment. CFS is the leading organization fighting genetically engineered (GE) crops in the US, and our successful legal challenges and campaigns have halted or curbed numerous GE crops. CFS's US Supreme Court successes include playing an historic role in the landmark US Supreme Court *Massachusetts v. EPA* decision mandating that the EPA regulate greenhouse gases. In addition, in 2010 CFS challenged Monsanto in the US Supreme Court (*Monsanto Co. v. Geertson Seed Farms*), which set key legal precedents. CFS has offices in Washington, DC, San Francisco, CA, and Portland, OR.

EXECUTIVE SUMMARY

Trees are being genetically engineered for a range of purposes aimed to accelerate large-scale, industrial monoculture tree plantations and increase profits for biotechnology companies as well as paper, biofuel, lumber, and energy industries.

Genetically engineered (GE) trees are a new frontier of plant biotechnology. These trees are promoted as the new green solution with claims that they will save native forests, protect wildlife and biodiversity, mitigate climate change, and more. But behind these false promises is a very different reality.

Instead, trees are being genetically engineered for a range of purposes aimed to accelerate large-scale, industrial monoculture tree plantations and increase profits for biotechnology companies as well as paper, biofuel, lumber, and energy industries. Already, tree plantations of eucalyptus, poplar, oil palm, and pine trees are widely planted around the world and have a legacy of extending deforestation, polluting ecosystems, and often violating human rights in local communities.

Poised on the precipice of adopting this novel, unregulated, and untested technology, this report serves as a primer to GE trees and explores the troubling short- and long-term ecological and socioeconomic dangers that transgenic trees pose.

An overarching theme of this report is that, fundamentally, GE trees—and tree plantations—extend and exacerbate an industrial, chemical-centric approach to agriculture that has already polluted soils, waterways, and air; diminished biodiversity; and emitted greenhouse gases. As with GE crops, monoculture GE tree plantations will

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require repeated and widespread dousing of chemicals to eliminate pests and plant diseases. But, eventually, these pests and plant pathogens become resistant to chemicals and require more toxic brews.

The vital functions of forests and the primary drivers of deforestation and forest degradation, with a particular focus on the role of biofuel and biomass production, are discussed in Chapter One. The influence of national and international energy policies is also reviewed.

Chapter Two profiles GE trees, focusing on the current status of research and development, ecological and socioeconomic concerns, and the unique attributes of trees that necessitate particularly stringent and long-term analyses with regard to genetic engineering.

In Chapter Three, we look at "what's past is prologue" and demonstrate how the hazards of GE crops portend potential problems with GE trees. Finally, Chapter Four outlines policy recommendations that urge a precautionary approach before determining if GE trees are a viable, sustainable way forward.

CURRENT STATE OF PLAY

Currently, there are five GE trees approved for commercial planting: virus-resistant papaya and plum in the US, another variety of virus-resistant papaya in China, and two species of poplar engineered for insect resistance in China. The GE papaya in the US is grown on around one thousand acres in Hawaii,[1] and the GE plum has yet to be planted on a commercial scale.

In China, a European black poplar engineered with an insecticide derived from ***Bacillus thuringiensis*** (Bt) is widely grown, with more than one million trees planted on hundreds of hectares as of 2003.[2] Another insect-resistant poplar was also approved for commercialization in China—a hybrid between white poplar and two Chinese poplar species—and is engineered with Bt and a novel insecticide, API, from arrowhead lily.[3] There are no reliable reports of how many of these GE white poplar hybrid trees have been planted. China also has commercialized a virus-resistant papaya, similar to the Hawaiian varieties. This papaya is thought to be widely planted in China, but there are no reliable estimates of acreage planted.[4] Both Hawaiian and Chinese virus-resistant papaya trees are approved to grow commercially and are being grown in Hong Kong as well.[5]

There are hundreds of field trials with dozens of GE tree species around the world.[6] In the US, trees in the genus ***Populus***, such as poplars, aspens, and cottonwoods are the most common experimental GE forest trees, along with species of pines and other conifers, and eucalyptus.[7] Field trials of GE citrus and apples trees are also underway, along with a small field trial of GE banana trees. Currently, there are over 1,000 acres of GE tree field trials in 20 states.

In 2010, the US Department of Agriculture (USDA) approved a widespread planting of experimental GE eucalyptus trees, covering 28 open-air test sites across seven southern states totaling 330 acres. These field trials, planted by ArborGen, the largest tree biotechnology company in the US, consisted of at least a quarter million GE eucalyptus trees. (The Center for Food Safety filed a lawsuit challenging these field trials.)

Simply put, GE trees and tree plantations are no substitute for the myriad complex functions of a forest.

Based on these field trials, ArborGen, a joint venture of MeadWestvaco Corp and New Zealand's Rubicon Ltd, requested permission from the USDA in 2011 to allow commercial plantings of its freeze-tolerant eucalyptus (FTE). If permitted, the GE eucalyptus will be the first transgenic forest tree approved for unrestricted cultivation and will most likely pave the path for speedy clearance of other GE tree species.

As of early 2016, USDA APHIS has indicated that its draft environmental impact statement is under review by the US Fish and Wildlife Service for possible effects on endangered or threatened species, under the endangered speces act (ESA). The industry has also said that it is now testing non-GE cold tolerant eucalyptus.

PARADISE LOST

Simply put, GE trees and tree plantations are no substitute for the myriad complex functions of a forest. The rich diversity of forests provides an array of ecological services such as building healthy soils; providing habitat for numerous creatures; performing critical hydrological functions; purifying air and storing carbon; and many other features.

Forests harbor a remarkable 70 percent of the world's animal and plant diversity.[8] Forests play a particular role in addressing today's simultaneous environmental crises. As one example, forests are essential in regulating climate change. Forests are reservoirs of soil, biomass, and trees and plants that absorb carbon dioxide (CO_2), a major greenhouse gas, and they also store carbon for many years. According to the United Nations Food and Agriculture Organization (FAO), today's forests have the potential to sequester about one-tenth of global carbon emissions projected for the first half of the 21st century.[9] However, if forests continue to disappear and deteriorate at present rates of 5.2 million hectares per year,[10] we will release even more CO_2 while simultaneously squandering the ability to mitigate climate change through carbon sequestration in forests.

Another central ecological and social predicament of our time is the imminent scarcity of fresh water. Forests are vital to preserving water systems—one-fifth of the world's fresh water is found in the Amazon Basin alone.[11] Given that by 2025 almost

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1.8 billion people will be living in regions with absolute water scarcity and two-thirds of the population could be living under water-stressed conditions, forest health is paramount.[12]

Forests also provide 1.6 billion people with shelter, food, water, and other essential daily needs.[13] For example, over 50 million people in India depend on forests for direct subsistence.[14] In West Africa, wild "bushmeat" from the forest provides an important source of protein for both rural and urban households.[15]

Additionally, forests harbor an incredible collection of plants that are critical to modern and traditional medicine. In the US, at least half of the most prescribed medicines come from natural sources found in forests,[16] and 70 percent of all new drugs introduced in the past 25 years have derived from forest plants, animals, and microbial material.[17] For example, a compound from a tropical legume (*Mucuna deeringiana*) is used to treat Parkinson's disease. Forests are also critical for traditional and herbal remedies. Over 5,000 plants are vital for traditional Chinese medicine.[18] The extraordinary treasures contained in forests have barely been tapped. Less than 1 percent of tropical trees and plants have been tested by scientists, who believe that many new compounds with medicinal properties are yet to be discovered.[19]

As naturalist John Muir reminds us: "The clearest way to the universe is through a forest wilderness."[20] Ultimately, a true forest is a wonderful, magnificent wild of the known and unknown that cannot be cultivated and cannot be replaced. To lose these ancient sanctuaries that formed over millions of years is to lose a fundamental life source.

Yet, deforestation and forest degradation are occurring at astonishing rates. The majority of deforestation has occurred in the last two centuries;[21] nearly half of the world's virgin forests have been lost in the last 50 years.[22] In addition to deforestation, forest health is declining due to industrial activities such as road construction, mining, water diversion projects, and a host of other such activities. This further disrupts biodiversity, wildlife habitat, soils and microbes, and other attributes necessary for planetary survival.

DRIVERS OF FOREST DEMISE

Our legacy of deforestation has profound implications for societies and for our future. Understanding the drivers of forest destruction is critical in order to construct viable, comprehensive solutions. What activities are leading to forest demise? What regions of the world are most affected? Do GE trees have a place in our vision of a sustainable future?

Historical trends of degradation vary according to geography, economies, and politics. In the US, deforestation largely happened prior to the 20th century with the arrival of European settlers.[23] Between 1990 and 2000, countries with the largest losses of forest area include Brazil, Indonesia, Sudan, Zambia, Mexico, and the Democratic Republic of the Congo.[24] Forest destruction occurs in these countries for a variety of reasons. For instance, in Brazil, soybean crops for biofuels are displacing cattle ranches. Perversely, more forests are then cut down to provide land for cattle.

As forester Aldo Leopold wrote: "Wilderness is the raw material out of which man has hammered the artifact called civilization."[25] These words sum up the essential driver of deforestation—the insatiable desire of industrial societies for energy and accoutrements of 21st century lifestyles. Specific causes of deforestation are numerous and complex. Most researchers agree that primary drivers of deforestation are extractive industries for lumber, wood-related products, and minerals such as clay; large-scale cattle ranching; and industrial, monoculture agriculture—both for food and fuel.

Some point to growing populations in developing countries as a major contributor to forest degradation; however, it is the most intensely industrialized countries that consume an overwhelming majority of forest and wood products. Comprising just 16 percent of the global population, North American, Japanese, and European consumers use around two-thirds of the world's paper and paperboard and half of its industrial wood.[26] Consumption of meat and biofuels is also much higher in these regions than in developing nations.[27]

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LOSING THE FORESTS FOR THE TREES

"It's through plantation forests and increased productivity that you protect native forests,"[28] maintains Barbara Wells, former CEO of ArborGen and former executive at Monsanto. Forest destruction in Indonesia detailed in this report debunks this theory and uncovers the full scope of negative consequences of tree plantations. Astonishingly, Indonesia has lost over half of its forests since the 1960s, primarily because of oil palm tree plantations.[29] Palm oil derived from oil palm trees, used largely for processed foods, biofuels, and personal care products, is a burgeoning commodity. As demand for palm oil increases, oil palm tree plantations expand and encroach into forests. Along with this, several species, including the orangutan and Sumatran tiger, are now endangered in Indonesia due to loss of habitat.[30]

Life-threatening smog due to regular and deliberate fires set by palm oil companies to clear fields and forests for more plantations is yet another consequence. Recent news stories document the widespread smog affecting local inhabitants and neighboring countries. Malaysia declared a state of emergency due to rising air pollution levels, and Singapore urged people to remain indoors because of "hazardous" levels of pollution.[31]

The continued expansion of tree plantations illustrates the basic principle that supply and demand do not remain static.

Economic imperatives ensure that more land will be cleared for tree plantations as demand increases for wood-based products.

Additionally, tree plantations are frequently associated with "land grabs" whereby richer, industrial countries purchase land in developing countries to grow crops for biofuels and other ventures. These land grabs by corporations or foreign governments often devastate local populations that have lived in these regions for generations, often with no formal claim to the land. While foreign investors promise jobs, food, and economic development, too frequently communities are left without livelihoods, food, or water, and are marginalized with little recourse.

Genetically engineered tree advocates consistently claim that tree plantations are a sustainable way to save forests, yet Indonesia's experience with land grabs reflects a growing trend of expanding tree plantations at the expense of forests and local populations. For example, in the Lumaco district of Chile, pine and eucalyptus plantations have expanded from 14 percent of land in 1988 to 52 percent in 2002, clearing forests and displacing local communities.[32]

The continued expansion of tree plantations illustrates the basic principle that supply and demand do not remain static. For instance, a Brazilian forest-asset company claims that the eucalyptus tree market has potential to expand by 500 percent over the next 20 years.[33] Economic imperatives ensure that more land will be cleared for tree plantations as demand increases for wood-based products.

National and International Energy Policies

As this report examines, national and international energy policies significantly encourage technologies such as GE trees. In the US, the Renewable Fuel Standard (RFS) program, part of the Energy Policy Act of 2005, sets mandates for production of corn ethanol and other biofuels. To spur biofuel development, policies prescribe a variety of federal, state, and local incentives such as tax credits and exemptions, grants, and loan guarantees. As a result, corn production used for biofuels increased from 1.168 to 4.900 billion bushels in the last decade.[34] US farmers increased the number of acres planted in corn from 80 million in 2000-2001 to 88 million in 2010-2011.[35] Such increased cultivation comes at the expense of former Conservation Reserve Program lands and other pristine areas.[36]

In order to meet mandates that steadily increase,[37] industry is looking to produce biofuels from cellulosic ethanol derived from trees or other woody plants, particularly poplar trees. Genetically altering or reducing lignin content, a structural component of wood, makes it easier to break down woody biomass and access sugars for ethanol production. However, lignin is an important component of trees. For example, lignin maintains the structural integrity of trees and helps to repel pests while also playing a central role in decomposition, which nourishes soils.[38] Reducing lignin in GE trees raises the additional concern that non-GE and wild trees may become structurally weaker if contaminated.

Biotechnology and many energy corporations promote GE trees, and the particular trait of reducing or altering lignin content, as a climate change mitigation measure; however, research does not support this claim. For instance, aspen trees with altered lignin store 30 percent less total plant carbon than non-GE aspens.[39]

In both the US and Europe, renewable energy mandates, in tandem with climate change mitigation measures, have also led to an increasing demand for biomass sources such as wood pellets. Large utility and energy corporations view fast-growing, as well as low-lignin, GE trees as a way to meet high demand. The pellets are typically burned in combination with coal, oil, or natural gas to power plants that generate electricity. However, emerging science reveals that burning trees and/or wood pellets produces high rates of greenhouse gas emissions and other pollutants and is not a sustainable solution to replace fossil fuels or coal.[40] Nevertheless, at least 30 wood pellet production facilities are operating or in development across the southern US,[41] and hundreds of new "renewable energy" facilities have been developed to burn wood pellets as a result of government support for wood products as an alternative fuel.[42]

Additionally, the US is now the world's largest exporter of wood pellets,[43] with most shipments transported from ports in the southeastern US to the EU where companies are seeking to comply with sulfur dioxide restrictions. Wood pellets are typically co-fired with coal to fuel power plants.[44] However, studies show that while wood pellet biomass does lower sulfur dioxide emissions, it increases a variety of other emissions and ultimately prolongs the life of these polluting power plants, all under the guise of climate-friendly energy production.[45]

ArborGen's freeze-tolerant eucalyptus tree, currently awaiting approval for commercialization, will enable eucalyptus trees to grow in colder climates of southeastern states and bolster wood pellet production for use both in the US and the EU.

In addition to discussing how domestic energy policies link to GE trees, the report provides examples of how international institutions and initiatives can also stimulate genetic engineering and plantation forestry. For example, the Clean Development Mechanism (CDM), an emissions reduction credit program that is part of the Kyoto Protocol, enables corporations to obtain saleable carbon credits for tree plantations. Critics of the CDM assert that this carbon credit scheme simply allows bad environmental practices to continue and even expand. To illustrate, Sierra Gold Corporation, a Canadian mining company operating in Sierra Leone, plans to use revenue from its 45,527 hectare Kiri tree plantation, valued at $715 million over 50 years, to expand mining operations in West Africa.[46]

In the same way that Monsanto and other agribusiness giants transformed the landscape of agriculture with GE crops, ArborGen and other tree biotechnology companies have a vision of a forest products industry dominated by plantations stocked with their proprietary GE trees.

Using GE trees to further expand tree plantations will almost certainly intensify global food crises as land once grown for food is shifted to production for biofuels.

Threatening Food Security

This report highlights the little discussed link between biofuel policies and increased hunger. With 40 percent of US corn now destined for biofuel production, corn commodity prices have surged.[47] For example, in 2009-2010, developing countries that were net-importers of corn paid 21 percent more for a bushel of corn.[48] This has led to food scarcity in some developing countries. A United Nations report concludes: "prices [of food commodities] are substantially higher than they would be if no biofuels were produced."[49] Using GE trees to further expand tree plantations will almost certainly intensify global food crises as land once grown for food is shifted to production for biofuels.

GE TREE PROFILES AND OVERVIEW OF POTENTIAL ECOLOGICAL IMPACTS

In the same way that Monsanto and other agribusiness giants transformed the landscape of agriculture with GE crops, ArborGen and other tree biotechnology companies have a vision of a forest products industry dominated by plantations stocked with their proprietary GE trees. ArborGen has projected its profits will boost yearly sales from $25 million to $500 million in 2017 if GE trees are commercialized.[50]

Genetically engineered forest trees such as pines, poplars, and eucalyptus would be used for traditional lumber and paper products and serve as raw material for biomass such as wood pellets, cellulosic ethanol, and fuels such as terpene extracted from pine trees. A nascent segment of the GE tree industry is developing fruit and nut trees with novel disease and pest resistance as well as altered ripening or storage characteristics.

Industry markets GE trees as being solutions to a host of environmental problems. The GE American chestnut is showcased as way to restore this lost "heritage tree"; other GE trees are promoted as being "climate-friendly." However, such pronouncements are often aimed to capture the hearts and minds of the public and obscure controversial endeavors that can result in serious ecological consequences.

In profiling GE trees and examining potential impacts on forests and wild trees and plants, the report highlights special attributes of trees and how they are more complex than agricultural crops. As one example, trees can reproduce over long distances via wind, water, and wildlife. The eastern cottonwood can produce almost 30 million wind-dispersed seeds in one season,[51] and some pine pollen can travel more than 25 miles and still be viable.[52] This presents significant concerns about transgenic contamination of non-GE trees and wild relatives, and more broadly, the health of forests.

For the GE eucalyptus, ArborGen claims to have minimized potential contamination by inhibiting pollination. However, the genetic alteration causes only male sterility, allowing for potential pollination between GE flowers and conventional, non-sterile eucalyptus.

In both the US and Europe, renewable energy mandates, in tandem with climate change mitigation measures, have also led to an increasing demand for biomass sources such as wood pellets.

These issues and more are discussed in Chapter 2 and demonstrate why it is essential to pursue a precautionary path and conduct long-term, comprehensive studies before determining if a GE tree should be cultivated.

In addition, this section of the report provides a vignette on how the development of GE trees, such as the GE American chestnut, can provide cover for polluting industries. Duke Energy, the largest electric power holding company in the US with major surface coal mining operations, is financing GE American chestnut development to stock tree plantations harvested for its wood pellet mills.

Paradoxically, Duke Energy views GE American chestnuts as being "highly effective carbon-sequestering machines,"[53] and, together with the Forest Health Initiative, plans to repopulate the company's coal mountain top removal sites with the trees. Not mentioned in the marketing of this highly touted project is that US federal law requires coal-mining industries to restore abandoned mine lands by 2015.[54]

PAST IS PROLOGUE

When assessing the potential impacts of transgenic trees, we can learn from the scientific and empirical experience of GE crops. As an early adopter and the largest cultivator of GE crops, the US experience portends potential environmental and socioeconomic consequences of GE trees. Chapter Three enumerates how GE crops have increased use of chemicals, contaminated conventional and organic crops with transgenes, created "superweeds," and more. As with GE crops, transgenic trees will potentially exacerbate the problems they purport to solve, and create new, often unintended, consequences.

GE FREE ZONES

Over the past decade, a number of counties in states such as Washington, Oregon, California, and Hawaii have passed laws prohibiting the cultivation of GE seeds, including trees. These ordinances were passed into law by county councils and/or through direct ballot voter initiatives. The laws' purpose and goals are protective: to protect the local environment and economy from the adverse impacts of genetically engineered crops. GE crops cause environmental and economic harm in several ways, but chief among them is through transgenic contamination: the unintended, undesired presence of transgenic material in organic or traditional crops, as well as wild plants. Transgenic contamination happens through, among other means, wind- or insect-mediated cross-pollination, seed mixing, faulty or negligent containment, and weather events.

Ultimately, a true forest is a wonderful, magnificent wild of the known and unknown that cannot be cultivated and cannot be replaced. To lose these ancient sanctuaries that formed over millions of years is to lose a fundamental life source.

Transgenic contamination is a harm that has both an economic and environmental component. Contamination can also be irreparable, because once it occurs, it becomes difficult or impossible to contain. Unlike chemical pollution, transgenic contamination can propagate itself over space and time via gene flow. And the risk of contamination itself creates costly burdens for organic and conventional farmers and businesses, such as the need for DNA testing or crop buffer zones. Additionally, escape of transgenes into related wild plant populations is, in most cases, irreparable.

Unfortunately, the U.S. Department of Agriculture has refused to regulate the harms of GE crops such as GE contamination, leaving the burden on traditional farmers and their communities to try and protect themselves. As a result, GE-free zones have and continue to proliferate. They are important seed sanctuaries for the future of our food and our forests.

The contamination risks of GE trees are naturally even greater than that of GE crops, given their size and duration. Potential economic risk to U.S. agriculture are similar for fruiting trees. And for forest trees, the risks of contamination of the wild is much greater than with plants.

Accordingly, should GE trees ever become a commercial reality, growing restrictions are a necessity. The current GE-free zones cover all GE seeds, including trees, and any future ordinances would likely similarly include a prohibition on any GE tree cultivation, in addition to crops.

POLICY RECOMMENDATIONS FOR A SUSTAINABLE FOREST FUTURE

Significant uncertainties and a wide range of ecological impacts of GE trees require diligent, immediate engagement of civil society, governments, the media, and the general public. Current laws and regulatory frameworks are outdated and woefully inadequate in regard to genetic engineering writ large. A predominant theme of this report is to encourage new legislation that emphasizes a precautionary regulatory framework for GE organism regulation and GE tree regulation specifically. A model law could draw on the approach of the EU, which has more stringent and long-term analyses of potential effects of this life-altering technology. Strategies to address national and international policies and arenas impacting biotechnology, particularly GE trees, are also discussed.

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Clearly, as demand for energy and wood-based products continues to expand, societies must craft solutions that revitalize and maintain the integrity of forests and wild creatures while also ensuring equitable distribution of essential needs for all communities. There are many approaches and paths that can be pursued—conservation; traditional plant and tree breeding; and reduction of energy, consumer goods, and paper product consumption; to name only a few measures. Solutions must be smart and also systemic, perhaps requiring a radical review of assumptions. Developing holistic assessments is essential.

This report suggests that GE trees and plantations are not a visionary, sustainable way forward, and instead will lead to myriad, widespread harm to nature and societies.

ENDNOTES

[1] USDA. 2012. "2011 Hawaii Papaya Utilization and Price Down."

National Agricultural Statistics Service. http://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Fruits_and_Nuts/annpapFF.pdf.

[2] FAO Forestry Department. 2004. "Preliminary review of biotechnology in forestry, including genetic modification." United Nations, December.

ftp://ftp.fao.org/docrep/fao/008/ae574e/ae574e00.pdf.

[3] Ibid.

[4] Mendoza EMT, Lauren AC, & Botella JR. 2008. "Recent advances in the development of transgenic papaya technology." *Biotechnology Annual Review* 14: 423 – 462. http://fbae.org/2009/FBAE/website/images/PDF%20files/Imporatant%20Publication/Evelyn%20Mae%20Tecson%20Mendoza%20et%20al%2008-%20BAR14.pdf.

[5] USDA Foreign Agriculture Service. 2013. "Hong Kong Agricultural Biotechnology Annual Report 2013." GAIN Report HK1327, June 11. http://www.usfoods-hongkong.net/res/mns/00314/HK1327.pdf.

[6] Harfouche A, Meilan R, & Altman A. 2011. "Tree genetic engineering and applications to sustainable forestry and biomass production." *Trends in Biotechnology* 29 (1): 9–17.

[7] GMO-Safety. 2012. "Deliberate Release of Genetically Modified Trees: An Abundance of Poplars - Basic Info." http://www.gmo-safety.eu/basic-info/311.abundance-poplars.html.

[8] USAID. "Forestry." http://transition.usaid.gov/our_work/environment/forestry/index.html.

[9] FAO. 2012. "Roles of forests in climate change." June 15. http://www.fao.org/forestry/climatechange/53459/en/.

[10] Hayden, L. 2011. "Climate Change: Success Hinges on Including Forests and Indigenous Peoples." The Nature Conservancy, September 28. http://www.nature.org/ourinitiatives/urgentissues/global-warming-climate-change/explore/success-hinges-on-including-forests-and-indigenous-people.xml.

[11] The Nature Conservancy. 2011. "Facts About Rainforests." October 6. http://www.nature.org/ourinitiatives/urgentissues/rainforests/rainforests-facts.xml.

[12] UN Water. "Statistics, Graphs & Maps: Water Resources." http://www.unwater.org/statistics_res.html#sthash.6h51UTUZ.dpuf.

[13] USAID. "Conserving Biodiversity and Forests." http://www.usaid.gov/what-we-do/environment-and-global-climate-change/conserving-biodiversity-and-forests.

[14] FAO. 2011. "Forests for Improved Nutrition and Food Security." http://www.fao.org/docrep/014/i2011e/i2011e00.pdf.

[15] Sene, EH. 2000. "Forests and food security in Africa: the place of forestry in FAO's Special Programme for Food Security." Food and Agriculture Organization, April. http://www.fao.org/docrep/x7273e/x7273e03.htm.

[16] Chivian E & Bernstein A. 2008. *Sustaining life: how human health depends on biodiversity*. New York: Oxford University Press.

[17] Newman DJ & Cragg GM. 2007. "Natural products as sources of new drugs over the last 25 years." *Journal of Natural Products*. 70(3): 461-77. http://www.chem.uwec.edu/Chem491_W01/Chem491-Medicinal%20Chem%202008/NatrualProductdrugreview25yrs.pdf.

[18] World Wildlife Federation. 2010. "Measure Future Success: The Economy and Biodiversity." May. http://www.un-ngls.org/mdgconsultation/upload/1273251199_195.65.220.98_Biodiversity%20cross%20sectoral%20integration.pdf.

[19] The Rainforest Foundation. "Rainforest Facts and Figures." http://www.rainforestfoundationuk.org/Rainforest_facts.

[20] Wolfe, LM. 1979. "John of the Mountains: The unpublished journals of John Muir." 432-33.

[21] People and Planet. "Forests: the earth's lungs." http://www.peopleandplanet.net/?lid=27109&topic=44&section=32.

[22] Ibid.

[23] Easterbrook, G. 2005. "'Collapse': How the World Ends." *New York Times*, January 30.

http://www.nytimes.com/2005/01/30/books/review/30EASTERB.html?pagewanted=print&position.

[24] International Union for Conservation of Nature. "Forest changes 1990-2000, quantity and quality." http://www.iucn.org/about/work/programmes/forest/fp_resources/fp_resources_forest_changes.cfm.

[25] Leopold, A. 1949. *A Sand County Almanac and Sketches Here and There*. Oxford University Press, New York.

[26] People and Planet. "Forests: the earth's lungs." http://www.peopleandplanet.net/?lid=27109&topic=44&section=32.

[27] The Economist. 2012. "Kings of the carnivores." *The Economist*, April 30. http://www.economist.com/blogs/graphicdetail/2012/04/daily-chart-17; In 2011, North America and Europe used 1290.1 thousand barrels per day, while the rest of the world used only 529.7 thousand barrels per day. US Energy Information Administration. "International Energy Statistics." http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=79&pid=79&aid=2.

[28] Kaskey, J. 2009. "International Paper Treads Monsanto's Path to 'Frankenforests.'" *Bloomberg* August 28. http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aEHNB_XJRWGU

[29] Adams, EE. 2012. "World Forest Area Still on the Decline." *Earth Policy Institute*, August 31. http://www.earth-policy.org/indicators/C56/.

[30] Bloc, B. 2009. "Global Palm Oil Demand Fueling Deforestion." Worldwatch Institute. http://www.worldwatch.org/node/6059.

[31] Stuart, H. 2013. "Indonesia Fires, Singapore Smog Likely Caused By Palm Oil Companies." *Huffington Post*, June 21. http://www.huffingtonpost.com/2013/06/21/indonesiafires_n_3479727.html.

[32] Petermann A & Langelle O. 2006. "Plantations, GM trees and indigenous rights." *Seedling* July. http://www.grain.org/article/entries/565-plantations-gm-trees-and-indigenous-rights.

[33] Big Lands Brazil. "Eucalyptus." Accessed June 15, 2013. http://biglandsbrazil.com/eucalyptus/.

[34] USDA. 2013. "Feed Grain Database." Last updated April 16, 2013. http://www.ers.usda.gov/media/866543/cornusetable.html.

[35] USDA Economic Research Service. "Corn: Background." Last updated July 17, 2013. http://www.ers.usda.gov/topics/crops/corn/background.aspx#.Ug5AOdKG1iN.

[36] McDonald, K. 2013. "Is Anyone Paying Attention? We've Lost 9.7 Million Acres of CRP Land in Five Years." Big Picture Agriculture, March 7. http://www.bigpictureagriculture.com/2013/03/weve-lost-9-7-million-acres-of-crp-land-in-five-years-334.html.

[37] EPA. "Renewable Fuel Standard (RFS)." Last updated August 6, 2013. http://www.epa.gov/otaq/fuels/renewablefuels/index.htm

[38] Voelker, SL et al. 2011. "Reduced wood stiffness and strength, and altered stem form, in young antisense 4CL transgenic poplars with reduced lignin contents." *New Phytologist* 189: 1096-1109. http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2010.03572.x/full; Austin AT & Ballaré CL. 2010. "Dual role of lignin in plant litter decomposition in terrestrial ecosystems." *Proceedings of the National Academy of Sciences of the United States* 107: 4618-4622. http://www.pnas.org/content/107/10/4618.full.

[39] Hancock, JE et al. 2006. "Plant growth, biomass partitioning and soil carbon formation in response to altered lignin biosynthesis in Populus tremuloides." *New Phytologist* 173 (4): 732-742. http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2006.01965.x/full.

[40] NRDC. 2013. "Burning Trees for Electricity Will Accelerate Climate Change and Destroy Southern Forests." Natural Resources Defense Council, April. http://www.nrdc.org/energy/forestsnotfuel/files/burning-trees-southern-forests-FS.pdf.

[41] Faulkner, W. 2013. "Demand for wood pellets in Europe a boon in southeast US." *Star News Online*, April 6. http://www.starnewsonline.com/article/20130406/ARTICLES/130409747?template=printpicart.

[42] Smolker, R. 2013. "Genetically Engineered Trees and Glowing Synthetic Plants? No Thanks." *Huffington Post*, May 24. http://www.huffingtonpost.com/rachel-smolker/no-thanks_b_3326165.html.

[43] NRDC. 2013. "Burning Trees for Electricity Will Accelerate Climate Change and Destroy Southern Forests." Natural Resources Defense Council, April. http://www.nrdc.org/energy/forestsnotfuel/files/burning-trees-southern-forests-FS.pdf.

[44] Smolker, R. 2013. "Genetically Engineered Trees and Glowing Synthetic Plants? No Thanks." *Huffington Post*, May 24. http://www.huffingtonpost.com/rachel-smolker/no-thanks_b_3326165.html.

[45] NRDC. 2013. "Burning Trees for Electricity Will Accelerate Climate Change and Destroy Southern Forests." Natural Resources Defense Council, April. http://www.nrdc.org/energy/forestsnotfuel/files/burning-trees-southern-forests-FS.pdf.

[46] The Oakland Institute. 2011. "Understanding Land Investment Deals in Africa." December. http://www.oaklandinstitute.org/sites/oaklandinstitute.org/files/OI_brief_false_climate_change_solutions_0.pdf.

[47] Wise, T. "US corn ethanol fuels food crisis in developing countries." *TripleCrisis*, May 28. http://triplecrisis.com/us-corn-ethanol-fuels-food-crisis-in-developing-countries/.

[48] Ibid.

[49] FAO et al. 2011. "Price Volatility in Food and Agricultural Markets: Policy Responses." 27.

http://www.oecd.org/tad/agricultural-trade/48152638.pdf.

[50] Kaskey, J. 2009. "International Paper Treads Monsanto's Path to 'Frankenforests.'" *Bloomberg*, August 28. http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aEHNB_XJRWGU.

[51] Steinbrecher RA & Lorch A. 2008. "Genetically Engineered Trees & Risk Assessment: An overview of risk assessment and risk management issues." Federation of German Scientists. http://www.econexus.info/sites/econexus/files/GE-Tree_FGS_2008.pdf.

[52] Williams, CG. 2010. "Long-distance pine pollen still germinates after meso-scale dispersal." *American Journal of Botany* 97(5): 846-855. http://www.amjbot.org/content/97/5/846.full.pdf+html.

[53] Duke Energy, "Environmental Footprint: Bringing back the American chestnut." http://sustainabilityreport.duke-energy.com/environmental-footprint/bringing-back-the-american-chestnut/.

[54] UN-Business Guidelines. "Restoration of the American Chestnut to Central Appalachian Forests." http://business.un.org/en/commitments/1012.

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