USDA Forest Service
Research and Development

Biotechnology in Forestry - Biofuels

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with a little help from my friends:

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The Opportunities for Biotech in Biofuels from Trees

Feedstock

- Forest Residues
- Hazardous Fuel Treatments
- Short Rotation Woody Crops
- Wood Waste
- Conventional Forestry
- Mill Wastes & Residues

Conversion

- Manufacturing
- Co-firing
- Combustion
- Gasification
- Hydrolysis
- Digestion
- Pyrolysis
- Extraction
- Separation

Uses

Fuels:
- Ethanol
- Renewable Diesel
- Hydrogen

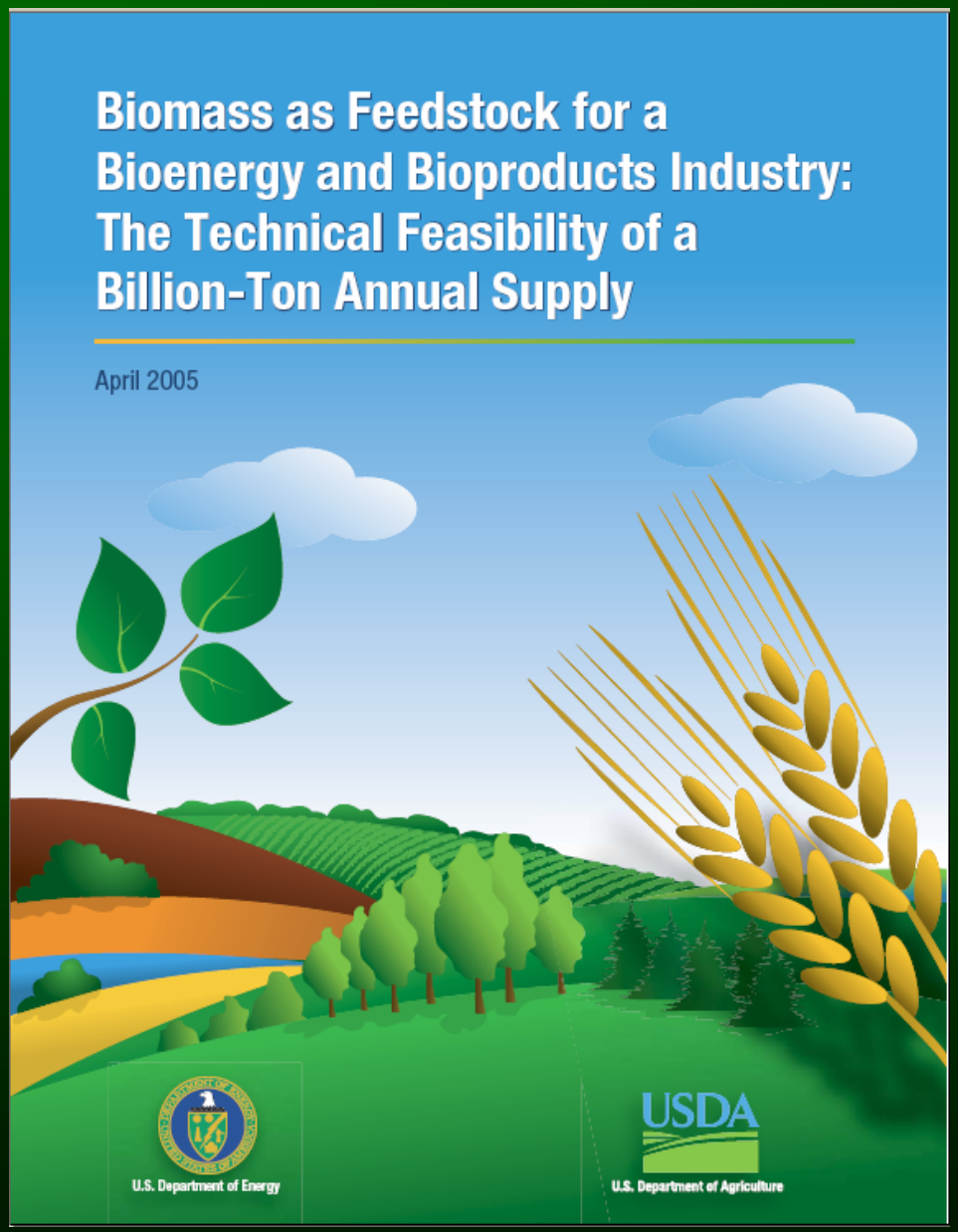
Electricity and Heat

Biobased Products
- Composites
- Specialty Products
- New Products
- Chemicals
- Traditional Products


Why trees?

Trees as Biofuels Feedstock

- "Agriculture" cannot meet all our biofuel needs
- Forestry is in addition to agriculture.



DOE & USDA estimates of potential feedstocks

Forest residues and thinnings for fuel reduction are estimated to contribute 368 million tons per year

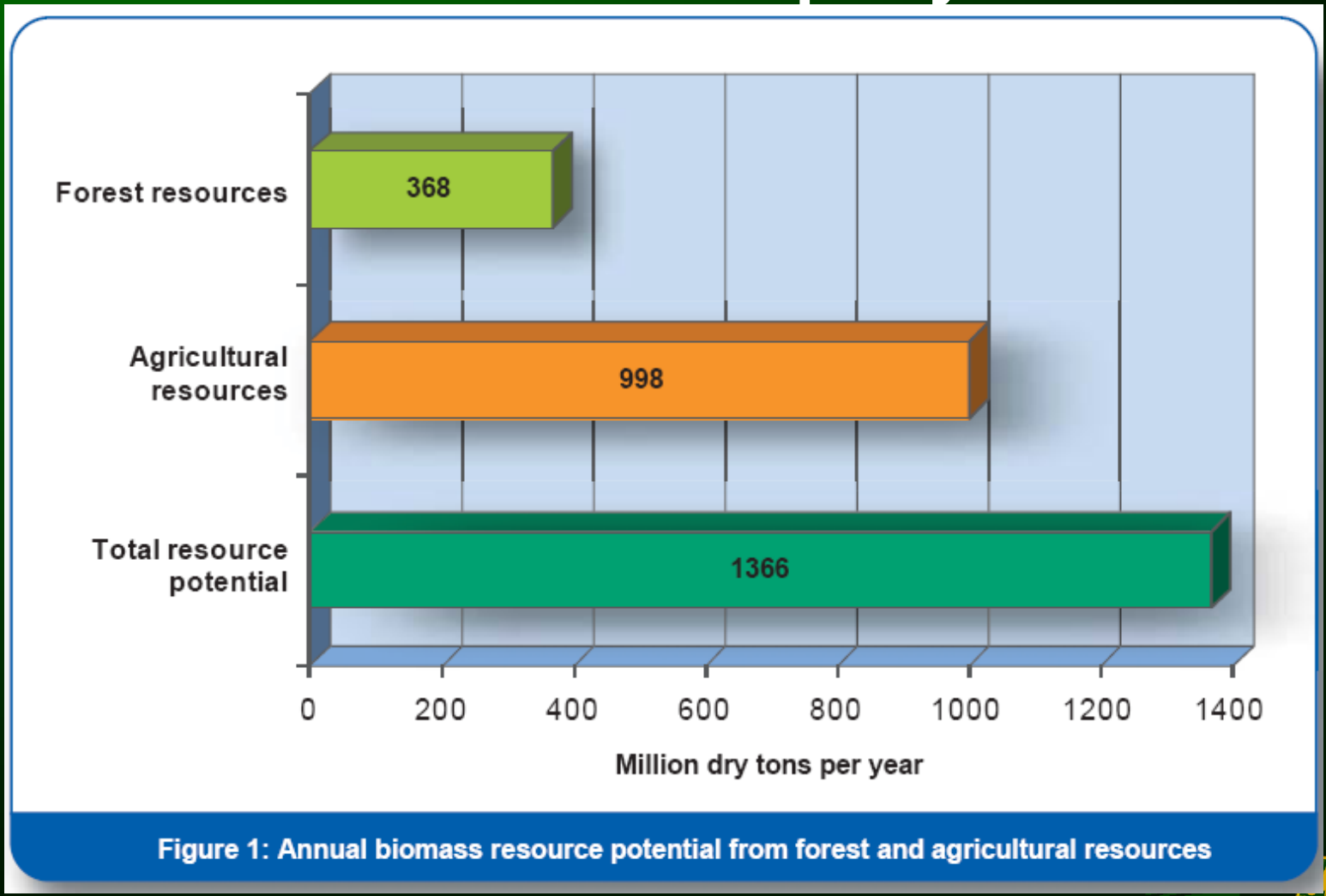


Figure 1: Annual biomass resource potential from forest and agricultural resources

http://www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf

An additional 100 to 200 million dry tons from short rotation plantations

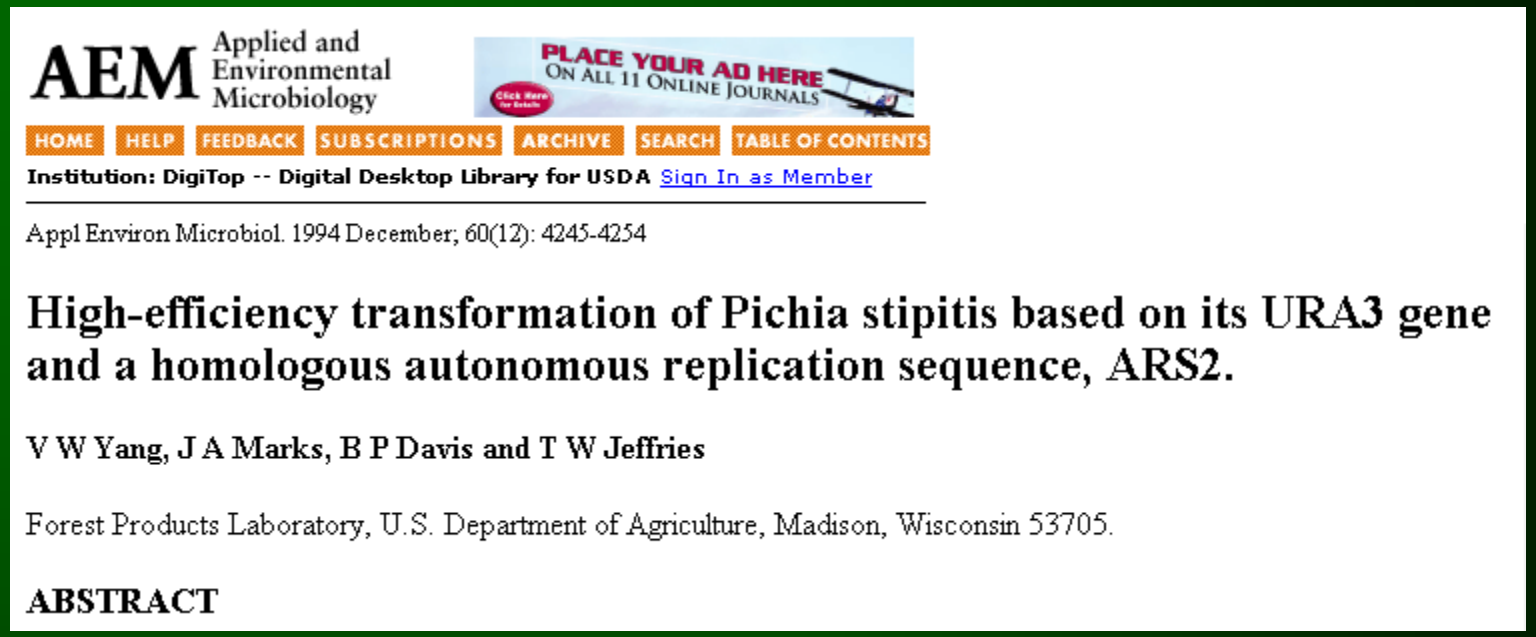

Photo: Jake Eaton, Potlatch Corporation

Trees as Biofuels Feedstock

- In addition to agricultural feed stocks
- No direct competition with food production.
- Can be grown on marginal lands.
- Provides secondary benefits.
  - Wildlife, soil, water quality.
- Perennial growth gives excellent yields.
- Lower intensity than agriculture mgmt.
  - Fewer mechanical treatments
  - Little or no fertilizer
  - Less herbicide
- Multiple Product Streams
- Optional harvest times, ease of storage and transport.

Existing Forest Industry and Infrastructure

Photos provided by Jake Eaton, Potlatch Corporation



AEM Applied and Environmental Microbiology

Appl Environ Microbiol. 1994 December; 60(12): 4245-4254

High-efficiency transformation of Pichia stipitis based on its URA3 gene and a homologous autonomous replication sequence, ARS2.

V W Yang, J A Marks, B P Davis and T W Jeffries

Forest Products Laboratory, U.S. Department of Agriculture, Madison, Wisconsin 53705.

ABSTRACT

- **Developed *Pichia stipitis*, a native xylose fermentor**
  - **Works on both 5 carbon and 6 carbon sugars**
  - **Works on polysaccharides therefore don't have to break down into monomers**
  - **Pay less for enzymes**
  - **Works on all lignocellulosic materials such as corn stover, plant material and wood**

Biotech in Forestry

Growing better trees

Only 2 GE trees deregulated in the US to date

Photo courtesy of Dennis Gonsalves

Rainbow and SunUp papaya, resistant to papaya ringspot virus

HoneySweet Plum, resistant to plum pox virus

Limited commercial plantations of GE insect resistant poplars in China

GE poplars in field trials

Growth rate

Phytoremediation

Other species in field trials

Cold hardy eucalyptus

Modified pines

I don't expect to see any GE forest trees released any time soon

GMO issues

- Intellectual property / patents
- Marketing
- Regulation

The issues: GMO patents

- Fragmented, diverse estate and technology with many patented pieces requires negotiation of many licenses – often costly to figure out and costly or impossible to acquire
- You can spend years studying a gene/trait and not be able to use it

The issues: GMO marketing

- The predominant “green” certification system for forestry—FSC (Forest Stewardship Council) has a complete ban on planting of GMOs
- Many companies subscribe to FSC to expand markets (green building codes), improve prices, avoid negative publicity
- Thus cannot help in field studies, disincentive to invest in research

SCIENCE : DISCOVERIES RSS

Opponents Take Swing at GMO Grass

Associated Press 04.09.04 | 4:15 PM

GERVAIS, Oregon -- In an unmarked site on the edge of this community of berry farmers, Bob Harriman puts one foot on the world's most controversial grass. It's a blanket of brilliant green -- as thin as a piece of paper and as uniform as cellophane. If it sounds unnatural, that's because it is.

The turf is a genetically modified version of the creeping bentgrass popular on golf course greens and fairways, and it is being tested here by Scotts Co., which hopes its creation will be resistant to a common weed-killing chemical.

Scotts keeps the test site incognito because environmentalists are trying to ban the bioengineered grass -- and radical groups have gone so far as to sabotage test plots elsewhere.

But while environmentalists have long opposed bioengineered crops of any kind, this silky turf has other powerful voices urging caution: the Bureau of Land Management and the U.S. Forest Service.

"Our concern is that if it was to escape onto public land, we wouldn't know how to control it," says Gina Ramos, senior weed specialist for the Bureau of Land Management.

"The patent holders 'act like God - they have way too much power over nature', said Mike, a farmer sued for unwittingly growing GE papaya without an official agreement."

The Scent of GE Papaya

SOURCE: www.greenpeace.org
DATE: July 3, 2003, Thailand/Bangkok
archive: www.greenpeace.org/international_en/features/details?item%5fid=290584

Papaya is the latest target of the genetic engineering (GE) industry.
The Thai government is seeking to introduce the crop to Thailand despite the fact that GE papaya has already been a failure in Hawaii, the only place in the world where GE papaya is grown commercially. Behind this push are the GE industry's big players, hoping to expand corporate control of the food chain into Asia.

Papaya is a staple food in some parts of South-East Asia. It is a vital part of the Thai kitchen and features in famous local Thai dishes such as Som Tam, a spicy papaya salad.

Why play with nature's green papaya?
Papaya grown on monoculture plantations, as is the practice on the island of Hawaii, the United States' 50th State, suffer from ringspot virus. Plant diseases and pests flourish in these unnatural, intensive plantations.

Thai farmers traditionally combat ringspot by growing papaya with other crops The insects that transmit the virus are controlled with environmentally friendly techniques. GE papaya is, therefore, an unnecessary solution to a problem that can be controlled naturally.

Rather than advocating a change in farming practices to deal with the virus, scientists decided that playing with nature was the better option.

A science based on luck
They decided to make the plant resistant to the virus by adding a gene from the virus to the papaya cell, along with other virus and antibiotic resistance genes. In tampering with evolution, you might expect that at least the scientists know what they are doing. But apparently they have no idea how the virus gene actual makes the papaya resistant to the virus. Not only this, but the scientists have also said that they could not control which type of papaya to make into GE papaya because it's a random process, based on luck.

Lucky for whom?

Plus the usual bad press we all have

The issues: GMO regulations

- All field research regulated by USDA
- Extra caution for forest trees since they:
  - Remain in the ecosystem a long time
  - Cross with wild relatives
  - Genes can't be removed from the ecosystem
  - Hard to research long-term consequences

Forestry strategy: Start with the "good guys"

American chestnut

January 10, 2008

Fighting pollution the poplar way: Trees to clean up Indiana site

WEST LAFAYETTE, Ind. - Purdue University researchers are collaborating with Chrysler LLC in a project to use poplar trees to eliminate pollutants from a contaminated site in north-central Indiana.

Richard Meilan inspects a row of hybrid poplars

The researchers plan to plant transgenic poplars at the site, a former oil storage facility near Kokomo, Ind., this

Beginning to use molecular breeding tools

RESEARCH ARTICLES

The Genome of Black Cottonwood, *Populus trichocarpa* (Torr. & Gray)

G. A. Tuskan,[1,3*] S. DiFazio,[1,4†] S. Jansson,[5†] J. Bohlmann,[6†] I. Grigoriev,[9†] U. Hellsten,[9†] N. Putnam,[9†] S. Ralph,[6†] S. Rombauts,[10†] A. Salamov,[9†] J. Schein,[11†] L. Sterck,[10†] A. Aerts,[9]

Sequencing and Assembly

A single female genotype, "Nisqually 1," was selected and used in a whole-genome shotgun

[1]Environmental Sciences Division, [2]Life Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA. [3]Plant Sciences Department, University of Tennessee, TN 37996, USA. [4]Department of Biology, West Virginia University, Morgantown, WV 26506, USA. [5]Umeå Plant Science Centre, Department of Plant Physiology, Umeå University, SE-901 87, Umeå, Sweden.

news

- JGI in the News
- Press Releases
- Scientific Publications
- The Primer

Press Release: June 8, 2007

DOE Joint Genome Institute Announces 2008 Genome Sequencing Targets

Eucalyptus, Foxtail Millet, Red Algae, and Novel Microbial Communities Added to Growing Bioenergy and Carbon Cycling Portfolio

Summary

- Biotech happening in the fermenting process
- Technology is available for altering trees for improved biofuel quantities and qualities
- Many hurdles to overcome before GE trees become operational
- Molecular markers will *soon* be used in our applied breeding programs.