Genetically engineered trees

Rationale, Constraints, and Progress

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Plan

- Types of tree/forest systems
- General benefits from GE methods
- Constraints to use
- Examples of progress

Types of forests

Four major types of tree-dominated communities

- Food: Orchards
  - High genetic control – often one or very few varieties (=clones) – Intensive agronomy
- Wood, pulp, energy: Short rotation, fast growing: agricultural
  - Often limited number of varieties (dozens), also agronomic management, 5-10 year cycle
- Wood, pulp: Planted but long rotation times
  - Very high genetic diversity, many decadal cycle, little management, ecological services
- Wild trees – Many genotypes, many species, many ecological services and social values

Plantations and wood production

Genetic improvement a large contributor to yields

Plantation forests occupy 5% of all forests and deliver 35% of industrial roundwood.
More yield = less potential impact on wild/conservation forests.

"SUSTAINABLE INTENSIFICATION" -- "LAND SPARING VS. LAND SHARING"

FAO:
- higher wood yield / ha
- improved wood quality

Conventional breeding can have powerful effects

One generation of breeding Monterey pine (from coastal California) in New Zealand made striking changes in growth & form

Poplar plantations an example of ag-like forestry

Eucalypts in Brazil another example of ag-like forestry

Wild forest tree protection or restoration the other extreme –

American Chestnut restoration

GMO methods of special value for trees due to breeding constraints

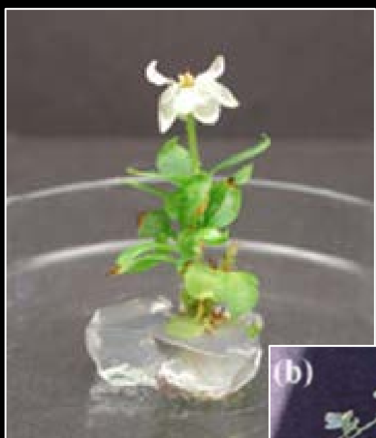
- Difficulty to inbreed
- Long breeding cycle

- Hard to introgress desired genes from other species or genotypes
- Hard to fix rare, desired (e.g., loss of function) mutations
- Hard to identify and use dominant, major genes
- Asexually propagated varieties of high value

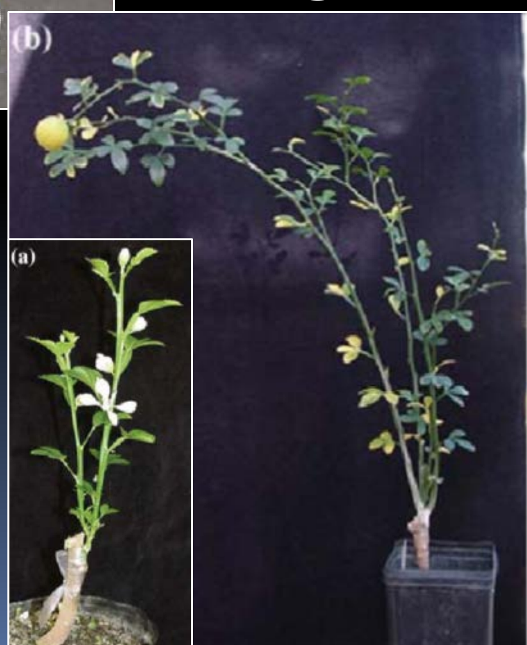
- *<u>Radical advance</u>? GE a powerful means to access "Mendelian genes" and breeding methods?*

Overexpression of endogenous flowering genes induce early flowering in several tree species

Apple



Orange



Plum

Poplar

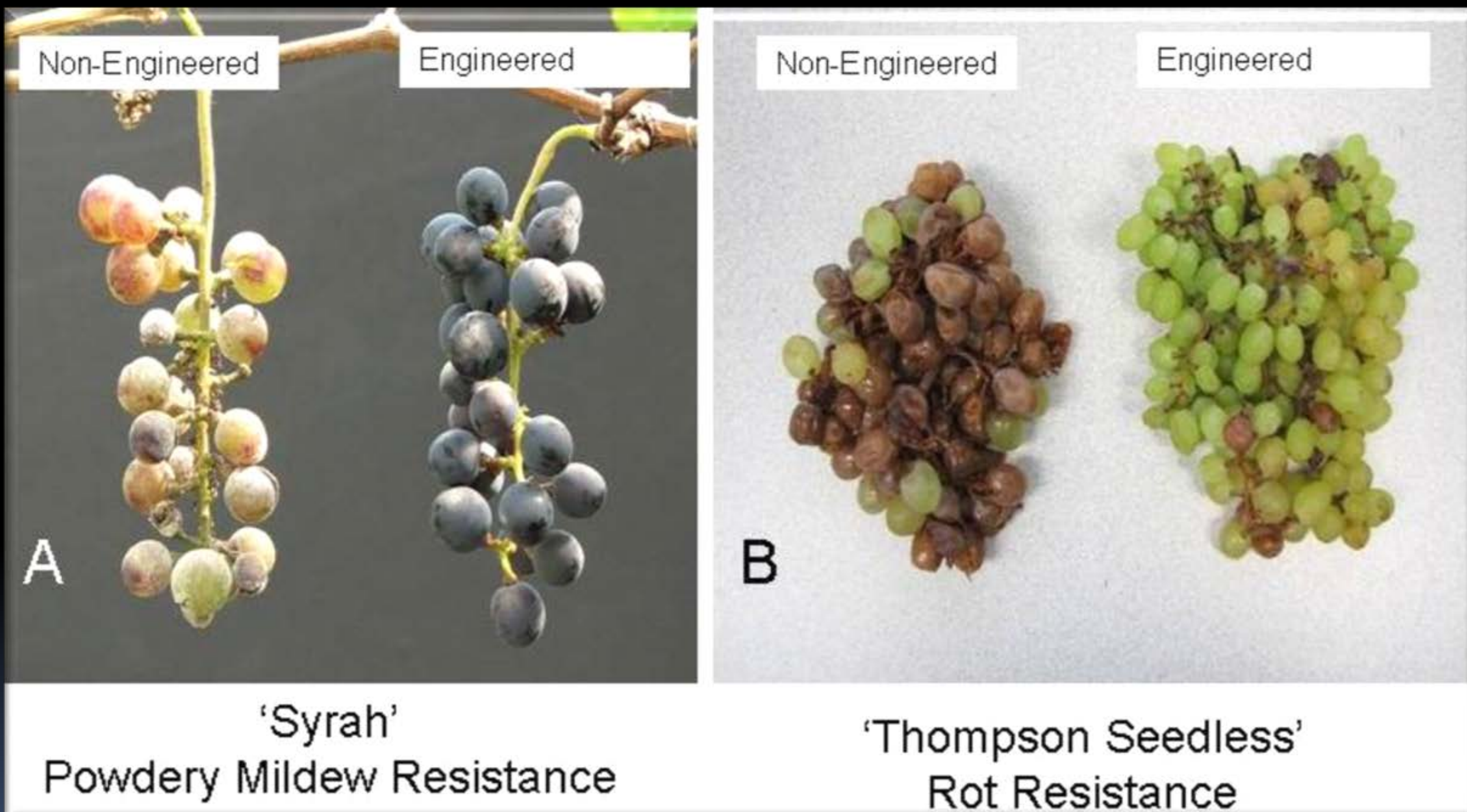
Dominant gene action

Lignin-modification of elite variety in France by RNAi

(Courtesy of G. Pilate, INRA)

Native grape genes for disease resistance in elite varieties

***Grape* VvAlb gene** **Grape VvTL-1 gene**



Courtesy of Denis Gray, UF/IFAS Mid-Florida Research & Education Center

http://mrec.ifas.ufl.edu/grapes/genetics

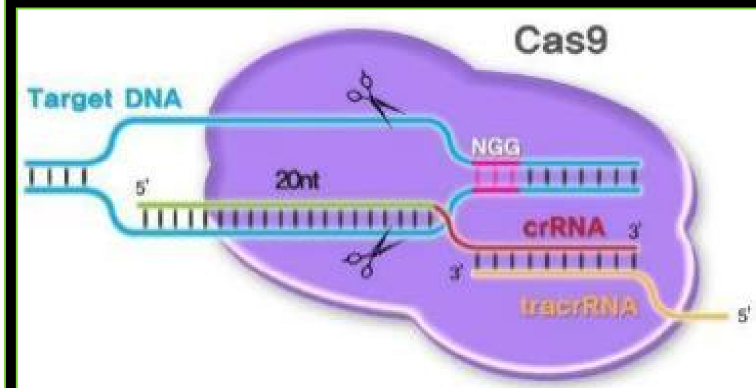
Coming: Gene editing technology for diverse traits

Science magazine names CRISPR 'Breakthrough of the Year'

By Robert Sanders | DECEMBER 18, 2015

In its year-end issue, the journal *Science* chose the CRISPR genome-editing technology invented at UC Berkeley 2015's Breakthrough of the Year.

A runner-up in 2012 and 2013, the technology now revolutionizing genetic research and gene therapy "broke away from the pack, revealing its true power in a series of spectacular achievements," wrote *Science* correspondent John Travis in the Dec. 18 issue. These included "the creation of a long-sought 'gene drive' that



- Precise control over gene insertion location
- Ability to modify native genes efficiently

Constraints are formidable

Biological constraints - 1

- Trees often rich in diversity due to early state of domestication
  - GE often not needed
  - Molecular markers, genomic selection generally a more potent and rapid molecular approach
- Genetic transformation methods often very difficult and highly genotype-specific
  - Very limited advances outside of a few intensively studied species – often mostly proprietary
- Wood properties (lumber, pulp, energy) often not precisely controlled
  - Most plantations are not clonal: Thus variable
  - Increased precision of GE not important

Biological constraints - 2

- Tree genes controlling traits poorly known, and often polygenic
  - One or few gene traits rare in most tree species
  - Association genomic studies rectifying this to some degree
- Long rotations: Economics of intensive genetics, asexual propagation, often marginal
  - GE science, technology, patents, regulations, market restrictions add considerably more cost and risk
- Thus, GE mostly for those cases where…
  - Extant genetic variation is inadequate or missing
  - Where an entirely new trait or property is desired
  - Short rotations to minimize economic risks
  - Can transform and get regulatory approval for many genotypes

Event-based regulation a serious problem for many trees

Ending event-based regulation of GMO crops

To the Editor:
Getting regulation of agricultural biotechnologies right is no simple task. Stringent regulations for genetically modified organisms (GMOs) in the European Union (EU: Brussels) have nearly stifled the use of biotech crops on farms or in derived foods there, and in the United States the diversified 'Coordinated Framework' has produced a strange patchwork of rules, exceptions and lengthy delays. As the Editorial in the December issue highlights[1], the US Executive Branch has launched a process to reform its regulatory structure, calling for an integrated system that recognizes and balances safety, environment, innovation and economic growth[2]. On the heels of the release of a White House memo, the US House of Representatives passed the Safe and Accurate Food Labeling Act of 2015, which is on its way to the Senate for consideration. Contrary to current regulations, this legislation would explicitly preempt state-by-state labeling and require the US Food and Drug Administration (FDA) to conduct a safety review for all GMOs entering commerce[3]. This recent activity by both the executive and legislative branches provides a welcome opportunity to take a fresh look at

Biological constraints - 3

- Gene flow often extensive
- Many factors contribute or exacerbate this
  - Large size
  - Wind-pollination and seed dispersal
  - Insect or animal pollination and seed dispersal
  - Weak domestication: Progeny can establish and compete
  - Sexually compatible wild or feral relatives
    - Is it ethically OK for a GE tree to mate with a wild tree?
    - Do regulations allow it?
    - How to predict the outcome?
- Highly productive and stress-tolerant trees often exotics and can be highly invasive

In poplar, paternity analysis showed that ~50% of pollen comes from >1 km to >10 km away from mother trees

Long distance but also extensive dilution a short distance from source as a consequence

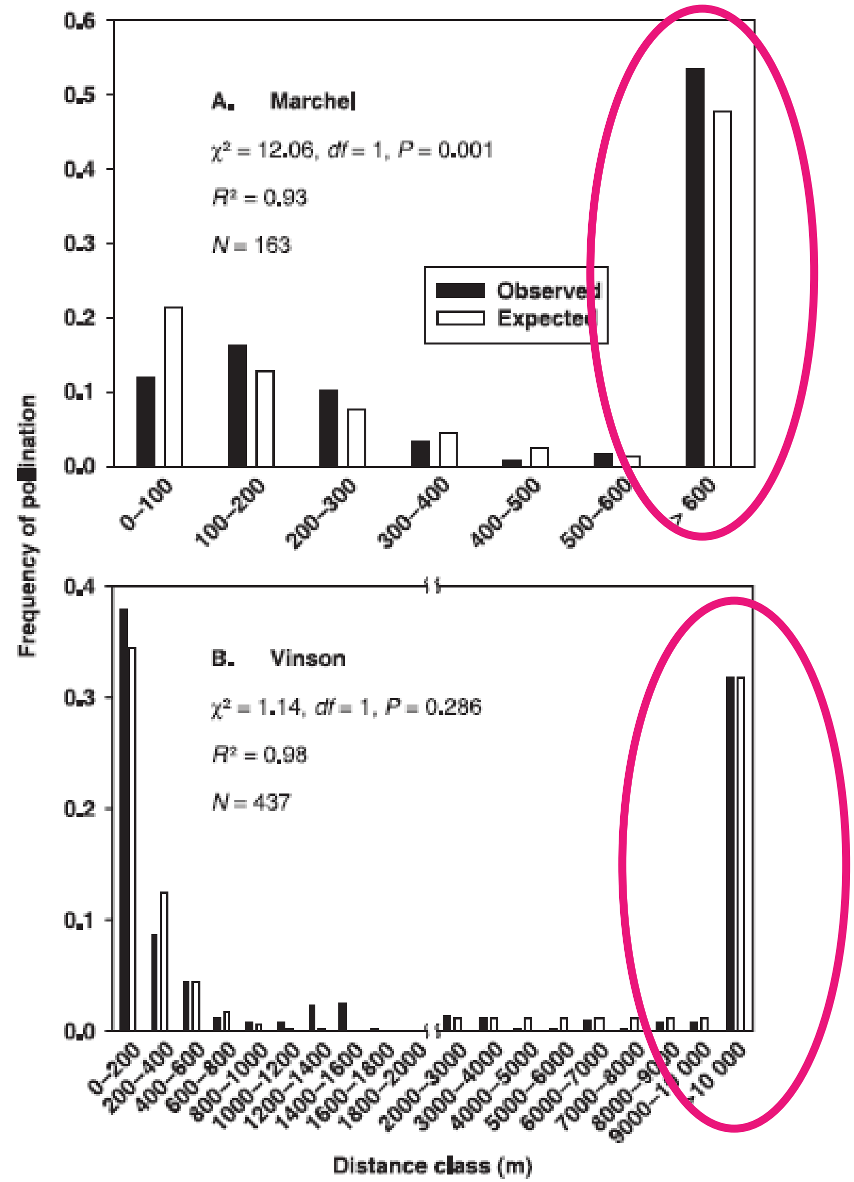


Fig. 5 Observed vs. expected pollination frequencies based on predictions from a mixed probability density function, whose parameters were estimated based on paternity analysis data.

Cottonwood seeds can also fly and float significant distances

Thus hard to completely isolate GE poplars from wild or feral populations, if that is required, without robust male and female gene flow control technology – even at research phase

Each species different in this respect, some better and some worse

The biological constraints of trees collide with annual crop-oriented regulatory systems and markets

A serious regulatory problem under USA system

Articles

Far-reaching Deleterious Impacts of Regulations on Research and Environmental Studies of Recombinant DNA-modified Perennial Biofuel Crops in the United States

STEVEN H. STRAUSS, DREW L. KERSHEN, JOE H. BOUTON, THOMAS P. REDICK, HUIMIN TAN, AND ROGER A. SEDJO

October 2010 / Vol. 60 No. 9 • BioScience 729

An international regulatory issue given Cartagena Protocol and trade

Strangled at birth? Forest biotech and the Convention on Biological Diversity

Steven H Strauss, Huimin Tan, Wout Boerjan & Roger Sedjo

Against the Cartagena Protocol and widespread scientific support for a case-by-case approach to regulation, the Convention on Biological Diversity has become a platform for imposing broad restrictions on research and development of all types of transgenic trees.

The Convention on Biological Diversity (CBD) has become a major focus of activist groups that wish to ban field research and commercial development of all types of genetically modified (GM) trees. Recent efforts to influence CBD recommendations by such groups has led to the adoption of recommendations for increased regulatory stringency that are inconsistent with the views of most scientists and most of the major environmental organizations. We suggest that the increasingly stringent recommendations adopted by the CBD in recent years are impeding, and in many places may foreclose, much of the field research needed to develop useful and safe applications of

A convention co-opted

Negotiated under the United Nations (UN) Environment Program, CBD was adopted in June 1992 and subsequently entered into force in December 1993. The CBD has been signed by 191 of the 192 members of the UN, making it one of the largest international treaties. The aim of the CBD is to promote the conservation and sustainable use of biodiversity, and the fair and equitable sharing of benefits from the use of genetic resources. Because transgenic organisms have the potential to affect biodiversity, special provisions of the CBD cover the use and trade in living modified organisms (LMOs, also known as genetically modified organisms; GMOs).

In 2000, the Cartagena Protocol on Biosafety
the CBD

Proposed regulatory solutions – tiered regulation, product vs. process

POLICY FORUM

GENETIC TECHNOLOGIES

Genomics, Genetic Engineering, and Domestication of Crops

Steven H. Strauss

Genomic sequencing projects are rapidly revealing the content and organization of crop genomes (*1*). By isolating a gene from its background and deliberately modifying its expression, genetic engineering allows the impacts of all genes on their biochemical networks and organismal phenotypes to be discerned, regardless of their level of natural polymorphism. This greatly increases the ability to determine gene function and, thus, to identify new options for crop domestication (*2*). The organismal functions of the large majority of genes in genomic databases are unknown.

portant to agricultural goals, but poorly represented in breeding populations because they are rare or deleterious to wild progeni-

huge numerical obstacle that is normally provided by extant wild and domesticated gene pools. Despite the great diversity of genes that can comprise GGTs, many of the modified traits are familiar, having a long history of domestication and consequent reduced fitness through artificial selection. Male sterility, seedless fruits, delayed spoilage, and dwarf stature are familiar examples.

GGTs that improve abiotic stress tolerance

Confinement level	Type 1 field trials (exploratory)	Type 2 field trials (precommercial)	Examples
High	Biological and physical confinement—detailed data		Highly toxic or allergenic pharmaceuticals and proteins
Medium	FSC, basic data	FSC, detailed data	Novel pest-management genes, low toxicity pharmaceuticals and proteins
Low: Stress tolerance	FSC, basic data	FSC, detailed data	Genomics-guided transgenes
Low: Domesticating	Petition for exemption?	FSC, basic data	

Categories of confinement and monitoring for small- and large-scale transgenic field trials. Biological confinement includes genetic mechanisms to preclude spread and/or reproduction. Physical confinement requires use of geographical isolation or physical barriers. FSC, farm-scale confinement; use of spatial isolation within and between farms and border crops, combined with ...oring. Detailed data include surveys of gene flow away from the site. Basic data ...hment of confinement mechanisms.

Proposed regulatory solutions – tiered regulation, product vs. process

PERSPECTIVE

nature biotechnology

Regulating transgenic crops sensibly: lessons from plant breeding, biotechnology and genomics

Kent J Bradford[1], Allen Van Deynze[1], Neal Gutterson[2], Wayne Parrott[3] & Steven H Strauss[4]

The costs of meeting regulatory requirements and market restrictions guided by regulatory criteria are substantial impediments to the commercialization of transgenic crops. Although a cautious approach may have been prudent initially, we argue that some regulatory requirements can now be modified to reduce costs and uncertainty without compromising safety. Long-accepted plant breeding methods for incorpo new diversity into crop varieties, experience from two deca

Regulatory costs also play a role in the growing disparity between the expanding global adoption of the large-market transgenic maize, soybean, cotton and canola crops[1] and the so-called 'small-market' or 'specialty' crops, for which field trials and commercial releases of transgenic food crops have all but stopped[3]. In 2003, fruits, vegetables, landscape plants and ornamental crops accounted for more than $50 billion in value in the United States, representing 47% of the total US farm

And just recently…yet again

Traces of the emerald ash borer on the trunk of a dead ash tree in Michigan, USA. This non-native invasive insect from Asia threatens to kill most North American ash trees.

BIOTECHNOLOGY

Genetically engineered trees: Paralysis from good intentions

Forest crises demand regulation and certification reform

By **Steven H. Strauss**[1*], **Adam Costanza**[2], **Armand Séguin**[3]

Intensive genetic modification is a long-standing practice in agriculture, and, for some species, in woody plant horticulture and forestry (*1*). Current regulatory systems for genetically engineered

recently initiated an update of the Coordinated Framework for the Regulation of Biotechnology (*2*), now is an opportune time to consider foundational changes.

Difficulties of conventional tree breeding make genetic engineering (GE) methods relatively more advantageous for forest trees than for annual crops (*3*). Obstacles

Although only a few forest tree species might be subject to GE in the foreseeable future, regulatory and market obstacles prevent most of these from even being subjects of translational laboratory research. There is also little commercial activity. Only two types of pest-resistant poplars are authorized for commercial use in small areas in China and two types of eucalypts, one approved in Brazil and another under lengthy review in the USA (*5*).

METHOD-FOCUSED AND MISGUIDED. Many high-level science reports state that the GE method is no more risky than conventional breeding, but regulations around the world essentially presume that GE is hazardous and requires strict containment

Forest stresses growing: No-analog scientific thinking should dominate today

PALEOECOLOGY PALEOECOLOGY PALEOECOLOGY

Novel climates, no-analog communities, and ecological surprises

John W Williams[1*] and Stephen T Jackson[2]

No-analog communities (communities that are compositionally unlike any found today) occurred frequently in the past and will develop in the greenhouse world of the future. The well documented no-analog plant communities of late-glacial North America are closely linked to "novel" climates also lacking modern analogs, characterized by high seasonality of temperature. In climate simulations for the Intergovernmental Panel on Climate Change A2 and B1 emission scenarios, novel climates arise by 2100 AD, primarily in tropical and subtropical regions. These future novel climates are warmer than any present climates globally, with spatially variable shifts in precipitation, and increase the risk of species reshuffling into future no-analog communities and other ecological surprises. Most ecological models are at least partially parameterized from modern observations and so may fail to accurately predict ecological responses to these novel climates. There is an urgent need to test the robustness of ecological models to climate conditions outside modern experience.

Front Ecol Environ 2007; 5(9): 475–482, doi:10.1890/070037

How do you study an ecosystem no ecologist has ever seen? This is a problem for both paleoecologists and

past or future, is heavily conditioned by our current observations and personal experience.

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Market barriers large

"Green" certification of forests create severe barriers to field research, markets

Plantation Certification & Genetic Engineering

FSC's Ban on Research Is Counterproductive

Steven H. Strauss, Malcolm M. Campbell, Simon N. Pryor, Peter Coventry, and Jeff Burley

ABSTRACT

Genetic engineering, also called genetic modification (GM), is the isolation, recombinant modification, and asexual transfer of genes. It has been banned in forest plantations certified by the Forest Stewardship Council (FSC) regardless of the source of genes, traits imparted, or whether for research or commercial use. We review the methods and goals of tree genetic engineering research and argue that FSC's ban on research is counterproductive because it makes it difficult for certified companies to participate in the field research needed to assess the value and biosafety of GM trees. Genetic modification could be important for translating new discoveries about tree genomes into improved growth, quality, sustainability, and pest resistance.

Keywords: biotechnology; entomology and pathology; ethics; genetics; silviculture

Genetic engineering, commonly called genetic modification (GM) in much of the world, is the use of recombinant DNA and asexual gene transfer methods to breed more productive or pest-resistant crops. It has been the subject of considerable controversy, with concerns raised from biological, socioeconomic, political, and ethical perspectives. Some of the issues are similar to those raised by the use of molecular biology and genetic engineering in medicine, which we see in the news headlines daily. However, genetic modification in agriculture and forestry raises environmental issues as well.

GM crops, mainly herbicide- and pest-resistant varieties of soybeans, maize, or cotton, have been vigorously adopted by farmers in North America because they are easy to manage and they improve yields, reduce costs, or reduce pesticide ecotoxicity (Carpenter and Gianessi 2001). However, the controversy, primarily embodied in regulatory barriers to trade of GM crops with Europe and Japan, has slowed their adoption considerably in recent years.

If GM trees are used in forestry in the near future, they are likely to occur primarily in intensively managed environments, such as urban forests or plantations. In urban forestry, genetic modification is expected to help trees adapt to the stresses and special demands of human-dominated systems. Examples would be trees that are more tolerant of heavy metals or other pollutants, resist urban pests or diseases, grow slower, or do not produce fruits when these create hazards in street environments (Brunner et al. 1998).

Plantations, although very different from natural forests in structure and function, are considered part of the spectrum of methods in sustainable forest management (Romm 1994). Plantations can relieve pressure on natural forests for exploitation and can be of great social value by supplying community and industrial wood needs and fueling economic development. The environmental role of plantations is recognized by the Forest Stewardship Council (FSC), an international body for certification of sustainably managed forests. FSC Principle 10 states that plantations should "complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests" (FSC 2001).

FSC has certified some of the most intensively managed plantations in the world, including poplar plantations and the intensive pine and eucalypt plantations of the Southern Hemisphere. Although many environmental mitigations are built into these certified plantation systems, within the areas dedicated to wood production they function as tree farms. Such intensive plantation systems often use highly bred genotypes, possibly including exotic species, hybrids, and clones, as well as many other forms of intensive silvicultural management. It is in the context of these biointensive systems that the additional expense of GM trees is likely to be worthwhile.

However, FSC currently prohibits all uses of GM trees, and is the only certification system to have done so

Forest Stewardship Council

"...genetically modified trees are prohibited..."

It has gotten worse, not better, since then

Traces of the emerald ash borer on the trunk of a dead ash tree in Michigan, USA. This non-native invasive insect from Asia threatens to kill most North American ash trees.

BIOTECHNOLOGY

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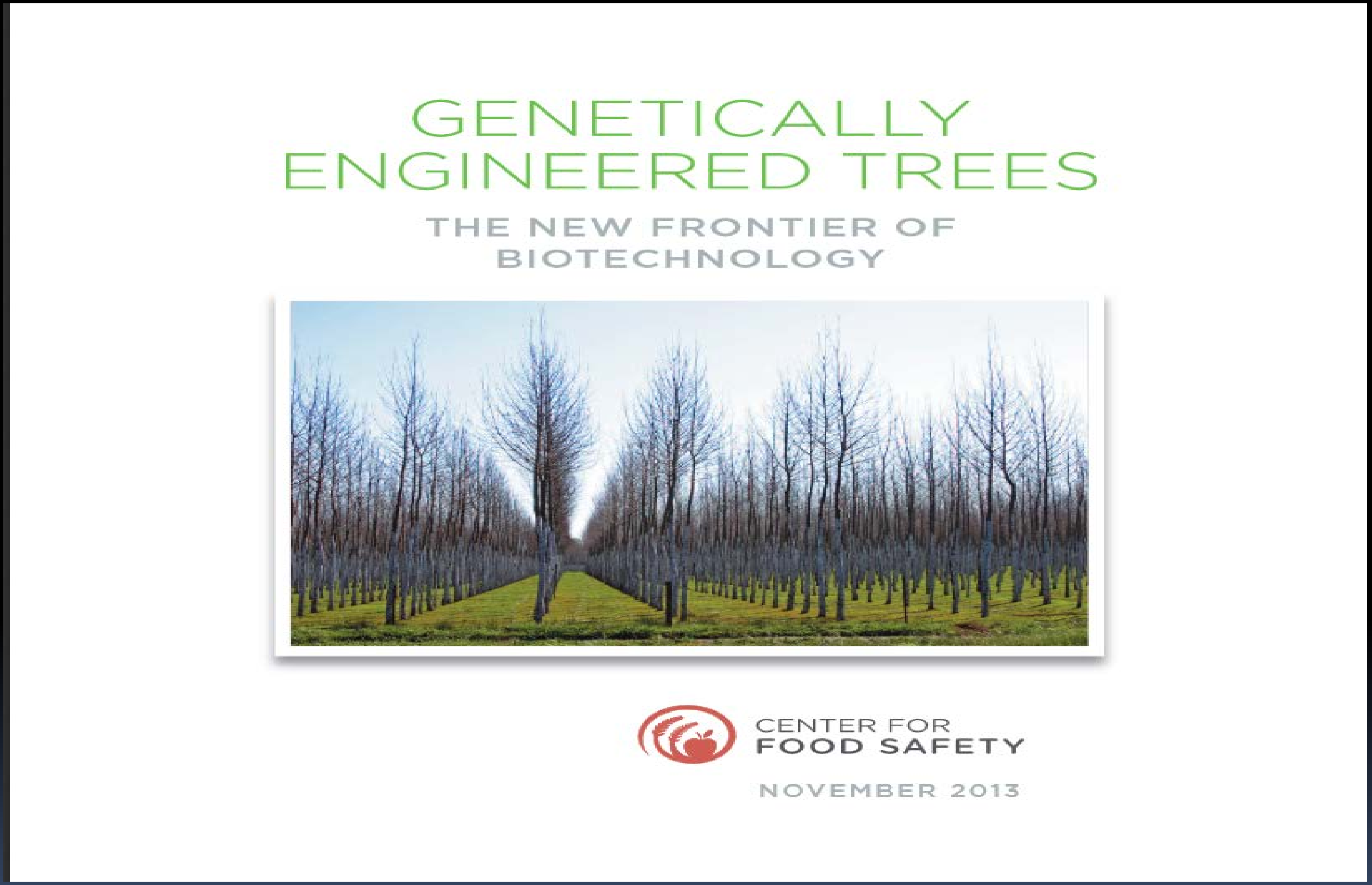
Forest certification systems universally ban all GM trees – no exemptions

System	Region	GM Tree Approach / Reason
PEFC : Programme for Endorsement of Forest Certification	International	**Banned** / Precautionary approach based on lack of data
FSC : Forest Stewardship Council	International	**Banned** / Precautionary approach based on lack of data
CerFlor : Certificação Florestal	Brazil	**Banned** via PEFC registration / No additional rationale
CertFor : Certficación Forestal	Chile	**Banned** via PEFC registration / No additional rationale
SFI : Sustainable Forestry Initiative	North America	**Banned** via PEFC registration / Awaiting risk-benefit data
ATFS : American Tree Farm System	USA	**Banned** via PEFC re No additional ra
CSA : Canadian Standards Association	Canada	**Banned** via PEFC re Allows public to detern
CFCC : China Forest Certification Council	China	**Banned** via PEFC re No additional ra

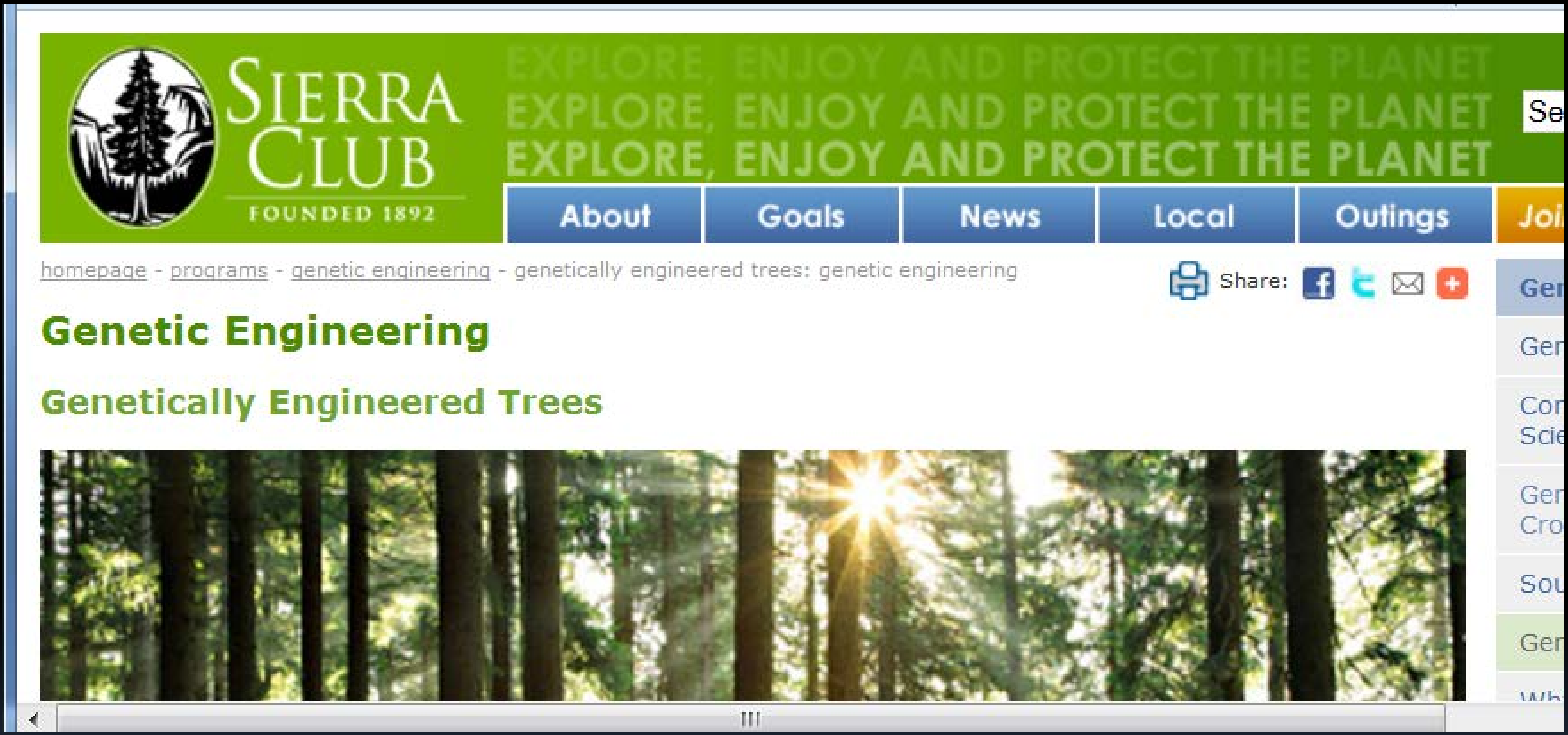
Adam Costanza, Institute for Forest Biotechnology

Anti-GMO eNGOs key reason for certification bans



Critical report from anti-GMO Center for Food Safety in USA – Released Nov 2013

Environmental groups promoting wild forests dislike GE trees



"The possibility that the new genes spliced into GE trees will interfere with natural forests isn't a hypothetical risk but a certainty. …genetic engineering may do as much damage to forests and wildlife habitat as chain saws and sprawl." (11/10/13)

Convention on Biological Diversity negotiations a focal point for activism against GM trees (Bonn, Germany)

ECO
The Voice of the NGO Community in the International Environmental Conventions
Volume 21, Issue 4
21 Feb 2008
Available on the internet at www.cbdalliance.org

NO GE Trees!

NO Case by Case!

Nearly 150 organizations around the world responded to the social and ecological threats of GE trees by demanding a global ban on the release of GE trees into the environment. These organizations, gathered in only 1 week's time and only from countries where research on the genetic modification of trees is being carried out (or has in recent years), are listed below, and an excerpt of the statement is found on the following page. The language being considered by SBSTTA at this point regarding GE trees is a big step backward from the decision on GE trees at COP-8. The decision to apply the precautionary approach to GE trees must be strengthened into a moratorium, not watered down. Delegates wishing to learn more about the impacts of GE trees are invited to attend a side event on the issue today at lunch in the Green Room.

1. 21st Paradigm, USA
2. A SEED Europe, The Netherlands
3. Acción Ecológica, Ecuador
4. AG Wald der Foum Umwelt und Entwicklung, Germany
5. Agenda 21 Anil&Azul - Rio de Janeiro, Brazil
6. Agenda Regional de La Araucania, Chile
7. Agrupación ambientalista Koyam Newen, Chile
8. Agrupación de jóvenes profesionales mapuche Konapewman, Chile
9. Alianza por una Mejor Calidad de Vida (RAP-Chile), Chile
10. Amigos de la Tierra España – Friends of the Earth Spain, Spain
11. AOPA - Associação para o Desenvolvimento da Agroecologia, Brazil
12. Argonautas Ambientalistas da Amazônia, Brazil
13. AS-PTA Assessoria e Serviços a Projetos em Agricultura Alternativa, Brazil
14. Associação de Programas em Tecnologias Alternativas-APTA, Brazil

24. Carbon Trade Watch, International
25. CAxTIERRA (Comisión de Apoyo X Tierra), Uruguay
26. Centro de Agricultura Alternativa do Norte de Minas - CAA NM, Brazil
27. Centro de Defesa dos Direitos Humanos – CDDH, Brazil
28. Centro de Estudos Ambientais (CEA), Brazil
29. CENTRO ECOLOGICO BORDE RIO, Chile
30. Centro Federal de Educação Tecnológica de Rio Pomba (CEFET-Rio Pomba), Brazil
31. CLOC (Coordinadoria LatinoAmericana de las Organizaciones del Campo), Republica Dominicana

32. Coalition for Safe Food, Powell River, British Columbia, Canada
33. COATI - Centro de Orientação Ambiental Terra Integrada - Jundiai, Brazil
34. CODEFF / Amigos de la Tierra, Chile
35. Comissão Pastoral da Terra - Diocese Itabuna/Bahia, Brazil
36. Coorporación Unión Araucana "XAPELEAI TAIÑ KIMVN", Padre Las Casas, Chile
37. Crescente Fértil, Brazil
38. Cumberland Countians for Peace & Justice, USA
39. Development Fund, Norway
40. Dogwood alliance, USA
41. Down to Earth - the International Campaign for Ecological Justice in IndonesiaUnited Kingdom
42. Ecodevelop - Publikation und Dienstleistung für ökosoziale Entwicklung, Germany
43. Ecologistas en Acción, Madrid, Spain
44. ESPLAR - CENTRO DE PESQUISA E ASSESSORIA, Brazil
45. ETC Group, Canada
46. Fair-Fish, Switzerland
47. Federação de Órgãos Para

57. Forum Ökologie & Papier, Germany
58. Friends of the Earth (England, Wales and Northern Ireland), United Kingdom
59. Friends of the Earth Australia
60. Friends of the Earth Europe
61. Fundação Vitória Amazônica, Brazil
62. Fundacion Sociedades Sustentables de Chile, Chile
63. Gaia Foundation, International
64. GE Free New Zealand, Aotearoa/New Zealand
65. GEEMA - Grupo de Estudos em Educação e Meio Ambiente, Rio de Janeiro, Brazil
66. GENANET - focal point gender, environment, sustainability, Germany
67. Gene ethical Network, Germany
68. Gesellschaft für Ökolgische Forschung, Munich, Germany
69. Global Forest Coalition, International
70. Global Justice Ecology Project, International
71. GM Freeze, United Kingdom
72. GM-Free Dorset Campaign, United Kingdom
73. Green Press Initiative, USA
74. Greenpeace, International
75. Grupo Ambientalista da Bahia - Gambá, Brazil
76. Grupo Mamangava, Brazil
77. GT Ambiente / AGB-Rio e AGB-Niterol, Brazil
78. IDESA (Instituto de Desenvolvimento Social e Ambiental), Brazil
79. Indiana Forest Alliance, USA
80. Indigenous Environmental Network (IEN), USA/Canada
81. Institute for Responsible Technology, USA
82. Institute for Social Ecology, USA
83. Instituto Ambiental Viramundo - Ceará, Brazil
84. Instituto para o Desenvolvimento Ambiental - IDA, Brazil
85. International Tribal Association, USA
86. Kentucky Heartwood, USA
87. Latin American Network Against Monoculture Tree Plantations, International
88. Les Amis de la Terre (Friends of the Earth France), France

96. Network for Environmental & Economic Responsibility, United Church of Christ, USA
97. Ngualien Pelu Mapu / protectores de la tierra, Chile
98. Northern Heritage Association, Finland
99. Northwest Resistance Against Genetic Engineering, USA
100. Northwoods Wilderness Recovery, USA
101. OroVerde - Tropical Forest Foundation, Germany
102. Pacific Indigenous Peoples Environment Coalition (PIPEC), Aotearoa/New Zealand
103. Plataforma Transgenicos Fora (Portuguese GM-Free Coalition), Portugal
104. Prairie Red Fife Organic Growers Cooperative Ltd., Canada
105. Prodema - UFC, Brazil
106. RAE - Rede de Educação Ambiental Escolar, Rio de Janeiro, Brazil
107. Rainforest Relief, USA
108. Red por una América Latina Libre de Transgénicos, Ecuador
109. Rede Ambiental do PiauÃ - REAPI, Brazil
110. Rede de Educadores Ambientais da Baixada de Jacarepaguá, Rio de Janeiro, Brazil
111. Rede de Integração Verde, Brazil
112. Rettet den Regenwald, Germany
113. Rising Tide North America, USA
114. Robin Wood, Germany
115. Safe Alternatives for our Forest Environment (SAFE)USA
116. Sierra Club, USA
117. Sindicato dos Trabalhadores de Rio Pardo de Minas - MG, Brazil
118. Sociedade Angrense de Proteção Ecológica, Brazil
119. Society for a Genetically Engineered British Columbia, Canada
120. Soil Association, USA
121. Stop GE Trees Campaign, International
122. Terra de Directos, Brazil
123. UITA - Unión Internacional de Trabajadores de la Alimentación y la Agricultura, International

134. World Rainforest Movement, International
135. Worldforests, Scotland
136. Worldview, USA
137. Xarxa de l'Observatori del Deute en la Globalització, Cataluña, Estado español

GE Tree Statement

Below is a brief description of the statement and letter signed by 137 groups.

Statement signatories begin by stating that their *"concern is based on the fact that the genetic manipulation being undertaken is aimed at consolidating and further expanding a model of monoculture tree plantations that has already proven to result in serious social and environmental impacts in many of our countries."*

The statement then provides a number of examples on how current research would impact on the environment, given that trees are being genetically manipulated for.

The signatories remind country delegates that "the last Conference of the Parties to the Convention on Biological Diversity (COP-8) adopted decision VIII/19", which *"recommends Parties to take a precautionary approach when addressing the issue of genetically modified trees"* and urge them *"to definitely ban GE trees - including fields trials – because of the serious risks they pose on the Planet's biological diversity."*

Full letter and signatories available at: http://www.wrm.org.uy/actors/BDC/SBSTT

NO GE Trees!

NO Case by Case!

Nearly 150 organizations around the world responded to the social and ecological threats of GE trees by demanding a global ban on the release of GE trees into the environment. These organizations, gathered in only 1 week's time and only from countries where research on the genetic modification of trees is being carried out (or has in recent years), are listed below, and an excerpt of the statement is found on the following page. The language being considered by SBSTTA at this point regarding GE trees is a big step backward from the decision on GE trees at COP-8. The decision to apply the precautionary approach to GE trees must be strengthened into a moratorium, not watered down. Delegates wishing to learn more about the impacts of GE trees are invited to attend a side event on the issue today at lunch in the Green Room.

ECO

The Voice of the NGO Community in the International Environmental Conventions

VOLUME 21, ISSUE 4
21 FEB 2008
AVAILABLE ON THE INTERNET AT WWW.CBDALLIANCE.ORG

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…global ban on the release of GE trees into the environment…" = NO FIELD RESEARCH

1. 21st Paradigm, USA
2. A SEED Europe, The Netherlands
3. Acción Ecológica, Ecuador
4. AG Wald der Foum Umwelt und Entwicklung, Germany
5. Agenda 21 Anil&Azul - Ri… Janeiro, Brazil
6. Agenda Regional de La A… Chile
7. Agrupación ambientalist… Newen, Chile
8. Agrupación de jóvenes p… mapuche Konapewman, …
9. Alianza por una Mejor Ca… Vida (RAP-Chile), Chile
10. Amigos de la Tierra Espa… of the Earth Spain, Spain
11. AOPA - Associação para o Desenvolvimento da Agroecologia, Brazil
12. Argonautas Ambientalistas da Amazônia, Brazil
13. AS-PTA Assessoria e Serviços a Projetos em Agricultura Alternativa, Brazil
14. Associação de Programas em Tecnologias Alternativas-APTA, Brazil

24. Carbon Trade Watch, International
25. CAxTIERRA (Comisión de Apoyo X Tierra), Uruguay
26. Centro de Agricultura Alternativa do Norte de Minas - CAA NM, Brazil

… Organizaciones del Campo), Republica Dominicana

32. Coalition for Safe Food, Powell River, British Columbia, Canada
33. COATI - Centro de Orientação Ambiental Terra Integrada - Jundiai, Brazil

41. Down to Earth - the International Campaign for Ecological Justice in IndonesiaUnited Kingdom
42. Ecodevelop - Publikation und Dienstleistung für ökosoziale Entwicklung, Germany
43. Ecologistas en Acción, Madrid, Spain
44. ESPLAR - CENTRO DE PESQUISA E ASSESSORIA, Brazil
45. ETC Group, Canada
46. Fair-Fish, Switzerland
47. Federação de Órgãos Para

57. Forum Ökologie & Papier, Germany
58. Friends of the Earth (England, Wales and Northern Ireland), United Kingdom
59. Friends of the Earth Australia
60. Friends of the Earth Europe
61. Fundação Vitória Amazônica, Brazil
62. Fundacion Sociedades Sustentables de Chile, Chile
63. Gaia Foundation, International
64. GE Free New Zealand, Aotearoa/New Zealand
65. GEEMA - Grupo de Estudos em Educação e Meio Ambiente, Rio de Janeiro, Brazil
66. GENANET - focal point gender, environment, sustainability, Germany
67. Gene ethical Network, Germany
68. Gesellschaft für Ökolgieche Forschung, Munich, Germany
69. Global Forest Coalition, International
70. Global Justice Ecology Project, International
71. GM Freeze, United Kingdom
72. GM-Free Dorset Campaign, United Kingdom
73. Green Press Initiative, USA
74. Greenpeace, International
75. Grupo Ambientalista da Bahia - GambA, Brazil

83. Instituto Ambiental Viramundo - Ceará, Brazil
84. Instituto para o Desenvolvimento Ambiental - IDA, Brazil
85. International Tribal Association, USA
86. Kentucky Heartwood, USA
87. Latin American Network Against Monoculture Tree Plantations, International
88. Les Amis de la Terre (Friends of the Earth France), France

96. Network for Environmental & Economic Responsibility, United Church of Christ, USA
97. Ngualien Pelu Mapu / protectores de la tierra, Chile
98. Northern Heritage Association, Finland
99. Northwest Resistance Against Genetic Engineering, USA
100. Northwoods Wilderness Recovery, USA
101. OroVerde - Tropical Forest Foundation, Germany
102. Pacific Indigenous Peoples Environment Coalition (PIPEC), Aotearoa/New Zealand
103. Plataforma Transgenicos Fora (Portuguese GM-Free Coalition), Portugal
104. Prairie Red Fife Organic Growers Cooperative Ltd., Canada
105. Prodema - UFC, Brazil
106. RAE - Rede de Educação Ambiental Escolar, Rio de Janeiro, Brazil
107. Rainforest Relief, USA
108. Red por una América Latina Libre de Transgénicos, Ecuador
109. Rede Ambiental do PiauÃ - REAPI, Brazil

118. Sociedade Angrense de Proteção Ecológica, Brazil
119. Society for a Genetically Engineered British Columbia, Canada
120. Soil Association, USA
121. Stop GE Trees Campaign, International
122. Terra de Directos, Brazil
123. UITA - Unión Internacional de Trabajadores de la Alimentación y la Agricultura, International

134. World Rainforest Movement, International
135. Worldforests, Scotland
136. Worldview, USA
137. Xarxa de l'Observatori del Deute en la Globalització, Cataluña, Estado español

GE Tree Statement

Below is a brief description of the statement and letter signed by 137 groups.

Statement signatories begin by stating that their *"concern is based on the fact that the genetic manipulation being undertaken is aimed at consolidating and further expanding a model of monoculture tree plantations that has already proven to result in serious social and environmental impacts in many of our countries."*

The statement then provides a number of examples on how current research would impact on … given that trees … cally manipulated …

… remind country … last Conference … the Convention on … ersity (COP-8) … VIII/19", which *"recommends Parties to take a precautionary approach when addressing the issue of genetically modified trees"* and urge them *"to definitely ban GE trees - including fields trials – because of the serious risks they pose on the Planet's biological diversity."*

Full letter and signatories available at: http://www.wrm.org.uy/actors/BDC/SBSTT

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Tree Biotechnology Conference at Oxford in 1999 - Vandalism against lignin modified trees to "welcome" conferees, Euro-press attacks

FRANKENSTEIN'S FOREST

The tree-top protesters, who confounded the Government's road-building programme by camping in the path of bulldozers, are now poised to target the very trees they might once have called home.

Whilst public attention has been focused on the threat of 'Frankenstein Foods', the same corporations who are forcing us to ingest

ment. Campaigners fear that GM trees will sap up water, nutrients and light, leaving indigenous trees to die out along with the host of insects, plants and fungi which rely upon them. In turn, birds and animals would lose many of their natural prey. Those surviving creatures would fall victim to herbicide weed-killer, liberally applied once the GM trees

1997. The trees, engineered by the University of Derby, to be disease- and insect-resistant were destroyed by removing the bark. A growing spate of raids on food crops caused AstraZeneca to make a statement to the press before a GenetiX Snowball action earlier this year, fearing damage to their GM poplars.

In April, Monsanto teamed up with two of

vention, which governs global emissions of greenhouse gases, came into force after the 1997 Kyoto conference, industrialised countries have been forced to clean up. However, the corporations argue that by planting more trees, they should be awarded 'carbon credits', because trees absorb carbon dioxide.

Recently, naturally rich native forests have

Whilst public attention has been focused on the threat of 'Frankenstein Foods', the same corporations who are forcing us to ingest genetically modified (GM) meals have been quietly perpetrating yet another crime against the environment.

”Eco” vandalism in USA / 2001

Pacific Northwest (2001)

U Wash

Oregon State

Recent vandalism in Brazil

March 5, 2015: 1,000 women of the Brazil Landless Workers' Movement (MST) vandalized FuturaGene’s GM eucalyptus research greenhouse at Itapetininga, in São Paulo

Examples of GE trees

Technology diverse and effective

A great diversity of traits, and economic and/or environmental values, have been demonstrated in field trials of trees

Stability & efficacy is great—unstable, mutant types rare—but few species, <u>mostly poplar</u>, studied

- Herbicide tolerance
- Biotic, abiotic stresses
- Wood or fruit quality
- Form/stature and growth rate
- Containment
- Accelerated flowering
- Bioremediation
- Novel bioproducts

RNAi: Virus-resistant papaya

"Immunization" via by implanting a viral gene in the papaya genome – RNAi (RNA interference)

Courtesy of Denis Gonsalves, formerly of Cornell University

GMO, virus-resistant trees

HoneySweet plum with RNAi resistance to plum pox virus

Ralph Scorza USDA-ARS

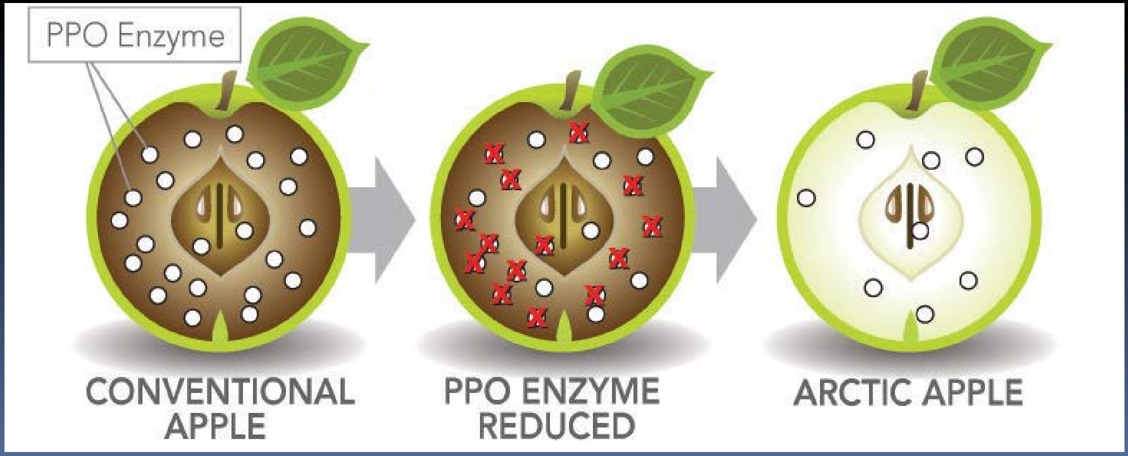
GE

Non-GE

Non-browning "Arctic Apple"

RNAi suppression of native polyphenol oxidase gene expression

Courtesy of Jennifer Armen, Okanagan Specialty Fruits, Canada

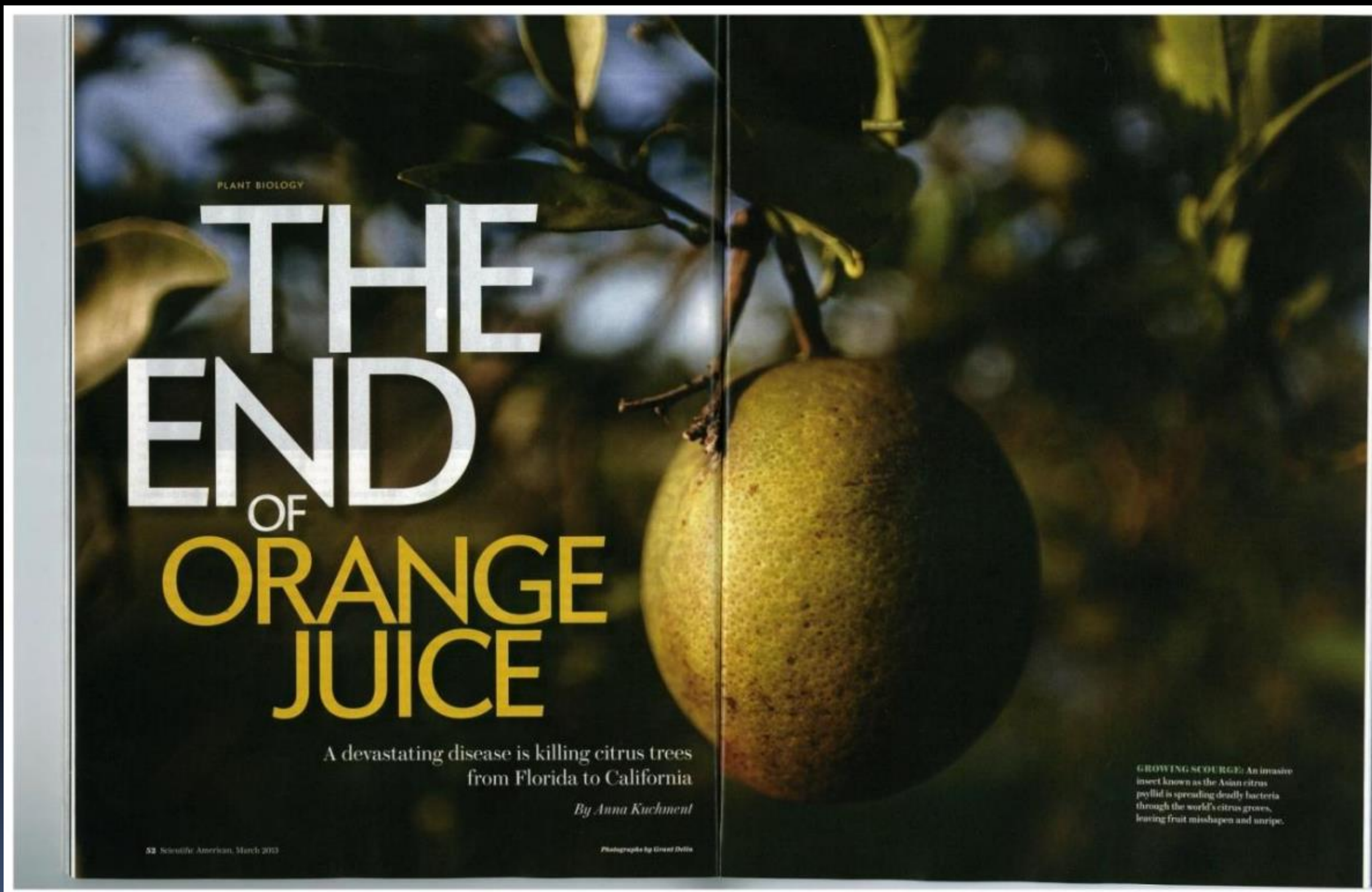


Non-browning "Arctic Apple"

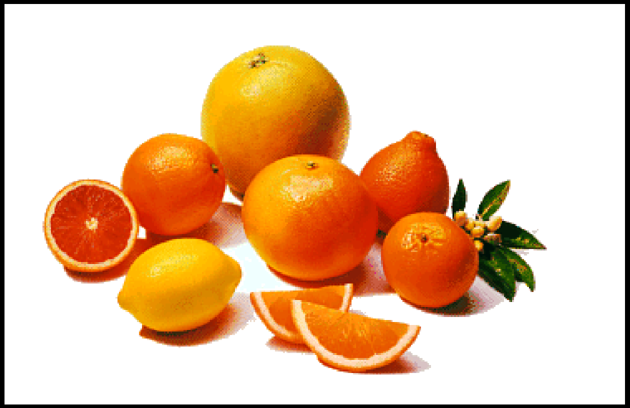
Time lapse video

GMO-based resistance transgenes promising in citrus

Scientific American
March, 2013



Defensin-like proteins from spinach promising



Courtesy of Eric Mirkov, Texas A & M

Insertion of a transgene that elevates natural systemic acquired resistance also promising

Courtesy of Manjul Dutt and Jude Grosser,
Citrus Research and Education Center,
Florida, USA

Early flowering transgenes effective in eucalypts

Plant Biotechnology Journal

Plant Biotechnology Journal (2015), pp. 1–12 doi: 10.1111/pbi.12431

FT overexpression induces precocious flowering and normal reproductive development in *Eucalyptus*

Amy L. Klocko[1], Cathleen Ma[1], Sarah Robertson[1], Elahe Esfandiari[1], Ove Nilsson[2] and Steven H. Strauss[1,*]

[1]*Department Forest Ecosystems & Society, Oregon State University, Corvallis, OR, USA*

[2]*Department of Forest Genetics and Plant Physiology, Umeå Plant Science Centre, Swedish University of Agricultural Sciences, Umeå, Sweden*

Received 8 April 2015;
revised 29 May 2015;
accepted 10 June 2015.
**Correspondence* (Tel (541) 760 7357; fax (541) 737 1393; email steve.strauss@oregonstate.edu)

Keywords: Eucalypts, breeding, transgenic, forest biotechnology, *Flowering Locus T*, genetic engineering.

Summary

Eucalyptus trees are among the most important species for industrial forestry worldwide. However, as with most forest trees, flowering does not begin for one to several years after planting which can limit the rate of conventional and molecular breeding. To speed flowering, we transformed a *Eucalyptus grandis* × *urophylla* hybrid (SP7) with a variety of constructs that enable overexpression of *FLOWERING LOCUS T* (*FT*). We found that *FT* expression led to very early flowering, with events showing floral buds within 1–5 months of transplanting to the glasshouse. The most rapid flowering was observed when the cauliflower mosaic virus 35S promoter was used to drive the *Arabidopsis thaliana FT* gene (*AtFT*). Early flowering was also observed with *AtFT* overexpression from a 409S ubiquitin promoter and under heat induction conditions with *Populus trichocarpa FT1* (*PtFT1*) under control of a heat-shock promoter. Early flowering trees grew robustly, but exhibited a highly branched phenotype compared to the strong apical dominance of nonflowering transgenic and control trees. *AtFT*-induced flowers were morphologically normal and produced viable pollen grains and viable self- and cross-pollinated seeds. Many self-seedlings inherited *AtFT* and flowered early. *FT* overexpression-induced flowering in *Eucalyptus* may be a valuable means for accelerating breeding and genetic studies as the transgene can be easily segregated away in progeny, restoring normal growth and form.

Lepidopteran-resistant poplars commercially approved in China - Bt *cry1*

- Trait stable
- Helps to protect non-Bt trees
- Reduced insecticide use
- Improved growth rate

Coleopteran resistant Bt-cottonwoods in eastern Oregon field trial

Growth benefits (10-20%) despite low insect pressure during large field trial of resistant genotypes

28

NRC Research Press

ARTICLE

Bt-Cry3Aa transgene expression reduces insect damage and improves growth in field-grown hybrid poplar

Amy L. Klocko, Richard Meilan, Rosalind R. James, Venkatesh Viswanath, Cathleen Ma, Peggy Payne, Lawrence Miller, Jeffrey S. Skinner, Brenda Oppert, Guy A. Cardineau, and Steven H. Strauss

Abstract: The stability and value of transgenic pest resistance for promoting tree growth are poorly understood. These data are essential for determining if such trees could be beneficial to commercial growers in the face of substantial regulatory and marketing costs. We investigated growth and insect resistance in hybrid poplar expressing the *cry3Aa* transgene in two field trials. An initial screening of 502 trees comprising 51 transgenic gene insertion events in four clonal backgrounds (*Populus trichocarpa* × *Populus deltoides*, clones 24-305, 50-197, and 198-434; and *P. deltoides* × *Populus nigra*, clone OP-367) resulted in transgenic trees with greatly reduced insect damage. A large-scale study of 402 trees from nine insertion events in clone OP-367, conducted over two growing seasons, demonstrated reduced tree damage and significantly increased volume growth (mean 14%). Quantification of Cry3Aa protein indicated high levels of expression, which continued after 14 years of annual or biannual coppice in a clone bank. With integrated management, the *cry3Aa* gene appears to be a highly effective tool for protecting against leaf beetle damage and improving yields from poplar plantations.

Résumé : La stabilité et la valeur de la résistance transgénique aux ravageurs pour favoriser la croissance des arbres ne sont pas bien connu…
être profita…
marché de…

Can. J. For. Res. 44: 28–35 (2014) dx.doi.org/10.1139/cjfr-2013-0270

Published at www.nrcresearchpress.com/cjfr on 28 October 2013.

Glyphosate herbicide resistance in cottonwood – In press (*New Forests*)

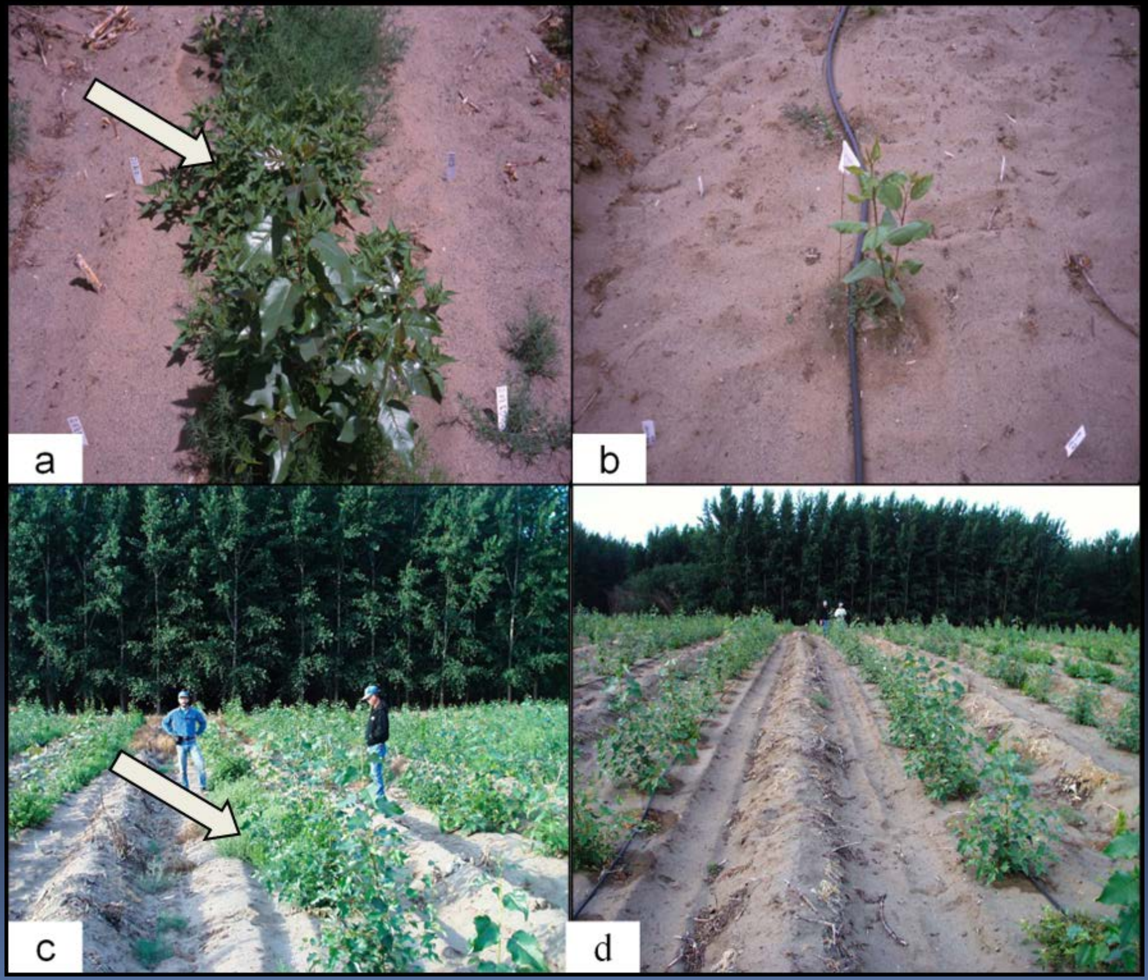
Screen of primary transformants

Wild type controls

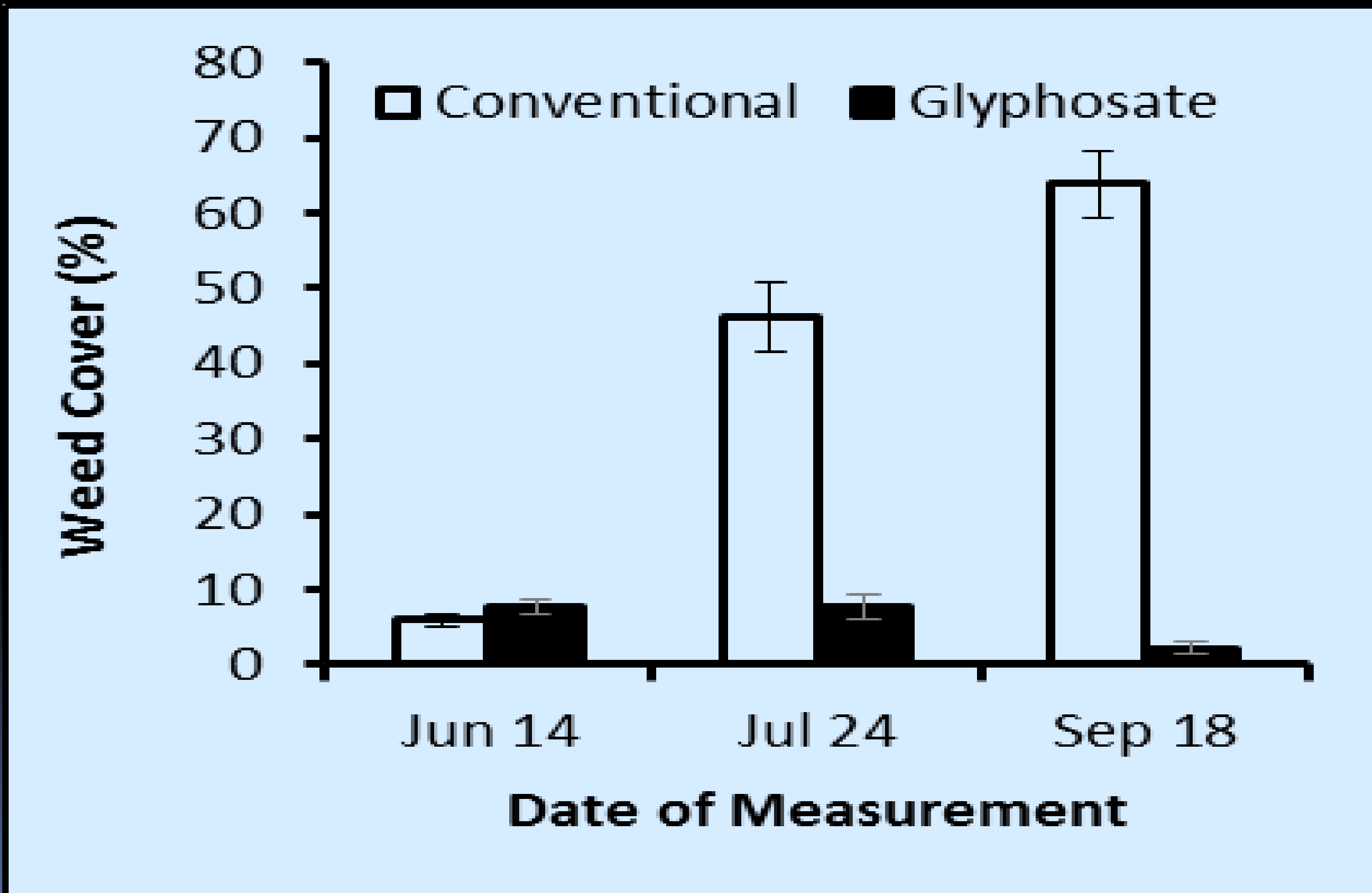
2 yr-old field trial

Roundup-resistance-tailored weed control much improved

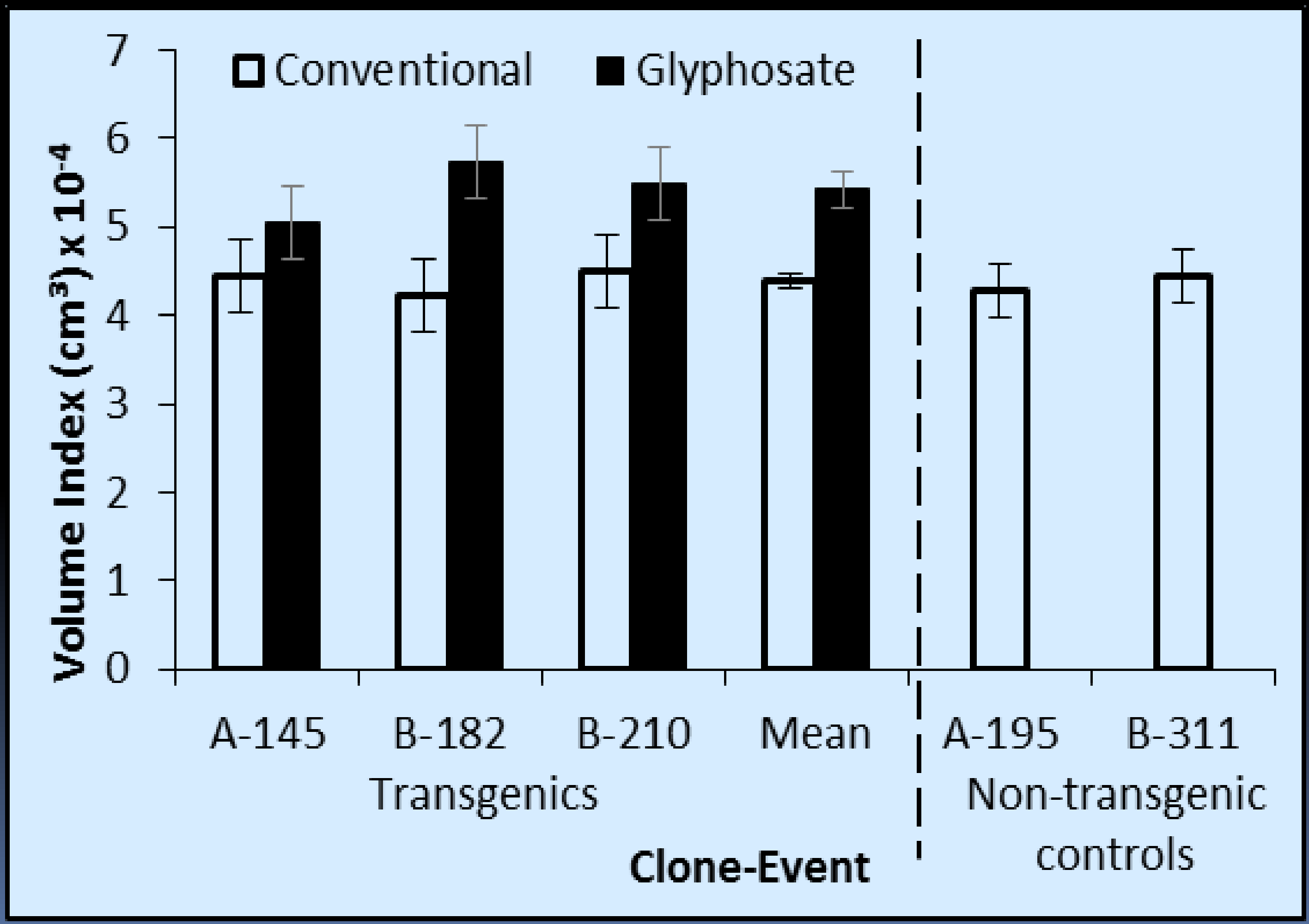
Conventional Roundup-resistant



Weed cover drastically reduced in Roundup-resistance tailored vs. conventional weed control



Growth benefit in Roundup-resistance tailored system: ~20% volume at 2 years



Wood modification to promote growth rate – just authorized by Brazilian government for commercial use

CASSIO VASCONCELLOS/SAMBAPHOTO/GETTY

Eucalyptus plantations near São Paulo in Brazil.

BIOTECHNOLOGY

Brazil considers transgenic trees

Genetically modified eucalyptus could be a global test case.

28 AUGUST 2014 | VOL 512 | NATURE | 357

Cold tolerant GE *Eucalyptus*

Provided by Arborgen

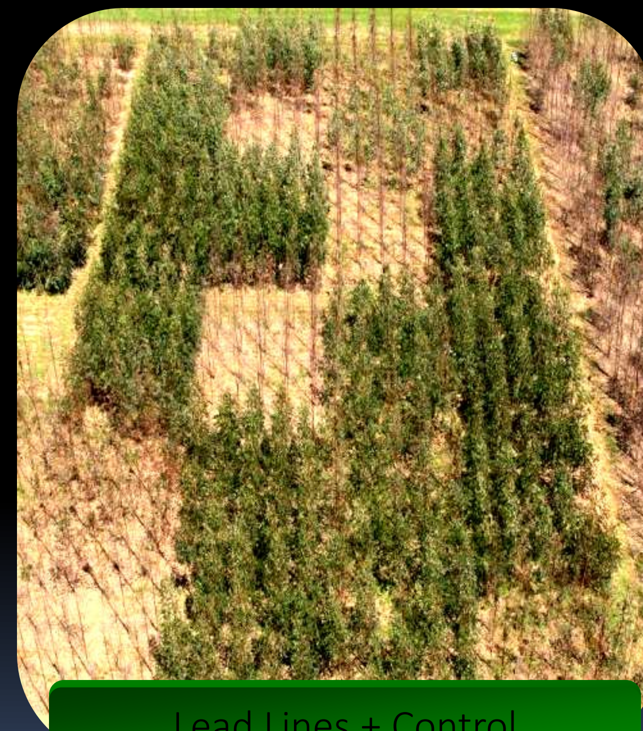
Proposed for commercial deregulation in USA

Results from first winter in South Carolina

Control

Lead Line

Results from second winter in Alabama



Lead Lines + Control

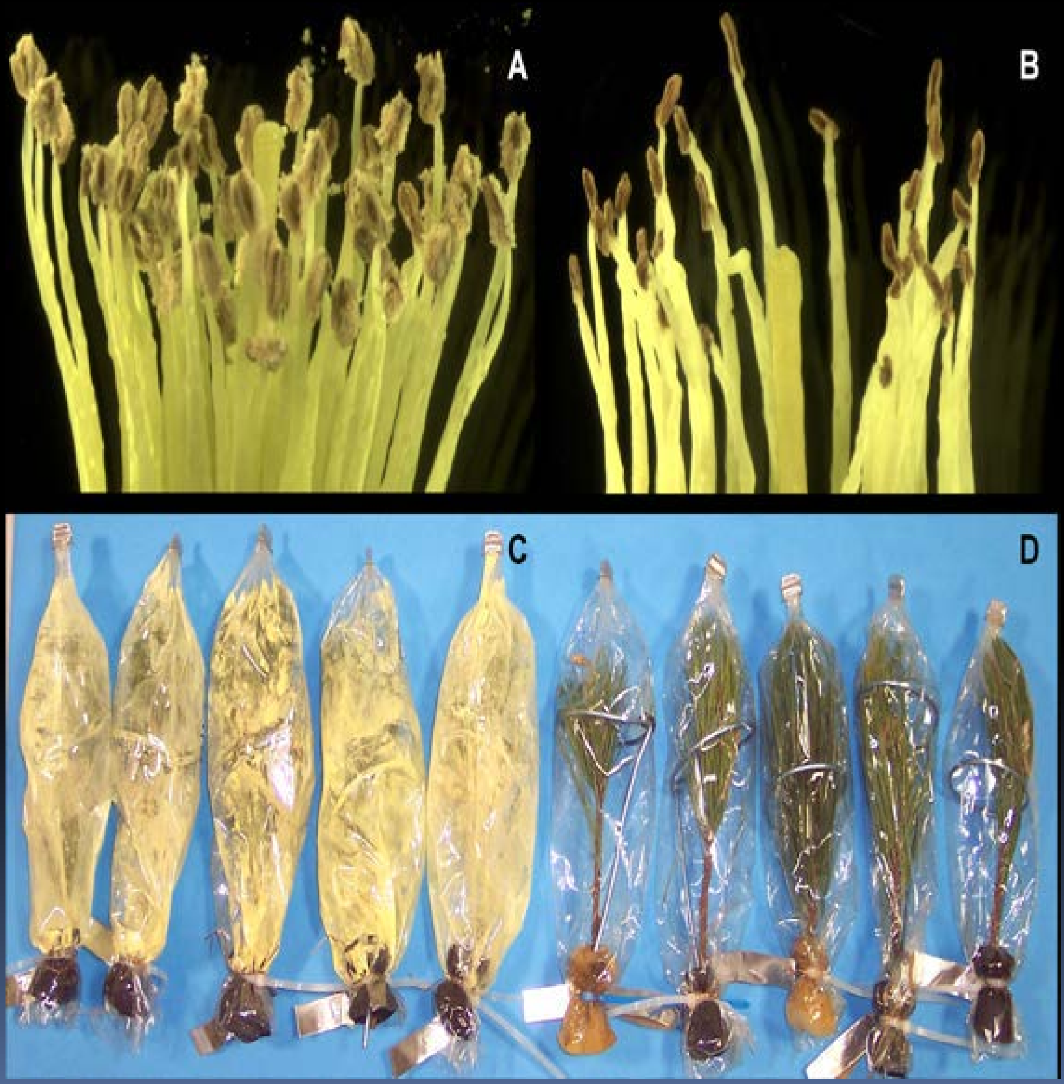
Field results indicate freezing tolerance to ~16°F (- 8° to - 9°C)

Many eucalypt field trials underway

Courtesy of
Les Pearson,
Arborgen

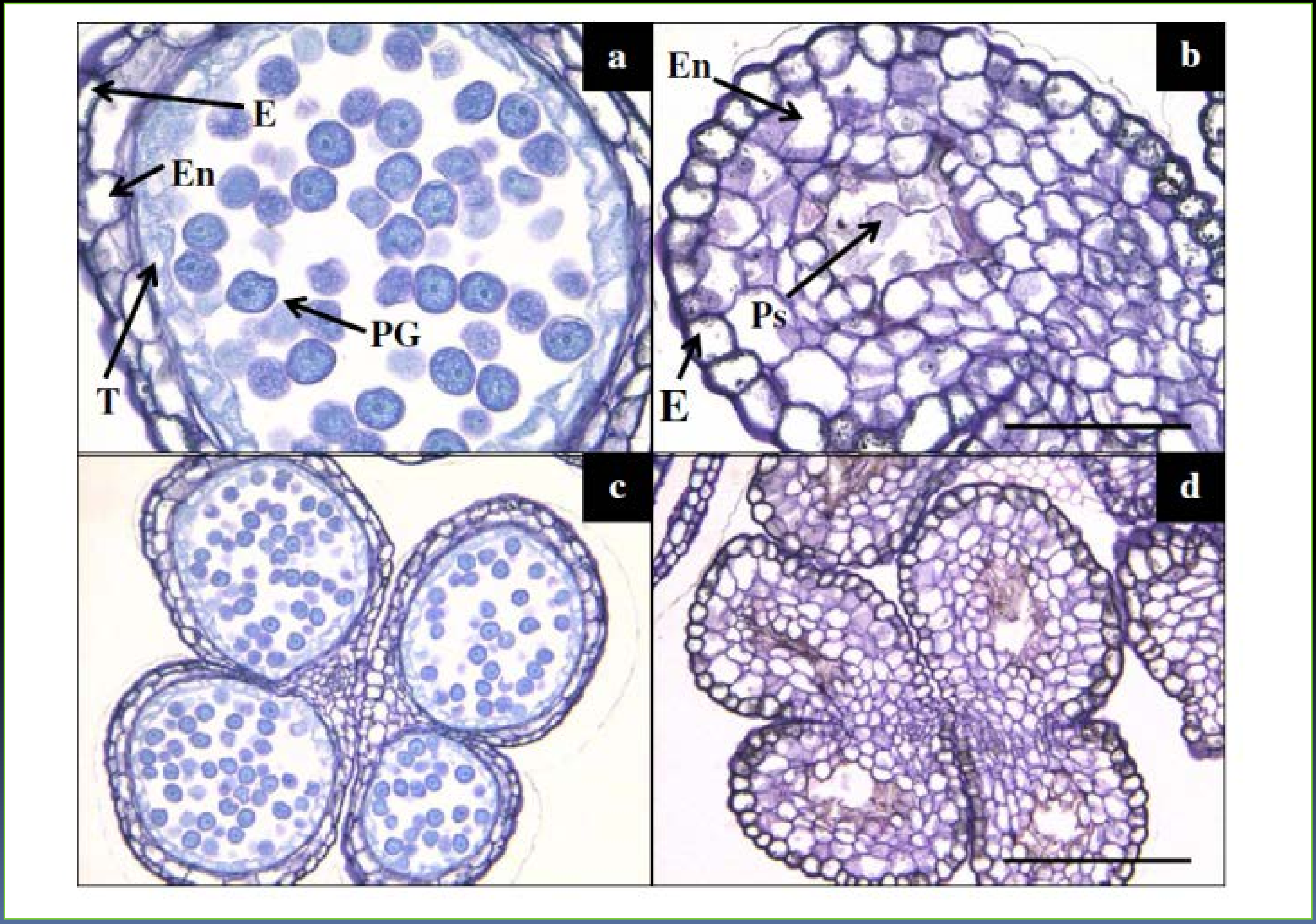
Sterility a valuable tool for transgene containment and containing exotics: “Wilding” in New Zealand, South Africa, and others

Male sterile eucalypts and pine - Arborgen



Anther-specific promoter driving expression of a strong RNAse prevents pollen maturation and release

Tapetal collapse



RNAi for complete sterility

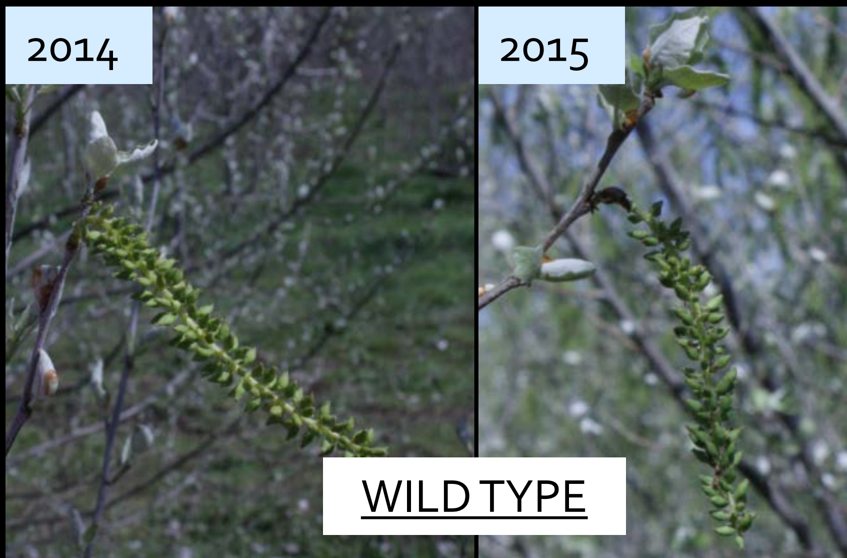
RNAi field trial of poplar in Oregon: 25 constructs, 3 genotypes, 4,000 trees, 9 acres

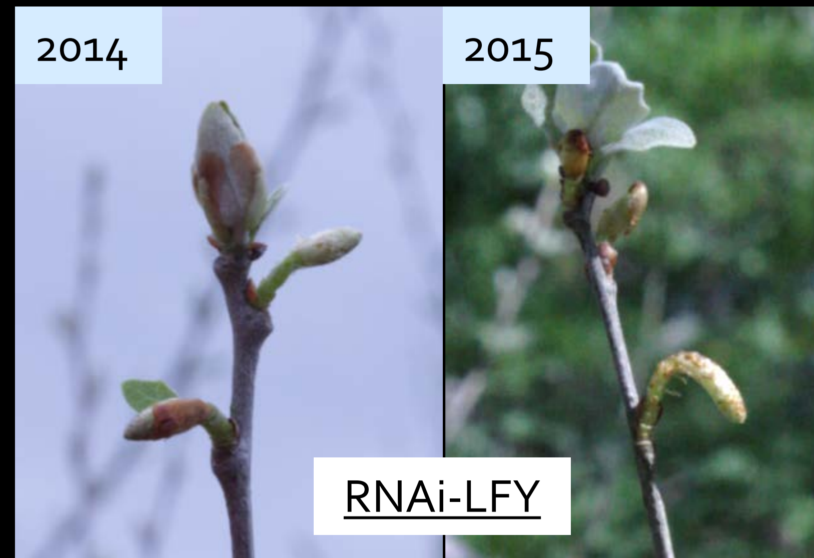
It's turned into a forest

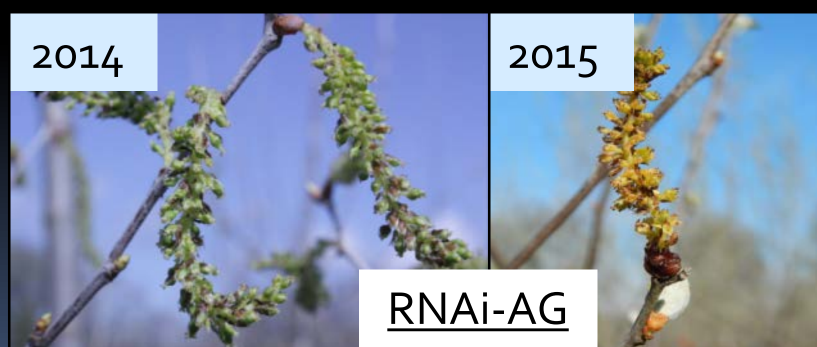
Complete sterility - Undeveloped catkins, stable suppression of native *LEAFY* gene in poplar (RNAi)

Klocko et al. 2014, American Soc. For Plant Biology, Portland, Oregon

Floral phenotypes were stable across growing seasons

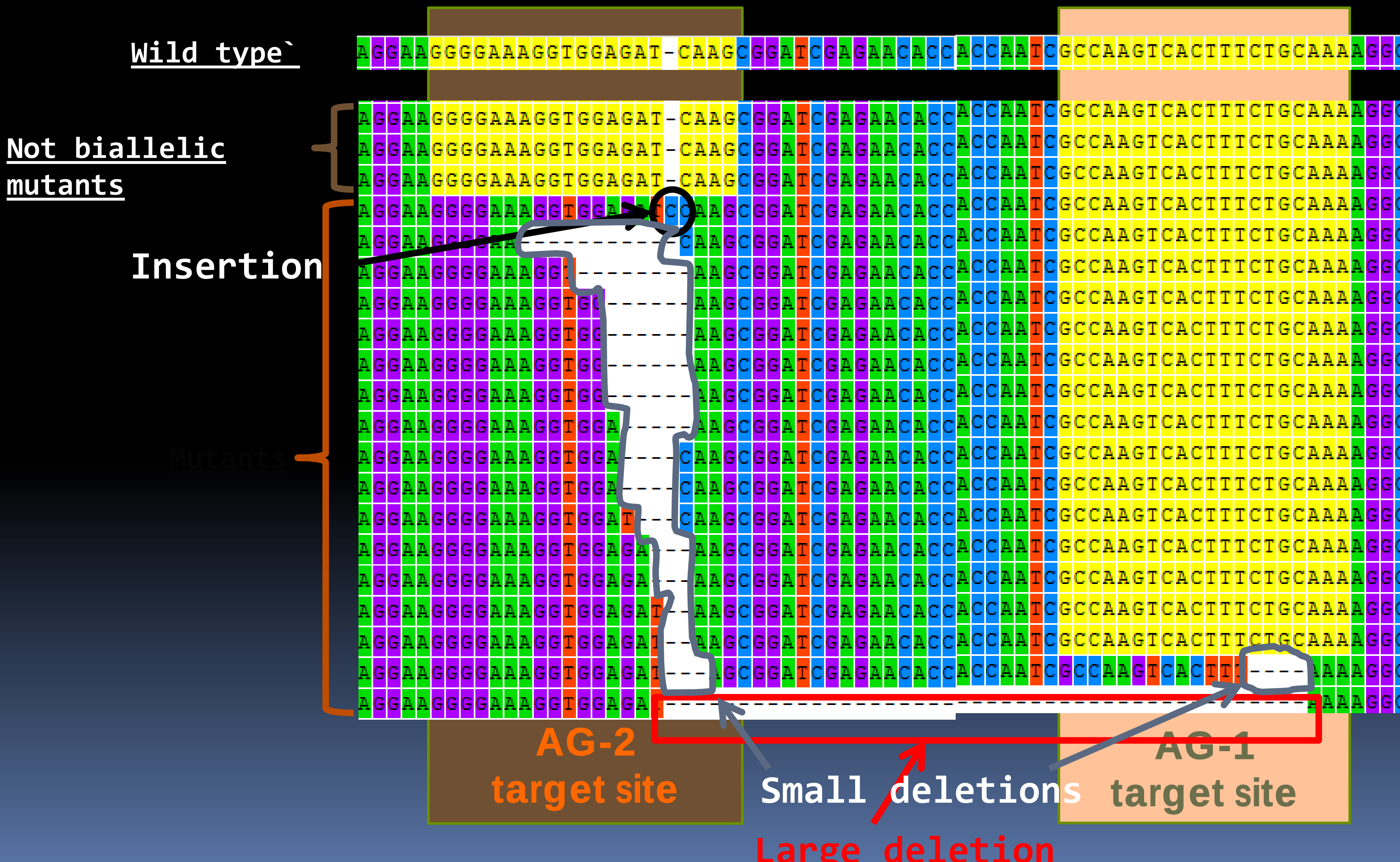






CRISPRs: Predictable, stable, certain sterility?

~10-20% biallelic mutation rate



Trees as chemical feedstocks

Prof. Norman Lewis, Washington State University

The Seattle Times
Winner of Nine Pulitzer Prizes

Local News

Originally published Sunday, February 9, 2014 at 9:10 PM

Rose scent in poplar trees? WSU turns to genetic engineering

A WSU team aims to turn poplars and other fast-growing trees into living factories that churn out valuable chemicals.

By Sandi Doughton

Seattle Times science reporter

Sniff the air around Norman Lewis' experimental poplars, and you won't pick up the scent of roses.

But inside the saplings' leaves and stems, cells are hard at work producing the chemical called 2-phenylethanol— which by any other name would smell as sweet.

Sweeter still is the fact that perfume and cosmetics companies will pay as much as $30 an ounce for the compound that gives roses their characteristic aroma. Because what Lewis and his colleagues at Washington State University are really chasing is the smell of money.

Production of 2-phenylethanol

Lignin reduction

Fragrances and jet fuel feedstock

Large scale field trials of a variety of genes and insertions underway

Norman Lewis, Washington State University

Forest health a major and growing concern

REVIEW

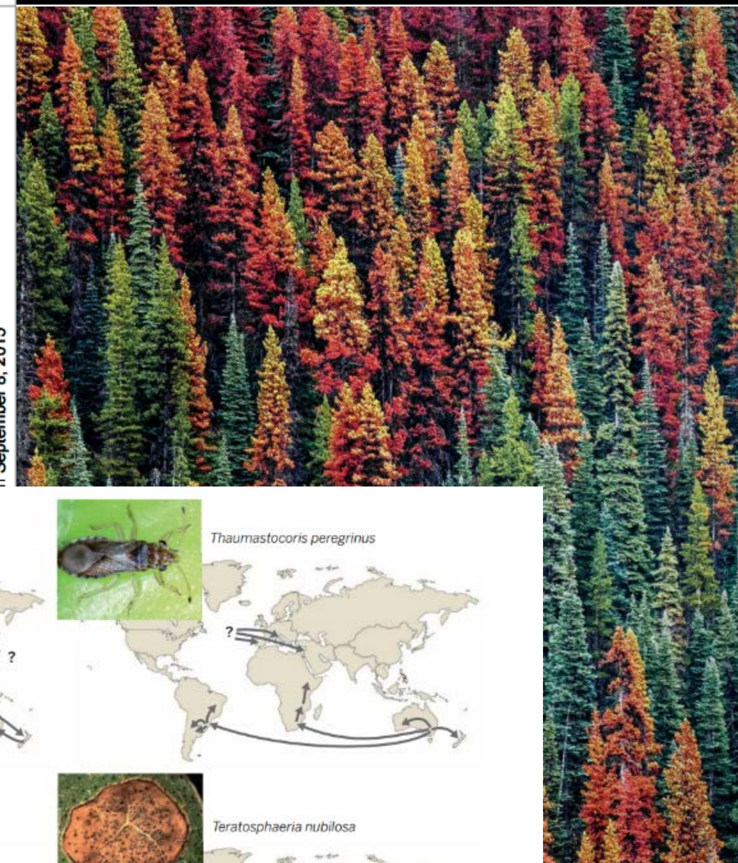
Planted forest health: The need for a global strategy

M. J. Wingfield,[1*] E. G. Brockerhoff,[2] B. D. Wingfield,[1] B. Slippers[1]

Several key tree genera are used in planted forests worldwide, and these represent valuable global resources. Planted forests are increasingly threatened by insects and microbial pathogens, which are introduced accidentally and/or have adapted to new host trees. Globalization has hastened tree pest emergence, despite a growing awareness of the ...ng of the costs, and an increased focus on the importance of ... and potential of planted forests, innovative solutions and a ...oach are needed. Mitigation strategies that are effective only in ...n invasions elsewhere in the world, ultimately leading to global ...st problems in the future should mainly focus on integrating ...lly, rather than single-country strategies. A global strategy to ...portant and urgently needed.

...ems are a huge-...ce, easily over-...l (1–3). Globally, ...ted to rely on

have been separated from their natural enemies. However, when plantation trees are reunited with their coevolved pests, which may be introduced accidentally, or when they encounter novel pests



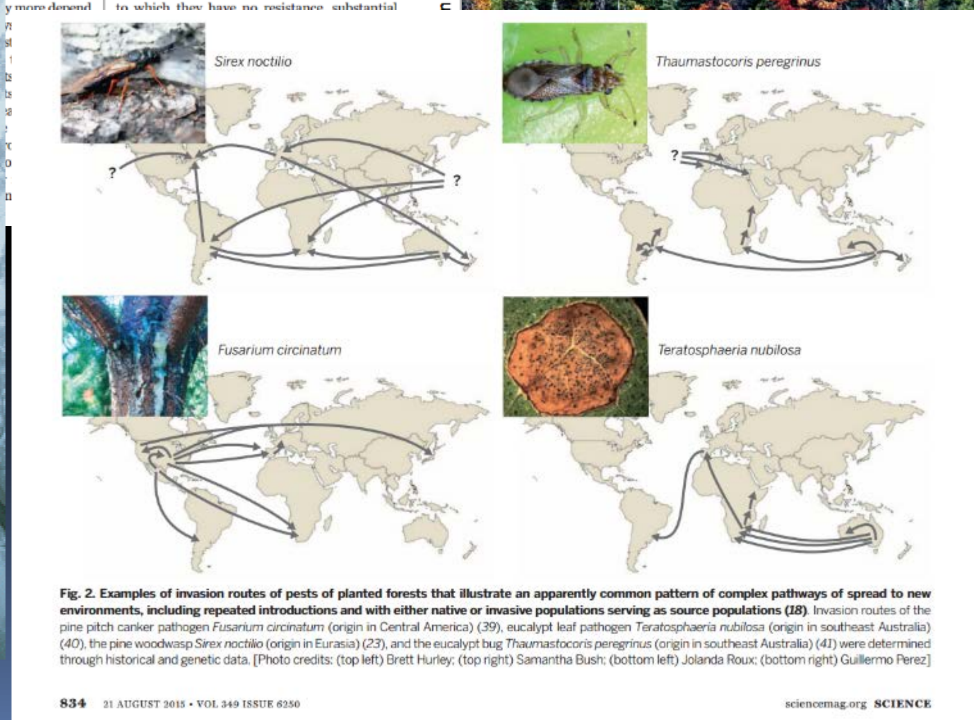


Fig. 2. Examples of invasion routes of pests of planted forests that illustrate an apparently common pattern of complex pathways of spread to new environments, including repeated introductions and with either native or invasive populations serving as source populations (18). Invasion routes of the pine pitch canker pathogen *Fusarium circinatum* (origin in Central America) (39), eucalypt leaf pathogen *Teratosphaeria nubilosa* (origin in southeast Australia) (40), the pine woodwasp *Sirex noctilio* (origin in Eurasia) (23), and the eucalypt bug *Thaumastocoris peregrinus* (origin in southeast Australia) (41) were determined through historical and genetic data. [Photo credits: (top left) Brett Hurley; (top right) Samantha Bush; (bottom left) Jolanda Roux; (bottom right) Guillermo Perez]

834 21 AUGUST 2015 • VOL 349 ISSUE 6250 sciencemag.org SCIENCE

Could GE be a useful too for battling the many exotic diseases that damage USA forests?

- 1892 - White pine blister rust
- 1904 - Chestnut blight
- 1923 - Port-Orford-cedar root disease
- 1920s - Beech scale complex
- 1930 - Dutch elm disease
- 1967 - Butternut canker
- 1976 - Dogwood anthracnose
- 2000s - Sudden oak death

American elm

American chestnut was an iconic, keystone forest tree in the USA

It was extirpated as a forest tree by Chestnut Blight

1912 photo of blight in NY

Complete destruction of chestnut trees in mixed stands. Note healthy condition of trees of other species. Views along Long Island Railroad, near Richmond Hill, New York.—*Photograph by Prof. Collins.*

American Chestnut restoration – genomics and genetic engineering

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SCIENTIFIC AMERICAN
The New Century of the Brain
See Inside

The American Chestnut's Genetic Rebirth

A foreign fungus nearly wiped out North America's once vast chestnut forests. Genetic engineering can revive them

By William Powell

In 1876 Samuel B. Parsons received a shipment of chestnut seeds from Japan and decided to grow and sell the trees to orchards. Unbeknownst to him, his shipment likely harbored a stowaway that caused one of the greatest ecological disasters ever to befall eastern North America. The trees probably concealed spores of a pathogenic fungus, *Cryphonectria parasitica*, to which Asian chestnut trees—but not their American cousins—had evolved resistance. *C. parasitica* effectively strangles

More In This Article

A New Generation of American Chestnut Trees May Redefine America's Forests

March 2014 issue - Scientific American

Most effective gene is oxalate oxidase from wheat – OK?

Hemlock in US under siege today

Corrected 2 September 2015; see full text. *FOREST HEALTH* **SPECIAL SECTION**

BATTLING A GIANT KILLER

The iconic eastern hemlock is under siege from a tiny invasive insect

By **Gabriel Popkin** *in Highlands, North Carolina; photography by* **Katherine Taylor**

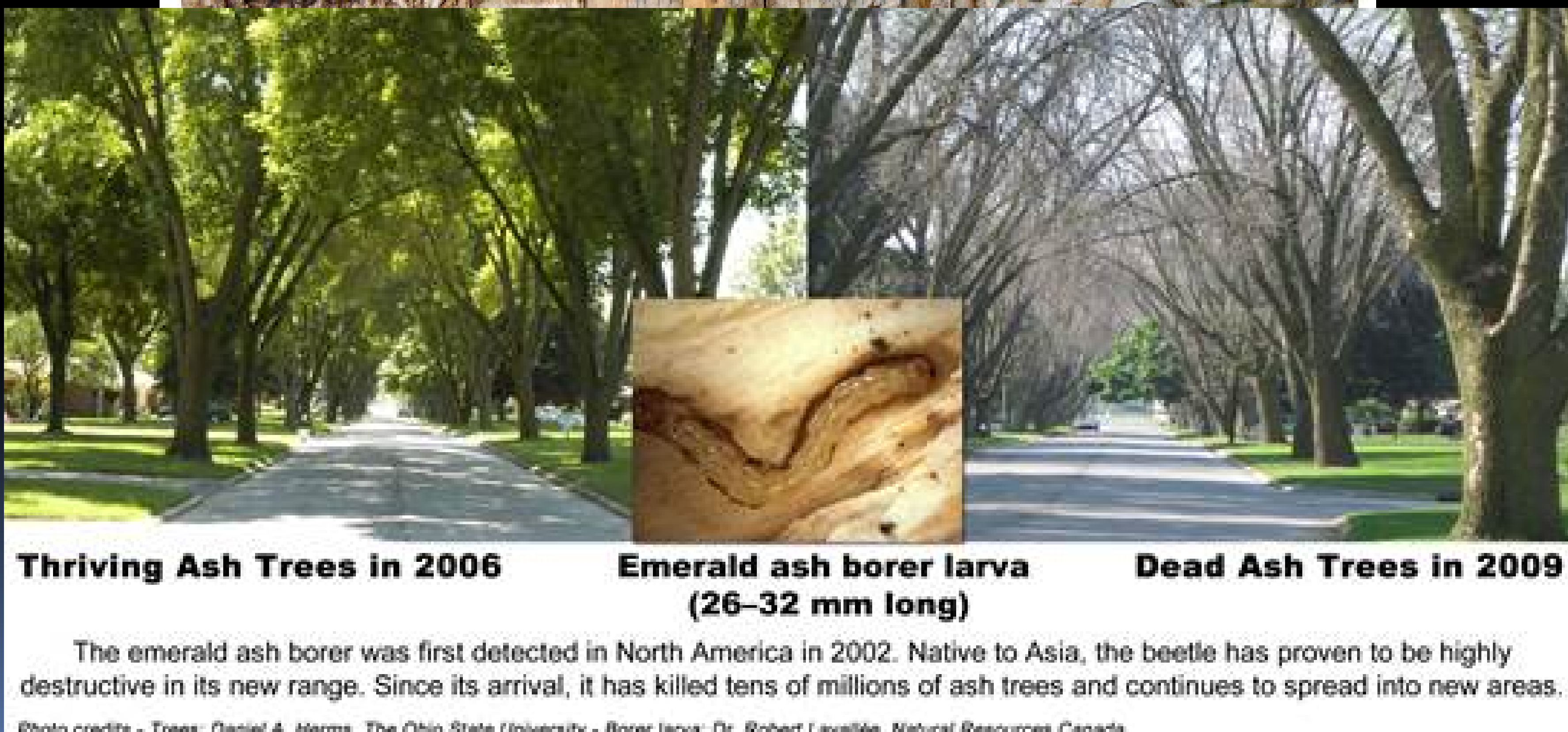
On a frigid morning this past March, arborist Will Blozan snuck behind a small church here and headed down into a gorge thick with rhododendron. He crashed through the shrubs until he spotted the gorge's treasure: the world's largest

park, "are in intensive care." Like the family of a gravely ill patient, ecologists are also preparing for the possibility that these efforts will fail, and the eastern forest will lose one of its defining species.

TSUGA CANADENSIS is one of eastern

branches, creating a thick canopy that blocks up to 99% of sunlight. Few plants grow in the gloom, but a hemlock seedling can bide its time for decades or more, waiting for a sunlit opening. Hundreds of species of insects, mites, and spiders appear to live primarily or exclusively in hemlock forests, and some

Emerald Ash Borer killing ~all ashes in USA – costing billions



Swiss Needle Cast in Oregon Douglas-fir – breeding ineffective

In summary

- Many examples show great progress on a wide variety of fronts
  - Mostly poplar
  - Despite very large social barriers and disinvestment over the last decade plus
- Extraordinary barriers based on biology and society – mainly GE process rather than product
  - Makes implementation of GE tools on a scale and speed relevant to need and benefit unworkable
- Need for fundamental regulatory and market change
  - Not likely in my lifetime ….

Has there been any mortality?