Transgenic trees

Remarkable progress, extraordinary constraints

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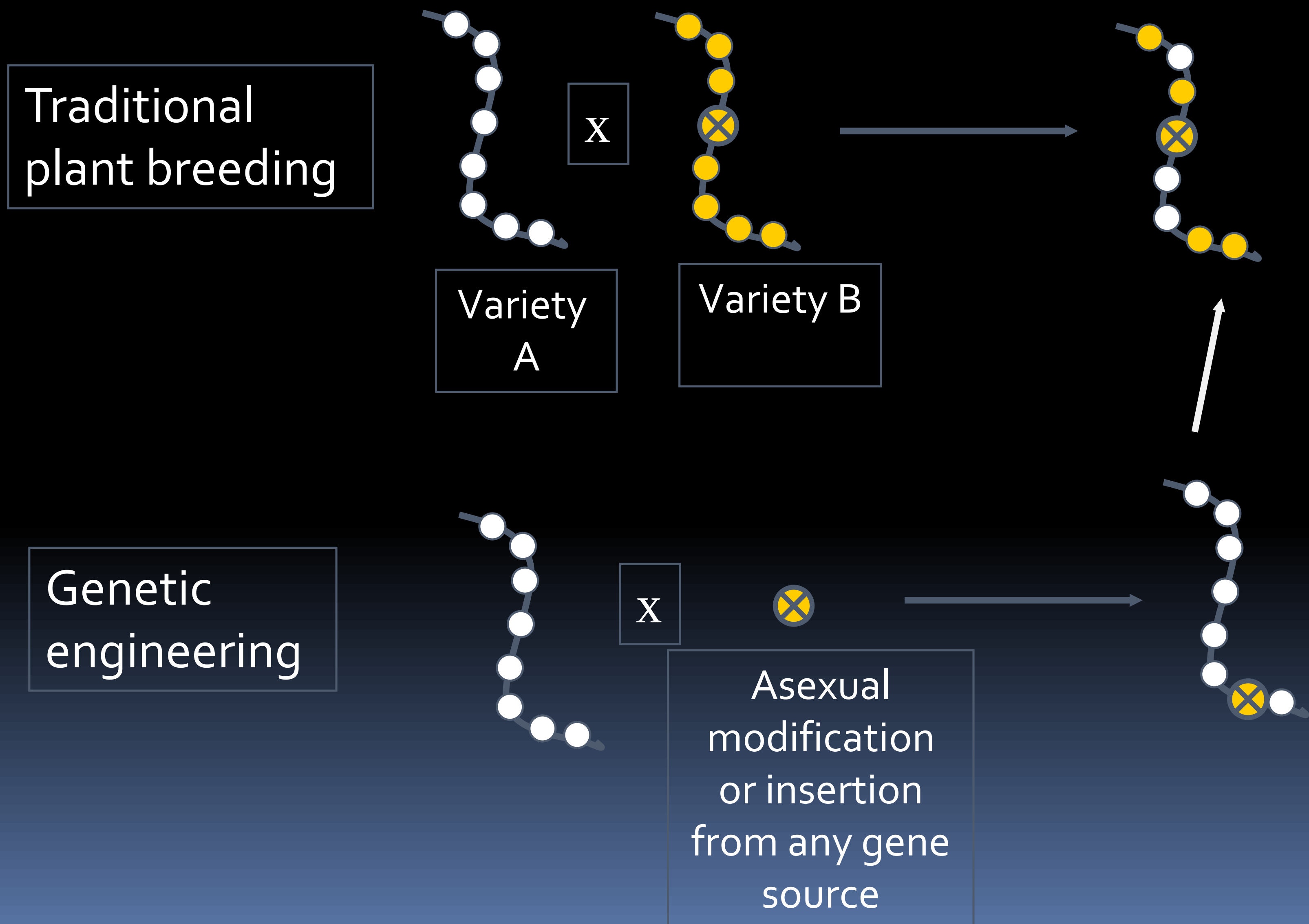
TM

Goals for today

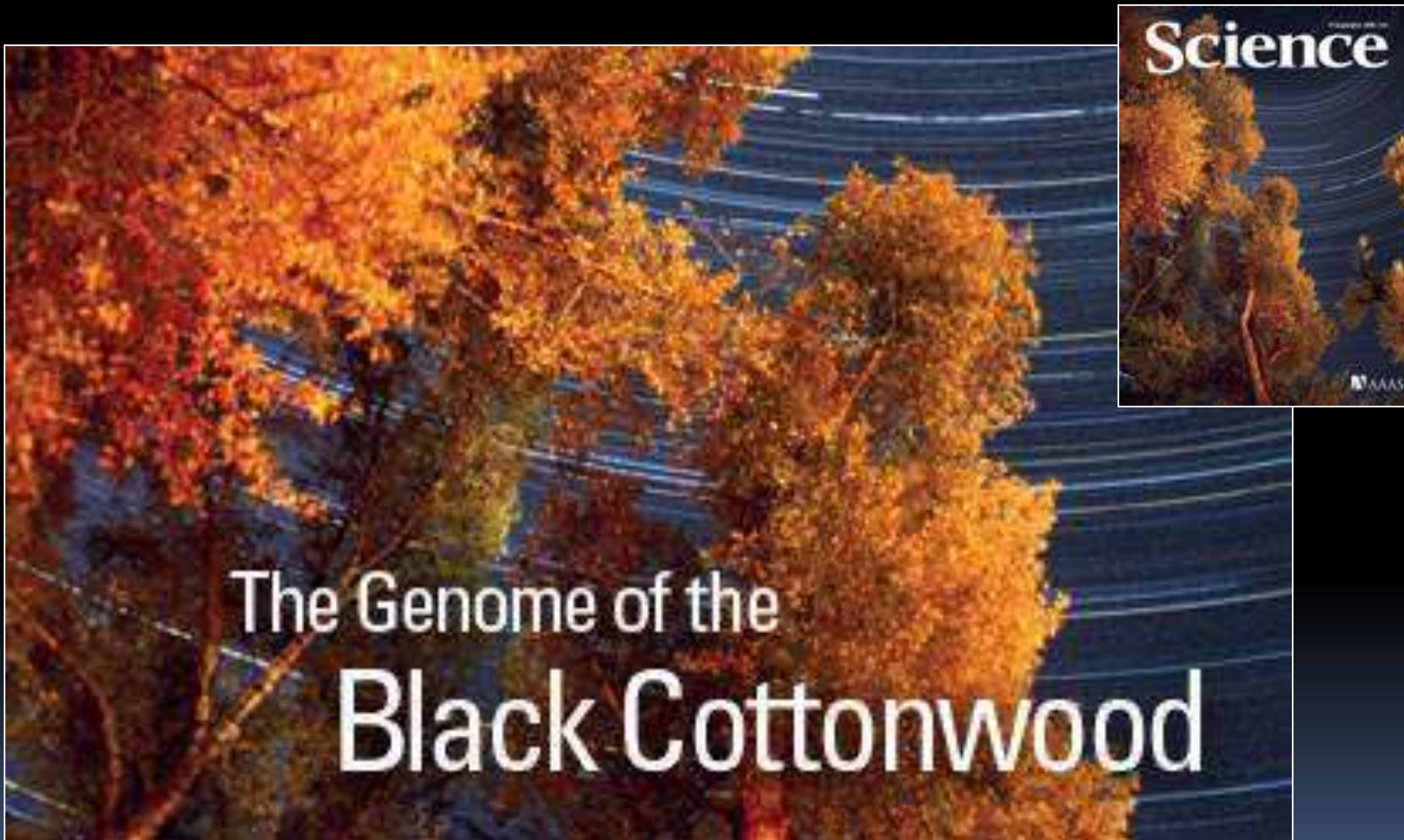
- GMOs defined, value of GMOs for trees and other woody perennials
  - Horticulture and forestry
- Overview of advanced GMO varieties in production or developmental pipelines
  - Examples from TBGRC Coop over the years
- Constraints and solutions

GMO method (genetic engineering) defined



Genomic progress helps lots

Poplar genome sequence – 3rd plant sequenced!



15 SEPTEMBER 2006 VOL 313 **SCIENCE** www.sciencemag.org

Eucalypt genome, transcriptome also in place

nature International weekly journal of science

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Archive > Volume 510 > Issue 7505 > Articles > Article

NATURE | ARTICLE OPEN

日本語要約

The genome of *Eucalyptus grandis*

Alexander A. Myburg, Dario Grattapaglia, Gerald A. Tuskan, Uffe Hellsten, Richard D. Hayes, Jane Grimwood, Jerry Jenkins, Erika Lindquist, Hope Tice, Diane Bauer, David M. Goodstein, Inna Dubchak, Alexandre Poliakov, Eshchar Mizrachi, Anand R. K. Kullan, Steven G. Hussey, Desre Pinard, Karen van der Merwe, Pooja Singh, Ida van Jaarsveld, Orzenil B. Silva-Junior, Roberto C. Togawa, Marilia R. Pappas, Danielle A. Faria, Carolina P. Sansaloni + *et al.*

New Phytologist

The floral transcriptome of *Eucalyptus grandis*

Kelly J. Vining[1], Elisson Romanel[2], Rebecca C. Jones[3], Amy Klocko[1], Marcio Alves-Ferreira[4], Charles A. Hefer[5], Vindhya Amarasinghe[1,6], Palitha Dharmawardhana[6], Sushma Naithani[6], Martin Ranik[7], James Wesley-Smith[8], Luke Solomon[9], Pankaj Jaiswal[6], Alexander A. Myburg[6] and Steven H. Strauss[10]

[1]Center for Genome Research and Biocomputing, Oregon State University, Corvallis, OR 97331, USA; [2]Departamento de Biotecnologia, Escola de Engenharia de Lorena, Universidade de São Paulo (EEL-USP), CP 116, 12602-810 São Paulo, Brazil; [3]School of Biological Sciences, University of Tasmania, Private Bag 55, Hobart, 7001 TAS, Australia; [4]Laboratório de Genética

Floral transcriptome a collaborative project of TBGRC Coop and Myburg laboratory and supporting companies

Constraints to breeding with trees are great – GMO methods offer very significant additional tools

Constraints include

- Long breeding cycle
- Difficult to inbreed
- Difficult to introgress new genes from hybrids
- Hard to find dominant, major genes for desired traits
- Common use of asexually propagated varieties of high value

GE of diverse value for trees

All demonstrated in the field

- Improved fruit quality/durability
- Resistance to insects and diseases
- Tolerance to salinity and temperature stress
- Phytoremediation of environmental toxins
- Modified properties to improve processing of wood for biofuels and pulp
- Tolerance to herbicides to reduce the environmental impacts, improve efficiency, or reduce costs of weed control treatments

GE of diverse value for trees

All demonstrated in the field

- Accelerated flowering for faster breeding and research
- Fertility control for control of spread and improved growth
- Improved growth rate and yield
- Synthesis of new, renewable bioproducts such as fragrances and chemical feedstocks

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RNAi a powerful tool

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

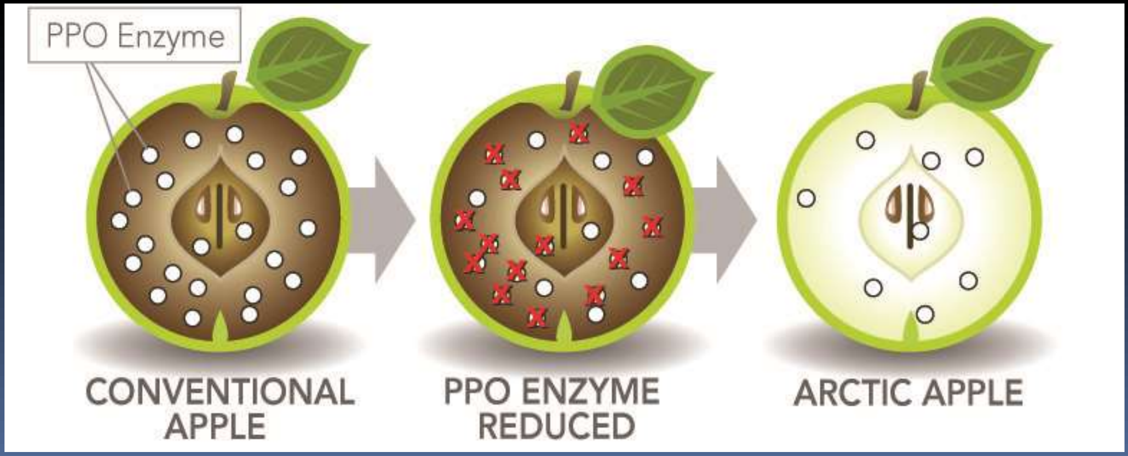
Non-GE

- **Virus resistance using this method also successful for cassava and many other species**
- **RNAi recently demonstrated for <u>insect</u> resistance – corn rootworm product under development**

Non-browning “Arctic Apple”

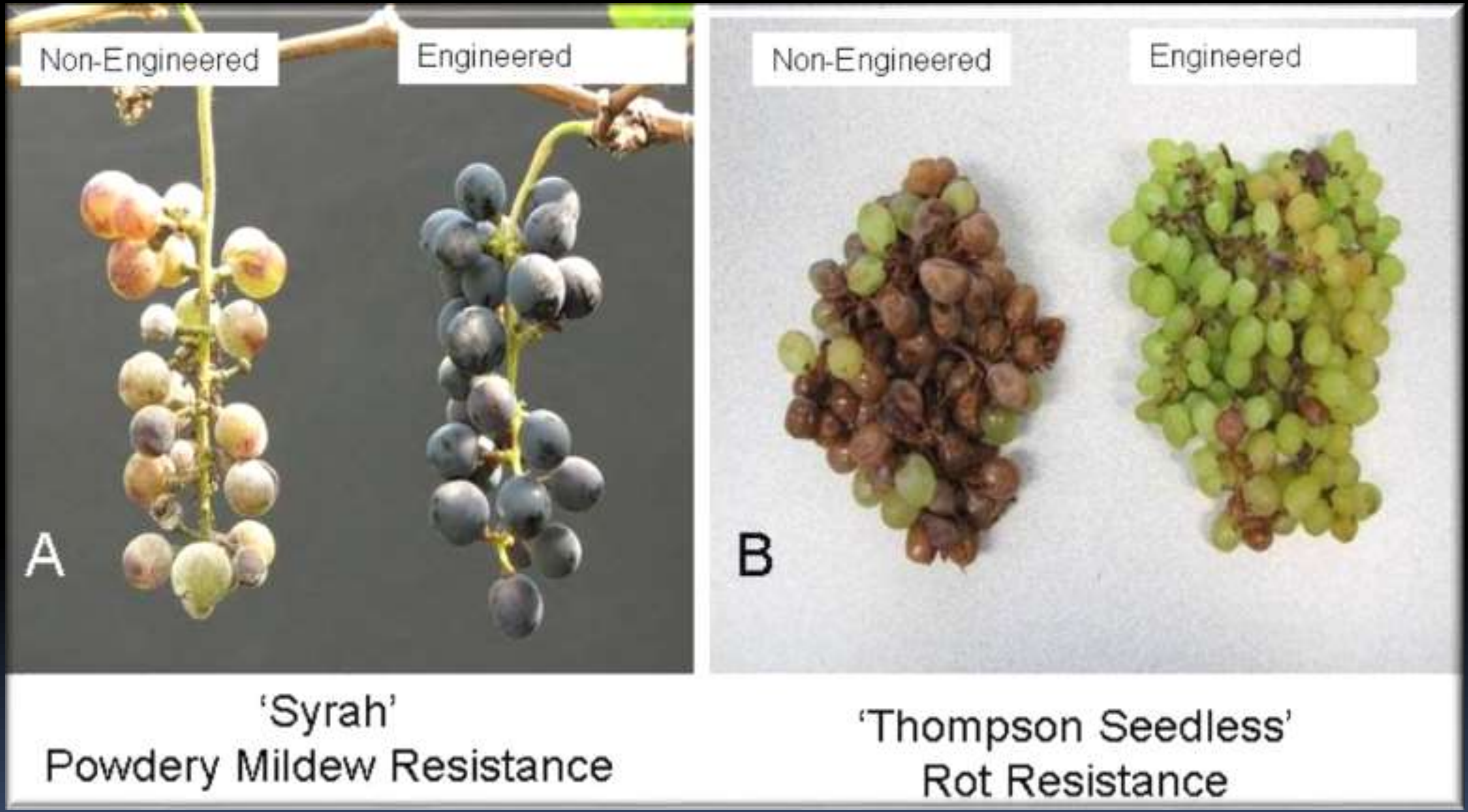
RNAi suppression of native polyphenol oxidase gene expression

Courtesy of Jennifer Armen, Okanagan Specialty Fruits, Canada



Native grape genes used to produce fruit rot resistance

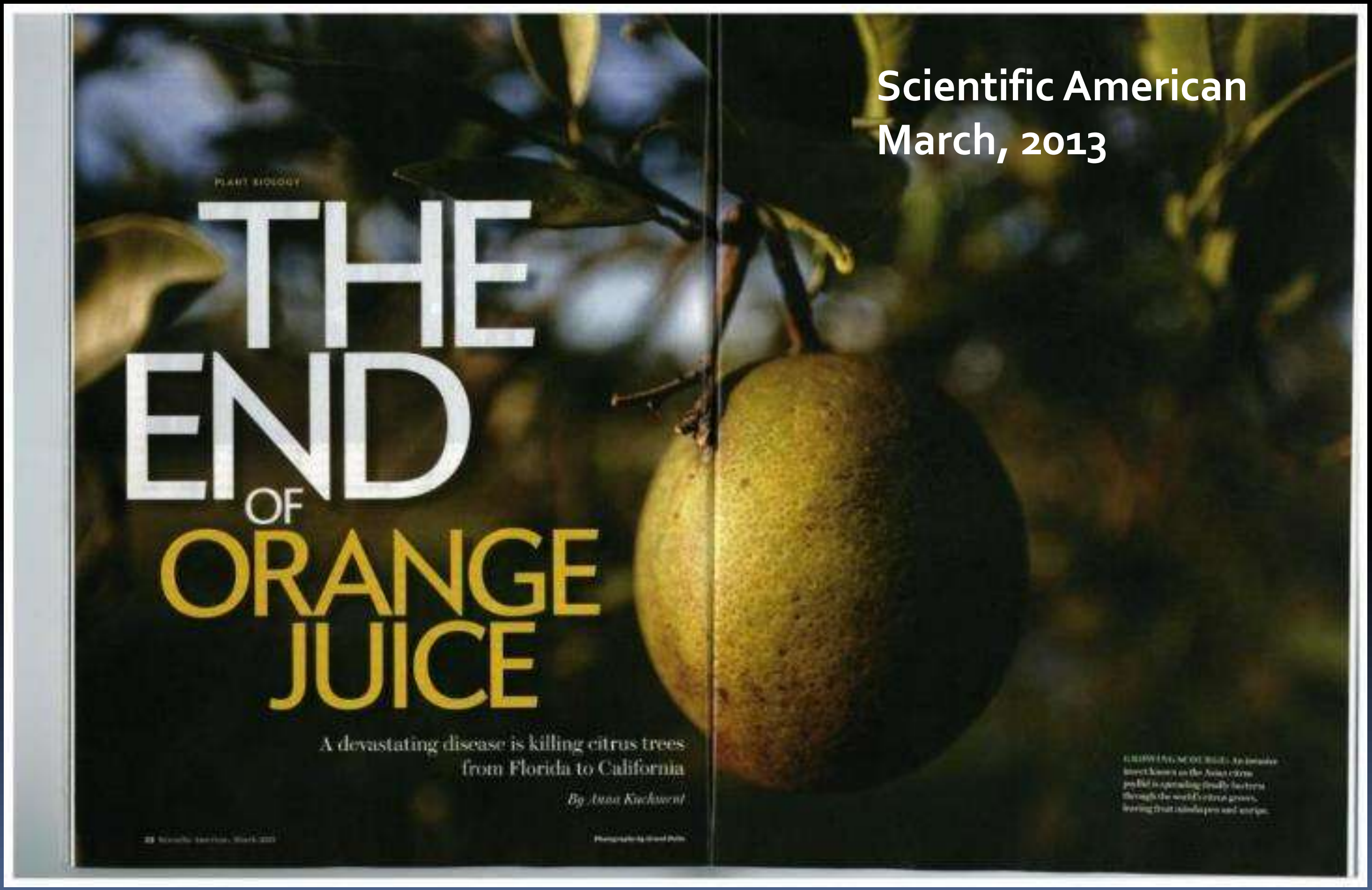
***Grape* VvAlb gene** **Grape VvTL-1 gene**



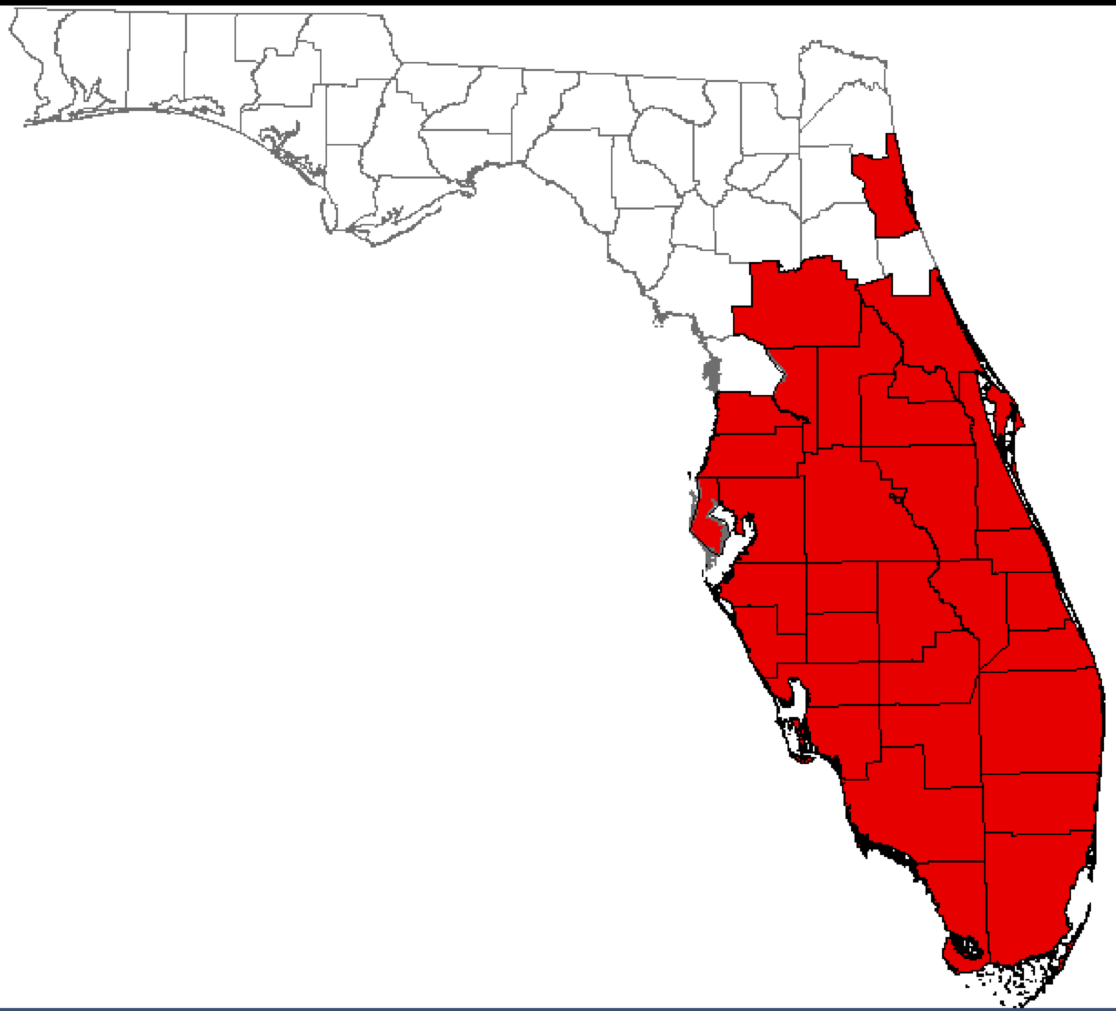
Courtesy of Denis Gray, UF/IFAS Mid-Florida Research & Education Center

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

Resistance transgenes promising solution/s to devastating 'citrus greening'



Rapid spread throughout Florida and of great concern in other citrus growing areas



32 counties

Courtesy of Eric Mirkov, Texas A & M

Defensin-like proteins from spinach promising

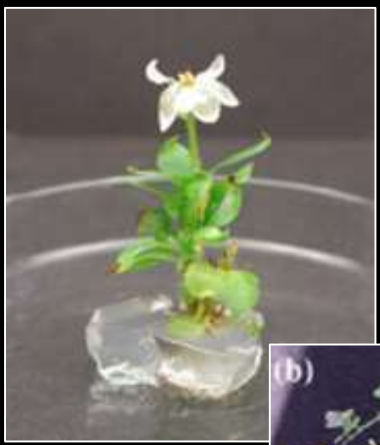

Courtesy of Eric Mirkov, Texas A & M

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

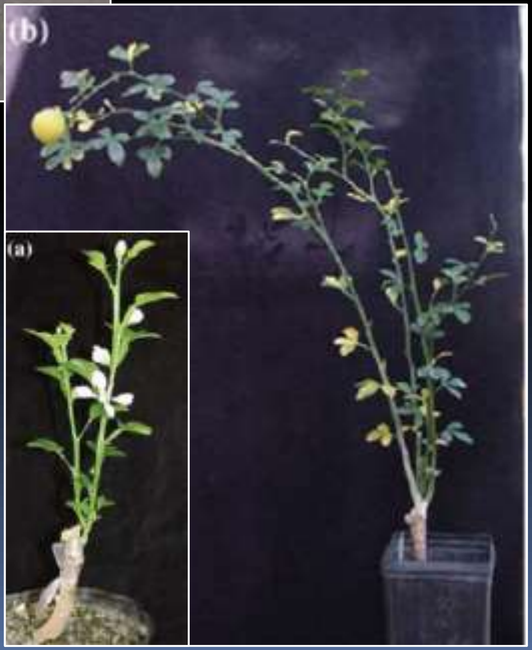
Courtesy of Manjul Dutt and Jude Grosser, Citrus Research and Education Center, Florida, USA

Overexpression of endogenous flowering genes induce early-flowering in many trees

Apple



Orange



Plum

Poplar

Rapid flowering of plum in the field to speed virus resistance breeding

Courtesy of Ralph Scorza, USDA ARS

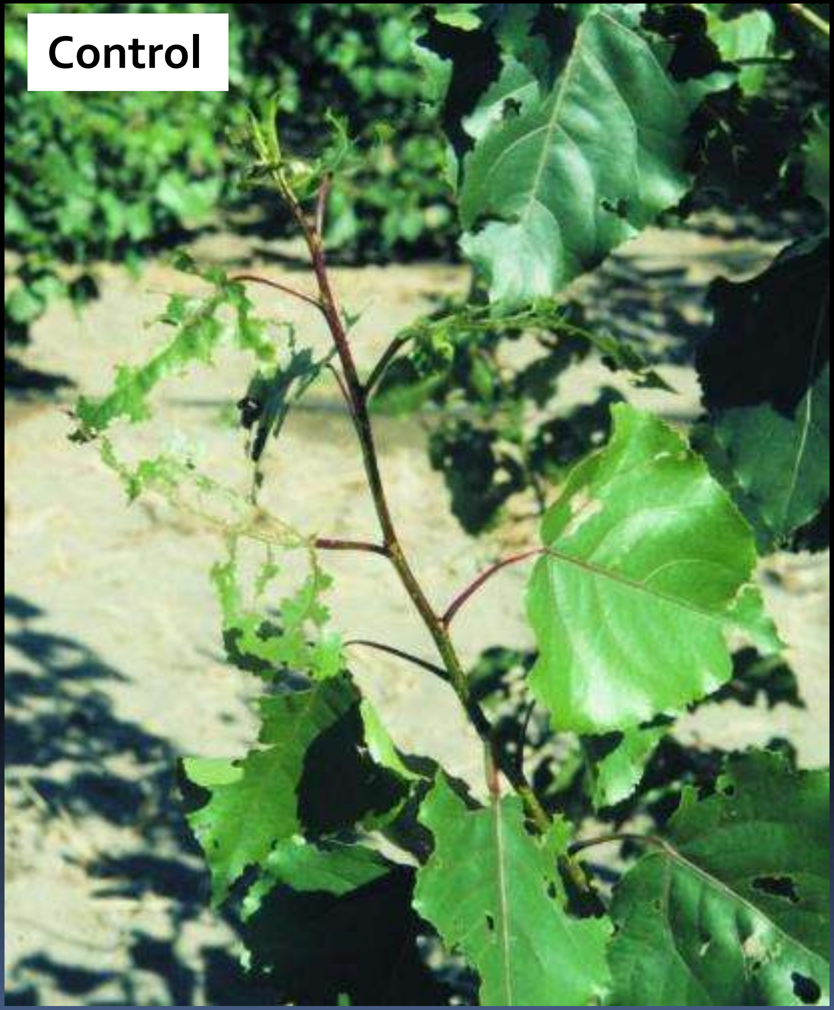
TBGRC Coop: Early flowering effective in eucalypts

Valuable to speed breeding and genomic selection

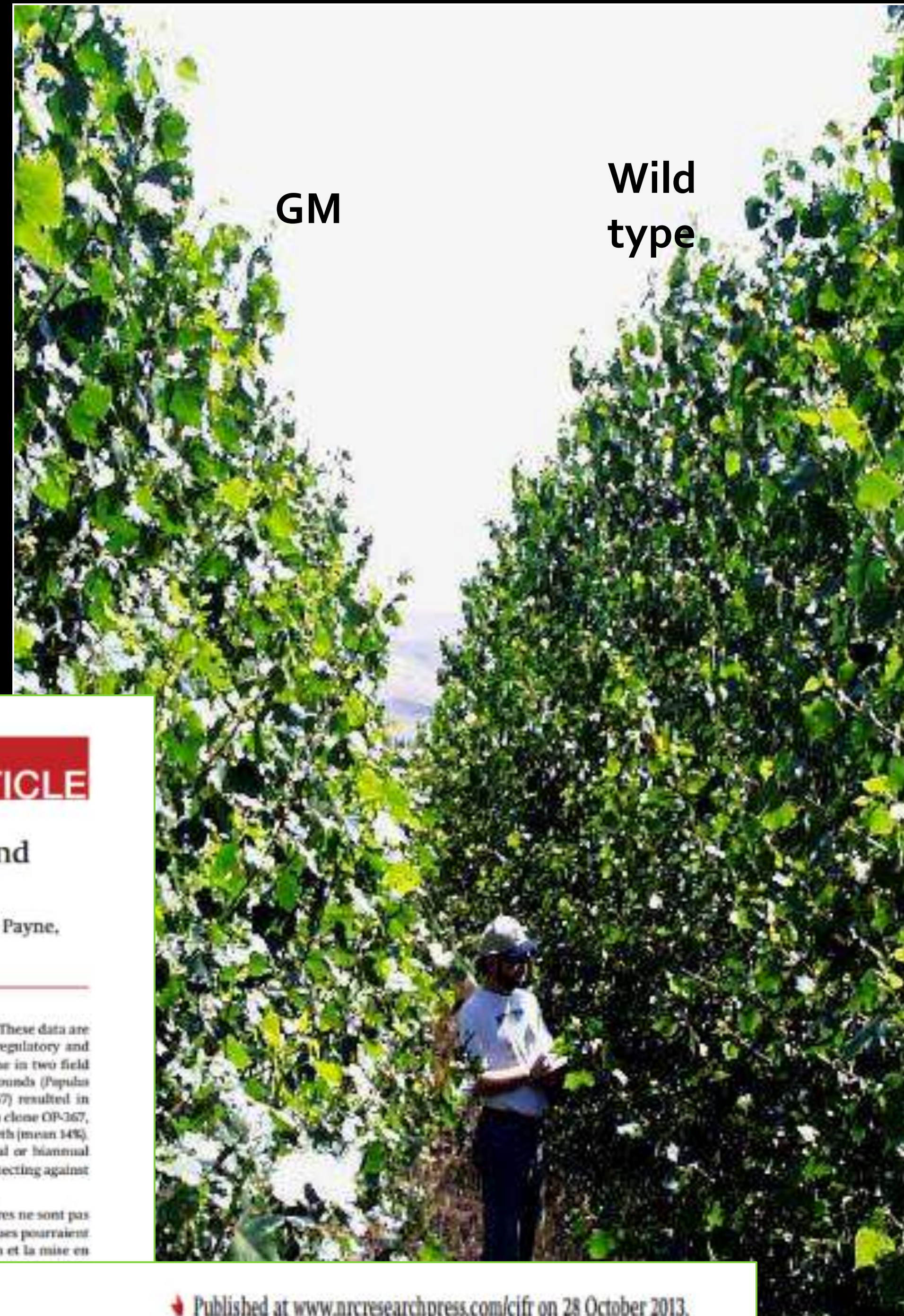
Caterpillar (leptidopteran)-resistant poplars commercially approved in China - *Bt cry1*

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

TBGRC: Beetle resistant Bt-cottonwoods in eastern Oregon field trial



TBGRC: 10-20% growth benefits despite low insect pressure during field trial



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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 connues. Ces données sont essentielles si l'on veut déterminer dans quelle mesure de tels arbres transgéniques pourraient être profitables pour des producteurs commerciaux considérant les coûts substantiels reliés à la réglementation et la mise en marché de tels arbres

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.

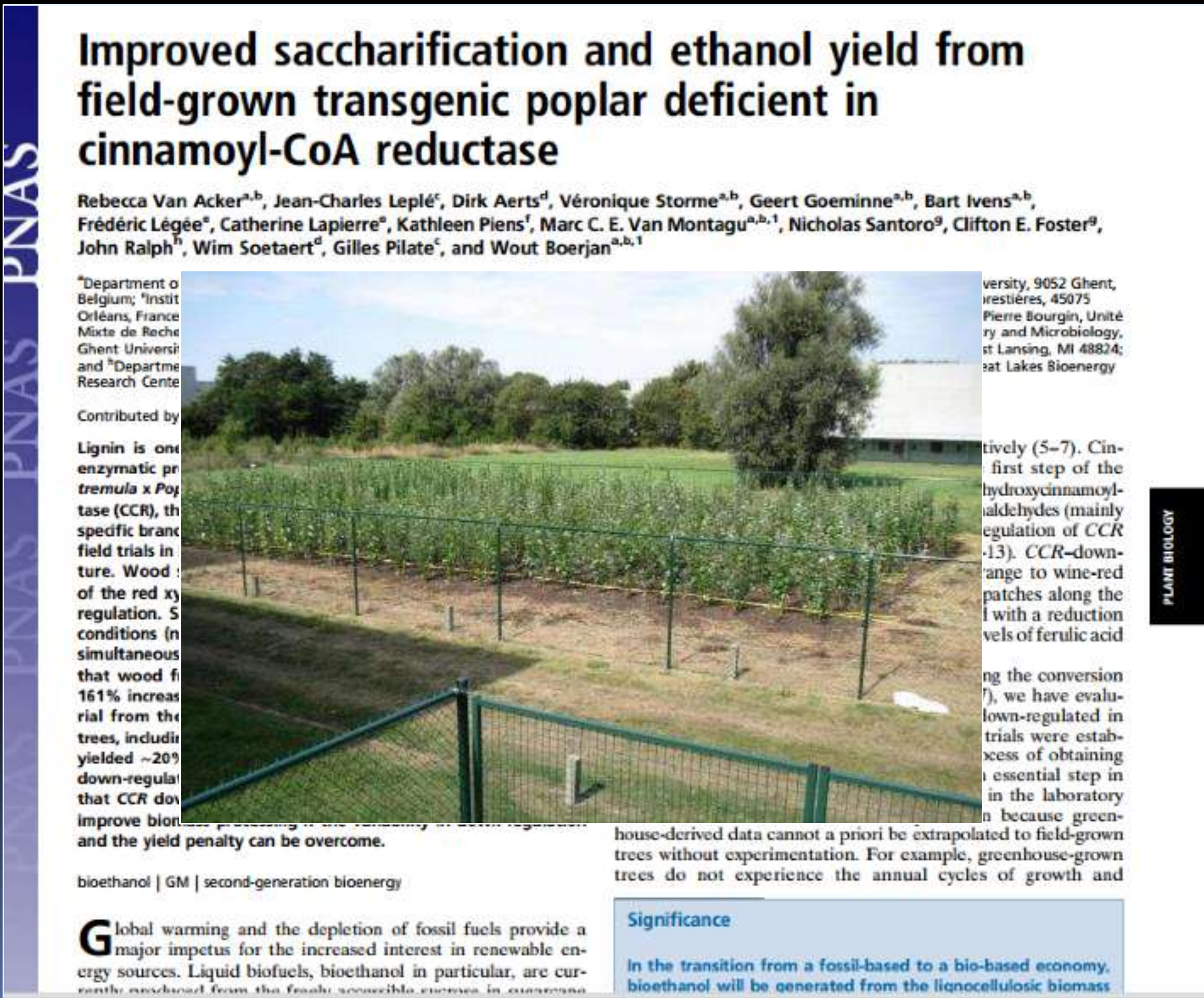
TBGRC: Glyphosate herbicide resistance in the field gave ~ 20% growth improvement

Screen of primary transformants

2 yr-old field trial

Wild type controls

Lignin-modified trees in Belgium, France gave large improvements in ethanol or pulp yield



PNAS

Improved saccharification and ethanol yield from field-grown transgenic poplar deficient in cinnamoyl-CoA reductase

Rebecca Van Acker[a,b], Jean-Charles Leplé[c], Dirk Aerts[d], Véronique Storme[a,b], Geert Goeminne[a,b], Bart Ivens[a,b], Frédéric Légée[e], Catherine Lapierre[e], Kathleen Piens[f], Marc C. E. Van Montagu[a,b,1], Nicholas Santoro[g], Clifton E. Foster[g], John Ralph[h], Wim Soetaert[d], Gilles Pilate[c], and Wout Boerjan[a,b,1]

and the yield penalty can be overcome.

bioethanol | GM | second-generation bioenergy

Global warming and the depletion of fossil fuels provide a major impetus for the increased interest in renewable energy sources. Liquid biofuels, bioethanol in particular, are cur-

house-derived data cannot a priori be extrapolated to field-grown trees without experimentation. For example, greenhouse-grown trees do not experience the annual cycles of growth and

Significance

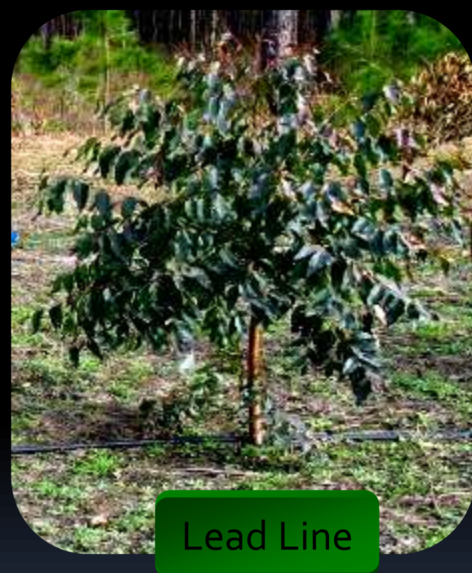
In the transition from a fossil-based to a bio-based economy, bioethanol will be generated from the lignocellulosic biomass

PLANT BIOLOGY

Freeze-tolerant, male-sterile *Eucalyptus*

Proposed for commercial deregulation in USA

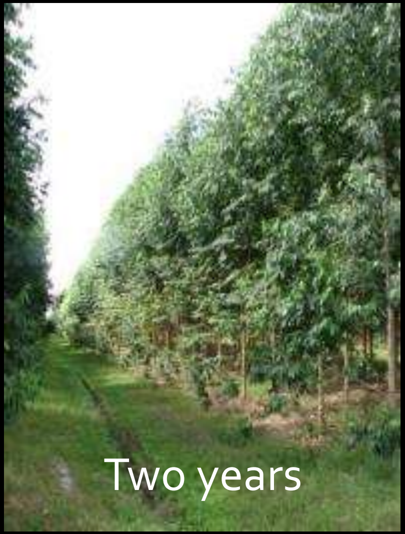
Results from first winter in South Carolina



Results from second winter in Alabama

Provided by Arborgen

Many eucalypt field trials underway



Courtesy of Les Pearson, Arborgen

Growth improved GE *Eucalyptus* (Futuragene)

Proposed for commercial use in Brazil

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.

BY HEIDI LEDFORD

Viewed from above, Brazil's orderly eucalyptus plantations offer a stark contrast to the hurly-burly of surrounding native forests. The trees, lined up like regiments of soldiers on 3.5 million hectares around the country, have been bred over decades to grow quickly.

On 4 September, a public hearing will consider bringing an even more vigorous recruit into the ranks: genetically engineered eucalyptus that produces around 20% more wood than conventional trees and is ready for harvest in five and a half years instead of seven. Brazilian regulators are evaluating the trees for commercial release; a decision could come as early as the end of this year.

Researchers, businesses and activists are watching closely. Eucalyptus (*Eucalyptus* spp.) — native to Australia — is grown on about 20 million hectares throughout the tropics and subtropics, and approval of the genetically engineered trees in Brazil could encourage their adoption elsewhere. "It would have ripple effects

a large scale. The ubiquity of eucalyptus makes Brazil's decision on the modified trees a special concern to environmental activists who oppose the use of genetically modified crops.

"They have become the target of very intensive and emotionally charged debate particularly among the NGOs and nature constituencies," says Walter Kollert, a forestry officer with the Food and Agriculture Organization of the United Nations in Rome.

A consortium of activists opposed to the plan intends to present a letter at the 4 September meeting, urging Brazil's National Technical Biosafety Commission to reject the trees. In all, 259 organizations — 106 of them from Latin America — have signed the letter, which expresses concern that the trees pose risks to the environment and will encourage the expansion of plantations.

The trees were developed by FuturaGene, a biotechnology firm in Rehovot, Israel, that was spun out of the Hebrew University in Jerusalem in 1993. The company found that certain proteins accelerate plant growth by facilitating cell-wall expansion. FuturaGene inserted into

FuturaGene's chief executive Stanley Hirsch is quick to point out the environmental benefits of his company's creation. The tree's speedy growth boosts absorption of carbon dioxide from the air by about 12%, he says, aiding in the fight to reduce greenhouse-gas emissions. The genetically modified trees may also require less land to produce the same amount of wood, reducing the conversion of natural forest into plantations.

Hirsch says that the company has tried to avoid public-relations mistakes made by agricultural biotechnology companies in the past: rather than shun activists, he has invited them to tour the company's field-trial sites. "Some of them were so surprised," he says. "They said, 'Wow, these look just like normal trees.'"

Hirsch's pitch has not convinced everyone. Anne Petermann, executive director of the non-profit organization Global Justice Ecology Project in Buffalo, New York, says that FuturaGene is trying to stave off opposition by 'greenwashing' its product. Faster-growing trees require more water and extract more nutrients from the soil, she adds, and they will only add to the economic incentive to seed more plantations.

Genetically engineered trees do pose some biosafety issues that do not apply to agricultural crops such as maize (corn) or soya, notes forest geneticist Steven Strauss of Oregon State University in Corvallis. They remain in the environment for years, increasing their potential impact on the plants, animals and soil around them. And trees tend to disperse pollen further than crops nearer the ground do, raising concerns about gene flow to native relatives. But eucalyptus has no native relatives in Brazil and is not particularly invasive in most areas of the country, says Strauss.

FuturaGene says that it identified no major environmental problems in eight years of field trials that collected data on everything from gene flow to leaf-litter decomposition to the composition of honey made by bees that visit the trees. Myburg, who does not work with FuturaGene but is familiar with the company's safety data, says that he found the firm's studies to be well designed and thorough.

While FuturaGene tests the waters in Brazil, a US company awaits a regulatory decision regarding its genetically engineered, freeze-tolerant eucalyptus. In 2008, ArborGen of Ridgeville, South Carolina, petitioned the US Department of Agriculture to allow commercialization of the trees in the southeastern United States. Delays of this length are not uncommon in the US regulatory system, says ArborGen's director of regulatory affairs Leslie Pearson.

For now, just the prospect that the trees might be approved has been enough to rally

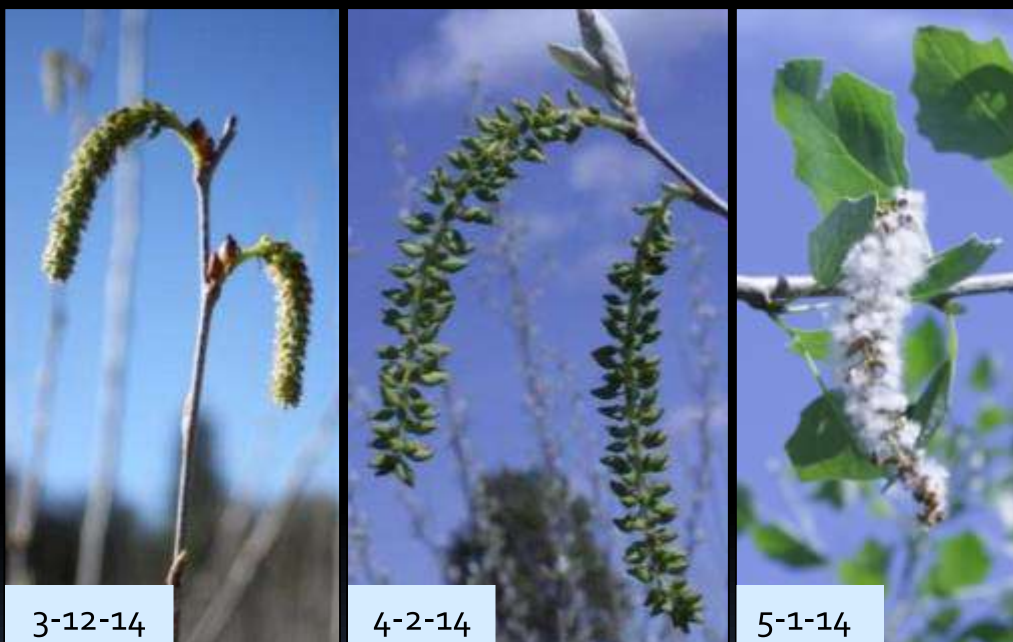
28 AUGUST 2014 | VOL 512 | NATURE | 357

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

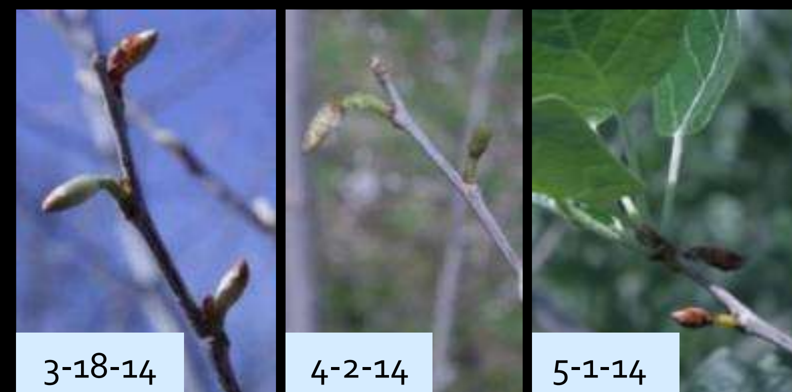
TBGRC: RNAi for complete sterility

RNAi field trial of poplar in Oregon: 25 constructs, 3 genotypes, 4,000 trees, 9 acres
(similar studies begun in eucalypts)

After maturation, RNAi:*LFY* catkins remained tiny and did not produce seeds or cotton

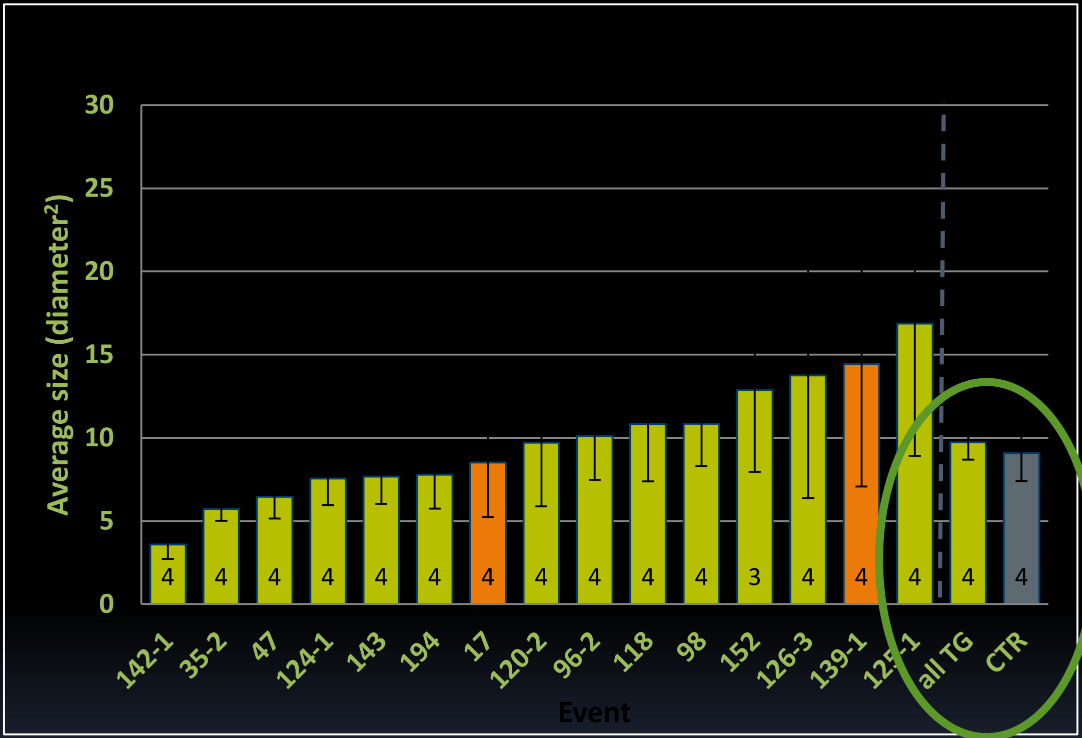


Control



RNAi-LFY

RNAi:*LFY* trees had robust vegetative growth



Events with tiny flowers had no differences in tree size, total leaf chlorophyll, leaf density or leaf area as compared to controls

TBGRC studies: Resaerch underway on site-directed mutagenesis in poplar and eucalpyts

NEWS & VIEWS

PLANT BIOTECHNOLOGY

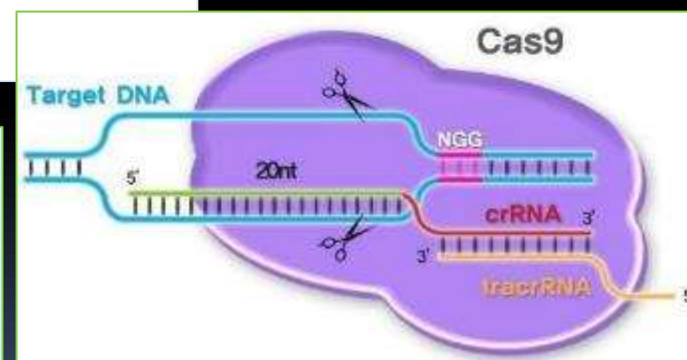
Zinc fingers on target

NATURE|Vol 459|21 May 2009

Matthew H. Porteus

The existing methods of creating genetically modified plants are inefficient and imprecise. Zinc-finger technology offers the prospect of opening up a swifter and more exact route for crop improvement.

CRISPRS



TALENs

Many exotic diseases have damaged or ravaged North American forests

<u>**Examples**</u>

1892 - White pine blister rust

1904 - Chestnut blight

1923 - Port-Orford-cedar root disease

1920s - Beech scale complex

1930 - Dutch elm disease

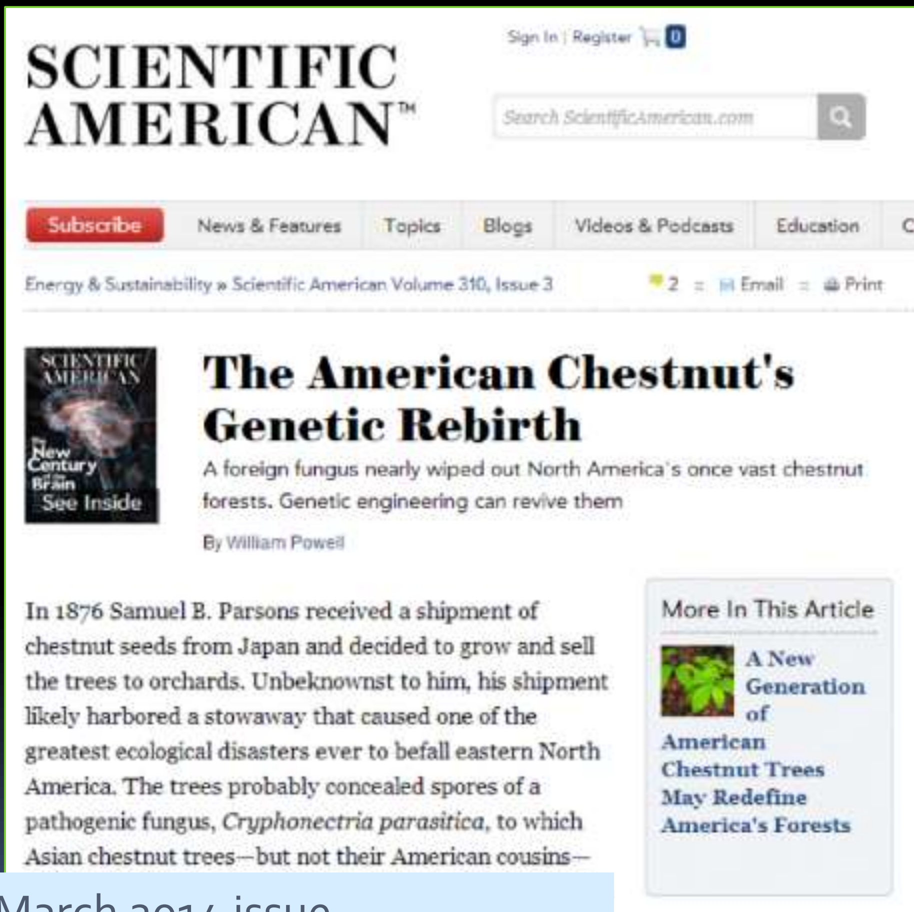
1967 - Butternut canker

1976 - Dogwood anthracnose

2000s - Sudden oak death

American elm

American Chestnut most advanced case with GE approach



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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—

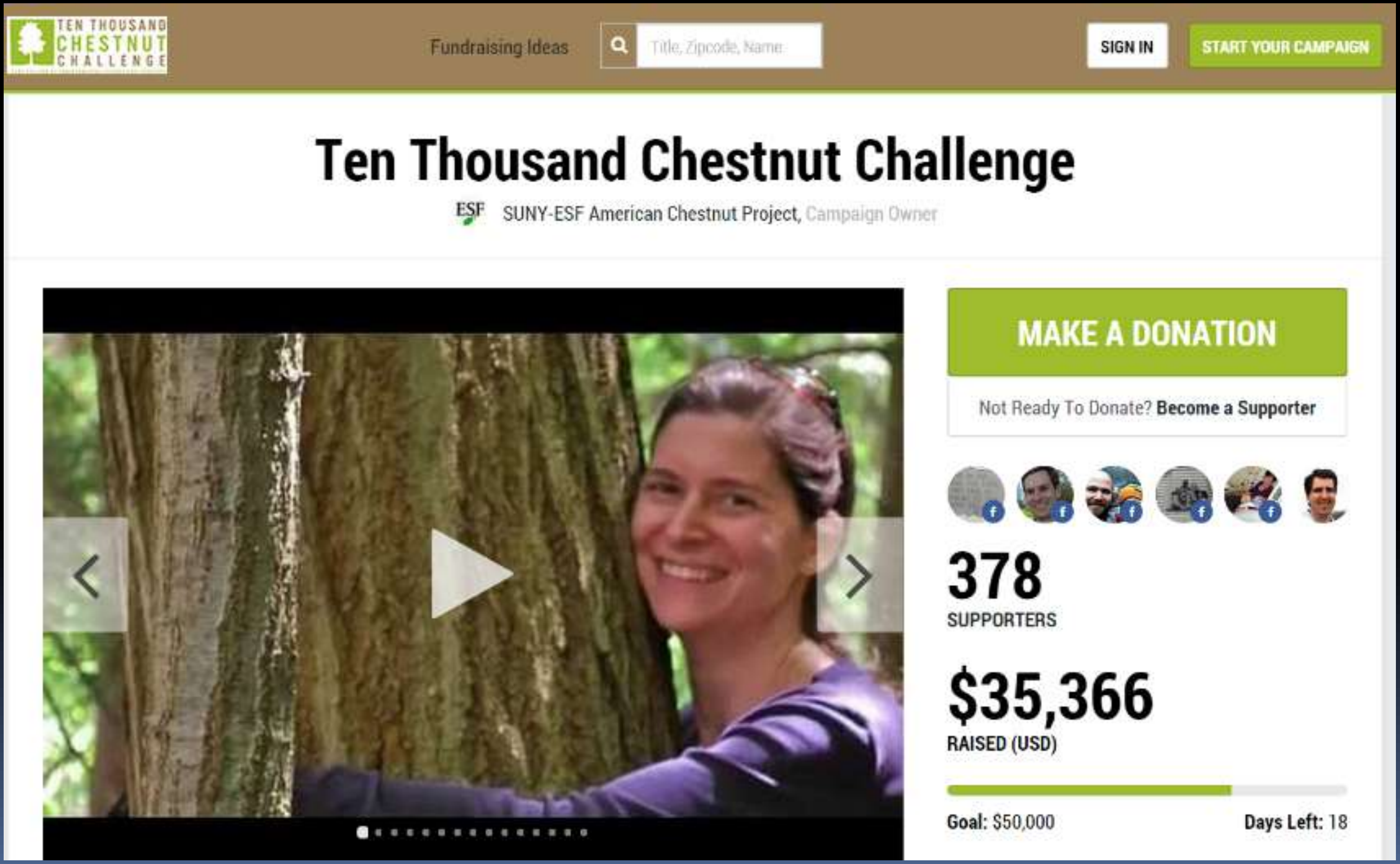
More In This Article

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

March 2014 issue
Scientific American

Courtesy of Bill Powell, SUNY Syracuse, USA

Crowdfunding campaign to fund GE chestnut work



https://fundly.com/10-000-chestnut-challenge

November 17, 2014

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.

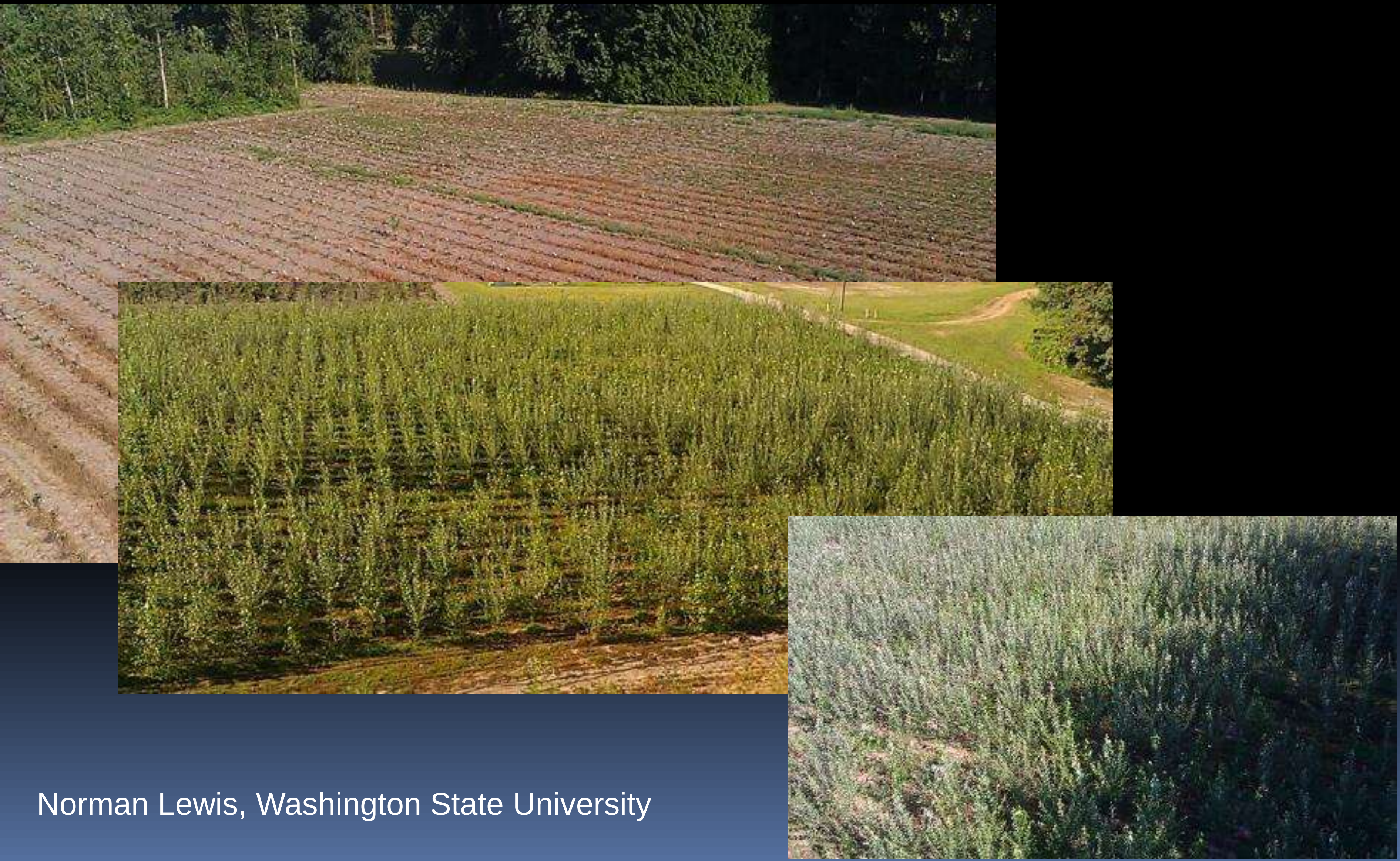
Sweeter still is the fact that perfume and cosmetics companies will pay as much as $30 an ounce for the compound that gives roses their characteristic aroma. Because what Lewis and his colleagues at Washington State University are really chasing is the smell of money.

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

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- Constraints and solutions

“Green” certification of forests create severe barriers to research and development

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

FSC

Forest Stewardship Council

“…genetically modified trees are prohibited…”

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 registration / No additional rati
CSA : Canadian Standards Association	Canada	**Banned** via PEFC reg Allows public to de approach
CFCC : China Forest Certification Council	China	**Banned** via PEFC reg No additional rati

Adam Costanza, Institute for Forest Biotechnology

Global admixture of GM and non-GM crops/food create immense coexistence, trade problems under current regulations

Many costly cases of trade disruption and lawsuits with corn, soy, and rice


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Steady increase in incidents of genetically modified crops found in traded food, UN agency reports

Source: UN Photo/Tobin Jones

Source: UN Photo/Tobin Jones

14 March 2014 – As a result of the increased production of genetically modified crops worldwide, the United Nations food agency warns in a ground-breaking survey that an increasing number of incidents of low levels of genetically modified organisms (GMOs) are being reported in traded food and feed.

18
Like

http://www.un.org/apps/news/story.asp?NewsID=47354&Cr=food+security&Cr1=#.UySzoPldVUV

Oregon GMO “wheat-gate” shows the risk in doing research

OREGON'S ACCIDENTAL CROP

The discovery of GE wheat highlights regulatory failures

BRENT WOJAHN/THE OREGONIAN

Wheat grows near Condon in north-central Oregon. Rogue genetically modified wheat found in an eastern Oregon field has prompted debate over how to contain, and how the U.S. regulates, genetically engineered crops.

trials, ensure that performance standards are met and trace back the source of contamination that might occur as a result of GE experiments. This lack of basic information not only hampers the government, but also threatens the agricultural

An agreed safe, well studied, extremely rare GMO left over from earlier research nearly crippled Pacific Northwest trade in wheat, led to lawsuits

Op-Ed in Oregonian
June 16, 2013

The problem worse for most forest trees

Molecular Ecology (2009) **18**, 357–373

doi: 10.1111/j.1365-294X.2008.04016.x

Extensive pollen flow in two ecologically contrasting populations of *Populus trichocarpa*

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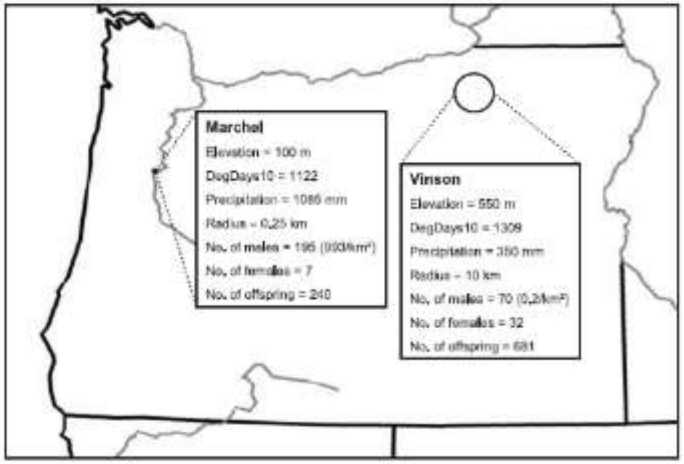

Gene dispersal during research and breeding a serious regulatory problem under USA system

Impedes or prevents complex trait testing, breeding with such genes

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 / BioScience

An example of the perverse risks of presumption of harm, method-based regulation

The strange case of the upright summer catkin

802
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Proposed regulatory solutions

Tiered regulation, product not process

GENETIC TECHNOLOGIES

POLICY FORUM

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.

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 incorporating new diversity into crop varieties, experience from two decades

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 crop income[9]. Of this, the only transgenic commodities currently mar-

Gene targeting, genome editing, coming along fast

= increased precision, safer than breeding

PLANT BIOTECHNOLOGY

NEWS & VIEWS

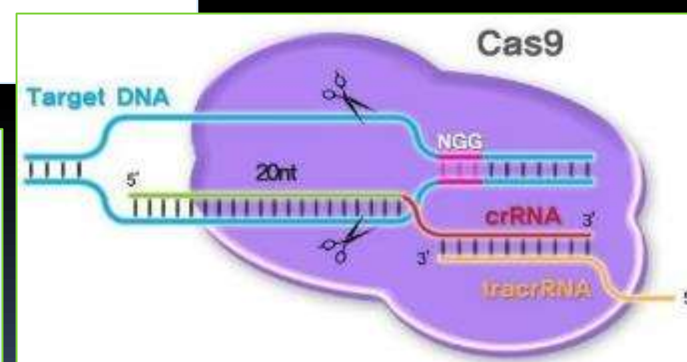
Zinc fingers on target

NATURE|Vol 459|21 May 2009

Matthew H. Porteus

The existing methods of creating genetically modified plants are inefficient and imprecise. Zinc-finger technology offers the prospect of opening up a swifter and more exact route for crop improvement.

CRISPRS



TALENs

Suggested regulatory modifications

- Approved, familiar markers and gene transfer systems based on approvals in other crops
- Mutagenesis of transformation system
- Cisgenic transfers from similar or closely related species (e.g., within genus)
- Modification of expression of native genes and pathways (intragenic)
- Genome editing or mutagenesis
- Low level presence due to authorized research or asymmetric approvals in trade

In summary

- Remarkable progress with transgenic trees on a wide variety of fronts
- Extraordinary regulatory barriers based on the process rather than the product
  - At odds with basic biology, breeding practice, genomic knowledge
  - USA National Academy of Sciences 1987
    "There is no evidence that unique hazards exist either in the use of rDNA techniques or in the movement of genes between unrelated organisms"
- Need for regulatory, certification changes to enable expanded research and breeding

Billions are struggling now, and it's a very scary future – agriculture and forestry of all kinds will become <u>much</u> more difficult

Billions are struggling now, and it’s a very scary future – agriculture and forestry of all kinds **are becoming** much more difficult

No-analog thinking

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 global-change ecologists, who seek to understand ecolog- past or future, is heavily conditioned by our current observations and personal experience.

The further our explorations carry us from the present

"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."

Are our regulations and certification systems worrying too much about the deck chairs on the Titanic, rather than providing tools for improved navigation of the ship?

Voltaire was right….

The perfect is the enemy of the good