Strauss laboratory work – past and present

November 2022

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Agenda

- Some background
- GREAT TREES Coop
- Research examples looking back and forward – field focus
- Social/interdisciplinary work

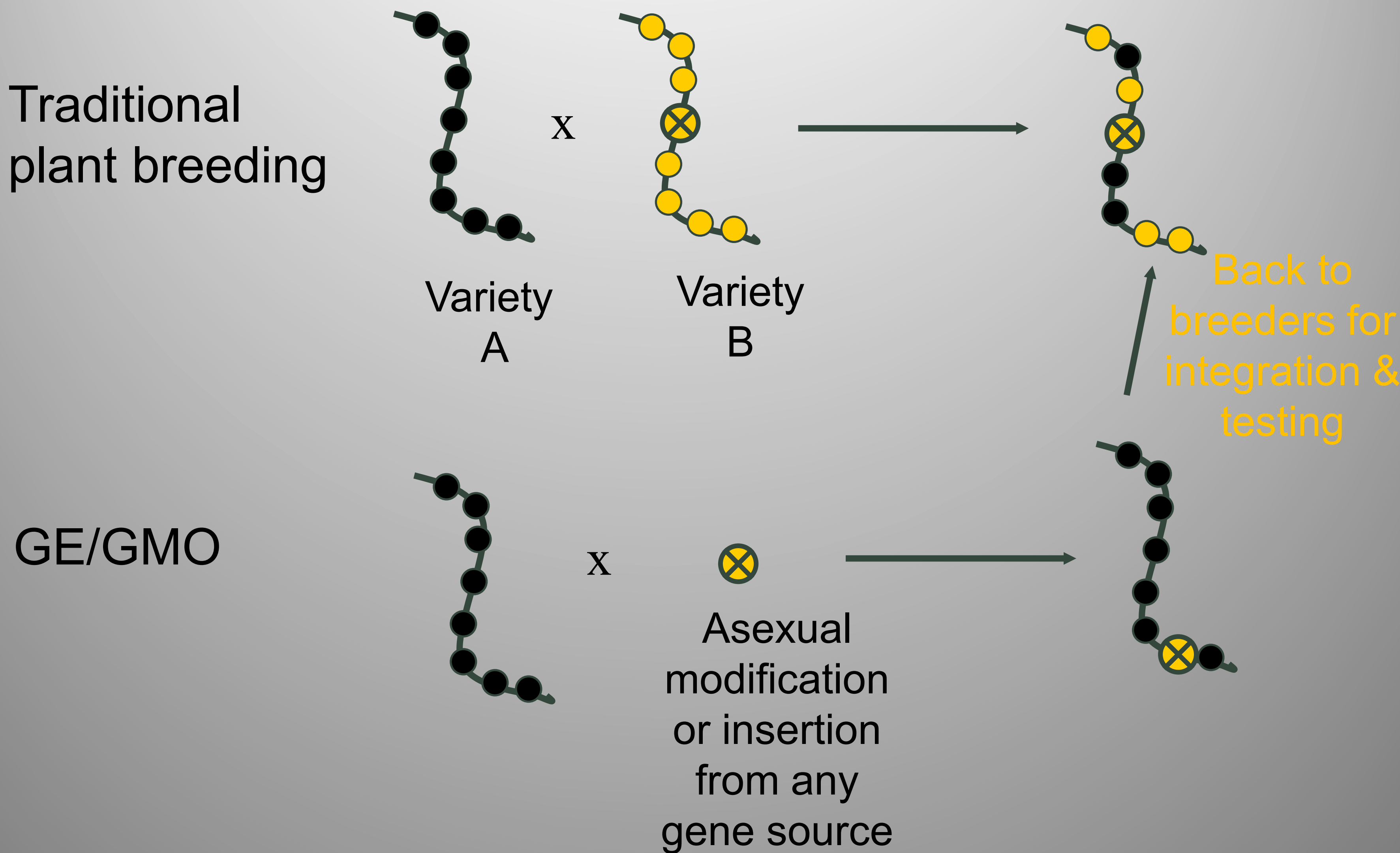
- All recent pubs here
- All recent presentations here

Aims of lab

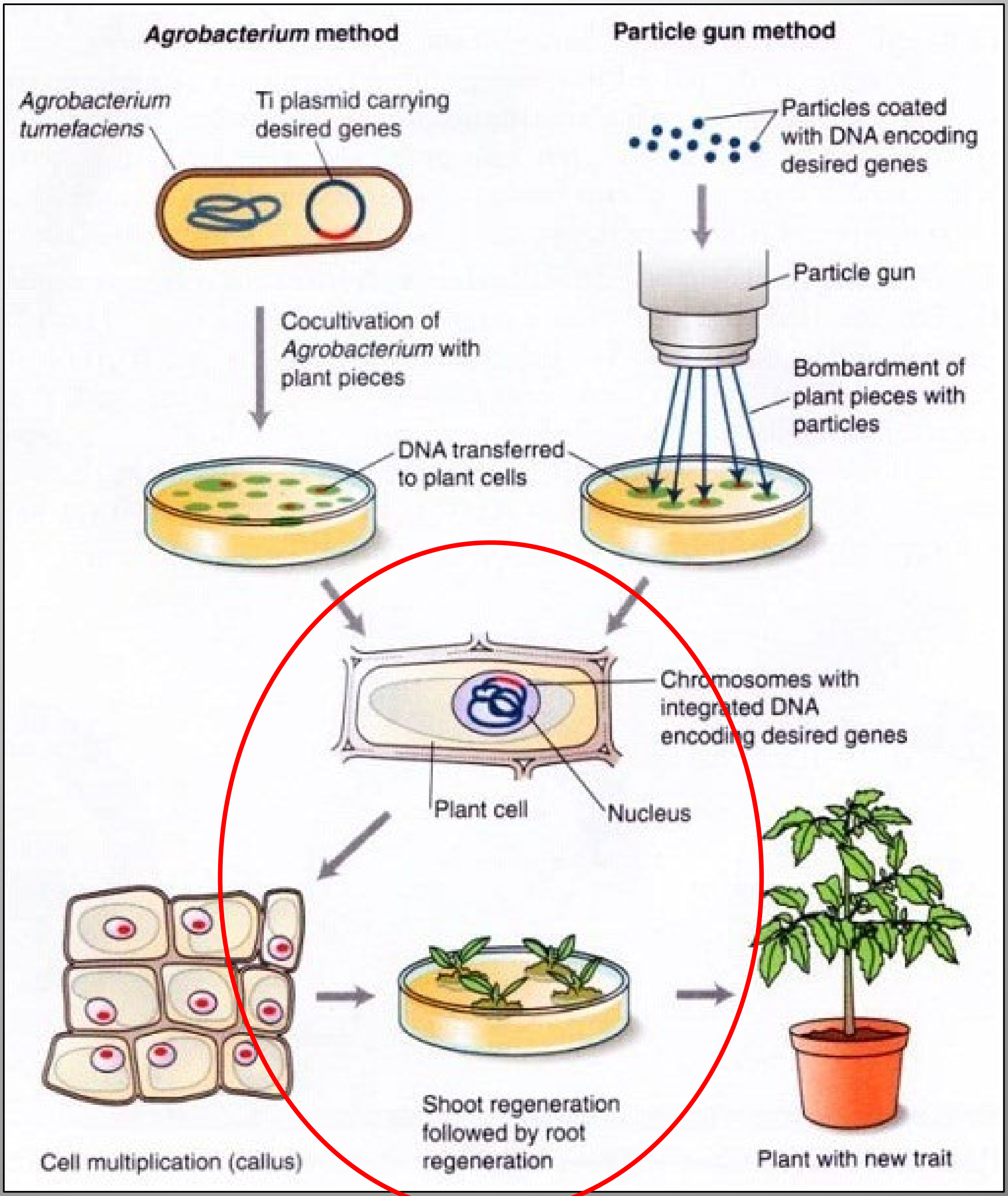
Try to connect basic biotech ideas and methods to practical outcomes in the context of intensive forestry systems

Communicate/analyze ecological and social issues to scientists and the public that govern biotech acceptance

Gene edit/GMO (GE) = “biotech” for the purpose of this talk – not genomic breeding



Overview of steps to create a GE plant



Poplar plantations are examples of my research ecosystem

Eucalypts in Brazil another example of relevant ecosystem for our work

GREAT TREES Coop focused on eucalypts, also poplars

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GREAT TREES Cooperative

Genetic Research on Engineering and Advanced Transformation of Trees

Our laboratory created and has directed the GREAT TREES university-industry consortium for 25 years. Its emphasis has been on genetic modification of flowering and field tests of flowering-modified trees. As of July 1st, 2019 the Research Cooperative previously known as TGERC/TBGRC changed its name to GREAT TREES and transitioned in its research focus to development of advanced gene editing and transformation methods. A key element of research is the application of development-controlling genes to promote regeneration of transformed or gene-edited plants (summary of GREAT TREES research goals).

Current members are SAPPI, Arauco, Futuragene/Suzano, Klabin, SweTree Technologies, and the University of Pretoria Forest Molecular Biology Program. Corteva Agrosciences is an Associate Member. Please contact Professor Steve Strauss, GREAT TREES Coop Director, to inquire about current studies and membership.

GREAT TREES flyer

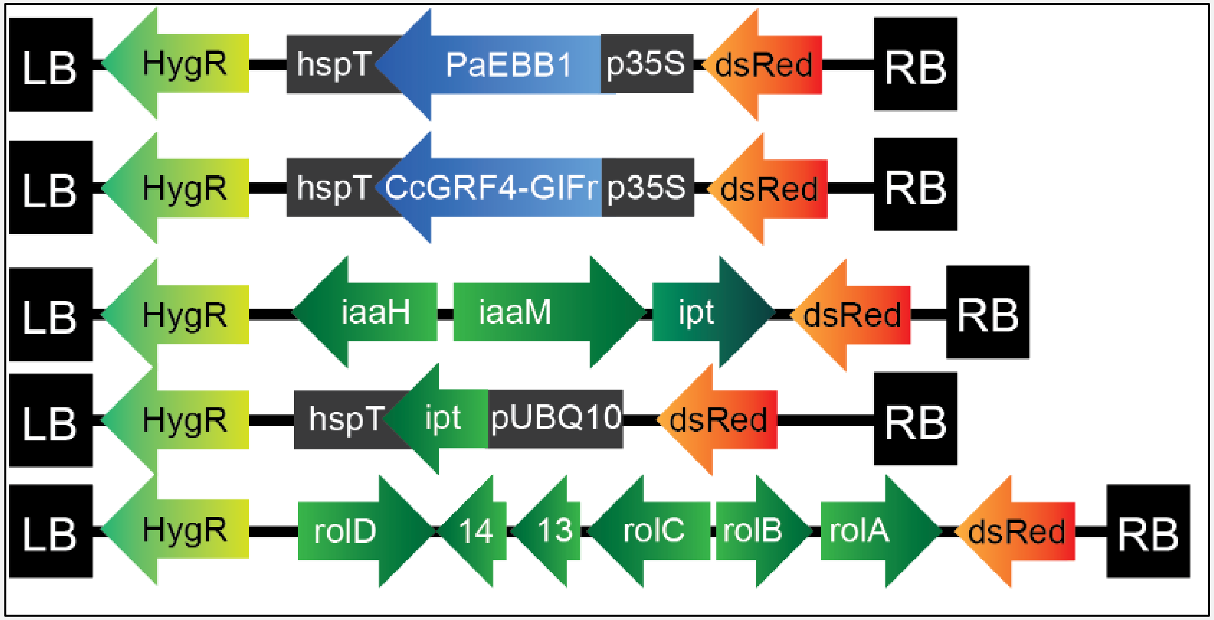
MOA – GREAT Trees Cooperative (PDF)

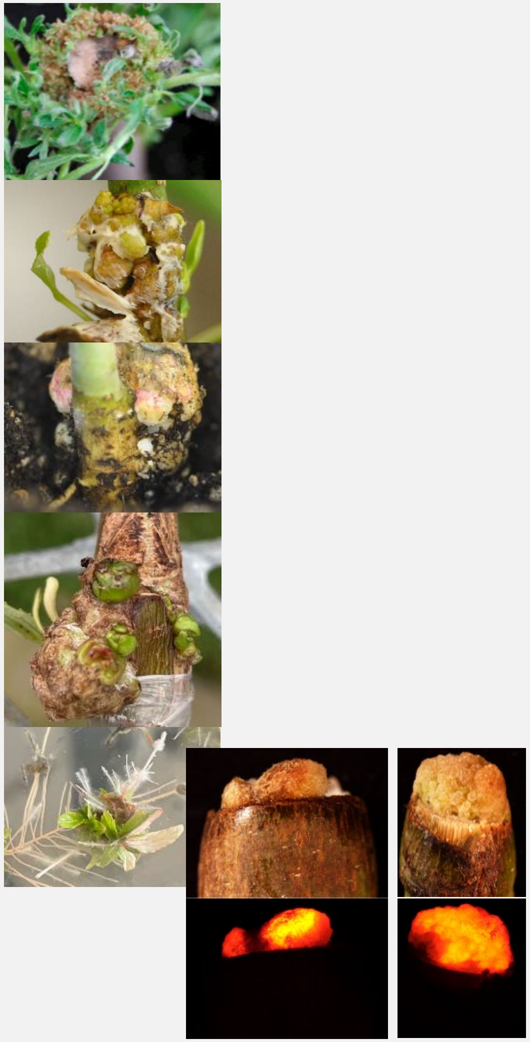
MOA – GREAT Trees Cooperative (Word)

GREAT TREES goals

- *Developmental ("DEV") genes as methods to enhance gene editing and transformation in eucalypts*
  - Identify genes
  - Test *in vitro* and *in planta* using eucalypt or as a comparator poplar plant tissues
  - Test accessory technology such as promoters, insulators, inducers, and recombinases
  - Adapt for gene editing / CRISPR

Some of the DEV genes we study using *in planta* approaches



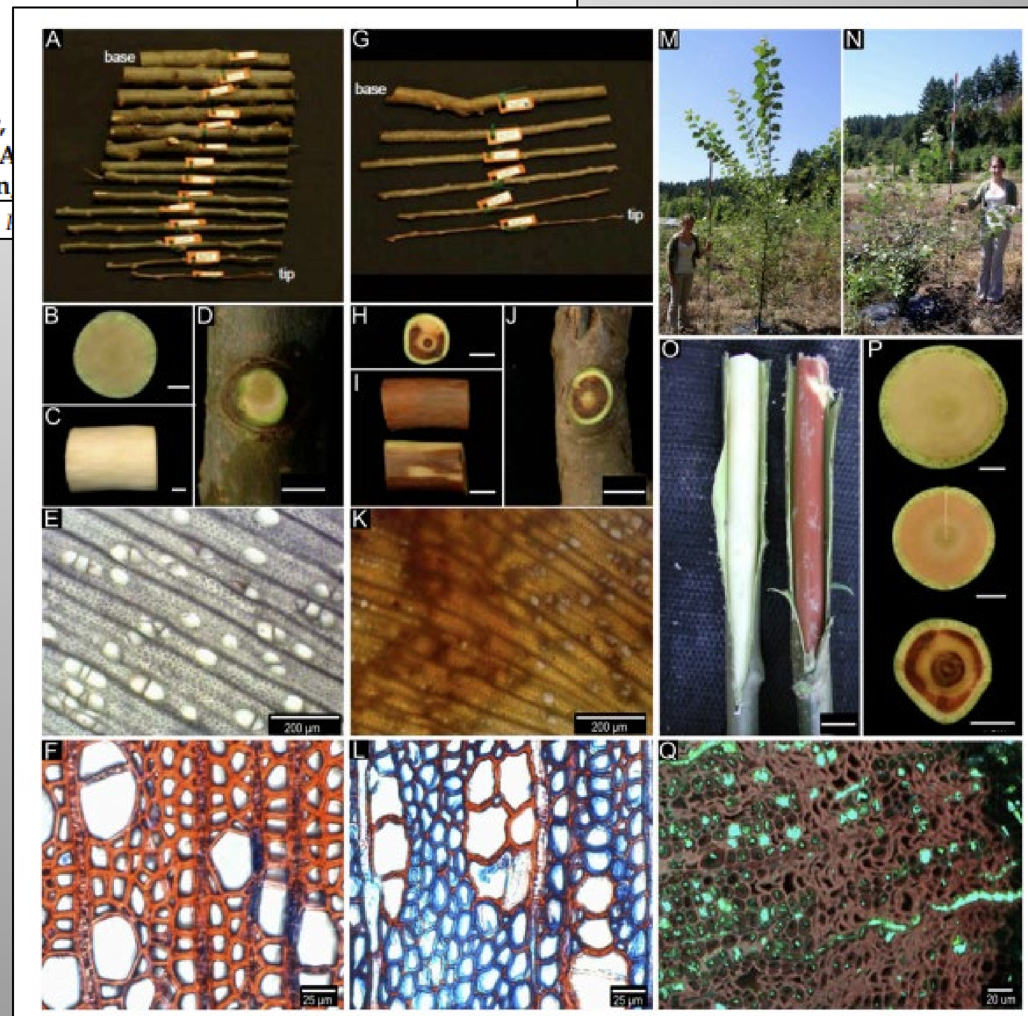


Greenhouse to field: Lignin reduction with its hazards

Antisense Down-Regulation of *4CL* Expression Alters Lignification, Tree Growth, and Saccharification Potential of Field-Grown Poplar[1][W][OA]

Steven L. Voelker, Barbara Lachenbruch, Frederick C. Meinzer,
Ann M. Patten, Laurence B. Davin, Norman G. Lewis, Gerald A
Michael J. Selig, Robert Sykes, Michael E. Himmel, Peter Kitin

Plant P



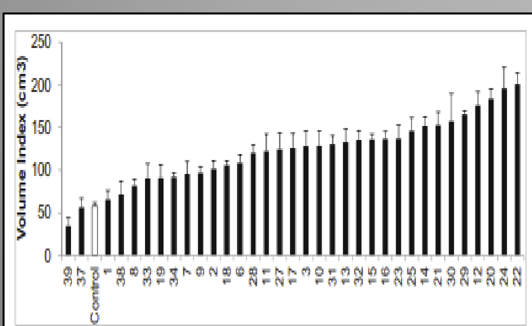
Modification of gibberellin activity modifies growth and biomass allocation – but highly variable effects in greenhouse vs. field

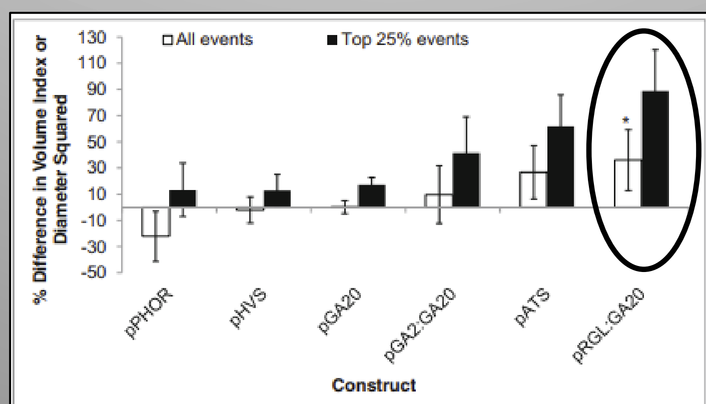
Tree Genetics & Genomes (2015) 11:127
DOI 10.1007/s11295-015-0952-0

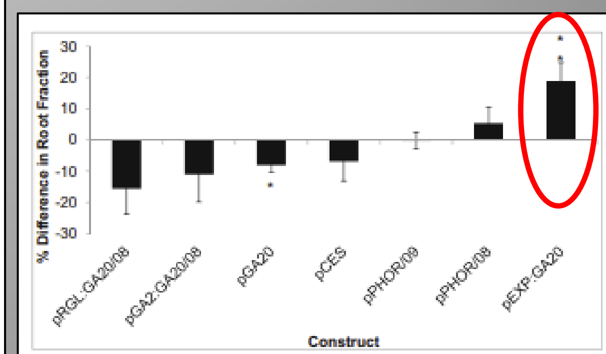
ORIGINAL ARTICLE

Recombinant DNA modification of gibberellin metabolism alters growth rate and biomass allocation in *Populus*

Haiwei Lu[1] · Venkatesh Viswanath[1,4] · Cathleen Ma[1] · Elizabeth Etherington[1,5] · Palitha Dharmawardhana[1,6] · Olga Shevchenko[1,7] · Steven H. Strauss[1] · David W. Pearce[2] · Stewart B. Rood[2] · Victor Busov[3]







Much metabolic engineering innovation needed for major, novel products

Plant Biotechnology Journal

Plant Biotechnology Journal (2011) **9**, pp. 759–767

doi: 10.1111/j.1467-7652.2010.00585

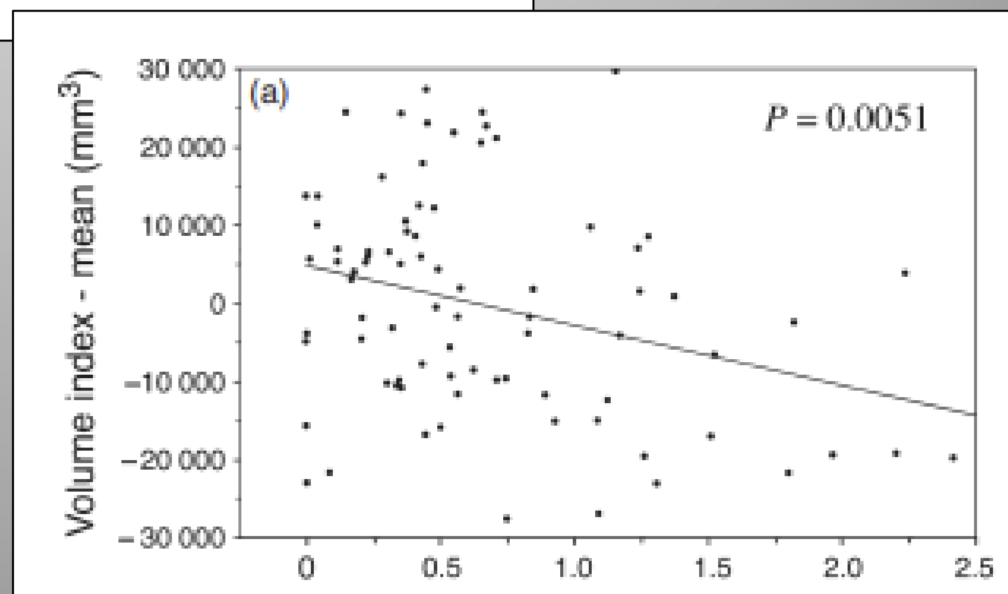
Trade-offs between biomass growth and inducible biosynthesis of polyhydroxybutyrate in transgenic poplar

David A. Dalton[1], Cathleen Ma[2], Shreya Shrestha[1], Peter Kitin[3] and Steven H. Strauss[2,*]

[1]*Biology Department, Reed College, Portland, OR, USA*

[2]*Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR, USA*

[3]*Laboratory for Wood Biology, Royal Museum for Central Africa, Tervuren, Belgium*



Field trials can pleasantly surprise – air pollution reduction

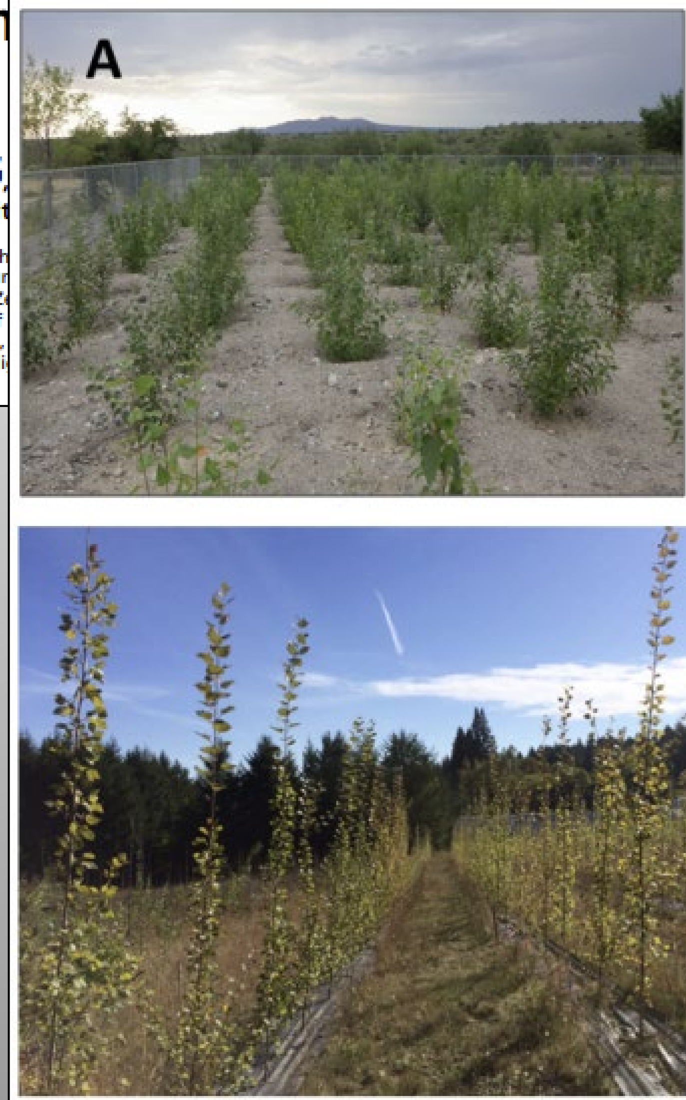
Check for updates

High productivity in hybrid-poplar plantation isoprene emission to the atmosphere

Russell K. Monson[a,b,1], Barbro Winkler[c], Todd N. Rosenstiel[d,1], Katja Block[c], Juliane Merl-Pham[e], Kori Ault[f], Jason Maxfield[d], David J. P. Moore[g], Nicole A. Trahan[g], Amberly A. Neice[g], Ian Shiach[g], Greg A. Barron-Gafford[h], Peter Ibsen[i], Joel T. McCorkel[j], Jörg Bernhardt[k], and Joerg-Peter Schnit

[a]Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ 85721; [b]Laboratory of Tree-Ring Research Tucson, AZ 85721; [c]Research Unit Environmental Simulation, Institute of Biochemical Plant Pathology, Helmholtz Zentrum Mün Germany; [d]Department of Biology, Portland State University, Portland, OR 97207; [e]Research Unit Protein Science, Helmholtz Ze Neuherberg, Germany; [f]Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331; [g]School of Environment, University of Arizona, Tucson, AZ 85721; [h]School of Geography and Development, University of Arizona, Tucson, Botany and Plant Science, University of California, Riverside, CA 92507; [j]Biospheric Sciences Laboratory, NASA Goddard Space Fli 20771; and [k]Institute for Microbiology, Ernst-Moritz-Arndt University, 17487 Greifswald, Germany

www.pnas.org/cgi/doi/10.1073/pnas.1912327117

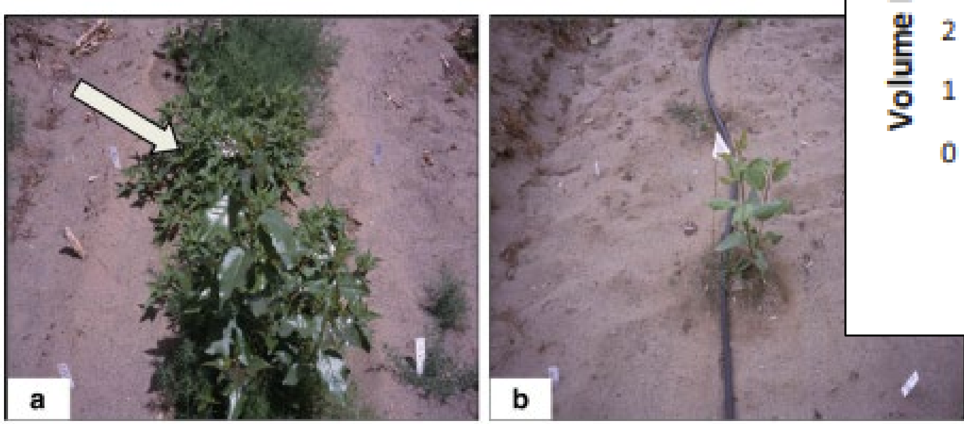


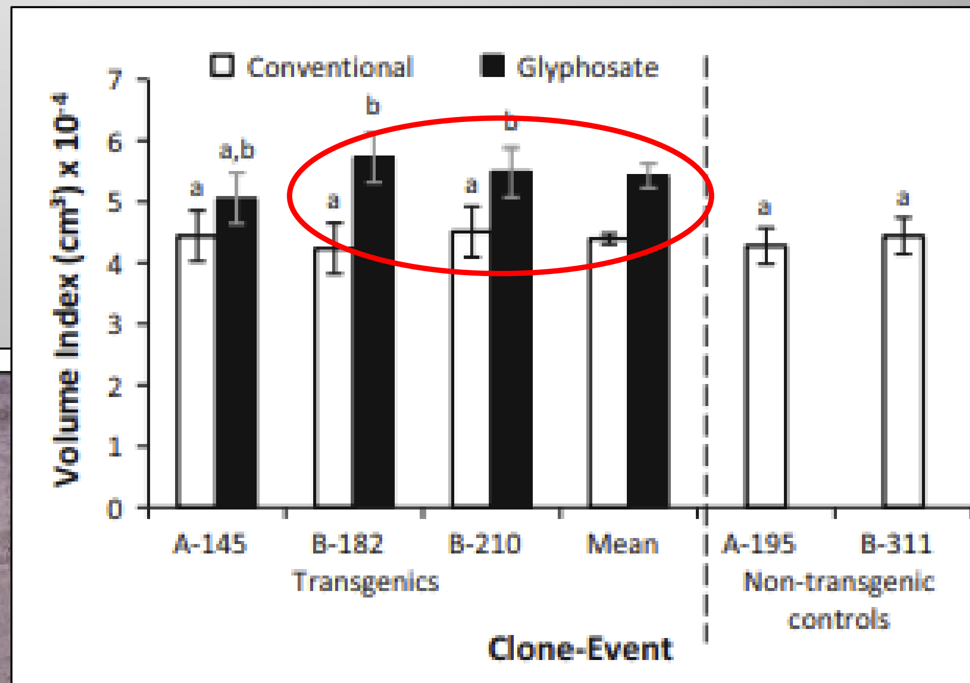
“Old” biotech traits can give large benefits – yield and water use (LCA) value of herbicide tolerance in poplar

New Forests (2016) 47:653–667
DOI 10.1007/s11056-016-9536-6

Improved growth and weed control of glyphosate-tolerant poplars

Kori Ault[1] · Venkatesh Viswanath[1,4] · Judith Jayawickrama[1] · Cathleen Ma[1] · Jake Eaton[2] · Rick Meilan[1,5] · Grant Beauchamp[2,6] · William Hohenschuh[3] · Ganti Murthy[3] · Steven H. Strauss[1]



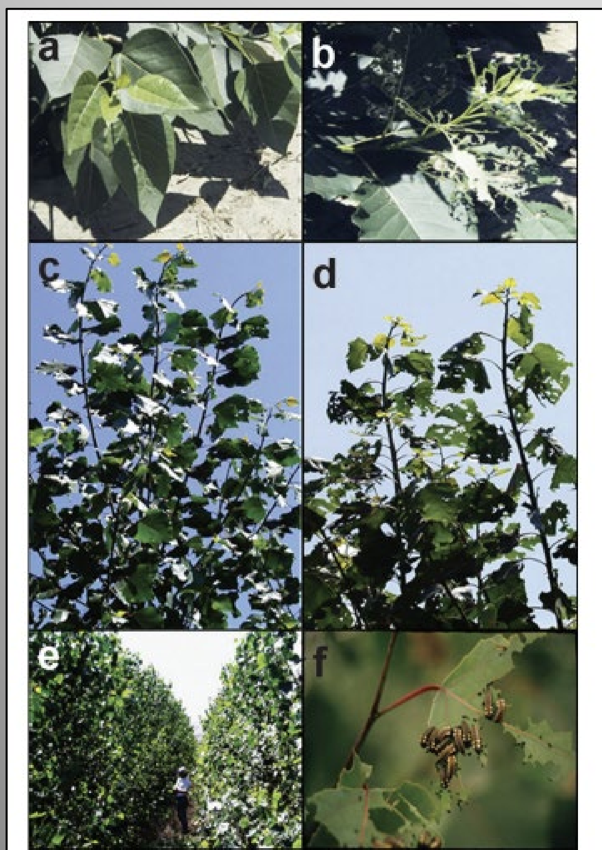


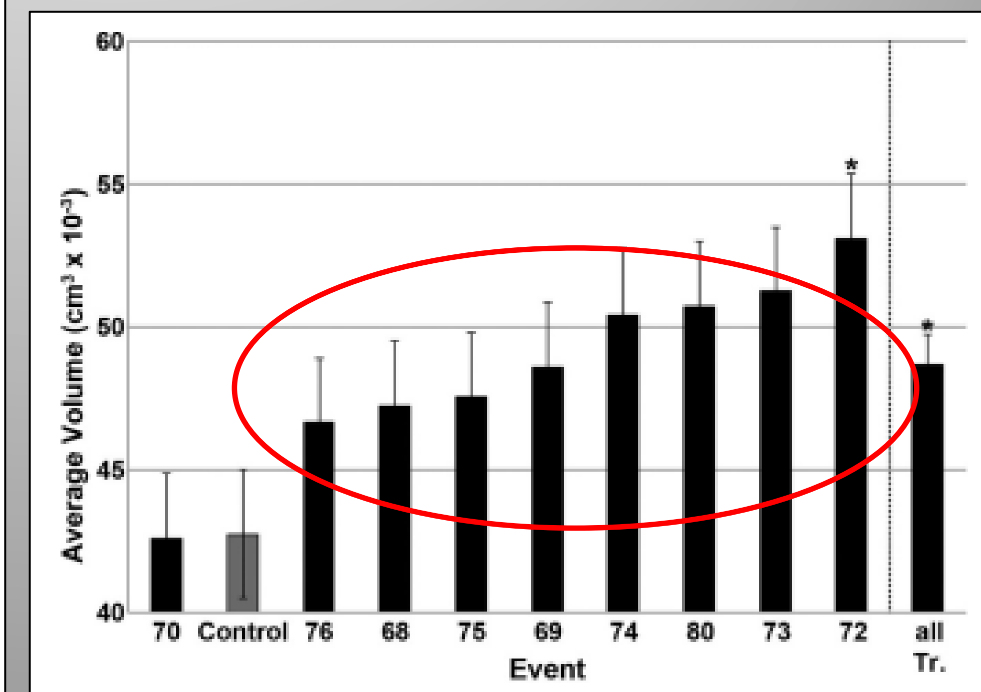
Large yield benefits from pest resistance genes in poplar

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

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





RNAi suppression and gene editing powerful tools for genetic containment

Plant Biotechnology Journal
Open Access

Research Article | Open Access

Genetic containment in vegetatively propagated forest trees: CRISPR disruption of *LEAFY* function in *Eucalyptus* gives sterile indeterminate inflorescences and normal juvenile development

Estefania Elorriaga, Amy L. Klocko, Cathleen Ma, Marc du Plessis, Xinmin An, Alexander A. Myburg, Steven H. Strauss

First published: 27 March 2021 | https://doi.org/10.1111/pbi.13588 | Citations: 1

Current USDA-regulated field trials

353 CRISPR trial 2017 (*P. tremula x tremuloides*)

Improving carbon gain by suppressing photorespiration

RESEARCH ARTICLE

PLANT SCIENCE

Synthetic glycolate metabolism pathways stimulate crop growth and productivity in the field

Paul F. South[1,2], Amanda P. Cavanagh[2], Helen W. Liu[3]*, Donald R. Ort[1,2,3,4]†

Photorespiration is required in C_3 plants to metabolize toxic glycolate formed when ribulose-1,5-bisphosphate carboxylase-oxygenase oxygenates rather than carboxylates ribulose-1,5-bisphosphate. Depending on growing temperatures, photorespiration can reduce yields by 20 to 50% in C_3 crops. Inspired by earlier work, we installed into tobacco chloroplasts synthetic glycolate metabolic pathways that are thought to be more efficient than the native pathway. Flux through the synthetic pathways was maximized by inhibiting glycolate export from the chloroplast. The synthetic pathways tested improved photosynthetic quantum yield by 20%. Numerous homozygous transgenic lines increased biomass productivity between 19 and 37% in replicated field trials. These results show that engineering alternative glycolate metabolic pathways into crop chloroplasts while inhibiting glycolate export into the native pathway can drive increases in C_3 crop yield under agricultural field conditions.

Science / Volume 363(6422):eaat9077
January 4, 2019

Current work example: GWAS to discover DEV genes in poplar

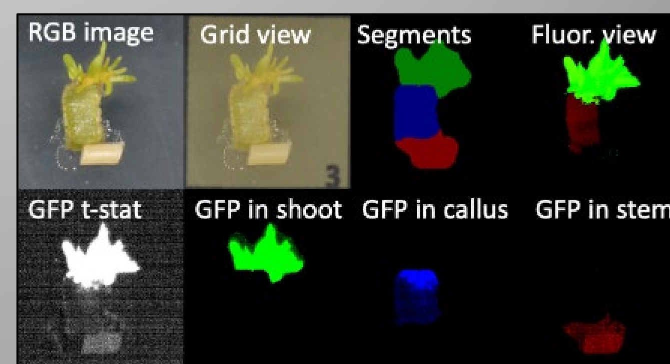
Four studies, machine vision system

1. In planta regeneration

2. Rooting

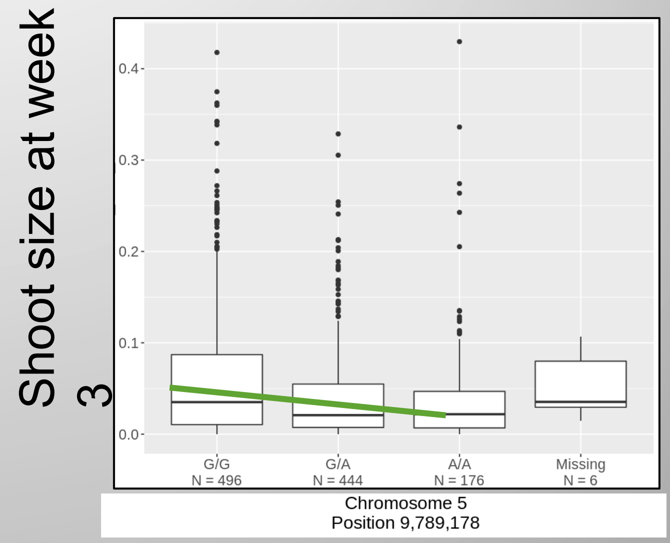
3. In vitro regeneration

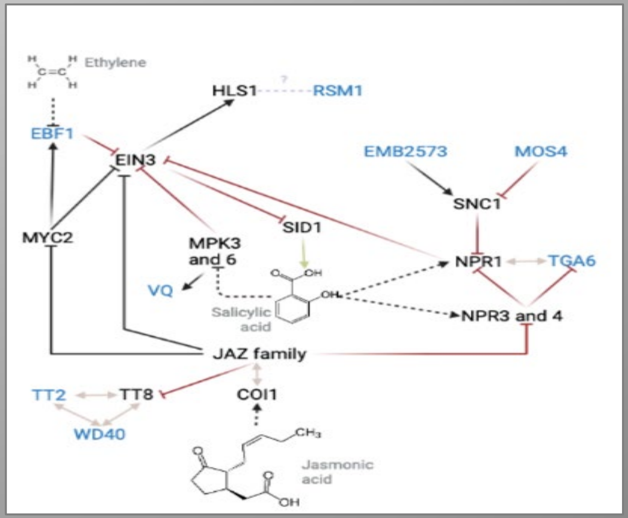
4. In vitro regeneration + transformation



Genome-Wide Association Studies (GWAS) uncover links between genetic markers and traits

- Genetic variation represented by single-nucleotide polymorphisms (SNPs) in and around genes
- Poplar GWAS features ~1,300 clones with over 30 million SNPs, most with low linkage disequilibrium
- GWAS uses statistical models to find significant correlations between SNPs and traits of interest
- Hundreds of candidate genes identified





Aims of lab

Try to connect basic biotech ideas and methods to practical outcomes in the context of intensive forestry systems

Communicate/analyze ecological and social issues to scientists and the public that govern biotech acceptance

Articles on regulation and problems thereof

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

The 2020 USDA SECURE system – does it help?

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USDA › MEDIA › PRESS RELEASES › **USDA SECURE RULE PAVES WAY FOR AGRICULTURAL INNOVATION**

USDA SECURE Rule Paves Way for Agricultural Innovation

(Washington, D.C., May 14, 2020) U.S. Secretary of Agriculture Sonny Perdue today announced a final rule updating and modernizing the U.S. Department of Agriculture's (USDA) biotechnology regulations under the Plant Protection Act. The Sustainable, Ecological, Consistent, Uniform, Responsible, Efficient (SECURE) rule will bring USDA's plant biotechnology regulations into the 21st century by removing duplicative and antiquated processes in order to facilitate

Press Release
Release No. 0260.20

Contact: USDA Press
Email: press@oc.usda.gov

SECURE: Sustainable, Ecological, Consistent, Uniform, Responsible, Efficient

Submitted RSR documents to find out

Oregon State University

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321 Richardson Hall, Corvallis, Oregon 97331
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USDA Animal and Plant Health Inspection Service
Attn: Sarah Prewitt
Phone: 301-851-3877
Email: biotechquery@aphis.usda.gov
6135 NE 80th Ave # A8
Portland, OR 97218

Summary:

The purpose of this document is to submit an initial review document as a part of a Regulatory Status Review for a construct x genotype combination that imparts bisexual sterility for biological containment. Transgenic events with this combination are presently part of a "CRISPR sterility trial" currently regulated under eFile AUTH – 0000176886. This RSR request focuses only on a transgenic construct containing a Cas9 gene, two guide RNA expression cassettes, and an antibiotic resistance gene, with targeted mutations produced to disrupt the function of the poplar homolog of the *LEAFY* gene (PtLFY) in poplar genotype 717-1B4 (*Populus tremula* x *alba*). We believe this construct x plant genotype combination does not pose a plant pest risk and should be deregulated under 7 CFR part 340.

Recently published reviews on realities & research for gene editing in forestry

Springer Link

Special Issue on Genome Editing | Open Access | Published: 19 July 2021

Gene editing in tree and clonal crops: progress and challenges

Greg S. Goralogia, Thomas P. Redick & Steven H. Strauss

In Vitro Cellular & Developmental Biology - Plant **57**, 683–699 (2021) | Cite this article

Open Access Perspective

Gene-Editing for Production Traits in Forest Trees: Challenges to Integration and Gene Target Identification

by Steven H. Strauss [1,*], Gancho T. Slavov [2] and Stephen P. DiFazio [3]

[1] Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331, USA
[2] Radiata Pine Breeding Company, 99 Sala Street, Rotorua 3010, New Zealand
[3] Department of Biology, West Virginia University, Morgantown, WV 26506, USA
[*] Author to whom correspondence should be addressed.

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Forests **2022**, *13*(11), 1887; https://doi.org/10.3390/f13111887

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Questions / thoughts?