Division 2
“Physiology and Genetics”

IUFRO Priorities 2010-2014
D2 Challenges & Contributions

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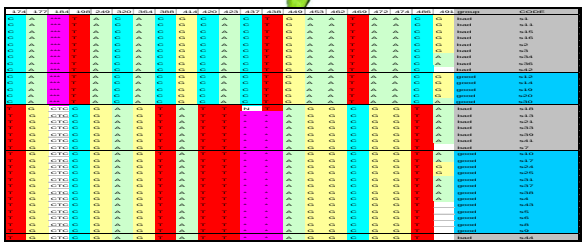
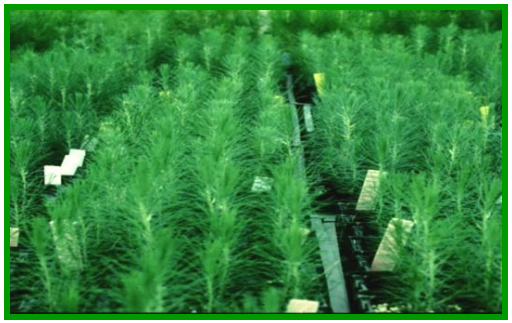
D2: Physiology and Genetics

Physiology research for whole tree, xylem, stem, canopy and roots; Sexual and vegetative reproduction

Genetics and breeding research in conifers and hardwoods; Quantitative and molecular genetics of trees and tree populations; Seed physiology and biotechnology

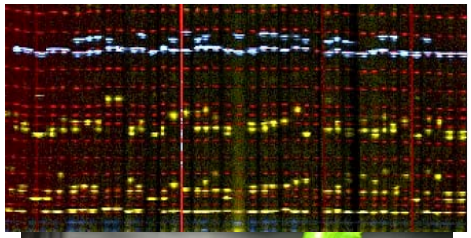


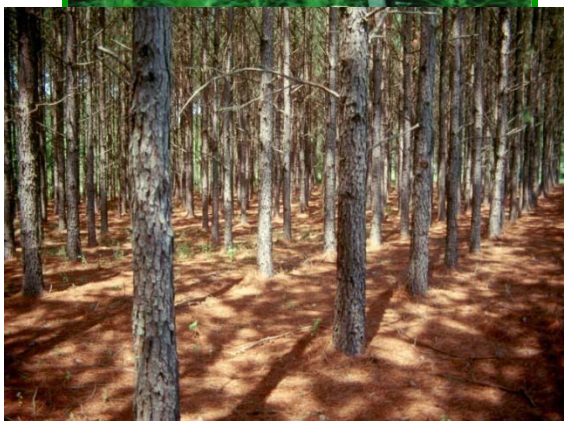


D2: Physiology and Genetics

5 Research Groups: 1) Physiology; 2) Conifer breeding and genetic resources; 3) Genetics; 4) Hardwood improvement, culture and genetic resources; 5) Tree seed, physiology and biotechnology

31 Working Parties: several working parties within each research group for specific research in physiology or genetics





IUFRO Priorities

How D2 can contribute to 6 research goals?

- FORESTS FOR PEOPLE**:** agro-forestry, food, livelihoods
- CLIMATE CHANGE AND FORESTRY: adaptation, conservation, C-sequestration
- ENERGY AND THE FOREST PRODUCTS INDUSTRY: traditional products, wood bio-energy, fibre production
- BIODIVERSITY CONSERVATION: biodiversity, conservation, plantation, clones
- FOREST AND WATER INTERACTIONS: water use in plantation, ecosystem and stand physiology
- RESOURCES FOR THE FUTURE: genetic resources

IUFRO Priorities

Major contributions to:

- **ENERGY AND THE FOREST PRODUCTS INDUSTRY**: Traditional forestry, wood bio-energy, fibre production
- **BIODIVERSITY CONSERVATION**: biodiversity, conservation, plantation, clones
- **CLIMATE CHANGE AND FORESTRY**: adaptation, conservation, C-sequestration
- FORESTS FOR PEOPLE**:** agro-forestry, food, livelihoods
- FOREST AND WATER INTERACTIONS: water use in plantation
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Challenge: Increased Wood Demand

- Growing global demand for wood
- Annual increase in pulp consumption in developing countries
- Demand for non-consumptive forest products continues to increase (wildlife, water, recreation, nature preserves, aesthetics)
- Limited harvesting on public land due to environmental pressures

Intensive Plantation Forestry

- Plantation forestry is a solution to the dilemma
- To meet the wood needs of 2050, fast growing industrial plantations will supply 50% of harvested wood
- Wood productivity per acre must be increased on limited land base
- Physiology and genetics are critical components of productive forestry

Genetically Improved Materials are used in major species

Major species: Application of Biotechnology & Clonal Forestry

Example: Impact of Plantation Program in Southern U.S.

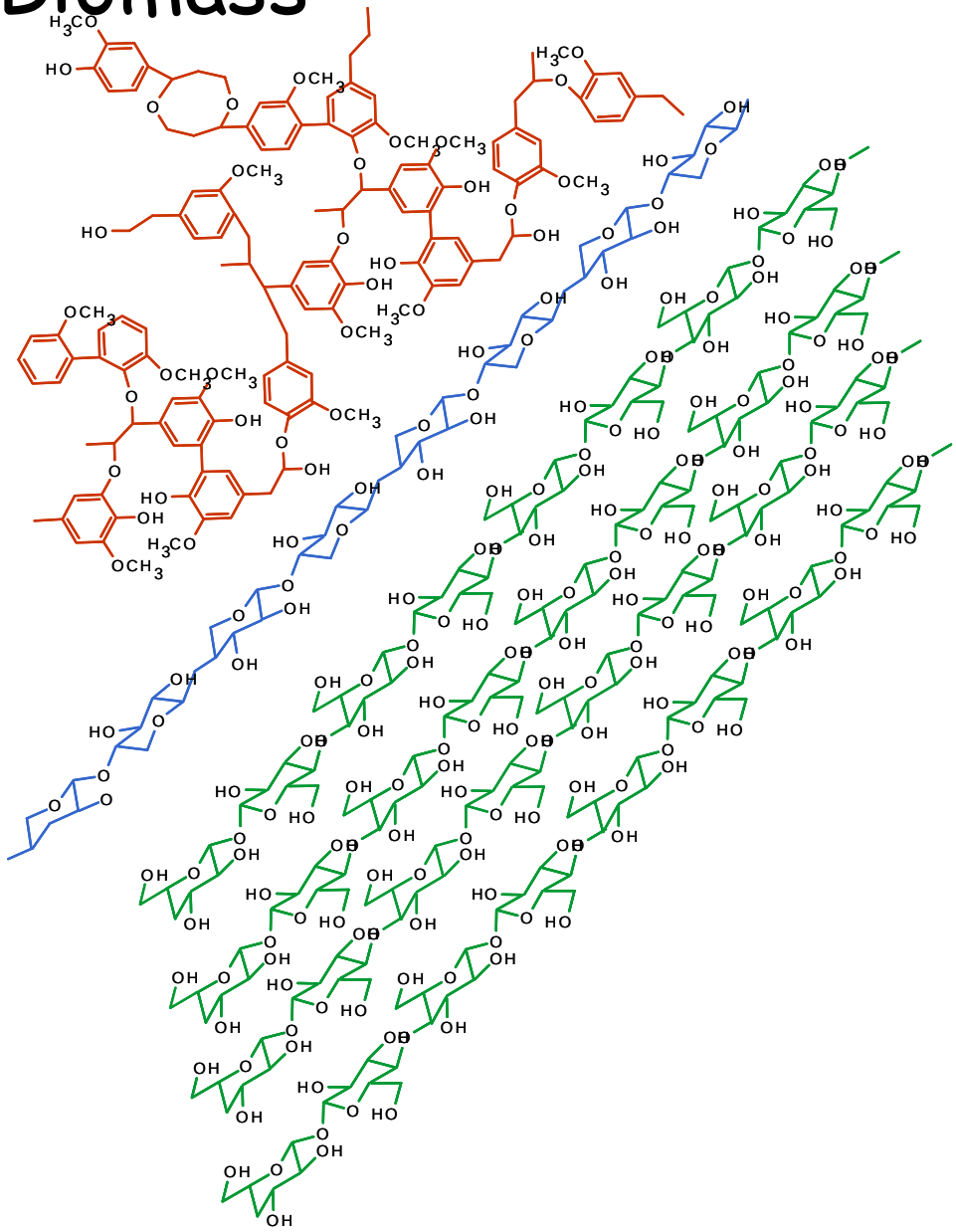
- **Plant 1.2 billion seedlings annually**
- **All genetically improved**
- **80% of US annual tree planting**
- **50% wood supply in US**

Short-rotation Plantation: A Clear Choice for Biofuels Feedstock Production

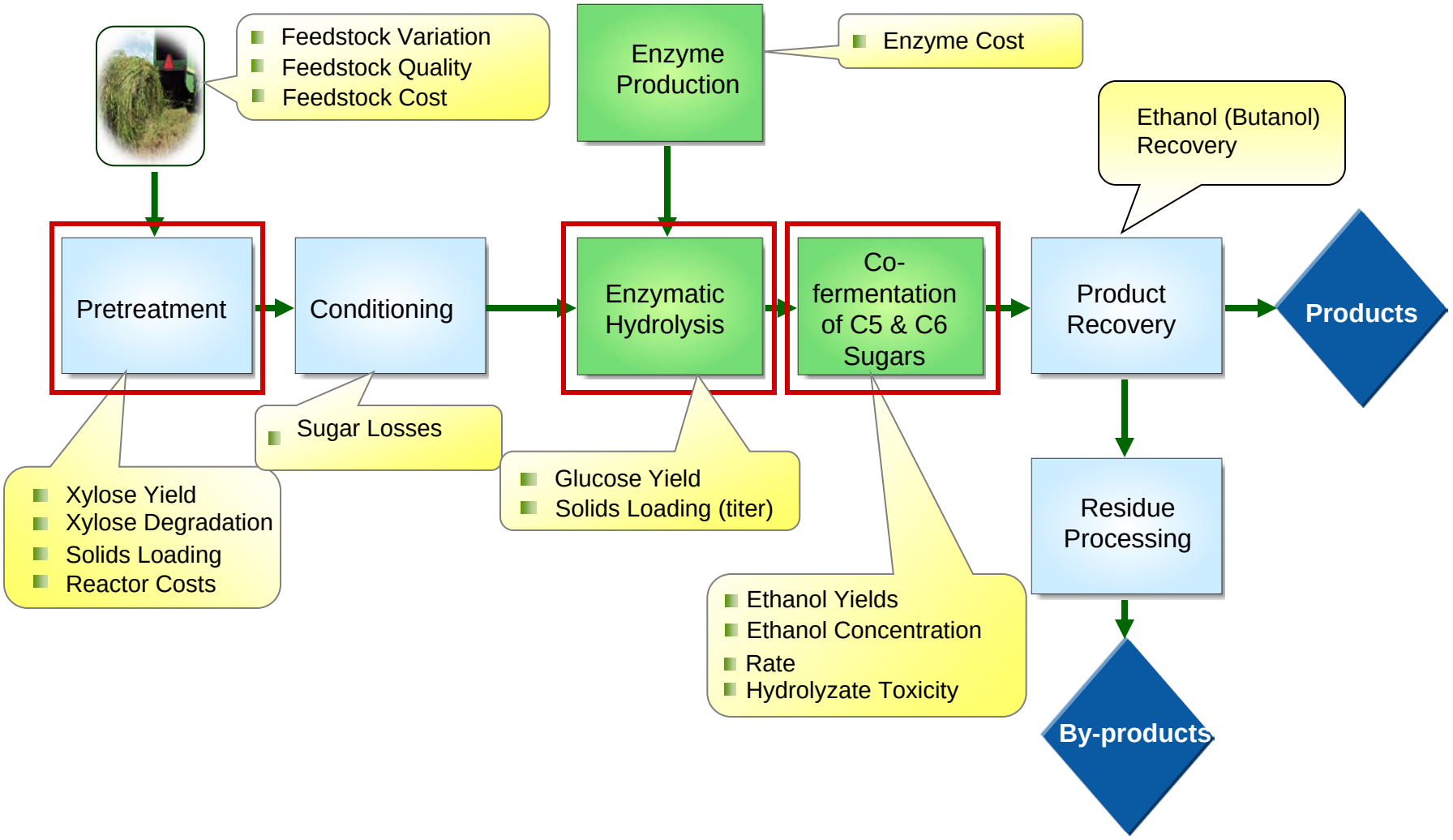
- An adaptable, abundant, and homogeneous feedstock source is key asset for biofuels utilization
- Biomass production that will not compete with food or fiber production on high-quality agricultural lands is a critical consideration in the choice of feedstocks.
- Need readily and commercially deployable, homogeneous source of forestry feedstock

Woody Biomass

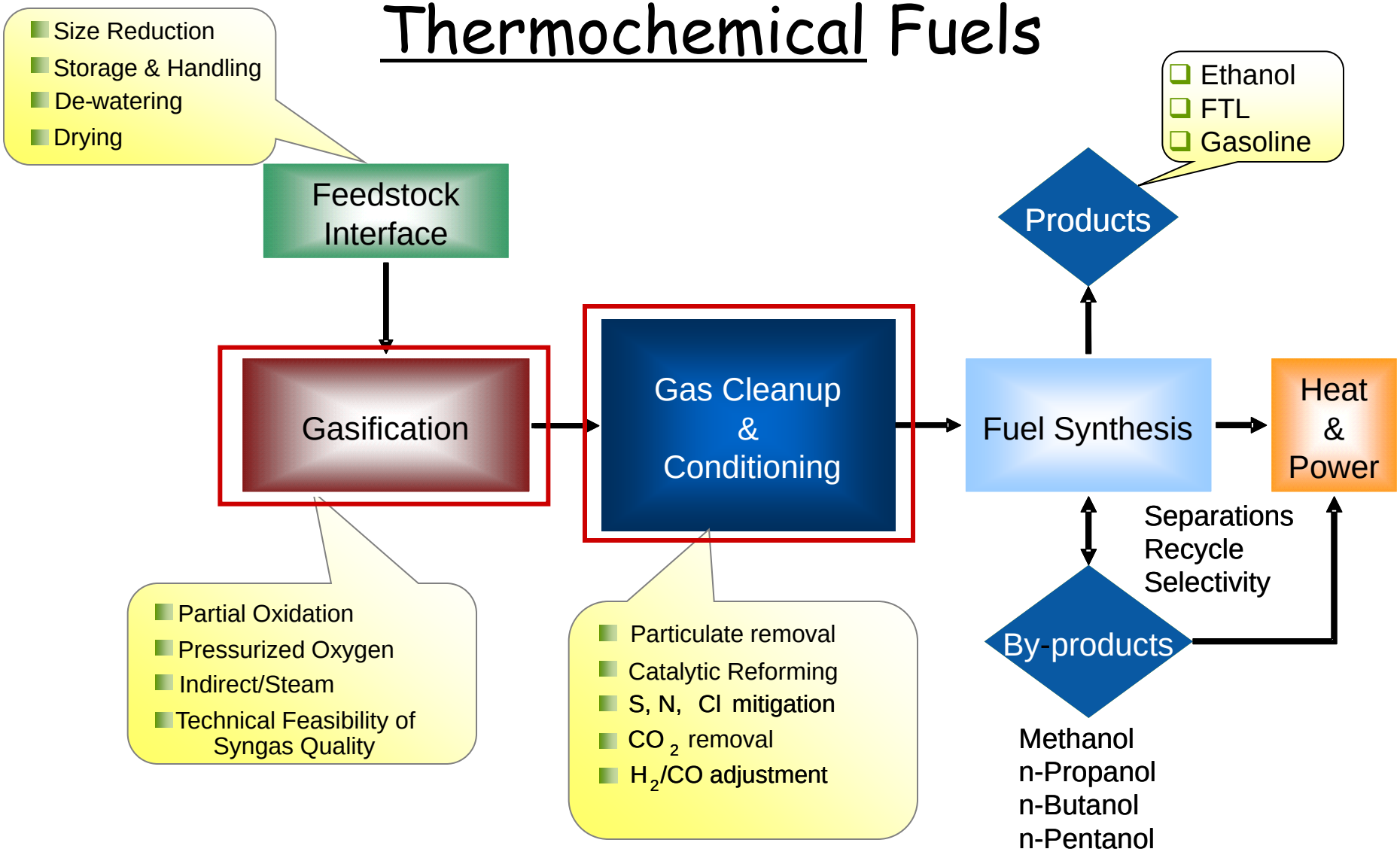
- Lignin: 20%–30%
  - Complex aromatic structure
  - Very high energy content
  - Resists biochemical conversion
- Hemicellulose: 23%–32%
  - Xylose is the second most abundant sugar in the biosphere
  - Polymer of 5- and 6-carbon sugars, marginal biochemical feed
- Cellulose: 38%–50%
  - Most abundant form of carbon in biosphere
  - Polymer of glucose, good biochemical feedstock



Technical Barrier Areas Biochemical Ethanol



Technical Barrier Areas
Thermochemical Fuels



Woody Biomass to Liquid fuels

- Economic feasibility is a function of both capital cost and operating cost
- At this time, enzymatic hydrolysis of cellulose followed by fermentation has the lowest projected capital cost
- Enzymatic hydrolysis is much more efficient on pulp from hardwood trees than pulp from softwood trees

Woody Biomass for Energy

- Increase the yield of biomass feedstock per acre through continued improvement in productivity using advanced breeding, testing and selection methods combined with improved silvicultural techniques
- Increase the yield of biofuel per green ton of biomass by identifying and exploiting genetic variation in wood properties that affect processing characteristics to identify trees with higher conversion efficiencies

Breeding for Bio-Energy

- Variation in ethanol yield from pulp is associated with variation in wood properties that affect other pulp characteristics.
- Relative amounts of lignin and cellulose, the wood density, and other wood properties are known to affect pulp yield and ethanol yield
- These properties can be improved to better use in ethanol production by fermentation.

Biodiversity Conservation and Climate Changes

Safeguard the genetic potential for adaptation and breeding

Traits are changing over time due to

climate changes, pollution & human activities

Breeding and gene conservation must be combined to cope with uncertainties

Dynamic diversity conservation

Genetic and Physiology Studies for Biodiversity Conservation

- Species and economic values
- Genetic variation among populations
- Individual variation within populations
- Biological nature and propagation methods

Biodiversity Conservation

In situ Conservation

Natural reserves

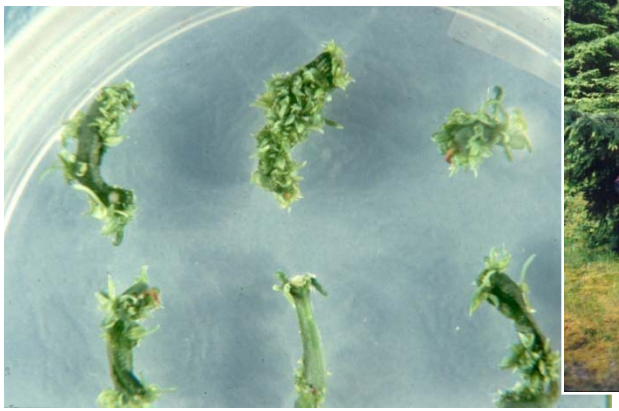
National parks

Managed natural reserves

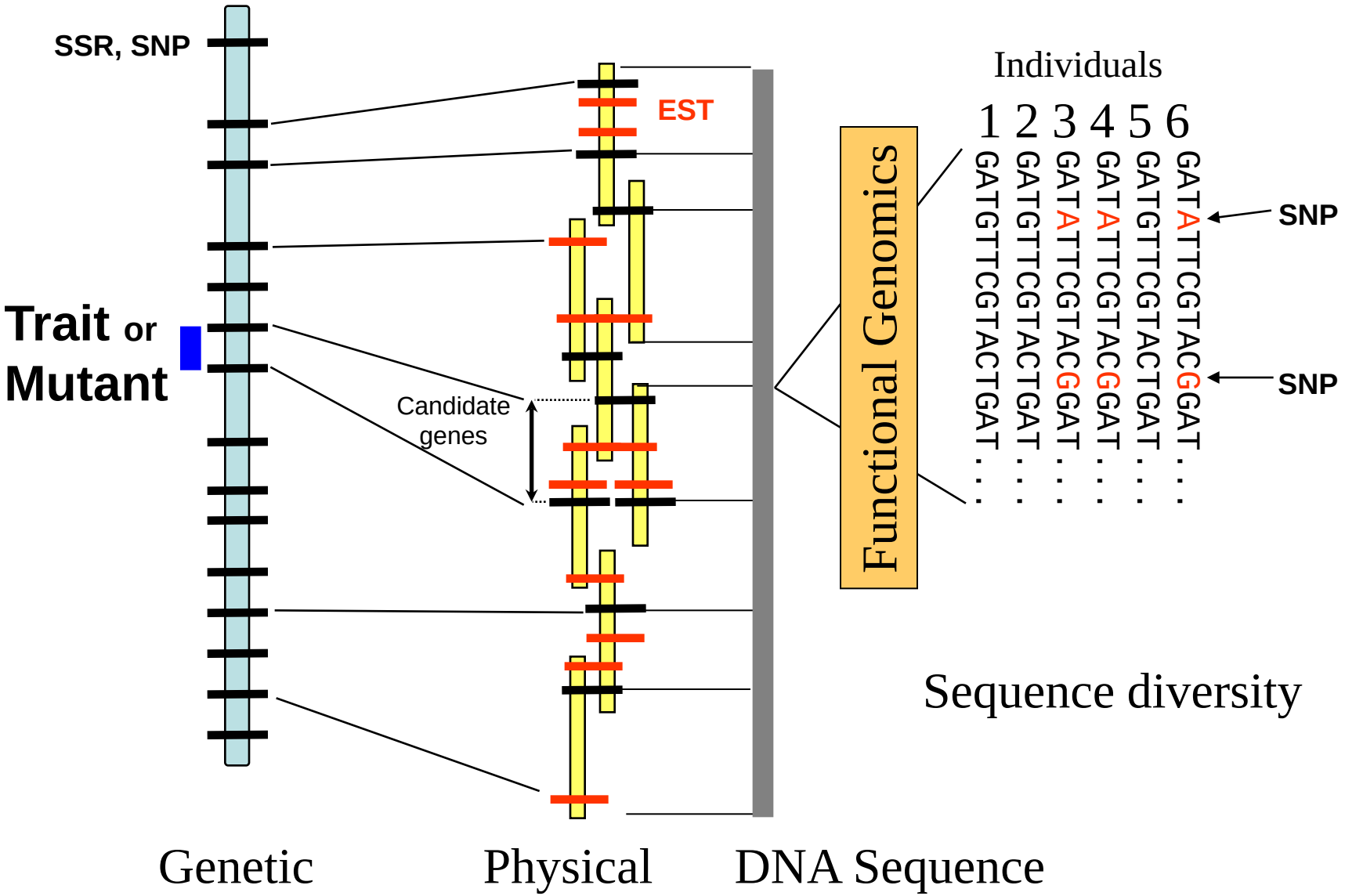
Ex situ Conservation

Conserve outside of the natural range

Establish living stands



Genomic Advances – Gene Discovery



Association Studies

Relate Genes to Phenotypes

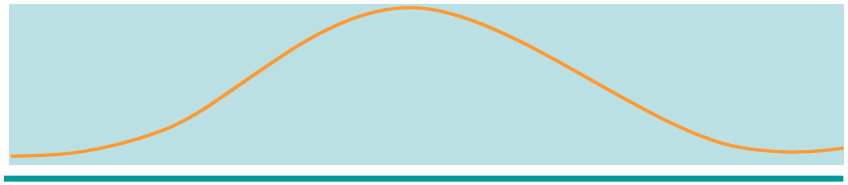
Quantitative Genetics

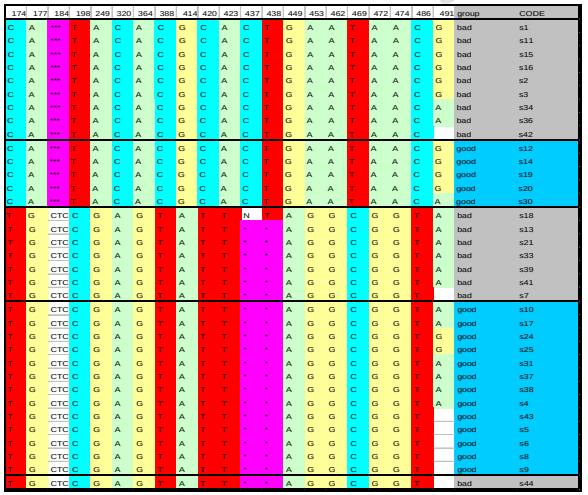
Phenotypic Variation

(quantitative measurements)

Analysis

Genetic Diversity





Individuals / haplotypes

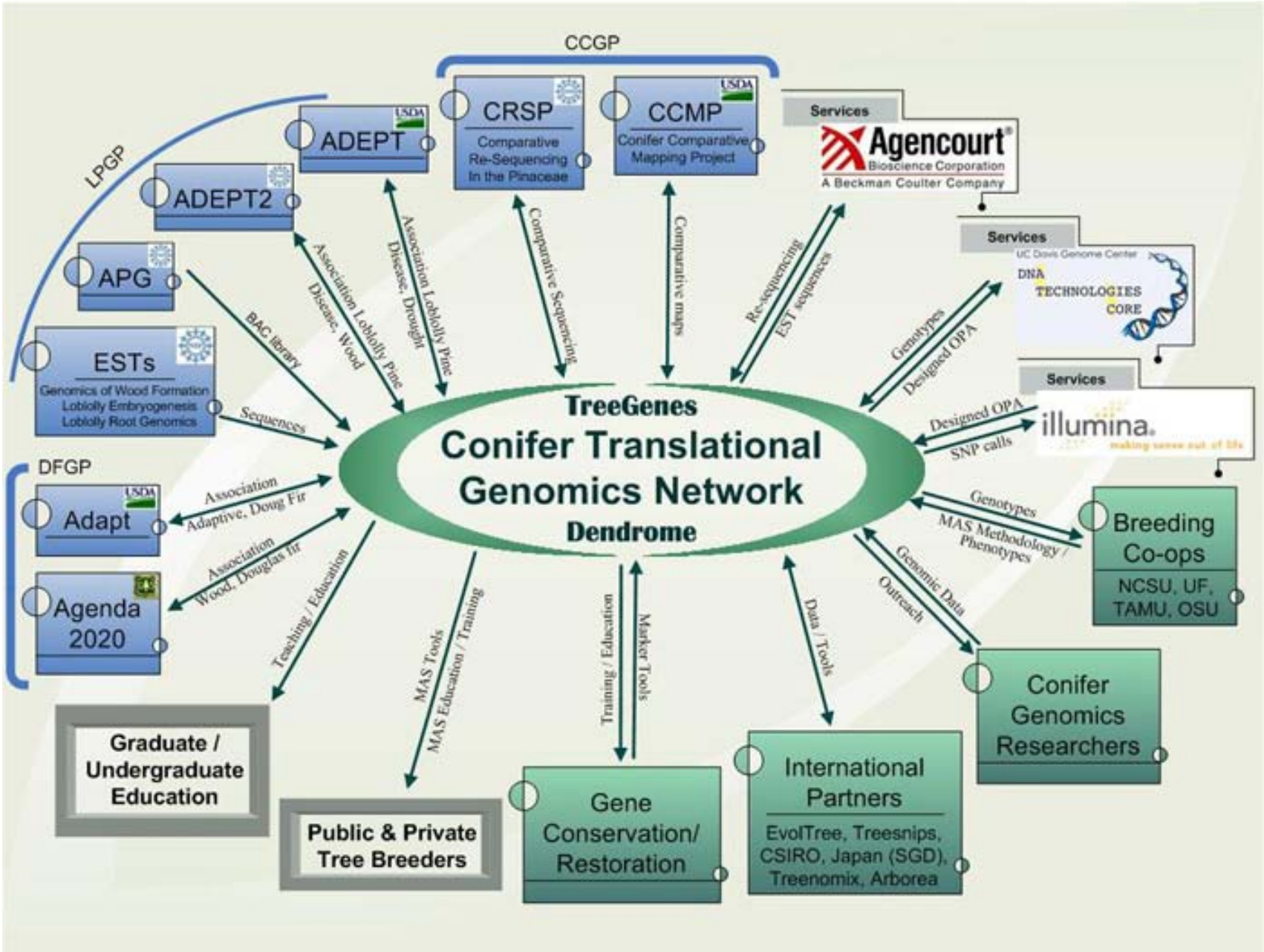
International collaboration for

Poplar genome sequence

Eucalyptus genome sequence

Other species - partial sequence

Conifer Translational Genomics Network



D2 Challenges
Ecological & Societal Issues

Genetic and biodiversity
Gene conservation
Clonal forestry
GM tree acceptance
Ecosystem impact

D2 Challenges

- Minor species breeding and tree improvement programs
- Technical challenges of clonal forestry for some species
- social aspects of clonal forestry
- Genomic applications for tree breeding
- Genetic diversity and gene conservation
- breeding for disease resistance,
- genetic gain modeling and prediction
- genetic improvement of wood quality

Examples of D2 Contributions

- Preservation of old growth forests via high efficiency plantations
- Improved wood supplies at pulp mill
- Industry able to meet environmental objectives
- Designer or purpose-grown trees
  - Bioremediation
  - Carbon uptake
  - Pharmaceuticals
  - Nutraceuticals
  - Bioenergy
- Restoration of threatened tree species
  - Chestnut Blight Resistance

Collective Challenges

IUFRO Priorities 2010-2014

Need to work more closely with other Divisions for all 6 research goals

- D1 Silvicultural management
- D3 Sustainable management
- D4 Growth and yield for gain estimation
- D5 Wood quality improvement
- D6 Social, economic & poicies
- D7 Insect and disease control
- D8 Ecology an societal issues