What would you, could you, do with wood?

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Direct Air Capture (DAC)

Carbon Storage in a multifunctional material

Soil Carbon Sequestration and Microbiome Interactions

Mass Transport Network
How can we increase the carbon-sequestration potential of trees and forests?

- Increase atmospheric carbon uptake
- Allocate carbon preferentially into high value solid form
- Improve growth rate
- Forest placement (arid, degraded land, etc.)
Maximizing CO$_2$ Uptake and Assimilation

- Improve light capture by engineering leaf architecture.

- Extend the waveband of light available for photosynthesis.

- Improve Rubisco kinetic properties.

- Enhance CO$_2$ concentrating mechanisms and redesign photo-respiration.

- Introduce the C$_4$ pathway into C$_3$ trees.

Increasing Carbon Transport and Allocation

– Improve the allocation of carbon to the woody biomass portion of the tree by modifying genes regulating:

  • Tree height, thickness, and dominance of the central stem (v. branching).
  • Biomass density through the biosynthesis and deposition of cellulose, lignin, and other carbon-based polymers.

– Can we apply synthetic biology techniques to accelerate tree engineering?

Affecting the Growth Rate of a Tree

Sequestered Carbon vs. Time
Affecting the Growth Rate of a Tree
Affecting the Growth Rate of a Tree

- Can we use genetics to grow an oak tree at the rate of bamboo?

- Poplar tree genes PXY and CLE control outward growth in the tree trunk.
  - Over-expression resulted in a 2x increase in growth rate.

- What are corresponding genes affecting growth rate in other species, and can they be modified?

- Can we engineer trees to grow on degraded, desertified, and nutrient depleted land?

Once carbon is captured and converted into woody biomass, how can we ensure that it stays sequestered?
Ensuring that Carbon stays Sequestered

- Look at mitigating biomass decomposition to CO$_2$ (often a decadal process)
  - Understand and engineer the soil microbiome

- Convert mature trees into long-lived carbon-rich materials
Putting Wood to Work

Mass Timber Construction

Displace 3.9 tCO$_2$e / ton dry wood

Sources:
From a Super Tree to a Super Carbon Sink

- Net Carbon Sequestered = \( f(\text{tree genetics}) \times f(\text{environmental interactions}) \)

- How can we improve biology to maximize forest carbon sequestration?
- How can we ensure carbon stays sequestered?
  - Identifying next-generation wood-based products
  - Achieve complete utilization of wood components

Your input is key!

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