Systems Perspective on Carbon Storage by Biomass Crops

Tom L. Richard
Professor, Agricultural and Biological Engineering
Director, Institutes of Energy and the Environment
Penn State University
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300 years of data

2 years of data

https://scripps.ucsd.edu/programs/keelingcurve/
Annual Terrestrial and Fossil Carbon Flux

Gross Photosynthesis
Respiration and Fire
Fossil Fuel Emissions
Net Land Use Change

Natural
Anthropogenic

Data from IPCC, 2013
Leveraging Natural Solutions

Opportunities
- Low Cost
- Large Volumes
- Synergies:
  - Biodiversity
  - Water Quality
  - Soil Health
- Rural Economic Development

Challenges
- Additionality
- Leakage
- Reversals
- Permanence
- Uncertainty & Verification
- Social Justice
  - Land tenure
  - Food security
  - Energy security

Adapted from Oldfield et al. 2021
https://www.edf.org/soilcarbon
Additionality: vs Business as Usual

Carbon Capture & Storage is permanent

Offset varies with fossil fuel

Net Ecosystem C Balance
Carbon to biochar
Carbon to Fuel
Carbon to CCS

Biomass Crop: Switchgrass, future yield assumes 2% annual increase, compounded
Process: Cellulosic ethanol, future includes hybrid CBP and thermochemical

Field et al. 2020
Leakage: Indirect Land Use Change

ILUC estimates for Corn ethanol

de Carvalho Macedo et al. 2015. p 597.
http://bioenfapesp.org/scopebioenergy/index.php/project-overview/
Reversals: Direct Land Use Change
Permanence: Future Generations?

Climate change impacts on soil carbon

Zhao et al. 2021
Uncertainty and Verification: Carbon For Good

- Community Engagement
- On-site Educators
- Localized Carbon models
- Satellite & Cellphone Verification
- Blockchain Accounting

AFRICAN FARMS AND RANGELANDS CAN STORE BILLION OF TONNES OF CARBON

Africa has contributed the least to climate change but can contribute the most to solving the problem.

BUY CARBON
To offset your footprint

777,290 TREES HAVE BEEN PLANTED FOR OFFSETTING

https://carbon4good.net/
Biofuels as a Vehicle for Carbon Storage

Sanchez et al., 2015: “We find that the value of BECCS lies primarily in the sequestration of carbon from biomass, rather than electricity production.”

https://www.nature.com/articles/nclimate2488
Fermentation Wastes? Or Treasure?

- Additionality
- Leakage
- Reversals
- Permanence
- Uncertainty & Verification

Lynd et al. in prep

Recalcitrant
Necromass

**Fractional Solubilization of Non-Lignin Structural Organic Matter**

**% Com Stover C Remaining After Biological Processing**

- Structural Carbohydrate
- Other structural organics*
- Lignin
- Microbial Cells
- Extractives

* Protein and hemicellulose-bound acetyl
Photosynthesis Rules

- Build a bioeconomy to maximize carbon storage
- Grow more plants
- Harvest biomass sustainably
- Increase carbon storage in soils and ecosystems

https://sdg-action.org/harnessing-the-power-of-photosynthesis-for-negative-emissions/
Penn State University
Professor Erica Smithwick
Professor Armen Kemanian
Professor Jay Regan
Dr. Michael Shreve (PostDoc)
Dr. Katie Hirl (soon Benedictine College)
Dr. Senorpe Asem-Hiablie (now Shell)
Dr. Stephanie Herbstritt (now Cornell)
Dr. Anahita Bharadwaj (now Meati Foods)
Dr. Veronika Vazhnik (now Jacobs)
Ms. Haley Stauffer (now InduFor)
Ms. Isamar Amador Diaz (now Abbott)

Dartmouth College
Lee Lynd
Mark Laser

Oak Ridge National Lab
John Field
Erin Webb
Robin Clark

UC Berkeley
Daniel Sanchez

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