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**Great Lakes Bioenergy Director**  
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***Coordinating Basic/Foundational Science and  
Applied R & D II***  
**Biomass 2010**  
**March 30, 2010**

# Great Lakes Bioenergy

- ✧ **Academic (7)**
  - UW-Madison**
  - Michigan State University**
  - Illinois State University
  - Iowa State University
  - Cornell University
  - University of Toledo
  - University of Minnesota
- ✧ **DOE National Labs (2)**
  - Pacific Northwest NL
  - Oak Ridge NL
- ✧ **Industry (2)**
  - Lucigen
  - C5-6 Technologies
- ✧ **DOE Office of Science**
  - Joint Genome Institute
  - BACTER Institute
  - ASCR
- ✧ **Wisconsin & Michigan**
  - Facilities, Faculty & Staff
- ✧ **Technology Transfer**
  - Wisconsin Alumni
  - Research Foundation (WARF), others

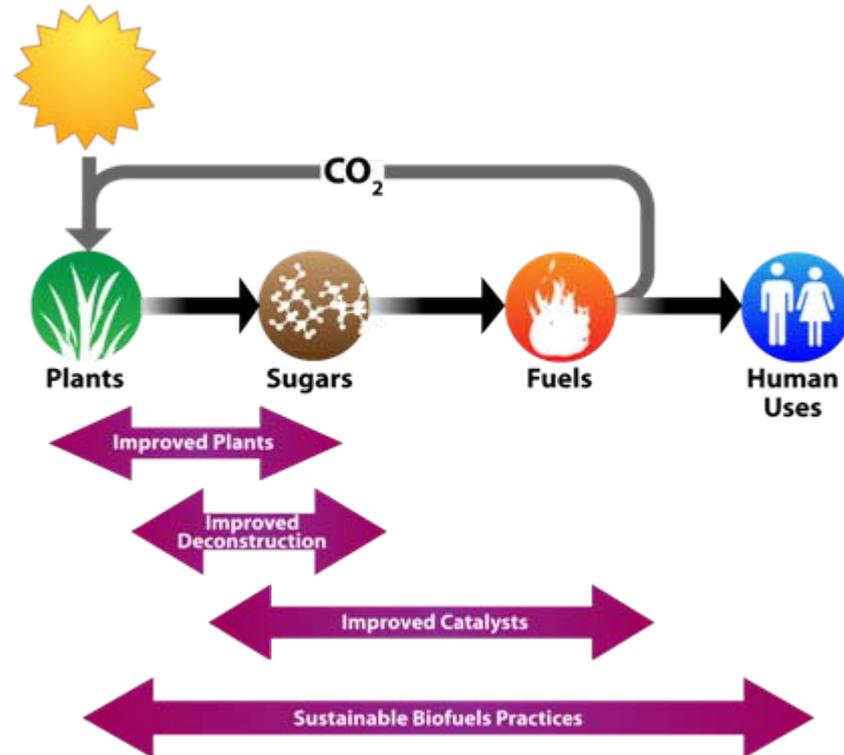


# Great Lakes Bioenergy Team

- ✗ Integrates ~400 “hand-picked” scientists/staff across sites & cultures
- ✗ Leverages diverse approaches to achieve a shared vision
  - ✗ Individual investigator creativity
  - ✗ Biological, physical & computational sciences
  - ✗ Wet, dry & field laboratories
  - ✗ High throughput core facilities
- ✗ Partners embrace mission, strategy & collaborative philosophy
  - ✗ Invest in strengths & collaborate with others (BESC, JBEI, JGI, etc.)



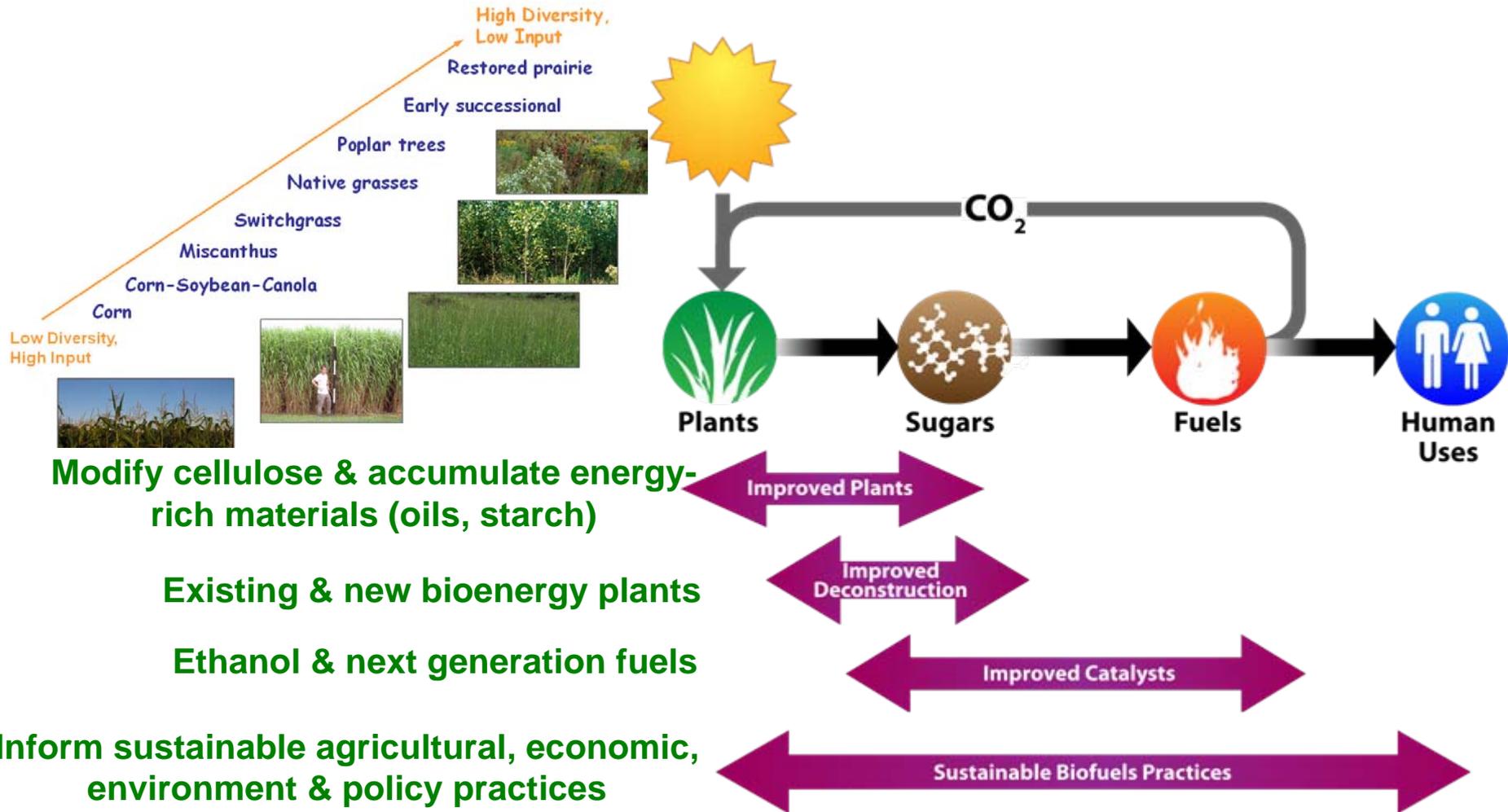
# Great Lakes Bioenergy Research Roadmap

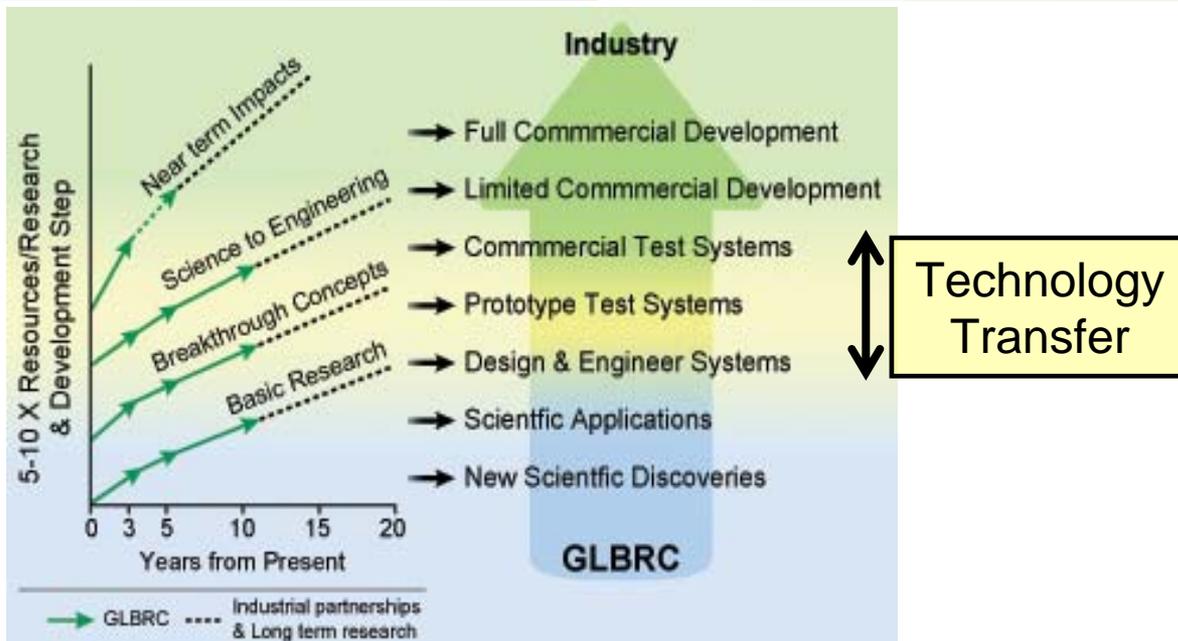
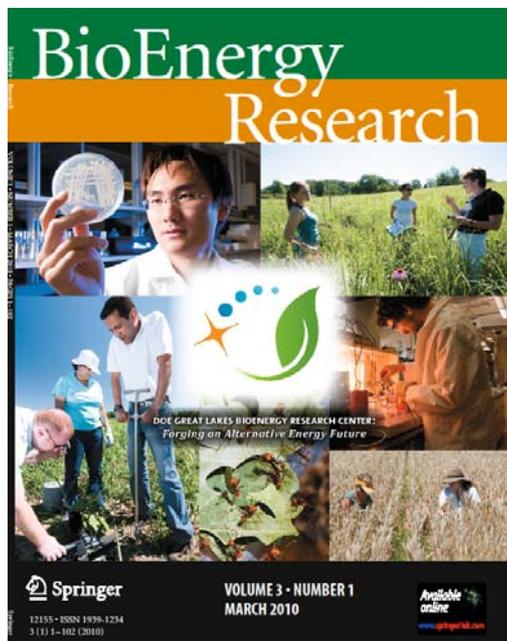


- ✘ Knowledge to improve plants for use as cellulosic biofuels feedstocks
- ✘ Knowledge to improve pretreatments and enzymes in order to generate low-cost, cellulosic sugar streams
- ✘ Knowledge to improve conversion of cellulosic sugar streams into ethanol & next generation biofuels (hydrocarbons, etc.)
- ✘ Knowledge to improve sustainability of cellulosic biofuel cropping systems

# Great Lakes Bioenergy Research Roadmap

Fundamental science to sustainably convert cellulosic biomass from different plants into ethanol & next generation fuels

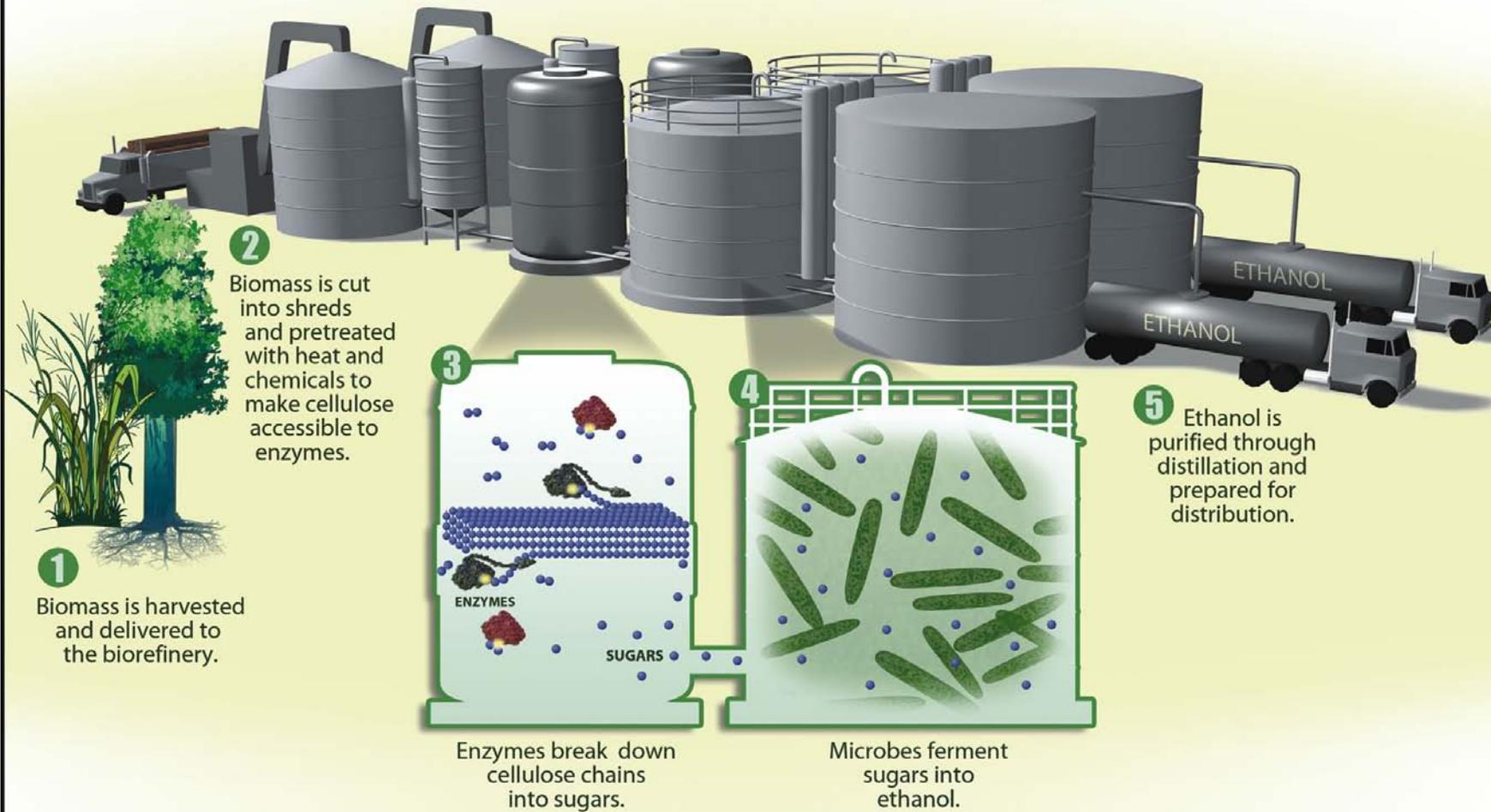




- ✗ ~80 papers/scientific reports since Fall, 2007
- ✗ ~20 patent disclosures being processed (**bioenergy plants, enzymes, microbial & catalytic production of sugars, precursors, ethanol or next generation fuels**)
  - ✗ Interest in “start up company” on at least one technology
  - ✗ Process scale up and licensing activities for others
  - ✗ Contact Jennifer Gottwald ([jennifer@warf.org](mailto:jennifer@warf.org)) at WARF for early technology access
  - ✗ Advisory board includes leaders from biofuels (logen, POET), automotive (GM), chemical (DuPont), fermentation (Miller) & investing (Piper Jaffray) sectors
- ✗ Collaborators on EERE-funded cellulosic biorefinery (Alpena) & ARRA project

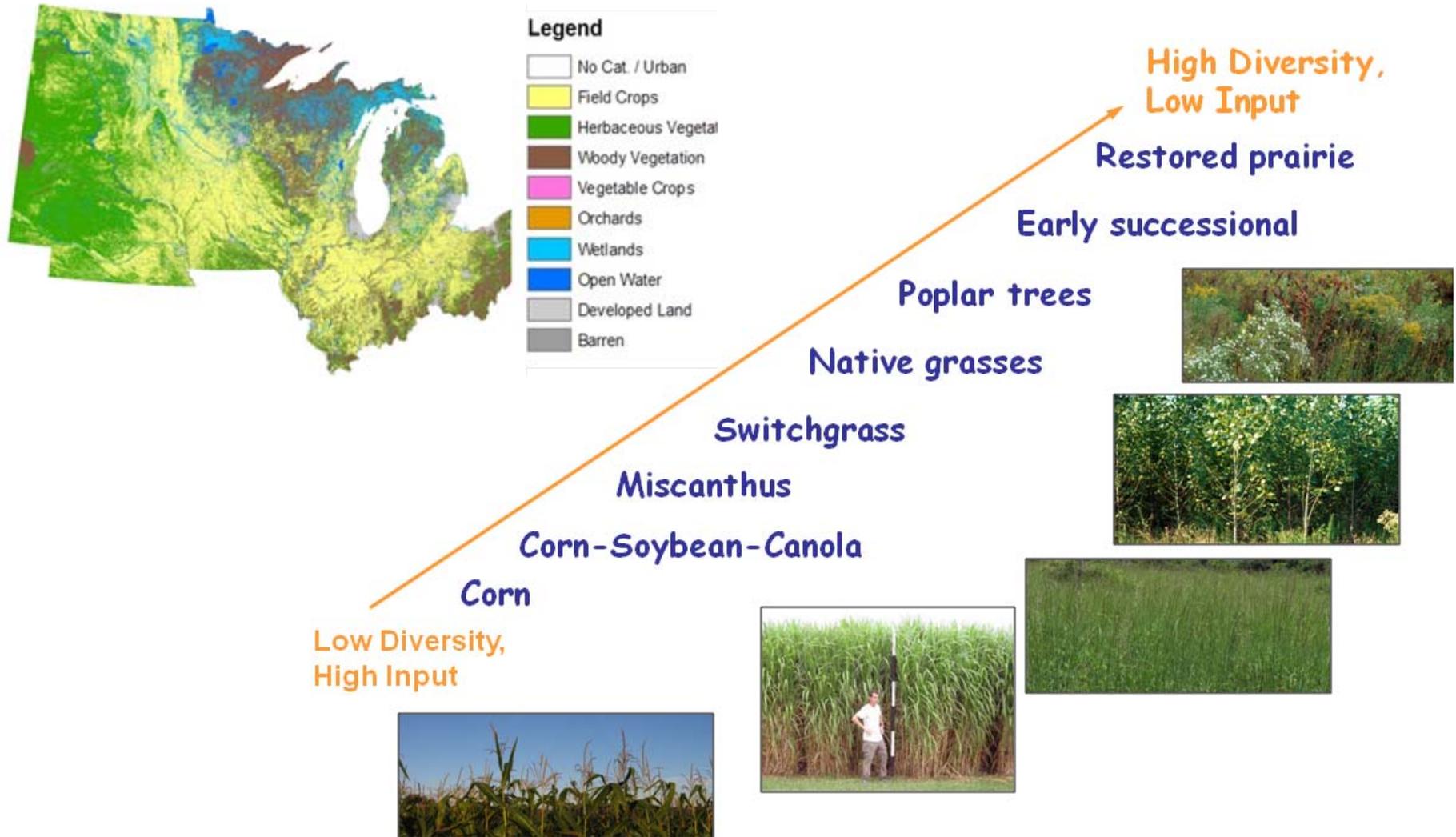
# How Cellulosic Biofuels Could be Made

Success depends on “*which, where and how* cellulosic biofuels are produced.” (Robertson *et al. Science* 2008)



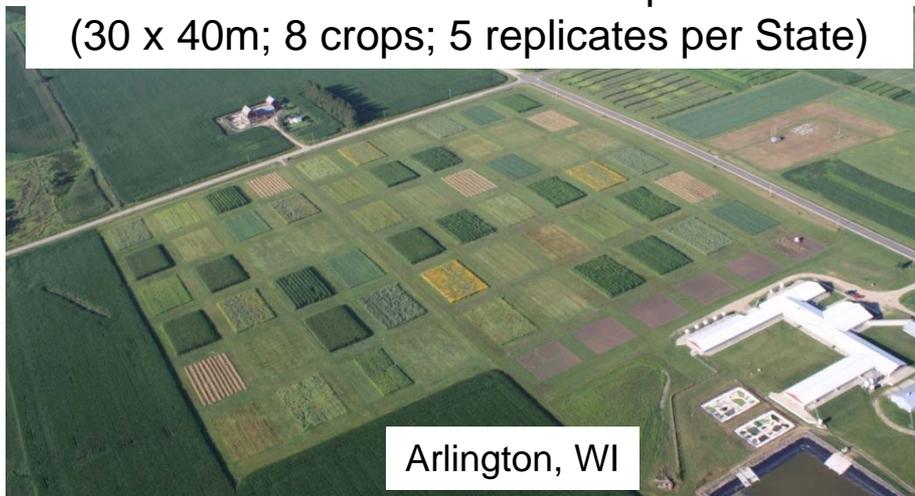
# Great Lakes Bioenergy Sustainability Research

Knowledge to improve sustainability of cellulosic biofuel cropping systems



# Analysis of Sustainable Biofuel Cropping Systems <sup>9</sup>

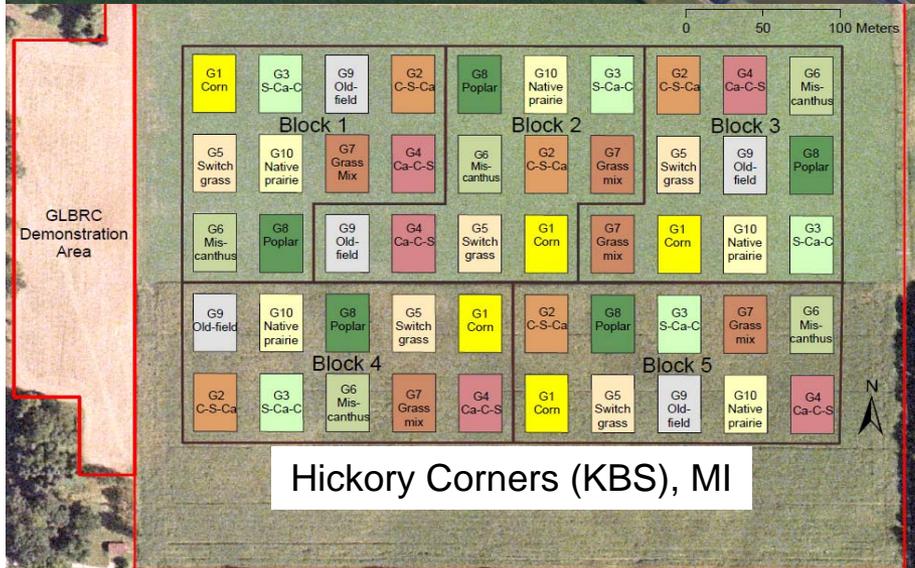
“Small scale” Intensive plots  
(30 x 40m; 8 crops; 5 replicates per State)



Arlington, WI

Attributes of high-performance cellulosic cropping systems that are most valuable & likely to win acceptance

- Microbial & Plant Outputs
- Biogeochemical Responses
- Biodiversity Responses
- Multi-scale/LCA Biofuel Models



Hickory Corners (KBS), MI

Larger scale activities

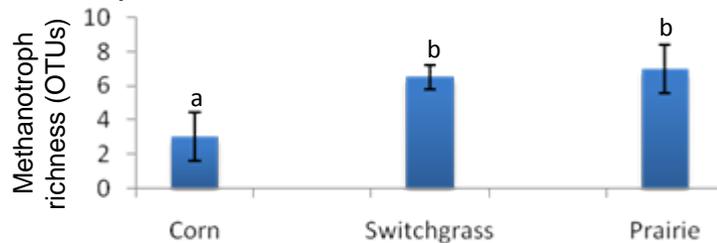
- “Scale Up” (3 crops @, 30-50 acres)
- “Extensive” wildlife monitoring sites (30 total for corn, prairie or switchgrass; up to 600 acres)
- Forestry/watershed analysis (ARRA)
- Multiple county modeling areas for economic, social & biophysical studies (MI & WI)

# Analysis of Sustainable Biofuel Cropping Systems

Attributes of high-performance cellulosic cropping systems that are most valuable & likely to win acceptance

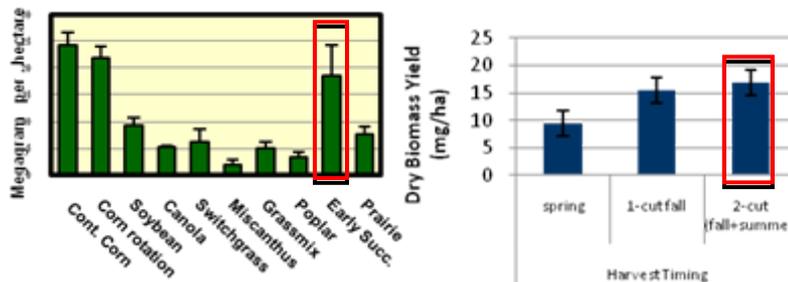
- Microbial & Plant Outputs
- Biogeochemical Responses

**Microbes:** More methanotroph (GHG reduction) diversity in switchgrass & prairie than corn



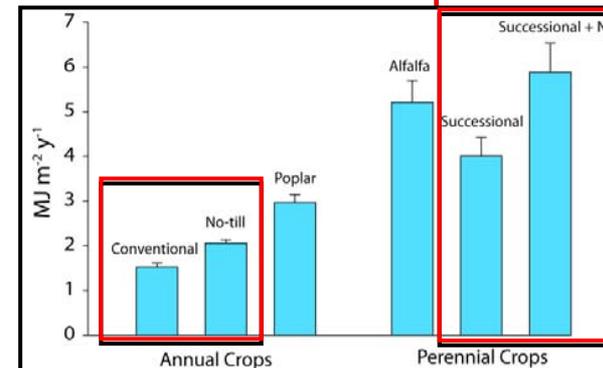
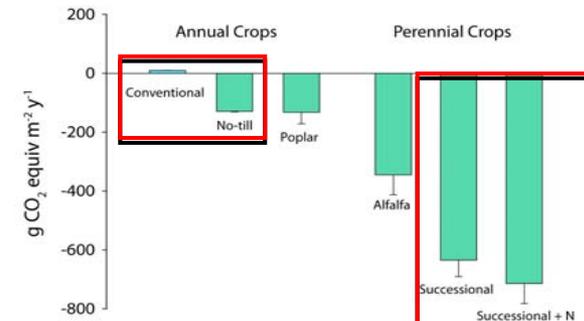
**Plants:**

- Excellent early successional yield vs corn
- 2X-harvest switchgrass yields same as 1X



**Biogeochemical Responses:**

- conventional tillage “carbon neutral”
- successional fertilization benefit, but offset by GHG
- early successional least carbon intensive & most land conserving
- energy yields relatively high

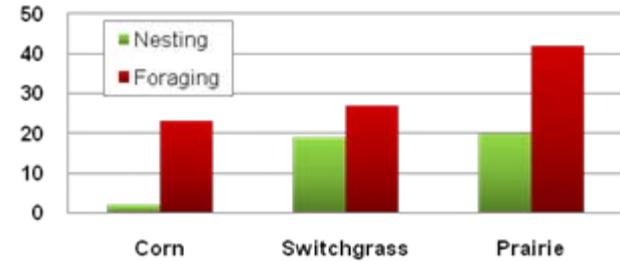


# Services & Scenarios of Sustainable Biofuels

Attributes of high-performance cellulosic cropping systems that are most valuable & likely to win acceptance

- Microbial & Plant Outputs
- Biogeochemical Responses
- Biodiversity Responses
- Multi-scale/LCA Biofuel Models

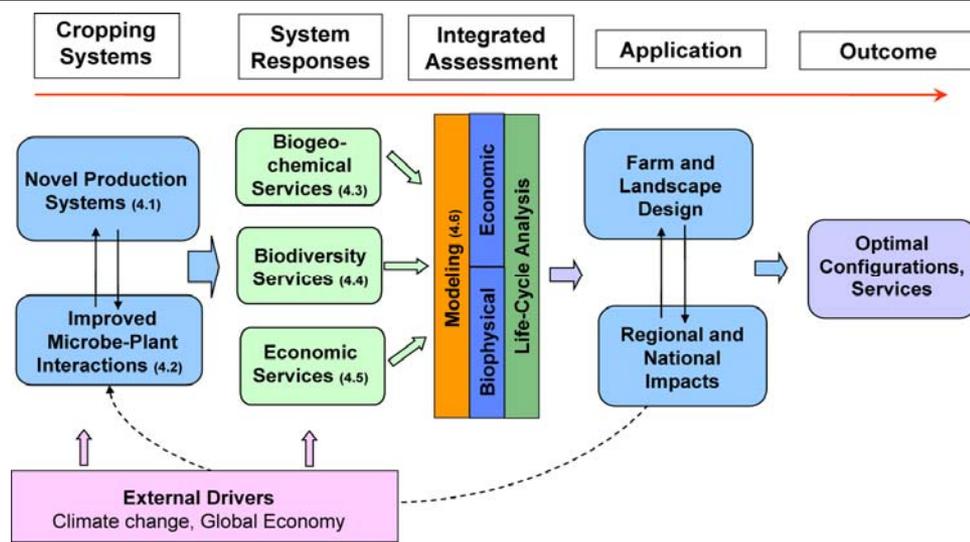
**Biodiversity Responses:** pest & disease control, pollination, wildlife services, etc.



- better foraging in prairie vs. corn or switchgrass
- “early conservation concern” for some bird species in perennials

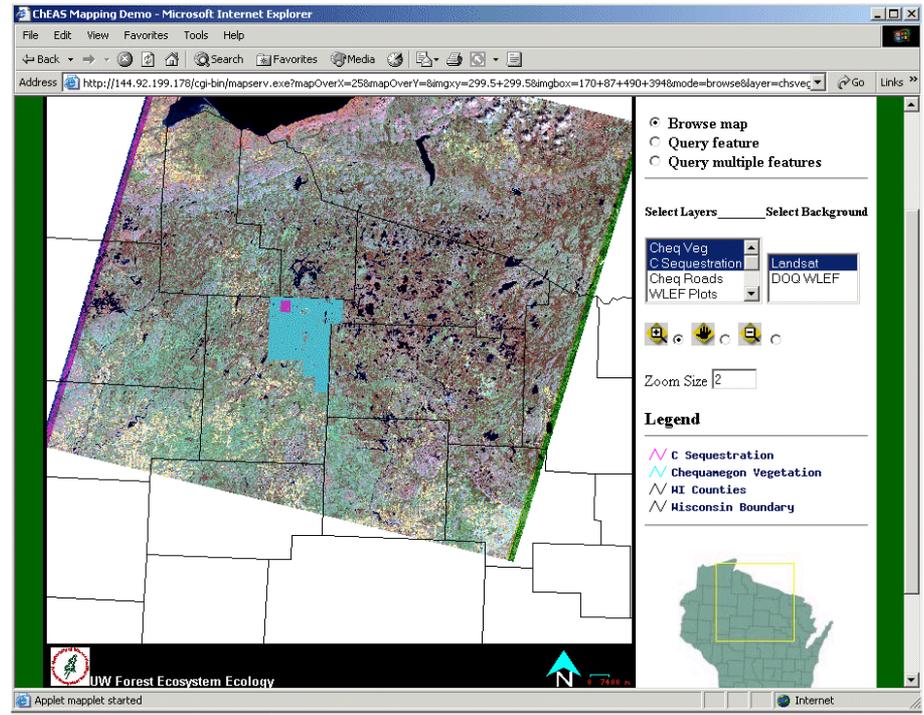
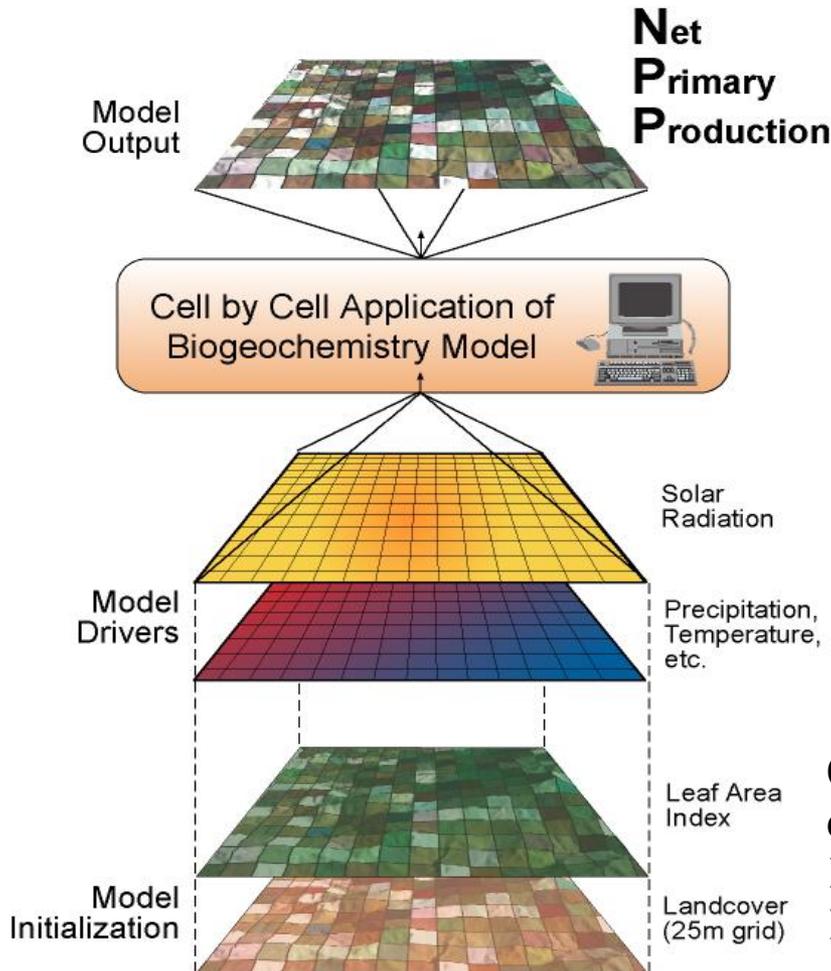
## Principles for multi-scale/LCA biofuels models:

- Compare landscape & biodiversity
- Agricultural management vs. biodiversity (APEX)
- How biofuels landscape patterns alter land-use
- Model scenarios with different services
- Predict “optimal” agricultural, economic & environmental practices
- Provide science to help inform policies/incentives



# Services & Scenarios of Sustainable Biofuels

Link terrestrial (agriculture, grasslands, forests) & industrial ecosystem process models to simulate carbon budget of “user-defined ecosystem goods”



Coding & populating system to integrate satellite, economic, field & other data sets

- single portal data repository
- test agricultural, economic, environmental scenarios

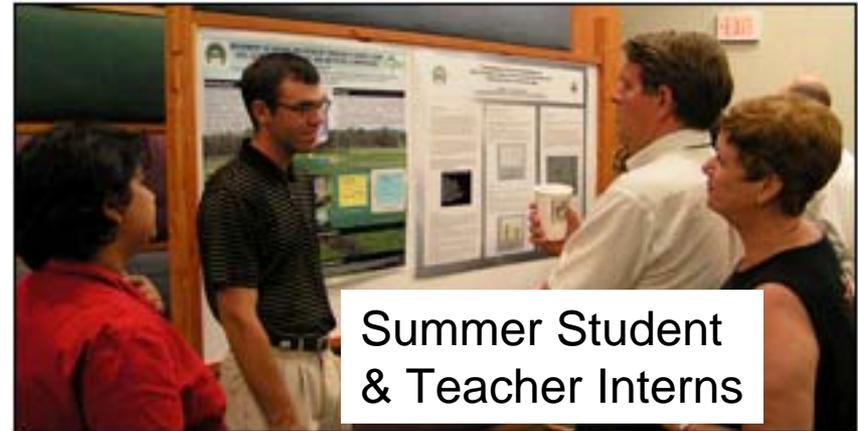
# Informing Society About Sustainable Biofuels

## Great Lakes Bioenergy Education & Outreach Program

*“training tomorrow’s leaders as we create the technology”*



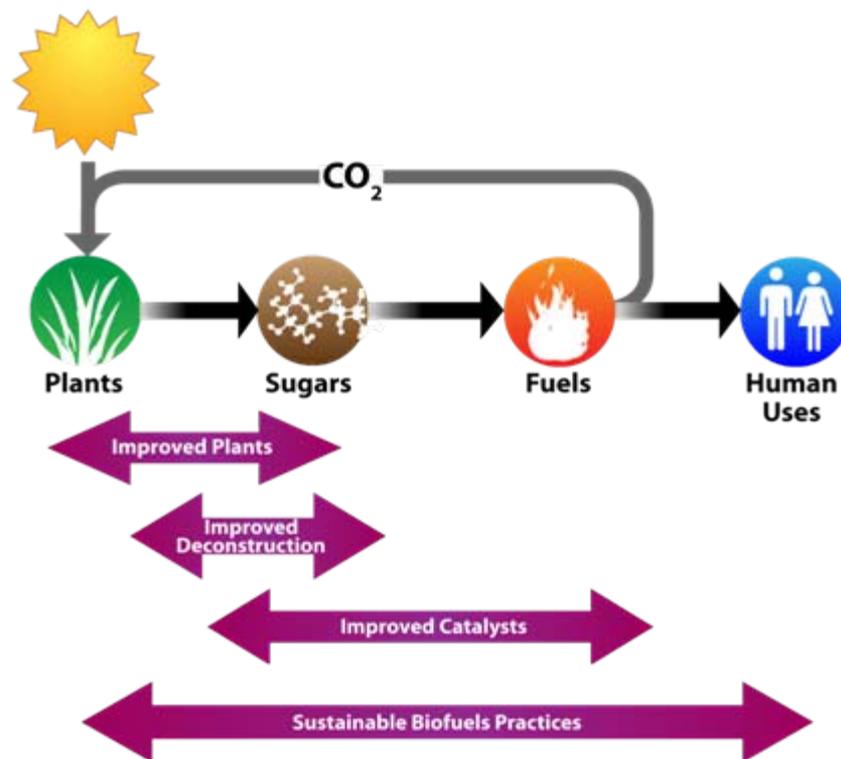
Media



Summer Student & Teacher Interns

Pipeline

- ✘ inform students, citizens, farmers, businesses, & policy makers about (cellulosic) biofuels



- ✗ Knowledge to improve plants for use as cellulosic biofuels feedstocks
- ✗ Knowledge to improve pretreatments and enzymes in order to generate low-cost, cellulosic sugar streams
- ✗ Knowledge to improve conversion of cellulosic sugar streams into ethanol & next generation biofuels (hydrocarbons, etc.)
- ✗ Knowledge to improve sustainability of cellulosic biofuel cropping systems
- ✗ **Center-wide knowledge to improve sustainability of cellulosic biofuels enterprise**