GREAT LAKES BIOENERGY RESEARCH CENTER

Lessons from the Bioenergy Farm

A Computer Game to Explore Land Management Complexities

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U.S. DEPARTMENT OF ENERGY

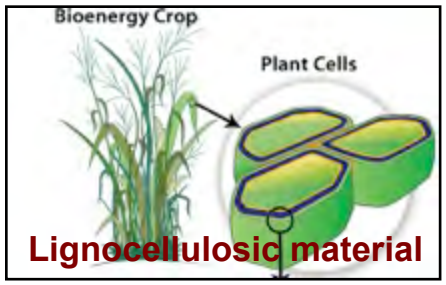
DOE Bioenergy Research Centers

Outline

- Next generation biofuels research (GLBRC)
- Gaming challenge & Learning opportunity
- Game development
- Game tour
- Experiences & Outcomes
- Next steps & Opportunities
- Discussion

Next Generation Biofuels Research (GLBRC)

Moving Beyond Corn Ethanol



Today's technology

Corn (kernels)

Starch

Heat and/or enzymes

Glucose

Fermentation (microbes)

Ethanol

Sugar Cane

Glucose

Fermentation (microbes)

Ethanol

Tomorrow's technology (GLBRC)

Plant biomass

? *Pretreat (grind, heat, chemicals, pressure)*

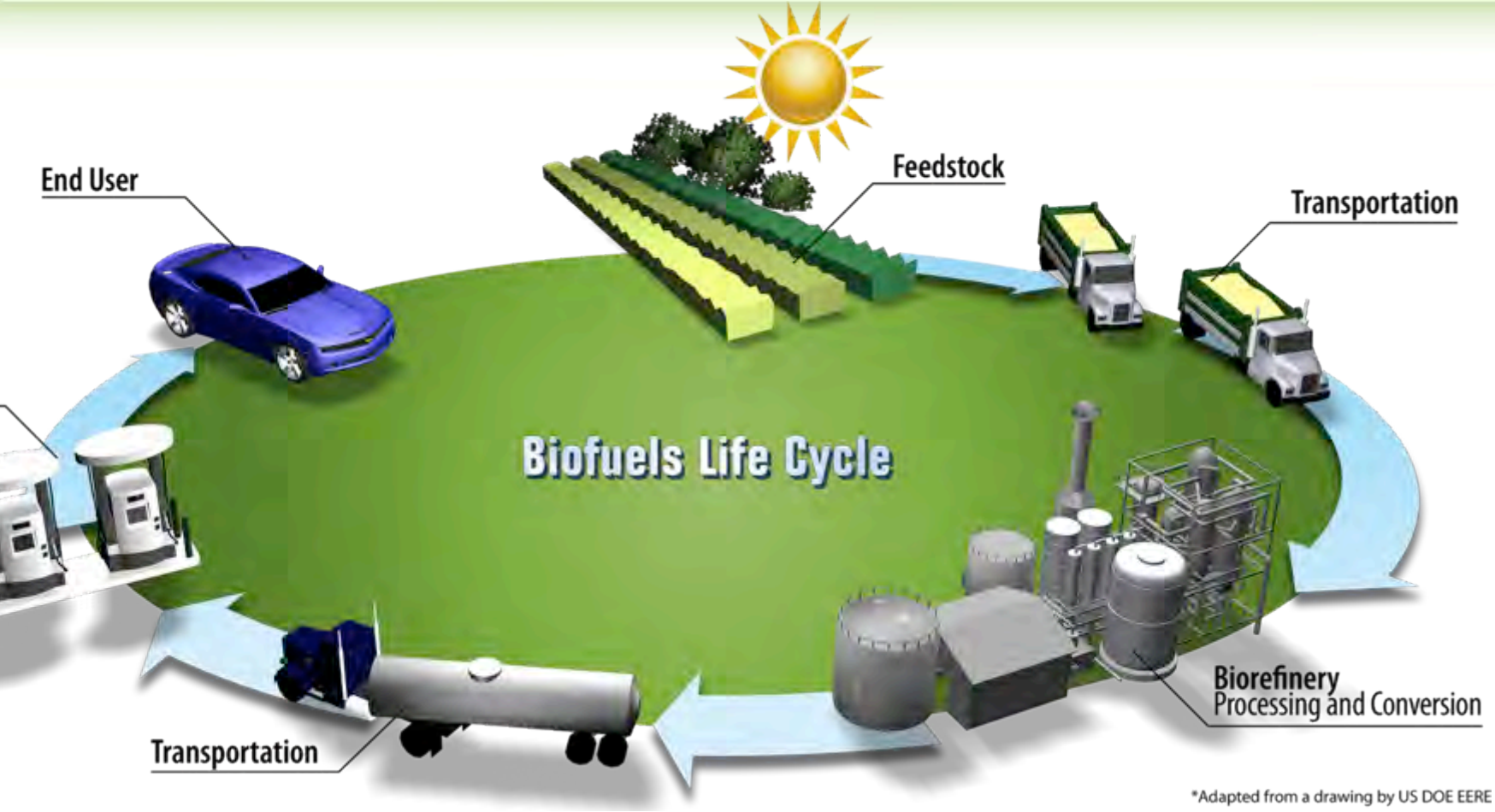
"Loosened" cell wall material (cellulose hemicellulose, lignin)

? *Enzymes (cellulases, etc) or microbes*

Mixed sugars, etc. (glucose, arabinose, xylose, phenolics, etc.)

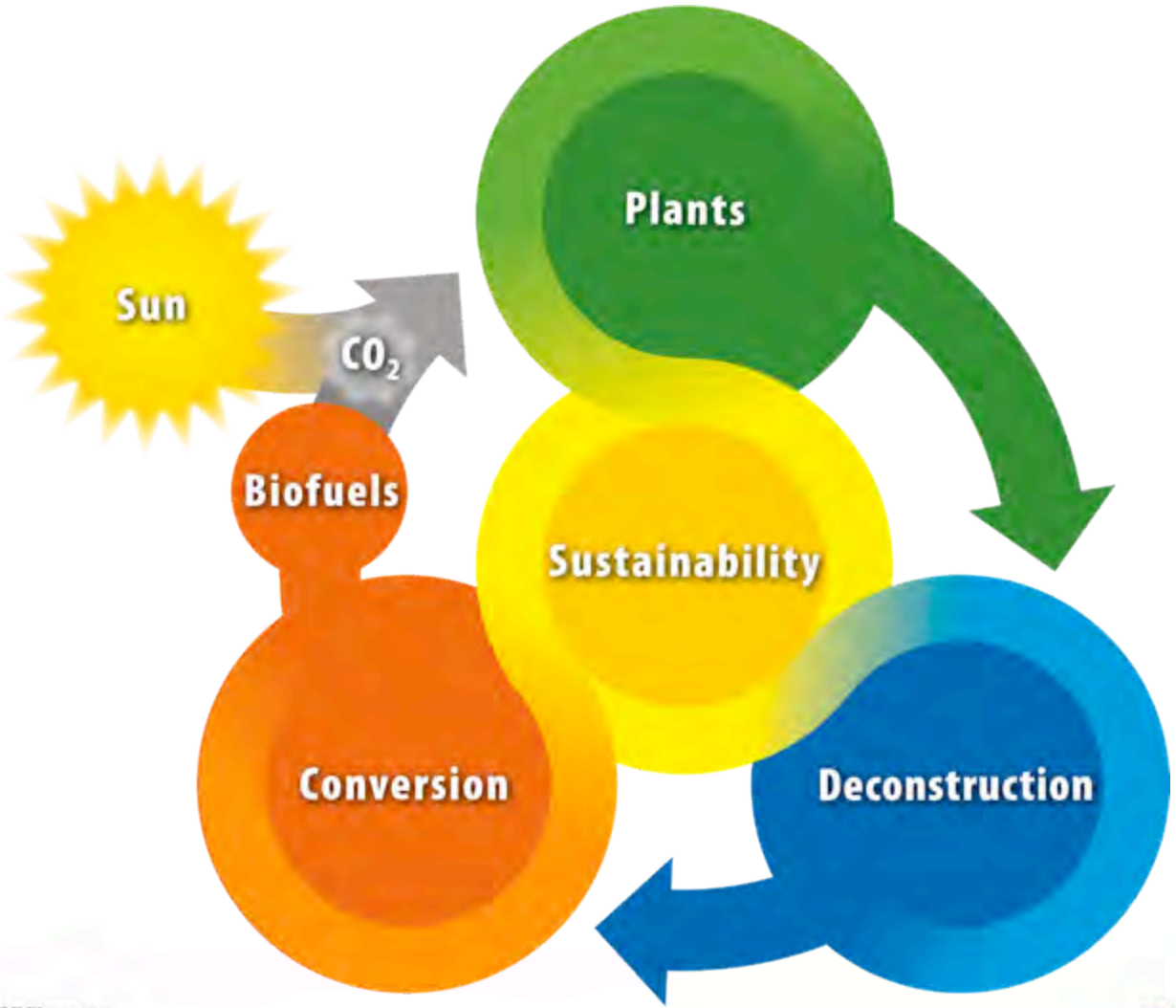
? *Fermentation (microbes) or catalysts*

Ethanol (next generation fuel)

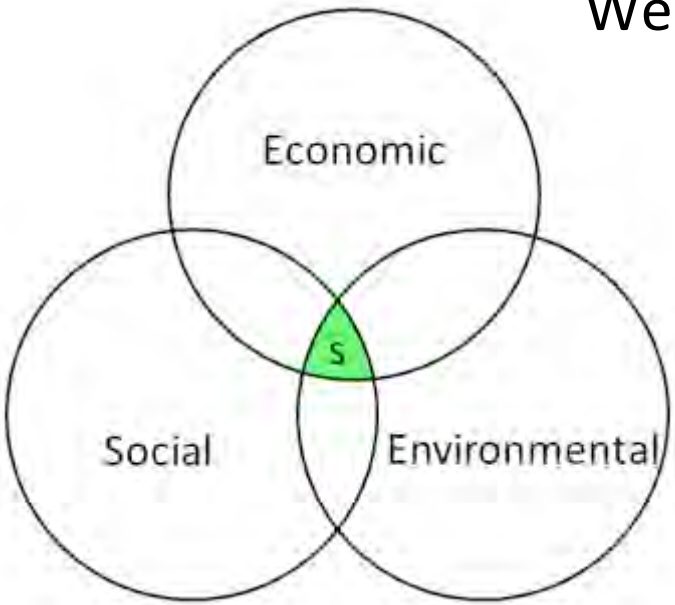


*Adapted from a drawing by US DOE EERE

GLBRC Research Pipeline: Sustainability is Key



Biofuel Sustainability



We **define sustainability** as the intersection of economic, environmental, and social objectives

- **Economic objectives** include profitability and the basis for farmer, refiner, and policy decisions about what to plant where and when
- **Social objectives** include energy and food security
- **Environmental objectives** include climate mitigation, water and nitrogen conservation, and the delivery of biodiversity services

Biofuel Cropping Systems

GLBRC Cropping systems experiment
Arlington ARS (WI) & Kellogg Biological Station (MI)

8 systems x 5 replicate blocks - Established 2008

Biofuel Crops and Sustainability

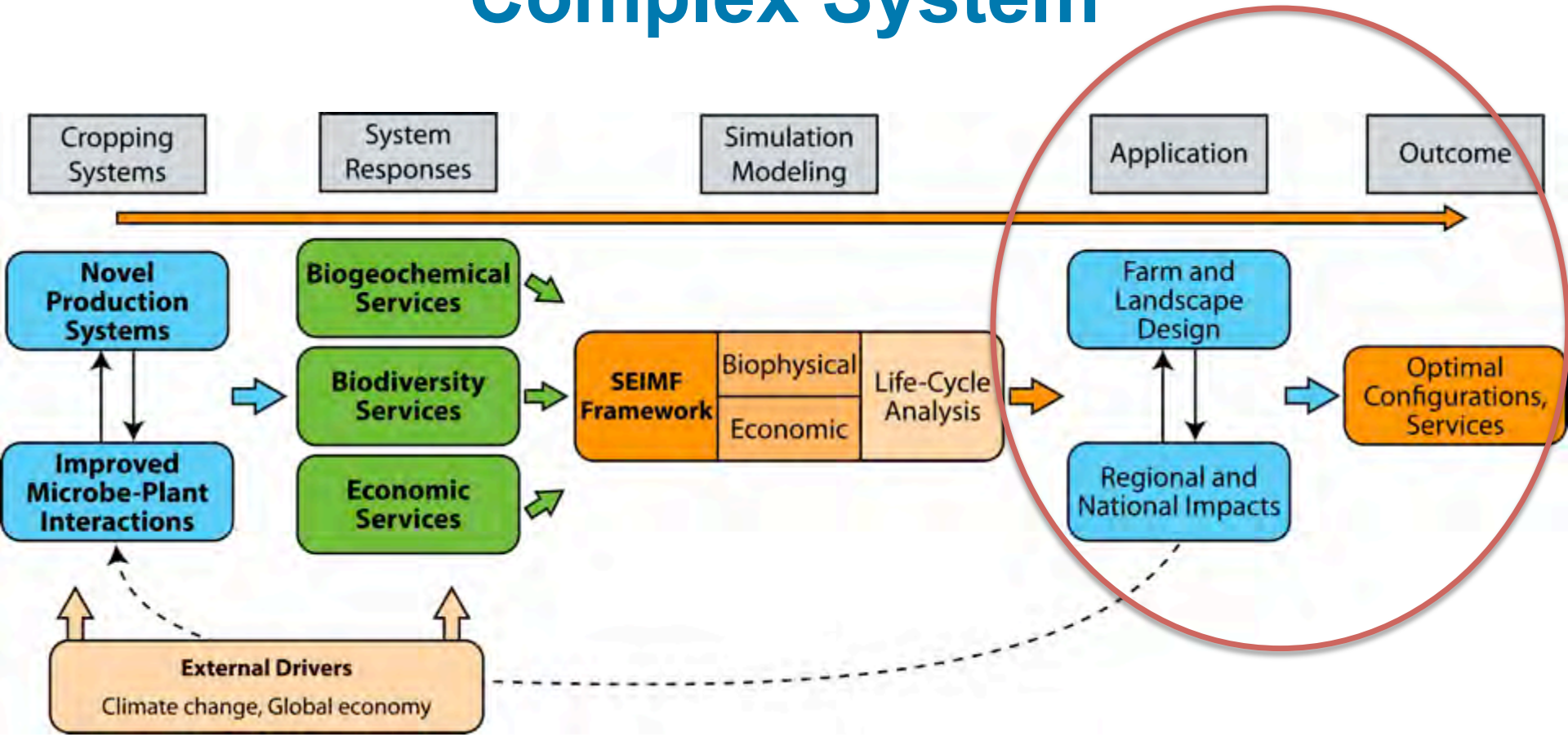
Lower Biodiversity	Higher Biodiversity
• Annual	• Perennial
• Monoculture	• Polyculture
• Exotic	• Native
• High input	• Low input

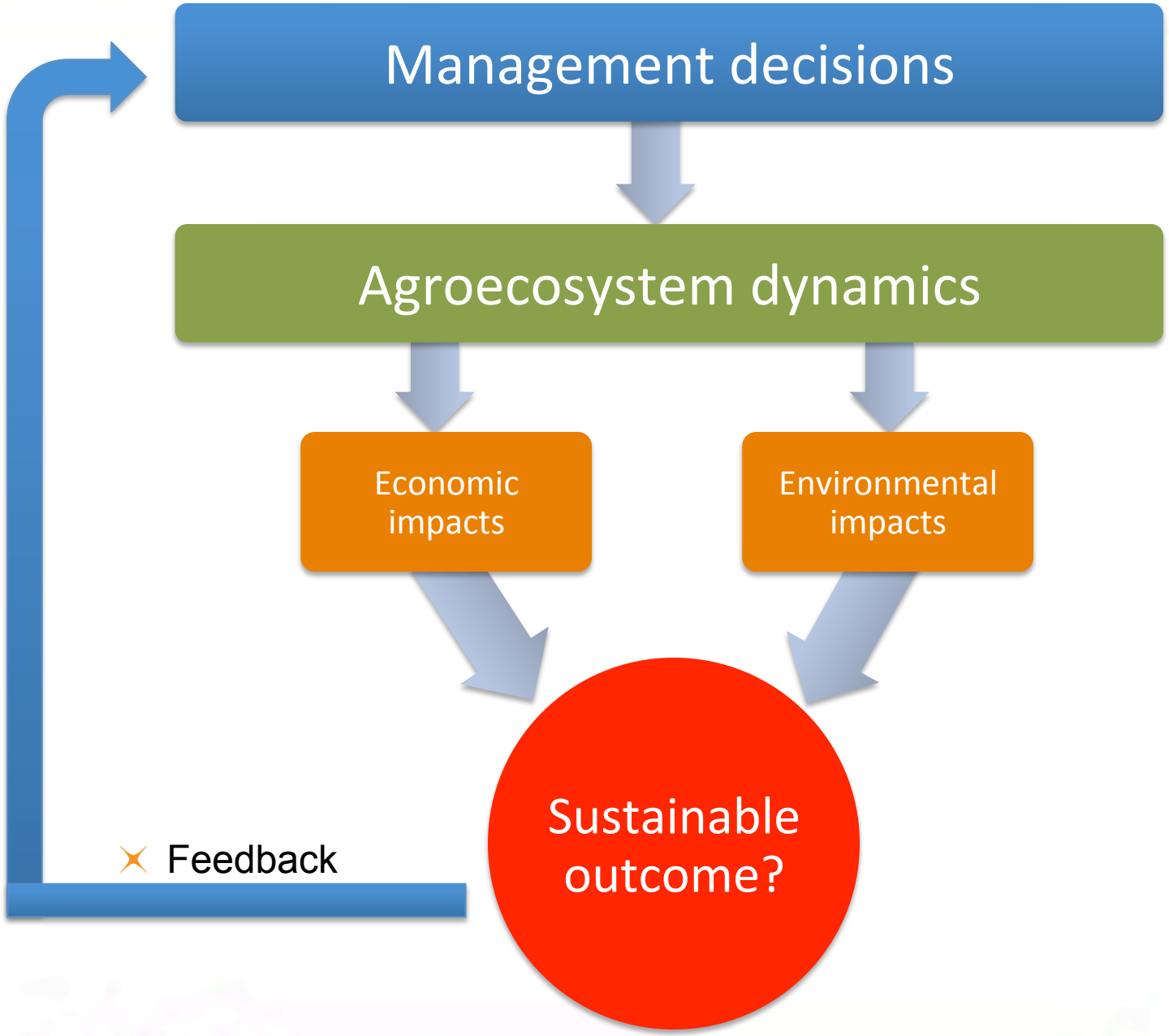
Corn

Switchgrass

Mixed prairie
"Low-Input High-Diversity"

Investigating and Modeling a Complex System




Management decisions
Agroecosystem dynamics
Economic impacts
Environmental impacts
Sustainable outcome?
Feedback

Managing Cropping Systems for Sustainability

Land management decisions

- Crop (what, when, where)
- Tillage
- Chemical application (fertilizers, pesticides)

Key Environmental Variables

- Greenhouse gas emissions
- Soil fertility
- Nutrient Runoff (water quality)
- Biodiversity

Key Economic Variables

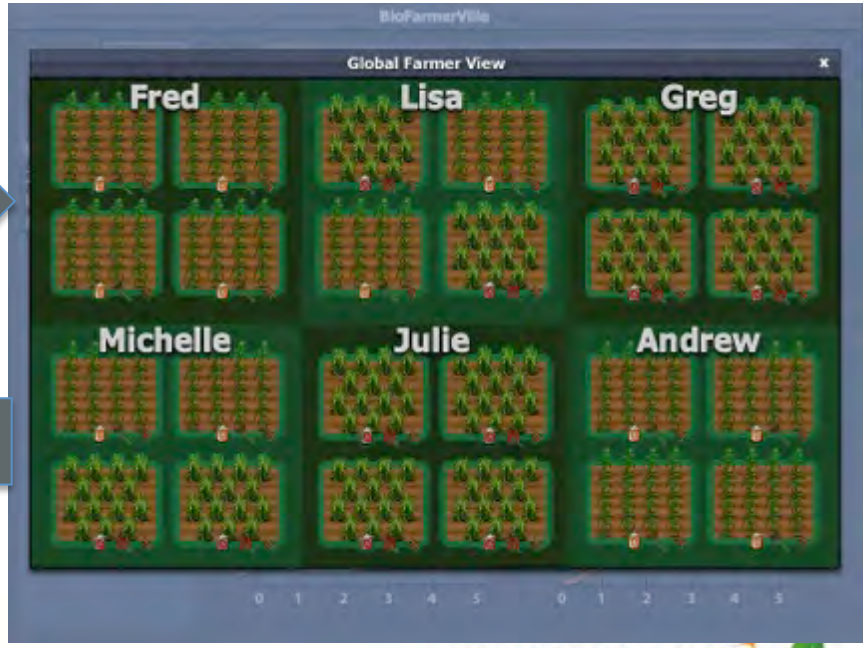
- Profitability
- Energy production

Agricultural Ecosystems:
Are There Sustainable Scenarios?

Gaming Challenge & Learning Opportunity

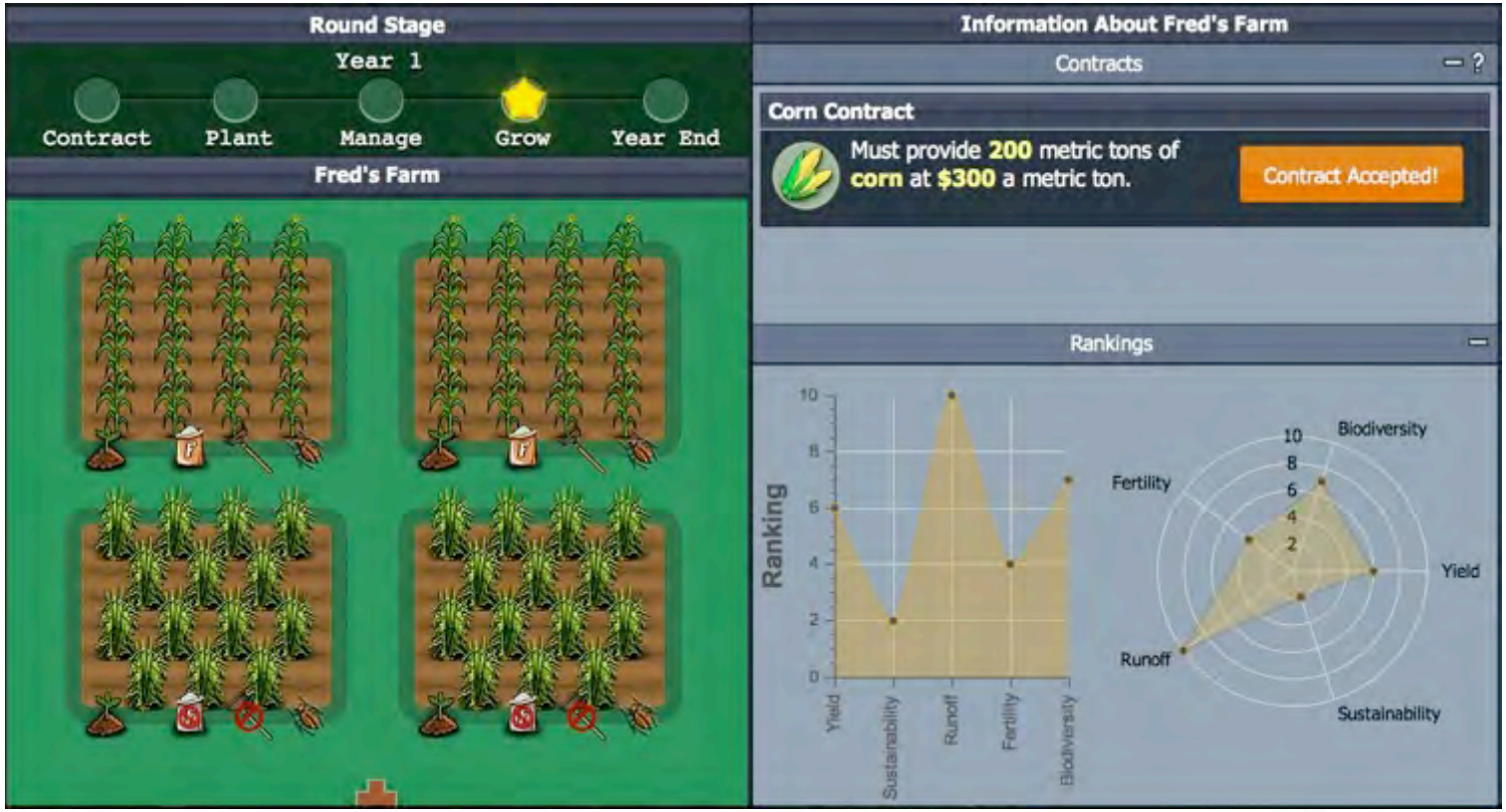
Objective

Develop an online multiplayer game in which players can explore outcomes of pursuing individual and collective goals in realistic modeled bioenergy crop production environment.



Player Challenge

Make farm management decisions to maximize ecosystem services, profits and energy production.



Learning Goals

After playing the game, players should better understand:

- Ecological and economic dimensions of sustainability
- Short-term vs. long-term dynamics of sustainable systems
- Local and global impacts of individual farmer management decisions

Game Development

Wisconsin Institute for Discovery

GREAT LAKES BIOENERGY RESEARCH CENTER

- Computer scientists
- Player feedback
- GLBRC scientists and staff

FIELDS of FUEL

- High school teachers
- Game developers
- Education researchers

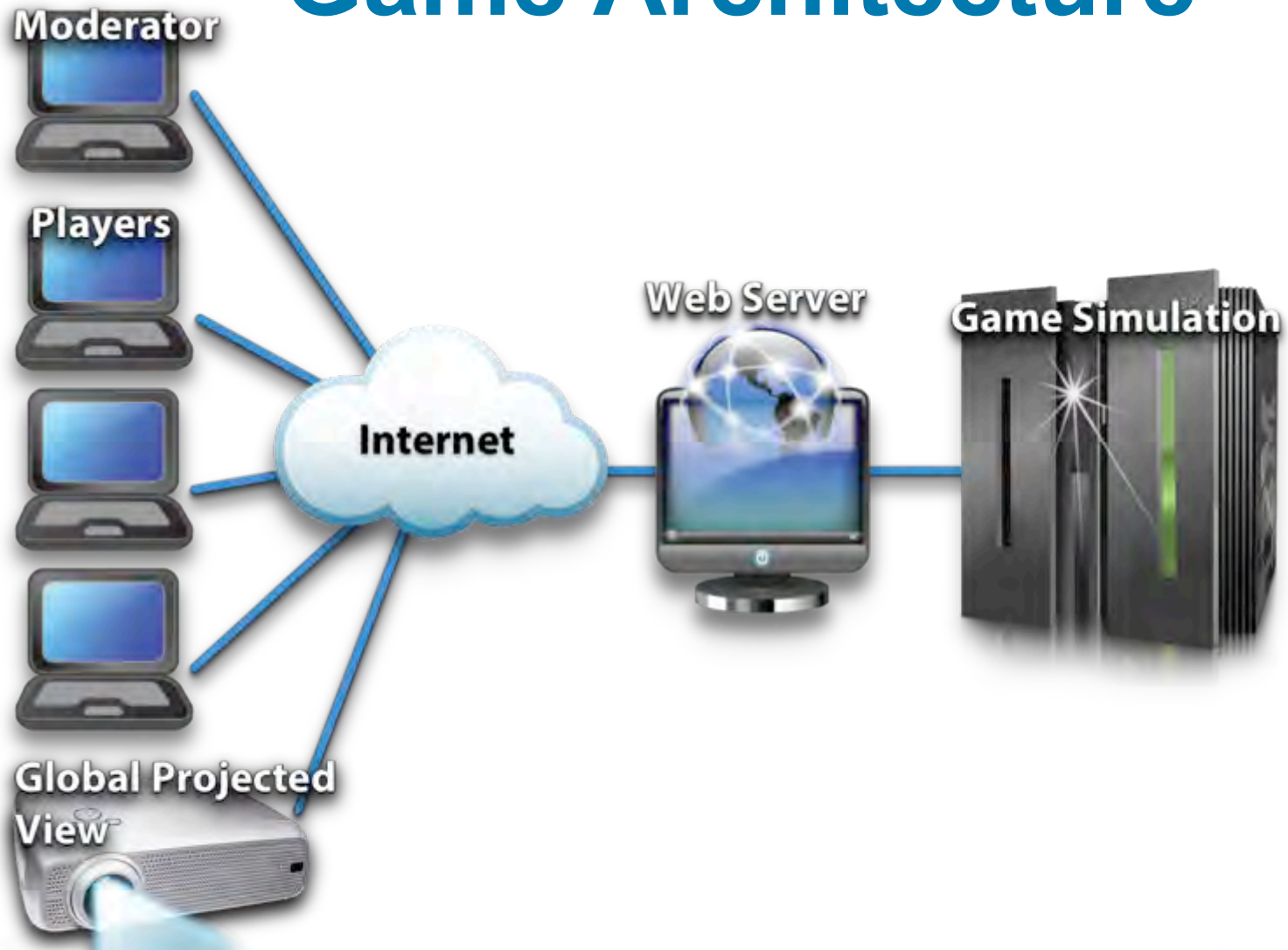
Middleton-Cross Plains Area School District
★ Inspire ★Challenge ★Empower

GLS GAMES + LEARNING + SOCIETY

DEPARTMENT OF Curriculum and Instruction
UNIVERSITY OF WISCONSIN–MADISON

Game Tour

Game Architecture



Key Features

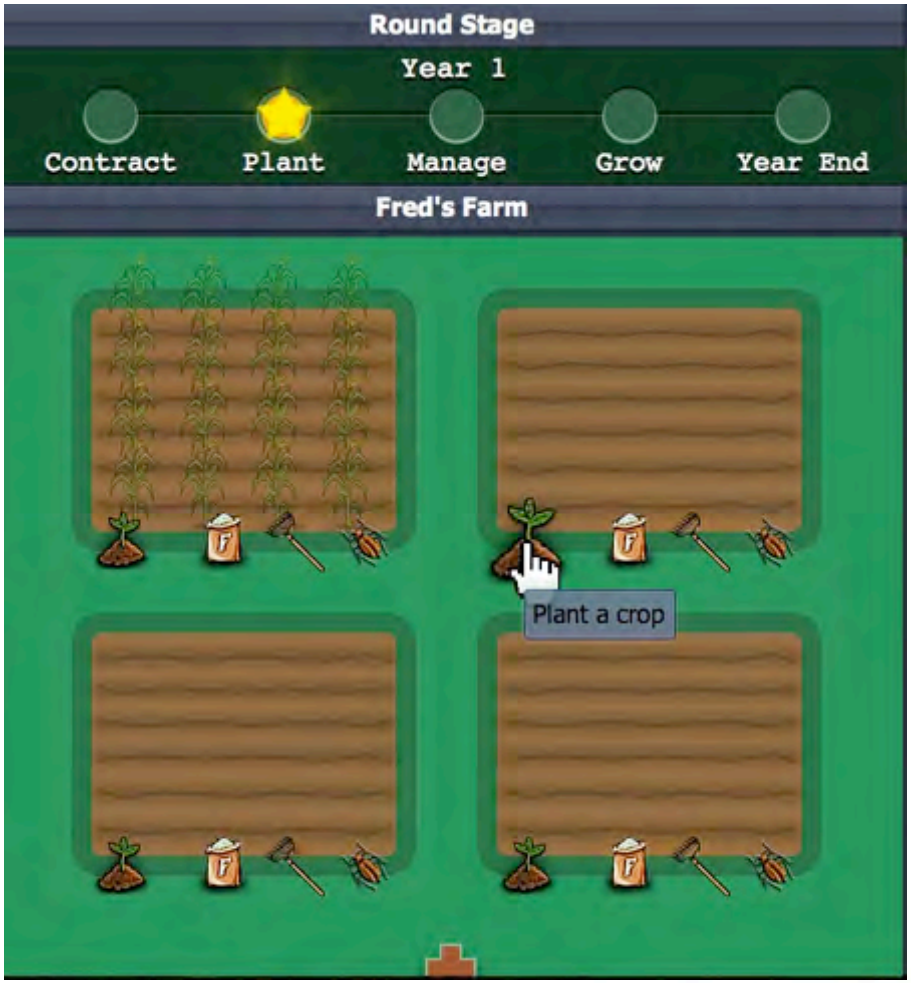
- Realistic & Dynamic Models
  - Economic and Ecological
- Local and global outcomes
- Moderator adjusts level of complexity based upon audience and learning goals
- Players can define their goals collectively

Flow of Play

- Round-based (year)
- Choose crop
- Manage (optional)
- Year advances (models run)
- Player feedback (economic and environmental)
- Adapt and continue

Player Decisions

- Basic:
  - Crop: Corn, Switchgrass, Cover crop
- Optional:
  - Fertilizer (Hi/Low)
  - Pesticides (Hi/Low)
  - Tillage (till or no till)



Player Feedback

- Over Sustainability Score
  - Composite of economic and ecological scores
- Environmental Score
  - Composite of GHG emissions, soil health & biodiversity
- Economic Score
  - Based upon income, yield and energy production
- More or less detail

Local vs Global Goals

- Global outcome
- Local outcome

Experiences & Outcomes

Preliminary Assessments

- Players highly engaged, positive response
- Discussions uncover strategies and thinking about economic and ecological systems
- Deeper understanding of economic environmental tradeoffs in sustainability
- Consideration of the components of agroecostystem sustainability
- Need better presentation of data for players to uncover and understand mechanisms

Next Steps & Opportunties

- Complete web-based version (Early April)
- Demonstrations and feedback: classroom and informal audiences
- Curriculum development
- Research on learning gains
- Crowdsourcing research to understand behavior and management strategies

Get Involved

- Research Experience for Teachers: We're recruiting a teacher to work on this project this summer.
- Bioenergy Institute for Educators (6/24-29): Apply by March 31
- Online education materials (glbrc.org/education)
- Sign up for our GLBRC newsletter
- Want to try the game? Let me know!

Acknowledgements

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Contact

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Education Programs

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