Sustainability of Biofuel Feedstock Production in Forestry Settings

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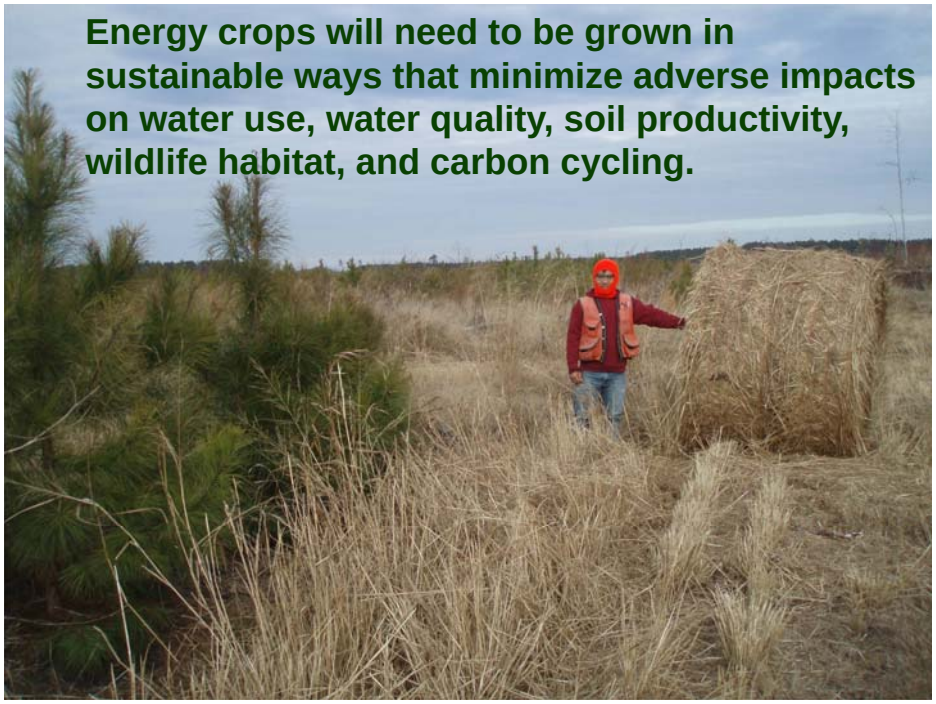
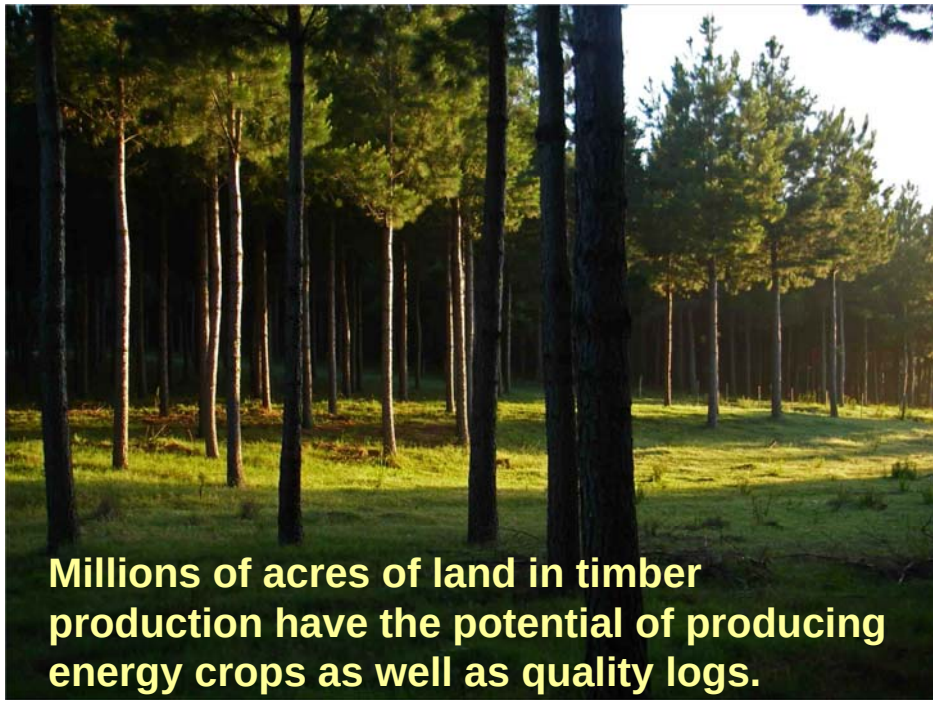
Weyerhaeuser

Catchlight Energy

Increased biomass production is essential for energy security and for a rapidly expanding biofuel industry.



Energy crops will need to be grown in sustainable ways that minimize adverse impacts on water use, water quality, soil productivity, wildlife habitat, and carbon cycling.



Millions of acres of land in timber production have the potential of producing energy crops as well as quality logs.

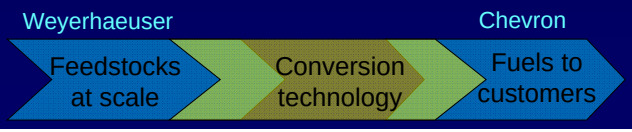
This potential stems from the fact that sparely grown high value crop trees leave room for a natural or managed understory

This area can be used for production of biofuel crops such as switchgrass

Catchlight Energy™

A Chevron | Weyerhaeuser Joint Venture

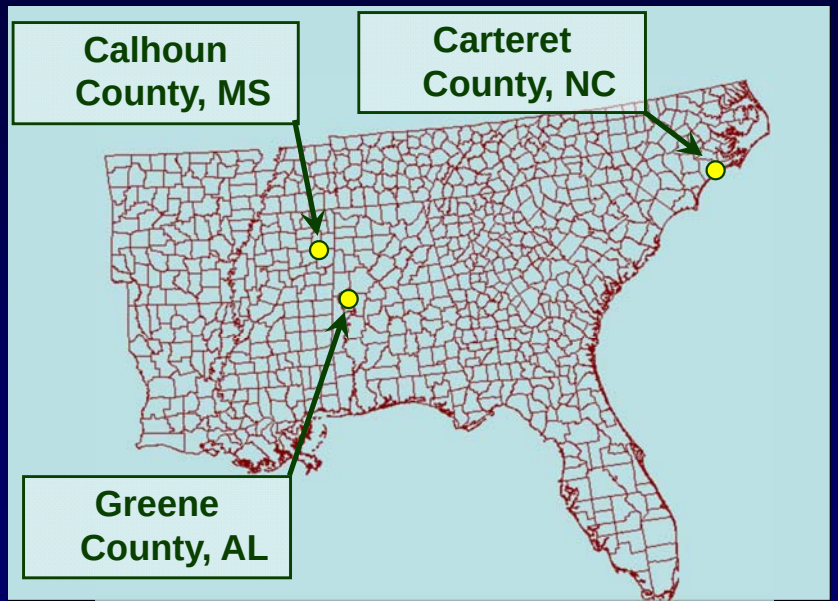
- 50-50 Joint venture of Weyerhaeuser and Chevron
- Created to commercialize large scale production of liquid transportation fuels
- Based on sustainable biofuel plantings on forest land



New Biofuel Crop Study in Southeast USA

- Three research sites
- Four to five watersheds each
- Treatments include:
  - Pine plantation
  - Pine and switchgrass interplanting
  - Switchgrass only
  - Pine plantation with understory harvest
  - Mature forest
- Data collection began January 2010

Watershed Study Sites



Matched Watershed Approach

- Similar adjacent watersheds
- Calibration period: 1 - 2 years in young Pine
- Control Watershed – Typical pine mgmt.
- Treatment Watersheds
  - Pine and switchgrass interplanting
  - Switchgrass only
  - Pine plantation with understory harvest
- Treatment period: 4 to 5 years
- Compare hydrology and water quality of control vs. treatment to determine effects

Site Instrumentation

- Weather station at each large watershed
- At each sub-watershed:
  - Flow monitoring structures
  - Stage recorders and Doppler velocity meter
  - Automatic sampler – storm sampling
    - Sediment
    - Nutrients
    - Other forest chemicals used in switchgrass
  - Groundwater wells – water level & WQ sampling
  - Carbon and Nitrogen sampling of soil and biomass

Additional Funding from US Dept. of Energy

More in-depth study of:

- Hydrology
- Nutrient cycling
- Carbon cycling
- Watershed model development

Additional Funding from US Dept. of Energy

More in-depth study to include:

- Biodiversity
- Soil Productivity and Stability
- Life Cycle Analysis (LCA)
- BMP Development and Guidance
- Economic Analysis

Cooperators

N. C. State University

Weyerhaeuser Company

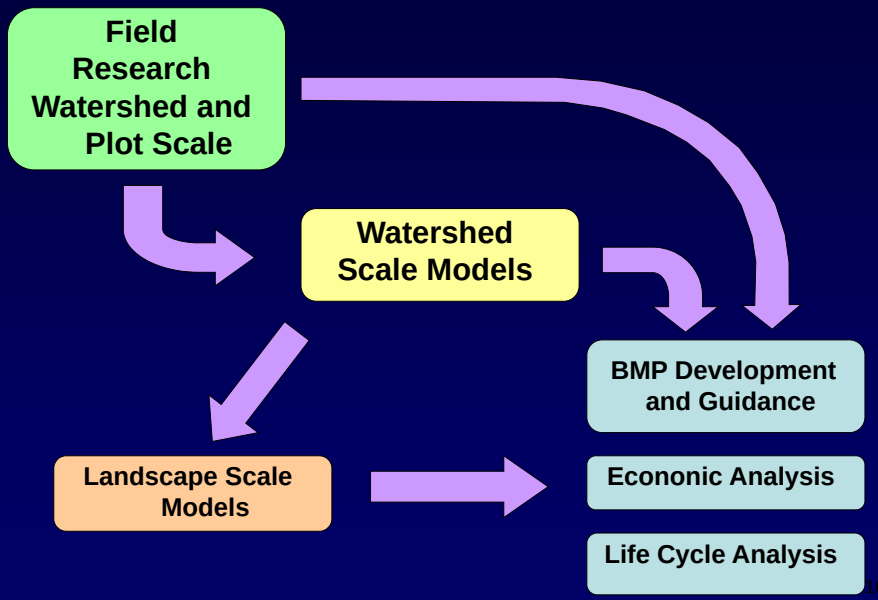
Catchlight Energy LLC (CLE)

Virginia Tech

US Forest Service

National Council for Air and Stream Improvement (NCASI)

Approach



Approach

Field Research Watershed and Plot Scale

Biodiversity
Crop Yield
Mgmt Costs
Soil Productivity

Hydrology
Water Quality
N & C Cycling
Evapotranspiration
Vegetation
Soil Properties

Alternate Scenarios

Watershed Scale Models

Water Yield
Water Quality

Land Use Parameters

BMP Development and Guidance

Econonic Analysis

Life Cycle Analysis

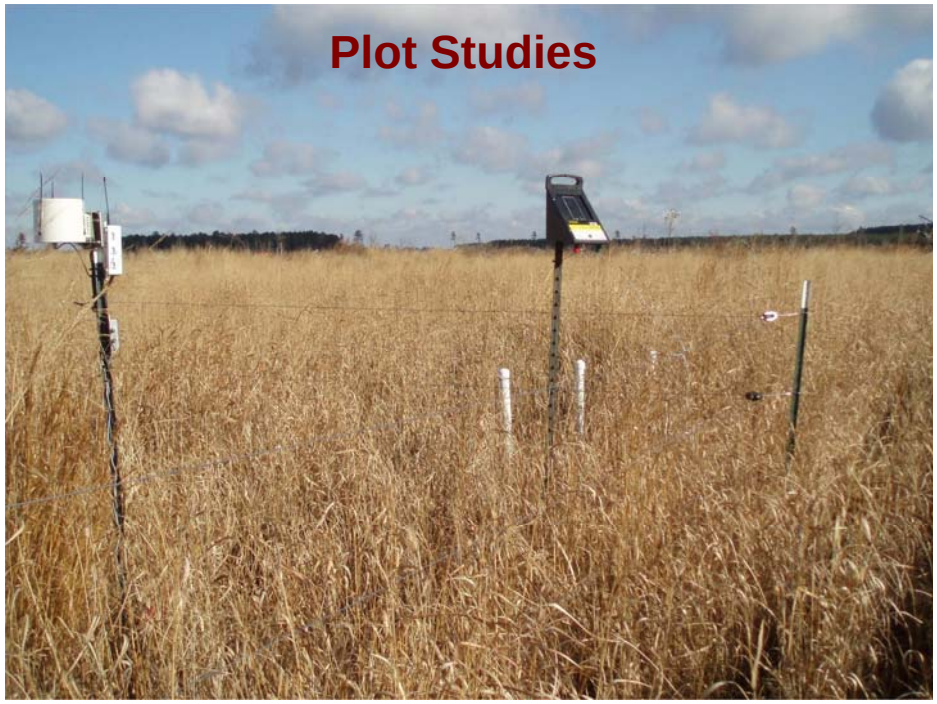
Landscape Scale Models

Alternate Scenarios

Water Yield
Water Quality

17

Plot Studies



The Lenoir County Study Site: Experimental Treatments

T0 Reference Stand	T1 Traditional Pine, RR	T2 Traditional Pine, RI	T3 Pine-Switchgrass, RR
T4 Pine-Switchgrass, RI	T5 Pine-Extra Flatbed Row, RR	T6 Pine-Extra Flatbed Row, RI	T7 Switchgrass Only

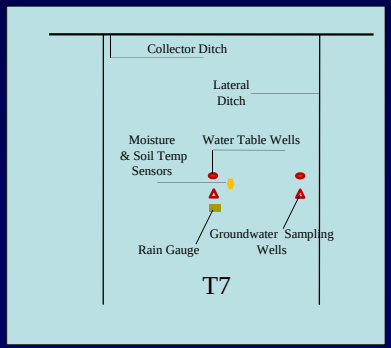
RR = residuals completely removed
RI = residuals in place

Plot size = 2-acre
Each treatment = replicated 4 times

Monitoring

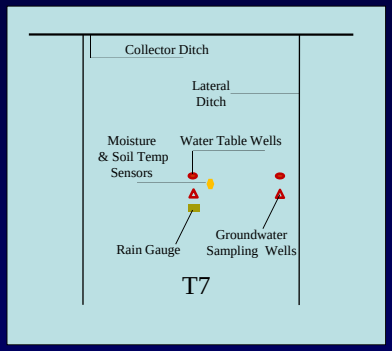
Hydrology

- Rainfall
  - automatic tipping bucket rain gauge
  - manual gauge (back up)
- Water table elevation
  - monitoring wells
    - with automatic recorders and data loggers
    - one midway between drains and another near the ditch



Monitoring

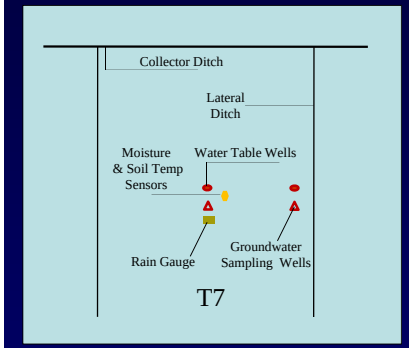
Hydrology



- Soil Moisture dynamics in the vadoze zone
  - automatic data recorder and logger
  - all layers in the soil profile
- Soil Temperature
  - automatic data recorder and logger
  - within 10 cm from the soil surface

Monitoring

Groundwater Quality



- Ground water sampling wells
  - 3 in the middle and 3 near the ditch
- Depths:
  - 0.6 – 0.9 m, 0.9 – 1.2 m, 1.8 – 2.1 m
- Parameters of interest
  - TKN, NH_4-N, NO_3-N, DON, DOC, Dissolved P, pH
- Frequency of sampling
  - bi-weekly
  - More frequent after fertilization

Monitoring

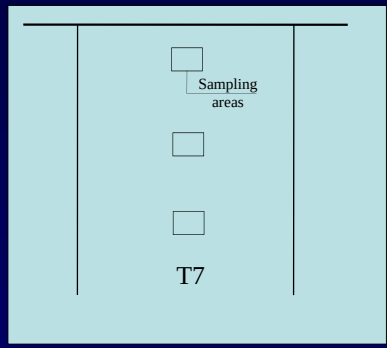
Nutrient Dynamics

❑ Field Data Collection Technique

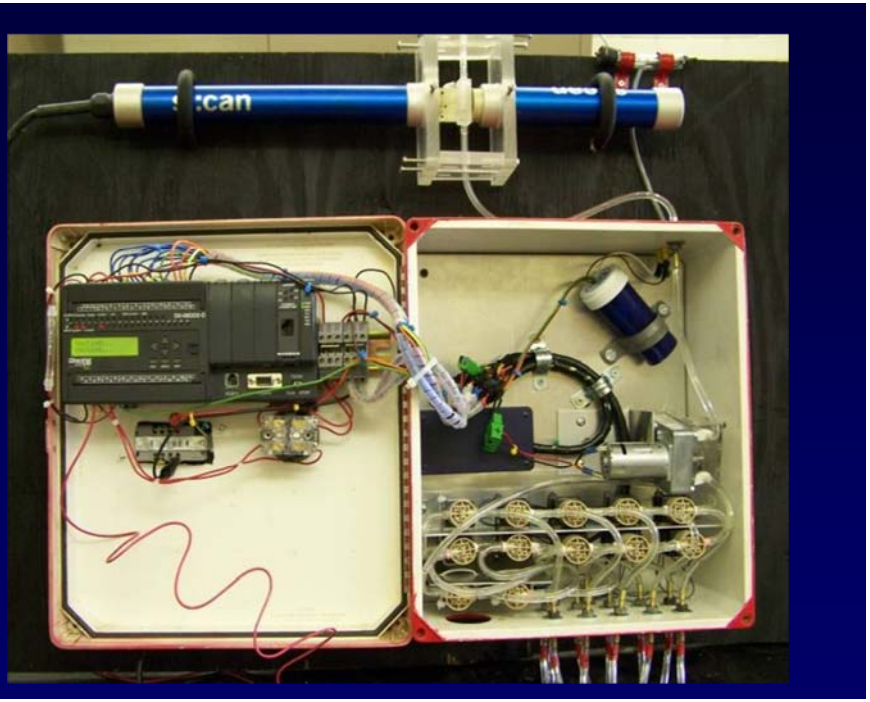
- Sequential In-situ Incubation Technique

(Raison et al., 1987; Robertson et al., 1999)

  - Soil cores incubated in PVC Pipes
  - In-situ in each sampling area
  - separate subsamples prepared for
    - **Total N measurement**
    - **N mineralization and nitrification**
    - **Denitrification**
    - **Total C**
    - **C Mineralization**
    - **Moisture content and pH**

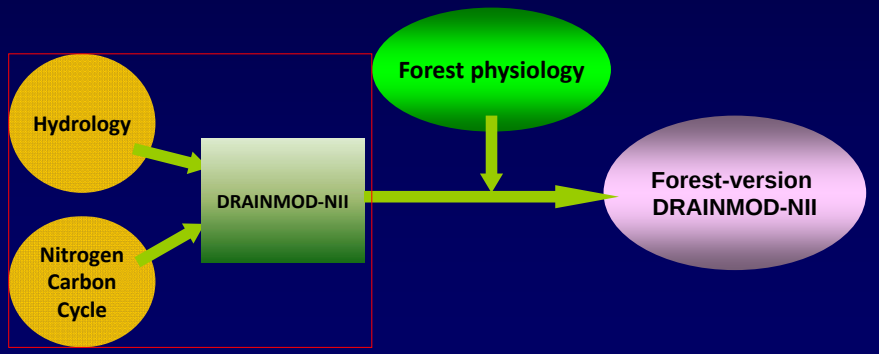


New Methods for Detailed Time Series Measurement of Water Quality

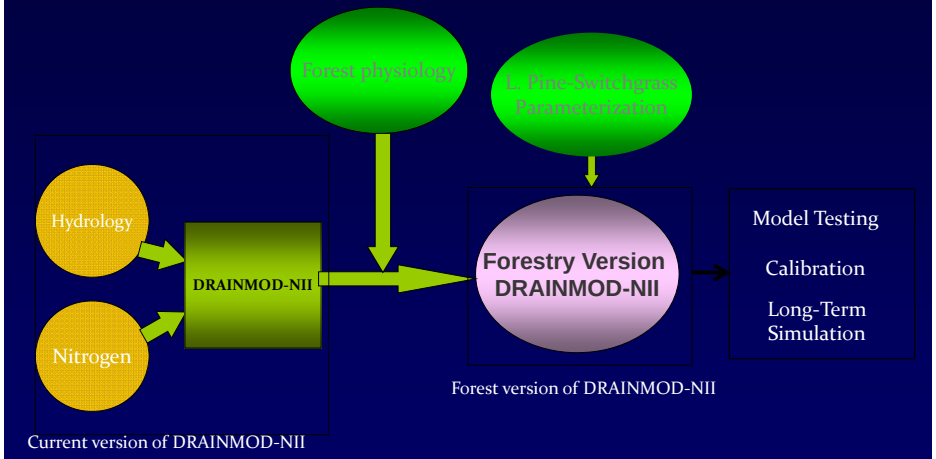


The Forestry version of DRAINMOD-N II

The model has been developed to simulate carbon, nitrogen and water cycling in drained forest ecosystems



Modify DRAINMOD-N II to Simulate Two Crop System



Summary

- Evaluate the environmental effects of large-scale forest biofuel feedstock production and utilize these results to optimize cropping systems in a manner that protects the important ecosystem services provided by forests while contributing to the development of a sustainable and economically-viable biomass industry in the southeastern United States.