Continuous Monitoring of Hydrology and Water Quality to Detect Impacts of Biomass Intercropping in Managed Pine Plantations of the Southeastern United States

Elizabeth Allen[1], François Birgand[1], George Chescheir[1], Christopher Osburn[3], Kyle Aveni-Deforge[1], Randall Etheridge[1], Jami Nettles[2]

1. Biological and Agricultural Engineering, North Carolina State University 2. Weyerhaeuser Co. Columbus, Mississippi 3. Marine, Earth, & Atmospheric Sciences, North Carolina State University

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1. Introduction

- Research is needed to assess the water quality and hydrology impacts of novel biomass feedstock production and removal solutions, especially at the watershed scale.
- In an effort to meet the nation's growing need for sustainable energy resources, Catchlight Energy LLC, a joint venture of Chevron and Weyerhaeuser, has initiated research to evaluate the environmental sustainability of producing biomass feedstocks from managed forest and energy crop resources.
- 3 matched paired watershed experimental study sites located in the southeast region of the U.S dedicated to this research (Figure 1)

Fig. 1

- Intercropping thinned pine plantations with an energy crop is an innovative, dual land use management practice being considered as an alternative biomass feedstock production method in this study (Figure 2)


Fig. 2

2. Study Site

- Location: Carteret County, North Carolina
- Topography has little to no slope in this region of NC, little surface runoff contributes to discharge
- 4 watersheds artificially drained by canals (Figure 3)
  - Outlets connect to a collector canal
- Site studied for over 20 years
- Paired watershed experimental design exploring biomass cultivation scenarios involving Loblolly pine trees and switchgrass of the Alamo variety

Watershed	Area (ha)	Treatment	Tree Birth Year	Switchgrass Planted
D0	24.0	Young Pine	2009	
D1	24.7	Young Pine/ Switchgrass Intercrop	2009	2011
D2	23.6	Mid-rotation Pine	1996	
D3	26.8	Switchgrass		2011

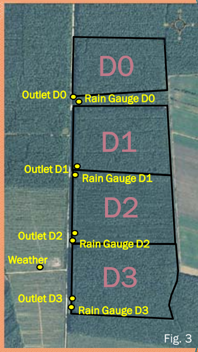

Fig. 3

3. Research Questions

- *Can the hydrologic and water quality effects of intercropping be observed and explained using continuous monitoring techniques?*
- *Is the investment in continuous monitoring equipment and techniques worth the risk?*
- *What are the differences in hydrology among treatments?*
  - What are the differences in the amount of water leaving the watersheds?
  - What are the differences in the flashiness among watersheds?
- *What are the differences in water quality among treatments?*
  - Can the uncertainties in nutrient/sediment mass loading be reduced by employing continuous water quality monitoring?
  - What are differences in nutrient/sediment loading and dynamics among treatments, especially during rain events?
  - Are there differences in the quality of organic matter being exported?

4. Continuous Monitoring and Sampling Methods

Hydrology

- V-notch weir (Figure 4)
- Pressure transducer to measure water height
- Weather station
- Rain gauges


Fig. 4

Water Quality

On-Site Continuous Water Quality Monitoring

1. Canal water pumped to a Manta 2 multi-parameter probe which measures pH, specific conductivity, and CDOM (chromophoric dissolved organic matter) fluorescence intensity (Ex.: 265-385 nm, Em.: 440-500 nm)
2. Water pumped to a UV-Vis spectrophotometer (Figure 5) which measures concentrations of NO_3^--N, DOC,TOC, and turbidity
3. Spectrophotometer lenses cleaned to reduce fouling with custom system
4. Water purged from the system back to the canal

- Measurement interval: 15 minutes
- Station serviced every 2 weeks


Fig. 5


Fig. 6. Continuous monitoring station and automated sampler located at the outlet of D3

Discrete Water Quality Sampling

- Samples taken every 12 hours by an automated sampler
- Samples collected every 2 weeks
- Parameters measured in the lab for select samples based on continuous monitoring data:
  - NO_3^--N, NH_4^+-N, TKN, TDN, DOC, TSS, PO_4^{3-}-P, TP, δC^{13} isotope ratios, fluorescence and absorbance
- Lab data will be used to correct continuous field data, calibrate instruments, and to test for the uncertainty associated with discrete sampling as a sole monitoring method

CDOM Fluorescence

- Chromophoric dissolved organic matter: the part of organic matter that can absorb light
- CDOM can emit light in the form of fluorescence when light is absorbed and this spectral signature can provide information about the source and characteristics of organic matter
- Fluorescence intensity was measured for a range of light wavelengths absorbed and emitted using a method called Excitation-Emission Matrix Spectroscopy, providing a CDOM "fingerprint" or EEM for each sample

5. Results

- ***Is the investment in continuous monitoring equipment and techniques worth the potential results gained?***
  - ✓A vast amount of additional information about a system can be acquired with a high-resolution dataset
  - ✓Provides access to spectral information about several other parameters than those being measured, which can be analyzed with statistical methods (PLSR)
  - ✓Knowledge gained about nutrient and sediment export dynamics can surpass research limits set by sampling alone
- ***Currently, continuous monitoring requires great care; it does not replace sampling altogether, but our team has discovered:***
  - ✓There are solutions to the problems that make continuous monitoring less practical, such as the fouling that spectral devices are exposed to when placed in certain types of water for extended periods of time
  - ✓*Solution:* Designed and assembled monitoring stations in which water is pumped to the instruments including a custom antifouling device
  - ✓There is great potential in understanding environmental systems with continuous monitoring
  - ✓There is still work that needs to be done to increase practicality

6. Illustrations

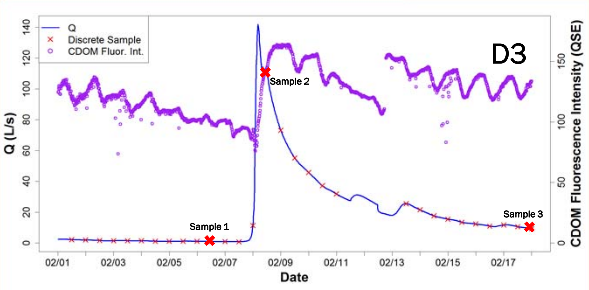

Fig. 7. Example of continuous CDOM fluorescence intensities monitored by the Manta 2 multiprobe during a February storm. Here, high resolution measurement frequency shows that CDOM fluorescence intensity increases and peaks slightly after peak discharge and slowly decreases as flow recedes.

February 2013 Storm

- CDOM fluorescence intensity displayed daily fluctuations as well as an increase in intensity with event discharge (Figure 7). Discrete sampling alone would not have provided such clear results.
- Sample variability between EEMs is only slightly noticeable upon visual inspection (Figure 8)
- PARAFAC modeling will be used in the future to model the DOM characteristics which best describe the variability among samples
- Principal Component Analysis will also be used to determine which variables are mainly the cause of changes in DOM characteristics such as site location, discharge, etc.

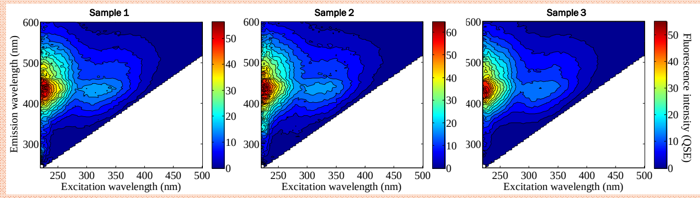

Fig. 8

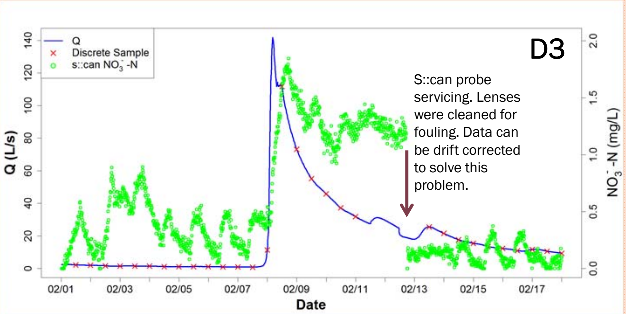

Fig. 9. Example of continuous nitrate concentrations monitored by the s::can probe during a February storm. Continuous measurements provide detailed information about the water quality dynamics, such as the nitrate concentration peak slightly lags peak discharge here.

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