Project Title: Sources, sinks, and yield of organic constituents in managed headwaters of the Upper Gulf Coastal Plain of Mississippi

Co-Principal Investigators:

Jeff A. Hatten Tel: (662) 325-7481 Email: jhatten@cfr.msstate.edu

Janet C. Dewey, Tel: (662) 325-8851 Email: jdewey@cfr.msstate.edu

Andrew. W. Ezell, (662)-325-1688 Email: aezell@cfr.msstate.edu

Department of Forestry, Mississippi State University, Box 9681, MS State, MS 39762

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ABSTRACT

Sediment, organic matter, and nutrients (particularly nitrogen) are the constituents that most often lead to the impaired designation for rivers in Mississippi (E.P.A. 2000). Headwater streams are very important contributors of water, sediment and nutrients to the downstream fluvial environment. Many studies of non-mountainous systems have focused on the *quantity* of particulate or dissolved forms of material (e.g. suspended solids, organic matter, and nitrogen); few have examined the *source* of this material. The relationships among origin, storage, consumption and export of organic matter (OM) with stream discharge and subsurface interflow represent significant gaps in our understanding of headwater processes. This study is part of a larger-scale study investigating the effects of silvicultural best management practices in ephemeral and intermittent drains on hydrologic function in small-scale headwaters. A 30 ha watershed located approximately 8 miles west of Eupora in Webster County, MS has been continuously monitored for water table elevation, precipitation intensity and duration, in-stream TSS, and chemical composition of water and particulates. Data were used to elucidate the transport and source/sink behavior of sediment, and dissolved and particulate forms of organic matter, in the form of nitrogen (N) and organic carbon (OC), over a broad range of hydrographic conditions. Results indicate that particulates in perennial and ephemeral-intermittent stream segments are derived from surface mineral soil horizons as a result of downcutting. The source of water in the perennial stream is dominated by ephemeral stream contributions rather than groundwater during dry periods. During the wet winter months perennial streamwater chemically resembles groundwater whereas ephemeral-perennial segments chemically resemble canopy throughfall waters. Ephemeral drains are significant contributors to downstream perennial streams, especially during dry periods; therefore it is important to consider ephemeral basins within an overall basin management plan.

INTRODUCTION

Forestland comprises 19.79 million acres (64.85%) of the total land area in MS; primary forest-based industries (e.g. logging, forestry) represent an annual contribution of $11-$14 billion to the state economy and approximately 54,000 jobs (MIFI, 2008; based on 2003 data). Much of the silvicultural activities upon which state economy depends occur in headwater catchments, thus silvicultural BMPs are designed to minimize forest-related non-point source inputs of sediment, nutrients and pesticides. In many upland-forested watersheds, surface and subsurface flow are temporally and spatially connected with respect to physicochemistry and biotic communities (Marshall and Hall Jr. 2004; Sobczak and Findlay 2002; Collins et al. 2007), however the ecological linkages between headwaters and larger order perennial streams are poorly documented. In particular, the relationships among origin, storage, consumption and export of organic matter (OM) with stream discharge and subsurface interflow represent significant gaps in our understanding of headwater processes (Wipfli et al. 2007). Sediment, organic matter, and nutrients (particularly nitrogen) are the constituents that most often lead to the impaired designation for rivers in Mississippi (E.P.A. 2000). Previous work has shown that headwater streams are very important contributors of water, sediment and nutrients to the downstream fluvial environment (Alexander et al. 2007). Many studies of non-mountainous systems have focused on the *quantity* of particulate or dissolved forms of material (e.g. suspended solids, organic matter, and nitrogen); few have examined the *source* of this material.

Organic constituents are important to aquatic ecosystems for several reasons. OM serves a vital function as a regulator of bacterial productivity, DO concentrations, nutrient cycling, and food web productivity (Sobcak and Findlay 2002). Organic matter supports macro invertebrate communities and nitrogen is a limiting nutrient in most terrestrial and aquatic ecosystems. While OM provides a number of benefits to aquatic ecosystems, it can also be a direct or indirect contributor to detrimental ecosystem processes. For example, excess terrestrial input of OM and associated nutrients (including N and C) can contribute to eutrophication which in turn can lead to hypoxia in marine/estuarine waters that are deficient in dissolved oxygen. Organic matter is also associated with many pollutants (e.g. mercury). Atmospherically-derived mercury forms strong complexes with organic matter (Ravichandran 2004; Liao et al. 2009) and is transported through erosion and fluvial processes, particularly flood or high discharge events that are responsible for transporting OC and sediment (Balogh et al. 2006 ; Babiarz et al. 1998; Caron et al. 2008). Increasing concern over food chain transfer of toxic contaminants such as methylmercury compels a greater understanding of OM sources and transfer within terrestrial watersheds.

In order to properly constrain the natural variability in these constituents and advise the development of TMDLs for impaired water bodies, it is necessary to understand the typical range in rates of delivery of sediment, carbon, and nitrogen. Understanding the source and transport of these compounds will allow us to better to determine what is “typical” and predict how forest management activities will affect sedimentation, N-capital, downstream ecosystems, pollutant transport, and C-cycling at ecosystem, regional, and global scales. Methods used in the major body of research regarding these constituents have avoided or under-sampled storm events. Storm events are primarily responsible for the transport of particulate constituents in smaller watersheds. Therefore, by under sampling these events the importance of sediment and particulate forms of carbon and nitrogen may not be realized. Shanley et al. (2008) suggested that utilization of a small-watershed approach coupled with event sampling may provide a reasonably reliable method to infer controlling processes of OM, nutrient, and contaminant cycling.

OBJECTIVES

This study presents an analysis of carbon dynamics within managed, forested headwaters in Webster County, MS. Focused sampling of storm events was conducted over a 12-month period in order to provide estimates of the timing of OC and nutrient load and subsequent transport. Data were used to elucidate the transport and source/sink behavior of sediment, and dissolved and particulate forms of organic matter, in the form of nitrogen (N) and organic carbon (OC), over a broad range of hydrographic conditions. The overall objective was to quantify the yield, source, and transport processes of OC and nutrients within managed watersheds. Specific objectives were (1) to determine the amount of sediment, OC and nutrients discharged during one year from watersheds with contrasting forestry management activities; (2) to determine the source(s) of sediment, OC, and nutrients in managed watersheds; (3) to elucidate potential change in source with changing season, management scenario and event character, and (4) to determine whether the load and character of sediment, OC, and nutrients change from intermittent to perennial stream systems.

STUDY SITE

The study was conducted at an established research site within a first-order headwater catchment located in the Hilly Coastal Plain Province of Webster County, MS. Land use at the study site primarily consists of short-rotation pine silviculture with seasonal hunting; silvicultural prescriptions range from undisturbed reference forest to heavily-trafficked clearcuts. Soils are predominately of the Sweatman series which is a fine, mixed, semiactive, thermic Typic Hapludult (McMullen et al. 1978). Soils are typically moderate to well-drained silt-loam; with a medium to high available water capacity, moderate permeability in the upper subsoil, and moderately high permeability in a fragipan at 18-38 inches depth. Precipitation is well distributed throughout the year with a 30 year mean of 1,451 mm. Mean winter temperature is 7 °C and mean summer temperature is 26 °C (U.S. National Weather Service gauge 222896 Webster, MS). A perched water table above the fragipan is common during wet seasons; depth to water table may be 12-24 inches. Hillslope water table typically drops to >2 m below the surface in the summer. Overstory vegetation is typical of forested loblolly pine (*Pinus taeda* L.) stands of similar age class with a lesser component of mixed hardwoods.

METHODS

This study is part of a larger-scale study investigating the effects of silvicultural best management practices in ephemeral-intermittent drains on hydrologic function in small-scale headwaters. Four ephemeral-intermittent drainage basins and the downstream perennial stream were selected for study. Drainage basins were monitored for duration and intensity of precipitation, streamflow, discharge, water table elevation, and total suspended solids (TSS) from March 2010 through February 2011. Samples were collected from four potential sources/sinks within the watershed (surface water, subsurface water, in-stream sediment and soil) to qualify the amount and partitioning of OC and N from the managed watershed, and to determine the relationship between organic exports and sediment yield. It is generally assumed that source areas will consist of soils and surface organic inputs to stream (e.g. vegetative litter and periphyton), that and that exports will be carried in either dissolved form via surface waters or as fine particulates associated with TSS. Groundwater at these sites may be a source or temporary sink depending on whether streams are influent or effluent at different times of the year.

Five monitoring/sampling stations were established: four ephemeral-intermittent stations and a downstream perennial stream station. Ephemeral-intermittent monitoring stations were established in January of 2007. Transects were established perpendicular to developed channels along the entire length of the ephemeral-intermittent stream segment (Figure 1) within each sub-watershed.

Groundwater: A total of 25 wells (5 m intervals within transect) were installed in each ephemeral-intermittent drainage basin for purposes of monitoring groundwater elevation and collecting subsurface water samples. Depth-to-water table was monitored bi-monthly with an electronic tape. Groundwater was sampled from four within each sub-watershed which best represent waters in the hyporheic zone (in-channel well), riparian zone, and from the hill slope. Standing water in wells was removed using a PVC sampling bailer, the well was allowed to recharge, and subsurface water was collected. Samples were decanted into acid-washed HDPE collection vessels, placed on ice and removed to the laboratory for analysis. Ground water was sampled 6 times throughout the year.

In situ Surface water monitoring/sampling: Surface water monitoring/sampling stations were established near the outlet of each sub-watershed. A 1.8 m length of 25.4 cm (i.d.) schedule 40 PVC was installed and stabilized with sandbags to constrain flow. Discrete samplers were installed on all ephemeral-intermittent monitoring stations. Samplers were linked to area velocity sensors mounted within 1.8m lengths of 25 cm i.d. PVC pipes. Sensors were programmed to measure level within the pipe and to trigger automated sampling continuously during rising and falling limbs of major flow events. Automatic samplers were programmed to sample at least once during the rising hydrograph, and then every 12 hours until the event ended (as determined by discharge falling below that of the initial sample). ISCO discrete samplers were programmed to collect an initial sample when stream depth is greater than 1.0 to 2.0 cm, depending on the stream and season. A fifth monitoring station consisting of a stilling well, an area-velocity sensor and a discrete sampler was installed downstream of the ephemeral-intermittent watersheds and was similarly programmed. Grab samples from all locations were collected whenever personnel were onsite. A rating curve (discharge vs. stage) was developed for the perennial stream. A stilling well was made from 12 cm ID PVC and equipped with a pressure transducer. In-stream water and suspended solids were co-collected as 1 L grab samples. Samples were fractionated into liquid and solid components in the laboratory using 0.7 µm combusted glass fiber filters (CGFF).

<u>Precipitation and Throughfall:</u> Precipitation intensity and duration was measured with an ISCO 674 tipping bucket rain gauge to relate the timing and volume of rainfall events to water levels in wells and stream discharge. The rain gauge was installed in an open area, away from trees and wind. Within the ephemeral watersheds, four through-fall buckets consisting of a screened, five gallon bucket were installed to collect precipitation during major events. Throughfall samples were decanted into acid-washed HDPE collection vessels, placed on ice, and removed to the laboratory for analysis.

<u>Soil Sampling</u>: Soils were sampled by horizon to a depth of 1 m from several locations representing distinct topographic positions within the reference ephemeral and perennial stream watersheds (e.g stream cut-banks, side slopes, and ridges). Soils were air dried and ground to pass a 2 mm sieve for chemical analysis. Soil solution was sampled using a lateral flow sampler custom constructed from a longitudinally-sliced ISCO discrete sampler bottle connected to an HDPE collection vessel with Tygon tubing. Soil solution samplers were placed flush with the surface of mineral soil immediately beneath the O-horizon.

<u>Sample analysis</u>: All water samples (*in-situ* stream water, perennial grab samples, groundwater, and throughfall) were fractionated into filtered water and residual solids; resultant solids were handled similarly to soils. Water samples were filtered through weighed 0.7 µm combusted glass fiber filters (CGFF) and dried at 60°C for TSS determination. Filtered water was split into four aliquots (for UV_{254}, DOC, DIN and DON), and immediately frozen. DOC and Stable isotopes ($\delta\,^{13}C$ and $\delta\,^{15}N$) were determined at the Stable Isotope Facility at UC Davis. UV absorbance at 254 nm was determined using a UV spectrophotometer; absorbance was normalized by DOC content to determine Specific UV Absorbance (SUVA; a measure of DOC aromaticity). Dissolved inorganic N (DIN; NH_4^+-N_{RAW}, and NO_3^--N_{RAW}) was determined using an ion chromatograph (Dionex, Inc., Sunnyvale, CA). Solid samples (soil and filtered particulates from CGFF) were analyzed for total C and N using a dry combustion analyzer. <u>Statistical analysis and data interpretation:</u> SAS was used to generate summary statistical data for chemical characteristics of water and solids from streams and potential source areas. Where management scenarios were compared, means separation was tested using a general linear model (SAS Institute). Duncan's multiple range test was used to evaluate statistical significance at alpha = 0.05. Sediment source was determined through a combination of elemental ratios (OC:N), stable isotopes ($\delta\,^{13}C$ and $\delta\,^{15}N$), and specific ultraviolet absorbance (SUVA) of DOC. End member mixing analysis is being used to further elucidate the source of sediment, OC, and N in each ephemeral and perennial stream.

RESULTS

Composition of Dissolved Constituents and Source of Water: Relative contributions of throughfall and/or groundwater to streamflow can be determined using the dissolved constituent make up of each of the endmembers (throughfall and groundwater) and comparing them to the concentration of dissolved constituents in surface runoff. We measured the composition of dissolved constituents in groundwater, ephemeral and perennial streamflow, and throughfall. In general, throughfall yielded the highest dissolved inorganic N and DOC (Table 1). Inorganic N and DOC may be derived from exudates in the forest canopy as well as that present in precipitation. Groundwater was shown to have similar dissolved inorganic N when compared with ephemeral streams, suggesting that groundwater and surface stream water is routed through the soil allowing uptake and adsorption processes to occur thereby removing these constituents from the dissolved load. Both groundwater and ephemeral streams yielded higher dissolved inorganic N compared with the perennial stream, which suggests that the dissolved load is diluted with source water low in dissolved inorganic N or that the N is adsorbed or denitrified.

Dissolved organic carbon concentrations were much higher in both ephemeral and perennial streams relative to groundwater as DOC is leached from organic rich surface soil horizons through lateral surface flow. There was a strong relationship between UV absorbance and DOC concentration as a result of aromatic moieties common in DOC that absorb light in the UV spectrum (Figure 2). This relationship permits comparison of DOC concentration across many more samples and estimation of DOC concentrations across time and future events. The ephemeral streams have a high UVA relative to the perennial stream and endembers and the relative differences between the sources and streams are much smaller than for DOC alone (Table 1). The lower relative differences are probably a result of changing composition of the dissolved organic carbon. Specific ultra-violet absorbance (SUVA) provides an indication of the composition of DOC by normalizing UVA by the concentration of DOC (i.e. UVA/DOC). Groundwater yielded the highest SUVA suggesting that this pool of DOC was composed of aromatic moieties such as phenols from lignins and tannins. The DOC in groundwater typically has a low attraction to soil surfaces as a result of low charge density and are typically not favored by soil microorganisms for metabolic functions; therefore they escape oxidation and adsorption to reside in the groundwater pool. Throughfall yielded a very low SUVA suggesting that DOC in this endmember was low in aromatic carbon and that the high DOC concentrations in this endmember were a result of saccharides or other highly mobile exudates that dissolve into water as precipitation moves through the canopy. The perennial and ephemeral streams yielded similar SUVA values suggesting that while the DOC concentrations decreased from ephemeral to perennial streams the quality of this material remained relatively constant. This also suggests that the source of water in the perennial stream is dominated by the ephemeral streams, and not groundwater.

During the dry part of the year, throughfall was enriched in DOC (as UVA in Figure 3) and depleted in Cl^- while the opposite was true for groundwater. The chloride ion is a robust conservative tracer of water in watersheds. The concentrations of both Cl^- and DOC (as UVA in Figure 3) decreased for groundwater and throughfall, respectively, as soil moisture and water table height increased during the wet part of the year (winter). There was a similar trend found in SUVA and DOC-δ13C data (Figure 4); throughfall and groundwater become more similar as watersheds were exposed to greater amounts of precipitation.

Ephemeral streamflow during storm events require significant antecedent moisture present during the winter and spring; therefore the chemical composition of stream water was similar to groundwater and throughfall during the wet parts of the year. The overall composition of water in the ephemeral and perennial channels was not very different; however, there do appear to be some minor differences in the source of water between the ephemeral and perennial streams.

In general, perennial streams appear to have a dissolved composition that more closely resembles groundwater while the composition of water in ephemeral streams resembles that of throughfall (Figures 3 and 4).

While we have only assessed one replicate of watersheds we have sampled many storms from which we can examine potential treatment effects of harvesting and BMP design on the chemical composition of stream water (Table 2). In general, the uncut stand yielded lower DOC concentrations and the DOC present yielded a higher contribution of aromatic compounds as evidenced by higher SUVA. These results may be due to alterations in the microclimate of the cutover stands which leads to production and leaching of DOC and subsequent depletion in aromatic materials. There was also found a significant increase in nitrate concentrations in the cutover stands, probably as a result of a decrease in uptake (from the clearcut) and a high level of mobility of nitrate in soils. The reference may have yielded a higher concentration of Cl^- as a result of higher rates of evapotranspiration.

Composition of Particulate Constituents and Source of Sediment: Soil is the ultimate source of sediment, but may be derived from overland transport of surface soils or mobilization of deeper soils through downcutting and pipeflow. Since organic matter is a dynamic constituent of soils and sediment we can use it to trace the source from which sediment is being derived within the watershed (i.e. the last soil profile of residence). Organic and mineral soils were examined from both near- and distal-stream topographic positions. Organic soil horizons were by definition higher in %C compared with mineral soils (Table 3). Organic soil horizons also yielded a higher C:N than mineral soils and were depleted in both $\delta^{13}C$ and $\delta^{15}N$ relative to mineral soil. There were also trends within the mineral soils in which A horizons typically yielded higher %C and C:N and were more depleted in $\delta^{13}C$ and $\delta^{15}N$ as compared with B and C horizons (Figures 5 and 6). The differences in composition among soils horizons provide information as to the source of sediment and erosion processes.

Suspended sediments from ephemeral and perennial streams appears to have a stable isotopic composition that is similar to soil A horizons (Figure 5). The C:N of these sediments more closely resembles that of B and C horizons (lower than A horizons), however, the carbon concentration is much too high to be derived from these deeper soil horizons. This trend may be partially satisfied by inputs of organic detritus from O horizons, but the suspended sediment does not appear to be a binary mixture of organic and deeper mineral soils. Our working hypothesis is that the suspended sediments are being derived from surface mineral soil horizons (A horizons) but that there is a preferential transport of smaller clay sized particles which may contain both high carbon and low C:N ratio. Further analysis (e.g. density and size fractionation) is needed to confirm or refute this process.

Table 1. Chemical characteristics in water from five sources within headwaters of Webster County, MS.

Parameter	Groundwater			Perennial stormwater			Ephemeral stormwater			Soil solution			Throughfall		
	n	mean	stderr	n	mean	stderr	n	mean	stderr	n	mean	stderr	n	mean	stderr
UVA	46	0.18	0.03	38	0.13	0.02	84	0.40	0.03	.	.	.	27	0.31	0.07
SUVA	10	0.11	0.04	12	0.04	0.01	28	0.04	0.00	.	.	.	8	0.02	0.00
DOC	10	1.67	0.27	12	6.57	1.45	29	12.57	1.27	.	.	.	8	31.09	13.78
DOC_13_pdb	10	-29.09	0.62	12	-28.70	0.24	29	-29.14	0.10	.	.	.	8	-29.73	0.72
NO3	40	0.59	0.23	33	0.10	0.03	68	0.60	0.16	.	.	.	24	1.31	0.34
NH4	60	0.15	0.03	55	0.07	0.01	123	0.13	0.02	3	0.30	0.30	37	0.18	0.02
N_dissolved	60	0.20	0.04	55	0.07	0.01	123	0.18	0.03	3	0.24	0.24	37	0.33	0.06
TSS	.	.	.	48	88.99	40.68	120	197.63	43.48	.	.	.	.	.	.

Table 2. Chemical characteristics of ephemeral streamwater by forest management treatment within headwaters of Webster County, MS. Means within a row followed by the same letter are not significantly different according to Duncan's Multiple Range test.

	Ephemeral stormwater by treatment															
Parameter	NO BMP				BMP1				BMP2				REF			
	n	mean		stderr	n	mean		stderr	n	mean		stderr	n	mean		stderr
UVA	9	0.67	**a**	0.09	17	0.42	**b**	0.06	37	0.38	**b**	0.05	21	0.29	**b**	0.06
DOC	7	19.41	**a**	1.84	9	14.80	**a**	0.93	6	6.72	**b**	2.33	7	7.87	**b**	2.22
DOC_13_pdb	7	-29.14	a	0.12	9	-29.05	a	0.07	6	-29.44	a	0.19	7	-29.01	a	0.36
SUVA	6	0.04	**ab**	0.00	9	0.03	**ab**	0.00	6	0.03	**b**	0.00	7	0.05	**a**	0.01
Cl	9	1.66	**b**	0.44	17	1.72	**b**	0.23	37	2.22	**b**	0.11	22	2.84	**a**	0.20
NO3	9	1.99	**a**	1.11	12	0.15	**b**	0.08	35	0.58	**b**	0.09	12	0.06	**b**	0.02
NH4	12	0.07	a	0.03	19	0.07	a	0.02	44	0.15	a	0.04	48	0.16	a	0.05
N_dissolved	12	0.39	**a**	0.19	19	0.07	**b**	0.02	44	0.22	**ab**	0.04	48	0.13	**b**	0.04
TSS	11	187.94	a	50.28	16	55.81	a	14.68	43	157.65	a	55.13	50	279.52	a	91.36

Table 3. Chemical characteristics of solid materials from five source areas within headwaters of Webster County, MS.

Parameter	Mineral soil			Organic soil			Ephemeral POM			Perennial POM			Channel sediment		
	n	mean	stderr	n	mean	stderr	n	mean	stderr	n	mean	stderr	n	mean	stderr
Sed_TotN	27	0.29	0.24	4	0.93	0.075	35	0.37	0.03	19	0.48	0.06	1	0.03	.
Sed_TotC	27	4.16	3.43	4	38.44	2.143	35	3.67	0.46	19	4.76	0.58	1	0.46	.
C/N	27	13.86	0.97	4	41.56	1.47	35	9.73	0.54	27	13.86	0.97	1	16.21	.
Sed_d13C	29	-26.27	0.23	4	-29.86	0.16	32	-27.52	0.19	2	-27.66	0.21	1	-28.99	.
Sed_d15N	29	3.68	0.30	4	-3.24	0.59	32	0.90	0.22	2	1.00	0.63	1	1.42	.

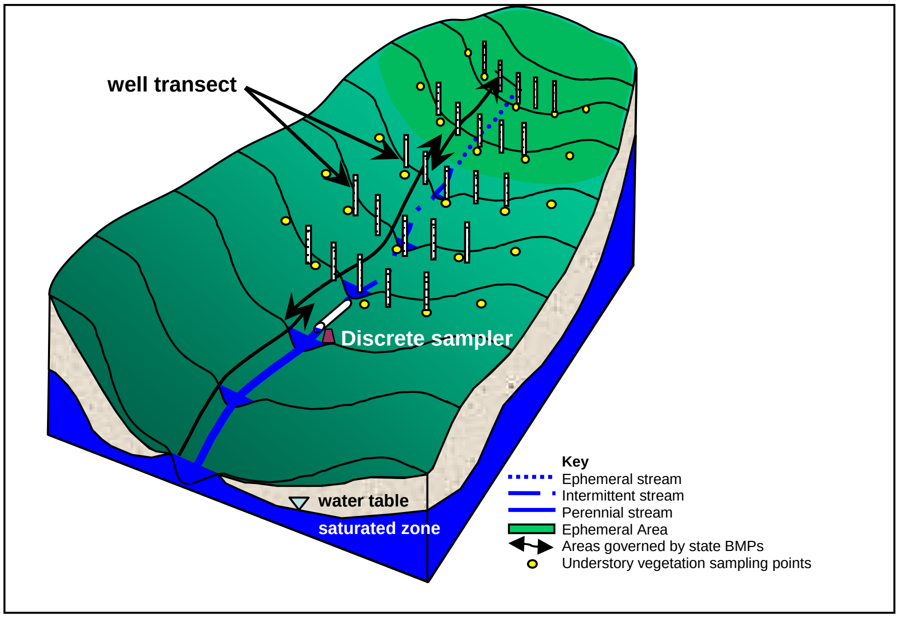

Figure 1. Schematic of an ephemeral-intermittent channel monitoring station in Webster County, MS.

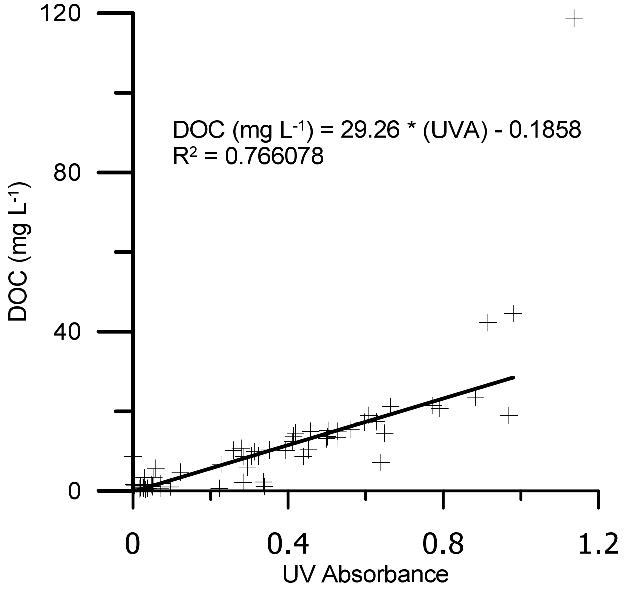

Figure 2. Relationship of UVA and DOC concentration within headwaters of Webster County, MS.

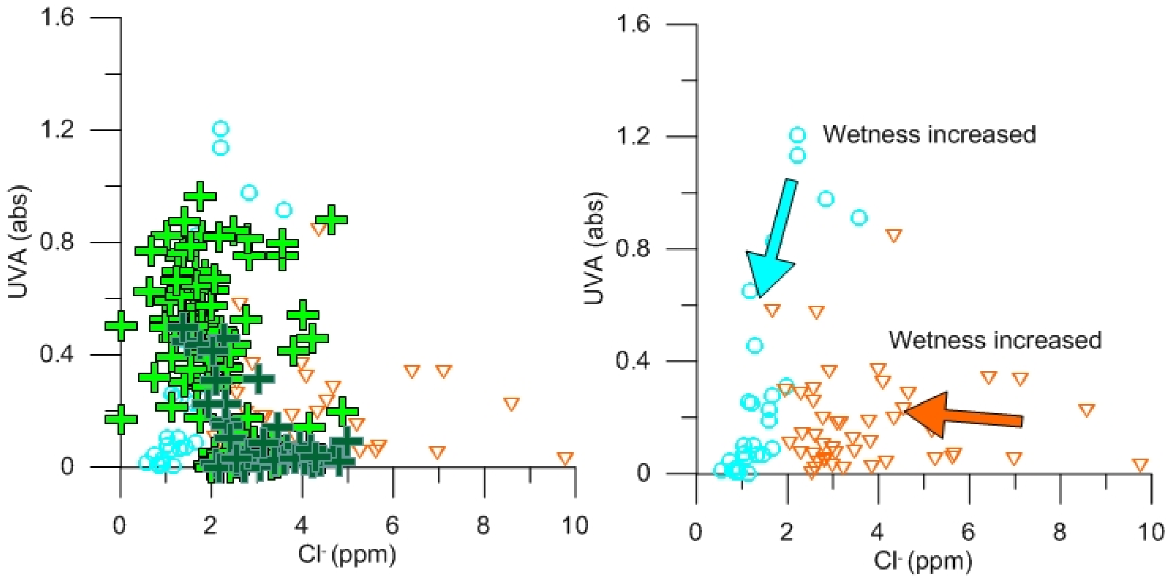

Figure 3. UVA and chloride concentration of groundwater (orange triangles), throughfall (blue circles), ephemeral stormflow (light green crosses), and perennial stormflow (dark green crosses) stream water samples. Arrows indicate changes in chemical composition as soil moisture and water table height increased into the "wet-season" for groundwater (orange) and throughfall (blue).

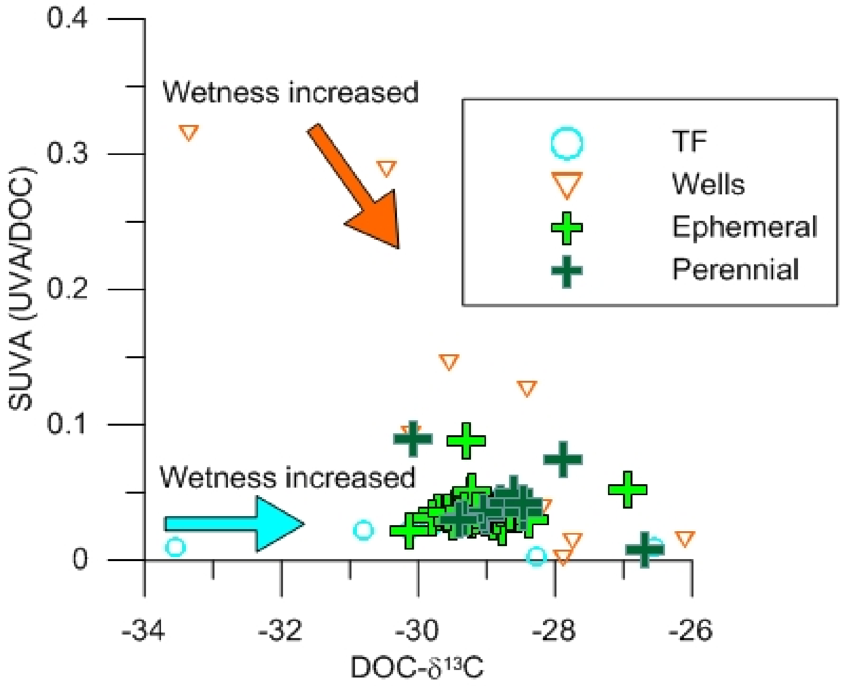

Figure 4. SUVA and DOC-δ^{13}C composition of groundwater (orange triangles), throughfall (blue circles), ephemeral (light green crosses), and perennial (dark green crosses) stream water samples. Arrows are describing trends in groundwater (orange) and throughfall (blue) composition as soil moisture and water table height increased into the "wet-season".

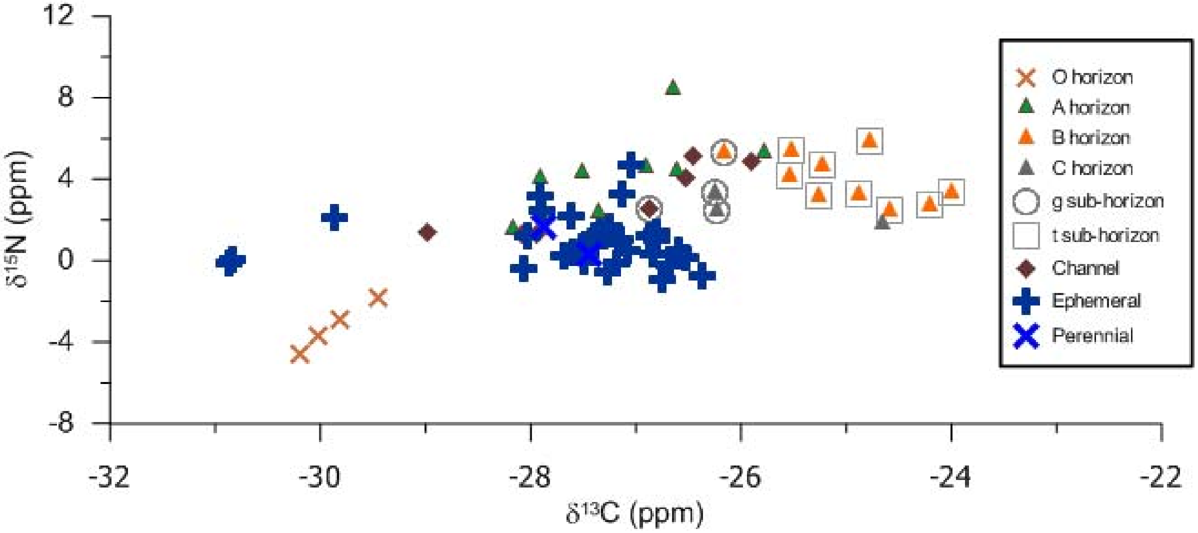

Figure 5. Stable isotopic composition of organic soil, mineral soil, perennial stream sediment and ephemeral stream sediment.

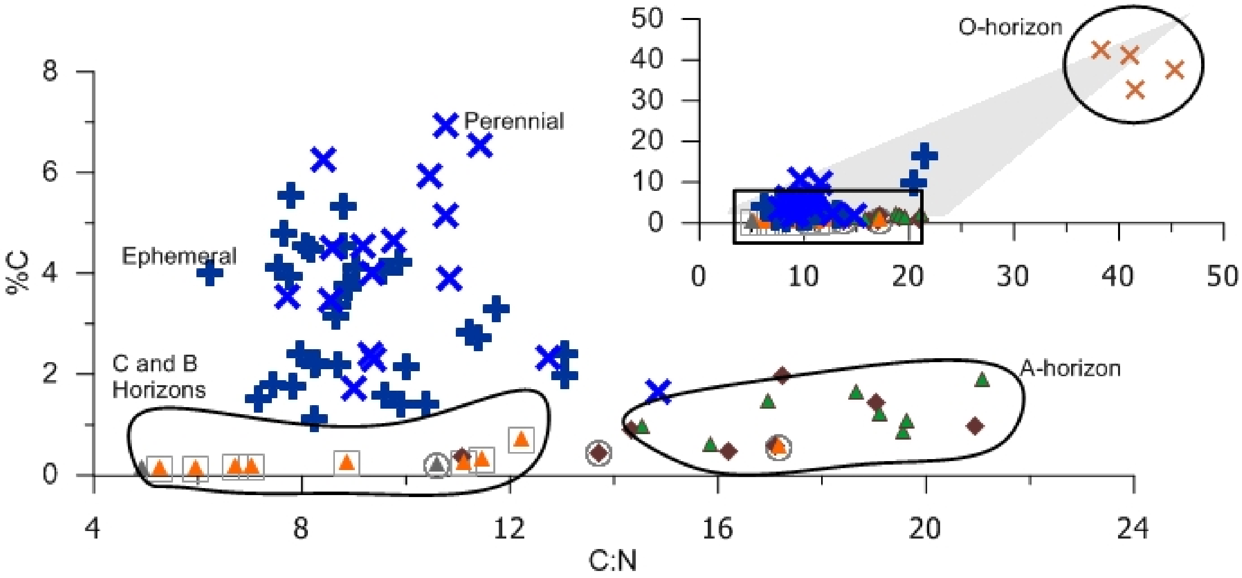

Figure 6. Carbon concentration and C:N of organic and mineral soil horizons and suspended sediments from perennial and ephemeral streams.

DISCUSSION

The load of TSS in river systems often has a positive exponential relationship with discharge, thus storm events are often responsible for the majority of solid transport (Miller and Orbock-Miller 2007). However, much of the research on POM has focused on conditions that may affect biologic components of stream systems (base and moderate flow), but have neglected storm flow (e.g. Jones Jr. and Smock 1991). The source of POM (POC and PON) is considered to be similar to the source of sediment. It is often thought that during baseflow conditions POM is derived from in-stream sources (e.g. algae; Ittekkot 1988; Hilton et al. 2008; Hatten et al. 2010). During moderate discharge conditions the source shifts towards near-stream terrestrial sources (e.g. riparian areas). As discharge progresses towards and past flood stage, the source shifts to more distal areas of the watershed (e.g. hillslope). In addition, some watersheds exhibit a hysteresis (similar to DOM) during events due to POM source limitations, and also as the source of POM shifts throughout the event (Coynel et al. 2005). In watersheds of the study area, POM was used as a proxy for sediment. Chemical composition of POM indicates that stream sediments are being derived from surface mineral soil horizons through processes of channel cutting, and that there is a preferential transport of fine carbon-rich particles downstream.

Dissolved organic matter and inorganic forms of nitrate and ammonium often exhibit a flushing effect; that is, their concentration is often highest during the rising limb of an event’s hydrograph but much lower on the falling limb (i.e. clockwise hysteresis; McGlynn and McDonnell 2003). At the onset of a precipitation event, runoff and dissolved constituents are dominated by inputs from carbon and nutrient-rich riparian areas. As an event progresses, the contribution of dissolved constituents and water increases from areas with lower nutrient and carbon content and longer pathways (e.g. deeper soil horizons and hillslopes). In watersheds of the study area, nitrogen existed primarily in the form of ammonium and nitrate. Dissolved N loads in streamwaters were lower than those found in groundwater, throughfall, or leachate indicating that as waters are routed through soils en-route to stream channels, N components are removed from the dissolved load through adsorption. One of the primary findings to date is that the source of storm water in the perennial stream is primarily from ephemeral streams; therefore it is worthwhile protecting these low order drainage basins as they may be a key to water quality and habitat within perennial streams.

SIGNIFICANT FINDINGS

- During dry seasons, the source of water in the perennial stream is dominated by the ephemeral streams rather than groundwater.
- During wet seasons, dissolved composition of water in the perennial stream more closely resembles groundwater; dissolved composition of water in ephemeral streams resembles that of throughfall.
- Ephemeral channels receiving some sort of best management practice provided better protection for streamwaters than those receiving no protection.
- Suspended sediments and particulates in stormwaters are being derived from shallow mineral soil horizons (A horizons) but that there is a preferential transport of smaller clay sized particles.
- Channel erosion rather than hillslope sediment movement is indicated as the primary mechanism for sediment introduction to streams.
- Chemical characteristics of POM are useful as a proxy for determining sediment source and flux within headwaters of this region.

FUTURE RESEARCH

Water and sediment samples from these watersheds will be collected through the end of May, 2011. These samples will be analyzed for dissolved organic and inorganic composition. At the completion of this work we will have more than one full water year of samples that can be analyzed for seasonal and hydrograph trends. We will use end member mixing analysis to determine the proportional composition of each stream sample collected.

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TRAINING POTENTIAL

This project employed one master's level graduate student and four part time undergraduate researchers. Results of this research have been presented at the following:

Hatten, J., Dewey, J., Mangum, C., Choi, B., and Brasher, D. 2010. Sediment, Particulate Organic Carbon, and Particulate Nitrogen Transport in Ephemeral and Perennial Streams of the Upper Coastal Plain Mississippi. Mississippi Water Resources Conference. Bay St. Louis, MS.

Hatten, J., Dewey, J., Mangum, C., Choi, B., and Brasher, D. 2010. Sediment, Particulate Organic Carbon, and Particulate Nitrogen Transport in Ephemeral and Perennial Streams of the Upper Coastal Plain Mississippi. Mississippi State University. College of Forest Resources Advisory Board Meeting. Starkville, MS.

A Master's Thesis is expected in June 2012. Two publications (one on sediment and one on water) from this research will be submitted for publication to a journal such as Water Resources Research.