# AQUATIC MACROINVERTEBRATE COMMUNITY RESPONSES TO DROUGHT CONDITIONS IN A COASTAL PLAINS FLOODPLAIN

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## Abstract

Coastal floodplains are productive ecosystems that depend on a regular hydrologic regime that includes a predictable flooding event. Since 2011, ~60-76% of Georgia has experienced abnormally dry to extreme drought conditions. To investigate how an extended drought affects a floodplain ecosystem, we characterized benthic macroinvertebrate communities and organic matter standing stocks on a floodplain of the Altamaha River at the Moody Forest Natural Area. Macroinvertebrate communities were sampled monthly from December 2011-April 2012 and characterized by functional feeding group (FFG) during pre- (December-January); peak- (February-March); and post- (April) flood conditions. There were observed differences in FFG composition over the course of the study. Collector-gatherers were the dominant FFG during pre-flood comprising 85-87% of the community. During peak-flood, filtering macroinvertebrates became more abundant (25-47% of total community). We observed monthly differences in dissolved oxygen (DO) with a trend of increasing DO with increasing flood stage and consequently decreasing as the waters receded. Changes in abiotic factors such as DO are predicted to contribute to changes in consumer communities. While there was a noticeable hydrological event at the area, gauge height readings indicated that flood stage (approx. 4m) was not reached and discharge remained under the 42 year average during the entire sampling period. Ongoing studies in this area will allow for a comprehensive assessment of the effects of extreme events such as drought on floodplain communities. Furthermore, this study will provide insight into the response and potential resiliency of one of Georgia's unique ecosystems to a commonly occurring disturbance in the region.

## Introduction

Floodplains are characterized by a predictable flooding event called the flood pulse. In the Southeastern Coastal Plain, this flood pulse typically occurs during the winter months (December-February) and is coupled with decreased evapotranspiration from riparian vegetation (Smock, 1999). During the flood pulse there is increased habitat and food resource availability which renders the floodplain an area of high biological productivity (Benke, 2001).

Aquatic macroinvertebrates serve as a critical link between primary production and higher trophic levels (Wissinger, 1999). Macroinvertebrate production is high in floodplains due to the large surface area, habitat availability, and rapid turnover of generations (Benke et al., 1984; Benke, 2001). High levels of secondary (i.e., animal) productivity provides energy as prey to larger aquatic consumers such as predatory macroinvertebrates, fish, and birds. In addition, some aquatic macroinvertebrates that have an emergent aerial phase heavily subsidize the diets of many terrestrial consumers (Baxter et al., 2005). Their productivity is linked directly to the occurrence of regular, predictable flooding events.

The Altamaha River is a high order river that runs through the Coastal Plains region of southeastern Georgia. The Altamaha contains no impoundments on the main stem of the river, which makes it a valuable study system (Benke and Cushing, 2010). Without artificially altered hydrology, the Altamaha provides a unique opportunity to study the effects of natural hydrological variations on aquatic ecosystems. The Moody Forest is a protected area of 1,794 hectares bordered by approximately 3 kilometers of the Altamaha and adjoining floodplain. The habitat contains one of Georgia's few protected bottomland hardwood forests and cypress-tupelo sloughs.

Since 2011, 60-76% of the state of Georgia has experienced severe to extreme drought conditions (U.S. Drought Monitor). Natural disturbances, such as drought, have negative impacts on biological communities. These disturbances can be defined as an event that varies in frequency, intensity, and duration from expected values (Resh et al., 1988; Lake, 2000). Drought in aquatic ecosystems can result in loss of habitat and food resource availability, which consequently leads to lowered biodiversity or productivity (Boulton, 2003). Due to the unpredictable nature of drought disturbances, there is a lack of baseline data about ecological communities before and during a disturbance (Lake, 2003;2008).

The following study characterized the aquatic macroinvertebrate community in a floodplain area along the Altamaha during the 2011-2012 flood season. It is hypothesized that the aquatic macroinvertebrate community will change in concert with the hydrology of the area.

This study is part of an ongoing effort to assess the ecosystem responses to supraseasonal disturbances, such as drought, which are expected to increase in frequency and intensity with predicted changes in climate.

## Methods

### *Site Selection*

The study site consisted of a backwater area connected to the main channel of the Altamaha River. Sites were chosen from floodplain areas that contained water prior to the start of the 2011 flood pulse and from areas known to regularly inundate during peak flood stages. The main sampling area in 2011 was located at 17N 0506772 354434 UTM.

### *Physicochemical Parameters*

Temperature (°C), dissolved oxygen (mg/L), conductivity (mS/cm), and pH were recorded monthly using a YSI Professional Plus Multi-parameter Water Quality Meter (YSI, Inc). Hydrologic data (discharge, gauge height) were obtained from USGS gauge 02225000 near Baxley, GA.

### *Aquatic Macroinvertebrates*

Invertebrates were collected at shallow depths (< 1m) using a stovepipe benthic corer with a sampling area of 0.032 $m^2$ and a maximum sampling depth of 0.61 m. Three core samples were collected monthly by inserting the core into the substrate and removing all the materials enclosed in the sampler to a depth of ~10cm into a 5 gallon bucket. Contents of the bucket were stirred and poured through a 250-µm sieve and materials retained in the sieve were placed into a labeled plastic bag and preserved in ~70% ethanol. At the laboratory, samples were rinsed through stacked 1mm and a 250 µm sieves in order to separate the sample into coarse benthic organic matter (CBOM) and fine benthic organic matter (FBOM). All invertebrates from the CBOM portion were later separated from organic matter and identified to lowest practical taxonomic level (usually genus for insects and order/family for all others) based on Smith (2001), Merritt et al. (2008) and Thorp and Covich (2010). All invertebrates were also classified into Functional Feeding Group (FFG) (Barbour et al., 1999; Merritt et al., 2008). Invertebrates from the FBOM portion were stored for later identification and use in an ongoing study.

### *Statistical Analysis*

Temporal patterns in aquatic macroinvertebrate communities were examined with nonmetric multidimensional scaling (NMDS) based on abundance data using DECODA software (Minchin 1989). Community dissimilarities were calculated using the Bray-Curtis Index (Bray and Curtis 1957). After examining scree plots (stress vs dimensionality), a two-dimensional plot was constructed based on interpretability of results.

To examine relationships between macroinvertebrate communities and flood stage, we log transformed total macroinvertebrate abundance [$\log_{10}(n) - 1$] and river discharge [$\log_{10}(Q)$] data to approximate equal variance. Data on physicochemical parameters and macroinvertebrate functional feeding groups were analyzed using Kruskal-Wallis tests using JMP Pro 10 (SAS Institute Inc., Cary, NC, USA).

## Results

During the sampling period, there was a noticeable hydrological event that resembled the natural flood regime of pre-, peak, and receding-flood stages. From January to April, there was observable increase in discharge near the sampling area (Figure 1). However, this flooding event was of relatively small magnitude as it did not reach the 42 year mean for the area, nor did the study area experience bankfull flooding. It is worth mentioning that data recorded at the USGS gauge are for the main stem of the Altamaha approximately 5-10 km upstream of the study site. The observable difference of discharge in the study area was not equal to that of the main stem, however a similar pattern in increasing and decreasing water depth was observed.

As expected, several physicochemical parameters varied monthly throughout the sampling period (Table 1). Kruskal-Wallis Test indicated that temperature ($\chi^2$= 28.858, df= 5, p <0.0001), dissolved oxygen ($\chi^2$= 18.430, df=5, p= 0.0025), conductivity ($\chi^2$= 18.728, df= 5, p=0.0022), and pH ($\chi^2$= 25.342, df= 5, p = 0.0001) differed between months. Most notably, February and April had the lowest mean DO levels (3.46 and 2.94 mg/L, respectively). Low DO levels in April coincided with decreasing discharge in the main stem and a lower water level in the sampling area. March, when the highest discharge was recorded, experienced the highest mean DO levels at 5.49 mg/L (Table 1).

Total macroinvertebrate abundance was inversely proportional with discharge rates and flood stage (Figure 2). Macroinvertebrate abundance was highest during the pre-flood stage months (Dec-Jan; range 2,094 – 2,973 ind./$m^2$), decreased during the peak-flood stages (Feb-Mar; range 293-823 ind./$m^2$), and subsequently increased as flooding receded (Apr; post-flood avg. 1,762 ind./$m^2$). Macroinvertebrate community structure also shifted during different flood stages with oligochaetes as the most abundant taxa in all but one month (March) and comprising >70% of the total macroinvertebrate community during pre-flood stages. As flood stage increased, macroinvertebrate communities were dominated by a mix of copepods (23% of total) and oligochaetes (32% of total) in February, to one comprised of the isopod *Caecidotea* (18%), minute freshwater bivales (Sphaeriidae; 19%), oligochaetes and copepods (19 and 25%, respectively) in March. During the post-flood stage macroinvertebrate communities were mainly represented by a mix of chironomid midges (19%), copepods (32%) and oligochaetes (38%). Macroinvertebrate family-level richness remained constant throughout the study and was highest during the month of February with 17 distinct taxa. Estimates from the month of March yielded the lowest family-level richness with only 10 representative taxa. A two dimensional NMDS plot (Figure 3) did not show any distinctive temporal patterns based on macroinvertebrate community structure. However, March was the only month that displayed the greatest degree of separation from the rest of the samples matrix. March was also the month with the highest mean monthly discharge (201 ± 47 $m^3$/sec) and consequently the highest level of flooding at the study site.

Macroinvertebrate functional feeding group composition shifted with flood stage at the site (Figure 4). During the early flood stages, gatherer-collectors were the dominant FFG. Kruskal-Wallis test indicated ($\chi^2$= 6.2078, df=2, p= 0.0491) that gatherer-collectors were the only feeding group that differed between flood stages (pre, full, and post-flood)As flood stage increased there was a higher prevalence of filterer-collectors that appeared to coincide with increasing discharge at the study site. Macroinvertebrate scrapers (e.g., grazers) only accounted for >1% of the total macroinvertebrate community during the month of February (~9% of total), whereas shredders only accounted for >3% of the total community during the month of March (~18% of total). Macroinvertebrate predators and parasites remained constant (~8-12% of total community) throughout the study.

## Discussion

The macroinvertebrate community of the Moody Forest floodplain consisted mainly of Oligochaeta, Chironomidae (Tanypodinae and non-Tanypodinae), *Crangonyx* amphipods, *Caecidotea* isopods, Mollusca (Viviparidae and Sphaeriidae), and microcrustacea (Copepoda, Ostracoda). This assemblage is similar to those found in other southeastern floodplain areas (Sklar, 1985; Gladden and Smock, 1990; Duffy and Labar, 1994). These organisms have adapted life history traits that allow them to cope with temporary habitat availability. Some of these strategies include resting egg stages, desiccation resistance, and the ability to migrate into the hyporheic zone (Smock et al., 1985; Smock, 1999; Griswold et al. 2008).

During the sampling period, March was the only month in which the macroinvertebrate community appears to differ in both structure and function (Figures 3 and 4). This difference was caused by a higher occurrence of Cladocera, Copepoda, *Caecidotea* and dytiscid larvae. Both cladocerans and copepods are filterer-collectors, which contributed to the increased prevalence of that functional feeding group during the peak-flood stage. Flooding at the study site may have also caused increased availability and export of high quality very fine particulate organic matter (VFPOM) as seston, which would potentially favor this feeding guild (Golladay et al., 2000). Smaller particle size have been found to be high quality food sources (low C:N ratio) which may promote increased production from filterer collectors (Atkinson et al., 2009). Microcrustacea, such as copepods and cladocerans, reproduce quickly under favorable environmental conditions especially in temporary habitats (Thorp and Covich, 2010). In a study of macroinvertebrate assemblages in experimental habitats in the Everglades, Rader and Richardson (1994) found that dissolved oxygen was the main physiochemical parameter that influenced communities.

The pattern of increasing discharge with simultaneous decreasing abundance could be due to increased habitat availability in the study area. More habitat availability would allow for organisms to disperse over a greater area thus resulting in a smaller yield of individuals in benthic samples. Alternatively, this pattern may be caused by increased predation by a secondary consumer such as fish. Centrarchids, especially bluegill (*Lepomis macrochirus*), are predominant in the floodplains of the Altamaha and have been shown to feed primarily on chironomid larvae (Lobinske et al., 2002; Bright et al., 2010). As habitat becomes more available to fish and other consumers, there may be increased habitat and resource usage.

Although there were subtle temporal differences in macroinvertebrate community structure and dominant taxa, there did not appear to be clear pattern that linked community structure with flooding stage. However, differences in mean abundances of macroinvertebrates as well as changes in composition of functional feeding groups through the sampling period can provide insight into habitat usage and food resource availability. Ongoing studies of organic matter standing stock as well as qualitative food web analyses at the site will help link consumers to available resources at the site.

With the prevalence of drought in the state of Georgia, monitoring biological communities is an important area of research. Due to the lack of baseline data before and during a drought, there is a need for data that captures community responses during the duration of the disturbance (Lake, 2008). In the Altamaha River, there is a unique opportunity to study an un-impounded system as it experiences a supra-seasonal drought disturbance. Data collected here can be used for future efforts or as a means for comparison with other heavily managed systems in the area that are susceptible to similar disturbances of hydrological variation.

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## Literature Cited

Atkinson, C.L., S.W. Golladay, S.P. Opsahl and A.P. Covich. 2009. Stream discharge and floodplain connections affect seston quality and stable isotopic signatures in a coastal plain stream. Journal of the North American Benthological Society 28:360-370

Barbour, M. T., J. Gerritsen, B.D. Snyder, and J.B Stribling. 1999. "Rapid Bioassessment Protocols for use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish Second ed." EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Baxter, C. V., K.D. Fausch, and W. C. Saunders. 2005. Tangled webs: reciprocal flows of invertebrate prey link streams and riparian zones. Freshwater Biology 50:201-220

Benke, A.C. 2001. Importance of flood regime to invertebrate habitat in an unregulated river-floodplain ecosystem. Journal of the North American Benthological Society 20: 225-240

Benke, A.C. and C.E. Cushing. 2010. Field Guide to Rivers of North America. Academic Press, Massachusetts.

Benke, A.C., T.C. Van Arsdall Jr., D.M. Gillespie, and F.K. Parrish. 1984. Invertebrate productivity in a subtropical blackwater river: the importance of habitat and life history. Ecological Monographs 54: 25-63

Boulton, A.J. 2003. Parallels an contrasts in the effects of drought on stream macroinvertebrate assemblagees. Freshwater Biology 48: 1173-1185

Bray, J.R. and J.T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecological Monographs 27:326-349

Bright, E.G., D.P. Batzer and J.A. Garnett. 2010. Variation in invertebrate and fish communities across floodplain ecotones of the Altamaha and Savannah rivers. Wetlands 30:1117-1128.

Duffy, W.G. and D.J. LaBar. 1994. Aquatic invertebrate production in southeastern USA wetlands during winter and spring. Wetlands 14:88-97

Gladden, J.E. and L.A. Smock. 1990. Macroinvertebrate distribution and production on the floodplains of two lowland headwater streams. Freshwater Biology 24:533-545

Griswold, M.W., R.W. Berzinis, T.L. Crisman, and S. W. Golladay. 2008. Impacts of climatic stability on the structural and functional aspects of macroinvertebrate communiteis after severe drought. Freshwater Biology 53: 2645-2483

Golladay, S., K. Watt, S. Entrekin, and J. Battle. 2000. Hydrologic and geomorphic control on particulate concentration sin Ichawaynochaway Creek, Georgia, USA. Archiv fur Hydrobiologie 149:655-678

Lake, P. S. 2000. Disturbance, patchiness, and diversity in streams. Journal of the North American Benthological Society 19: 573-592.

Lake, P.S. 2003. Ecological effects of perturbation by drought in flowing waters. Freshwater Biology 48:1161-1172.

Lake, P.S. Drought, the "creeping disaster." Effects on aquatic ecosystems. 2008. Land and Water Australia. Canberra ACT, Australia.

Lobinske, R.J., C.E. Cichra and A. Ali. 2002. Predation by bluegill (*Lepomis macrochirus*) on larval chironomidae (Diptera) in relation to midge standing crop in two central Florida lakes. Florida Entomologist 85:372-375

Merritt, R. W, and K. W. Cummins, M. B. Berg (Editors). 2008. An introduction to the aquatic insects of North America. 4th Edition. Kendall/Hunt Publishing, Dubuque, Iowa.

Minchin, P.R. 1989. Montane vegetation of the Mt Field Massif, Tasmania- a test of some hypotheses about properties of community patterns. Vegetatio 83:97-110

Rader, R.B. and C.J. Richardson. 1994. Response of macroinvertebrates and small fish to nutirnet enrichment in the northern Everglades. Wetlands 14:134-146

Resh, V.H., A.V. Brown, A.P. Covich, M.E. Gurtz, H.W. Li, G.W. Minshall, S.R. Reice, A.L. Sheldon, J.B. Wallace, and R.C. Wissmar. 1988. The role of disturbance in Stream Ecology. Journal of the North American Benthological Society 7:433-455

Sklar, F.H. 1985. Seasonality and community structure of the backswamp invertebrates in a Louisiana cypress-tupelo wetland. Wetlands 5:69-86

Smock, L.A., E. Gilinsky, and D.L Stoneburner. 1985. Macroinvertebrate production in a southeastern United States blackwater stream. Ecology 66:1491-1503

Smock, L.A. 1999. Riverine floodplain forests of the southeastern United States. Pages 137-165 *in* D.P. Batzer, R.B. Rader, and S.A. Wissinger (editors). Invertebrates in Freshwater Wetlands of

North America: Ecology and Management. John Wiley & Sons, Inc. New York, USA.

Thorp, J.H. and A.P. Covich (editors). 2010. Ecology and Classification of North American Freshwater Invertebrates. Elsevier Academic Press, Burling ton, MA U.S. Drought Monitor. 2011.

U.S. Drought Monitor Southeast. <http://droughtmonitor.unl.edu/DM_southeast.htm>

Wissinger, S.A. 1999. Ecology of wetland invertebrates: synthesis and application for conservation man agement. Pages 1043-1086 *in* D.P. Batzer, R.B. Rader, and S.A. Wissinger (editors). Inverte brates in Freshwater Wetlands of North America: Ecology and Management. John Wiley & Sons, Inc. New York, USA**.**

Table 1. Physicochemical parameters (mean ± SE) at the Moody Forest study site from December 2011-April 2012. Values estimated from monthly point reading (n=3) using a YSI Professional Plus Multiparameter Water Quality Meter (YSI, Inc.).

| | Temperature (°C) | Dissolved Oxygen (mg/L) | Conductivity (µs/cm) | pH |
|---|---|---|---|---|
| December 2011 | 9.38 ± 0.404 | 4.95 ± 0.514 | 0.109 | |
| January 2012 | 7.56 ± 0.080 | 5.04 ± 0.138 | 0.227 | |
| February 2012 | 14.6 ± 0.532 | 3.46 ± 0.665 | 0.152 | |
| March 2012 | 19.4 ± 0.054 | 5.49 ± 0.354 | 0.113 | |
| April 2012 | 20.0 ± 0.120 | 2.94 ± 0.174 | 0.143 | |

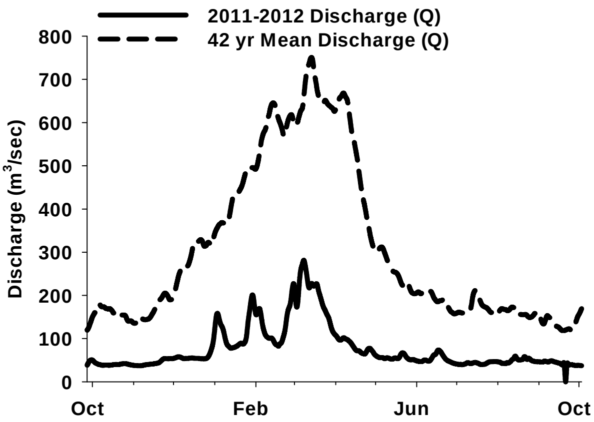
## Figure Captions

Figure 1. Hydrograph from the Altamaha River (USGS gauge 02225000 near Baxley, Georgia). Full line denotes monthly discharge rate (m$^3$/sec) for the study year (2011-2012) and dotted line denotes the 42 year mean discharge rate for the site.

Figure 2. Macroinvertebrate community mean monthly abundance and monthly flood stage denoted as river discharge rate. Data were log transformed (log (N) – 1; log (Q)] for interpretability.

Figure 3. Two-dimensional NMDS ordination plot showing aquatic macroinvertebrate monthly abundance patterns for the 2011-2012 sampling period (●DEC = December; ○JAN = January; ▼FEB = February; ΔMAR = March; ■APR = April.

Figure 4. Percent composition of macroinvertebrate functional feeding groups (FFG) by month. FC= filterer-collector, GC= gatherer-collector, PA= parasite, PR= predator, SC= scraper, SH= shredder.



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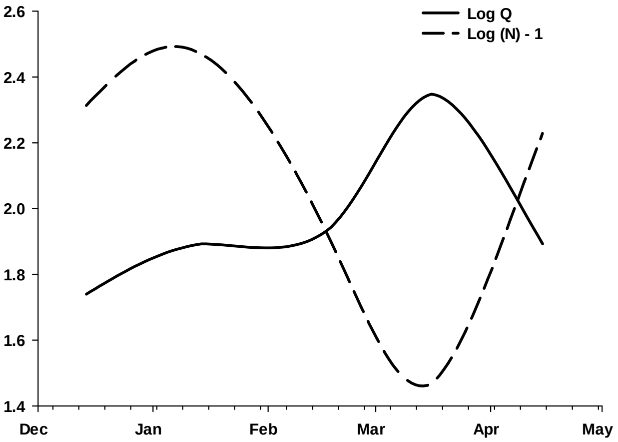

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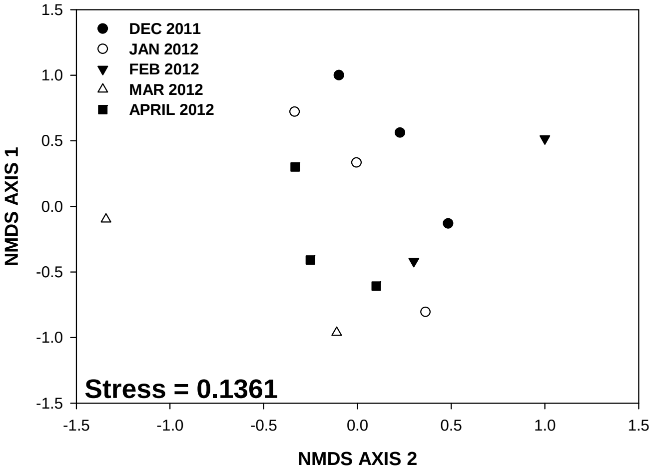

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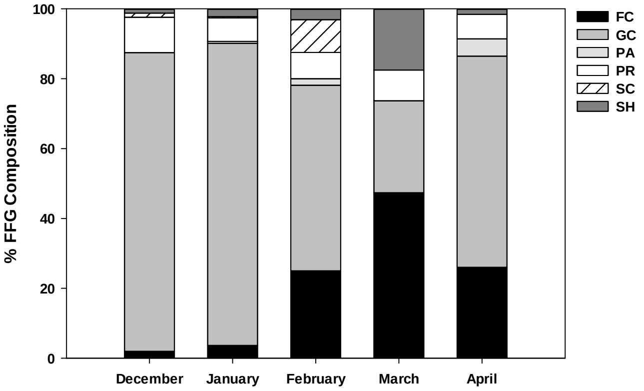

Figure 4.