

Relationship between macroinvertebrate assemblage structure and ecosystem function in two Coastal Plain blackwater streams

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Introduction

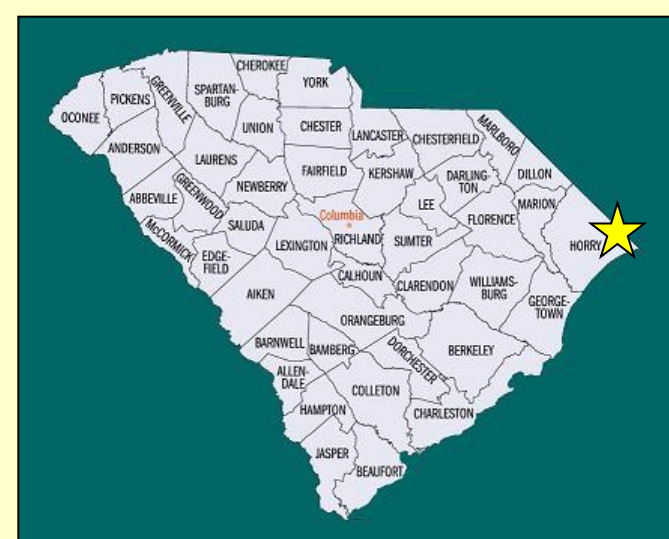
- Ecosystem structure is often used to indicate ecosystem function in studies of stream integrity because structure is usually much easier to measure. Whether structure can be substituted for function, however, is seldom assessed.
- Commonly used methods that assess stream structure (e.g., Rapid Bioassessment Protocols, Barbour et al. 1999) are often completed in a single day. It is uncertain how well these short-term measures accurately predict longer-term ecosystem function.
- Leaf breakdown is an essential stream ecosystem process in forested headwater streams that reflects microbial and aquatic invertebrate activities. As such, one structural parameter commonly measured (i.e., macroinvertebrates in the shredder functional feeding group) and one parameter infrequently measured (i.e., fungal biomass on leaves) in stream rapid bioassessments can be tested for their ability to predict an important ecosystem process.

Objective

- Can structural measures (i.e., % of total benthic macroinvertebrates classified functionally as shredders and fungal biomass on leaves) be used to predict ecosystem function (i.e., leaf breakdown rate)?

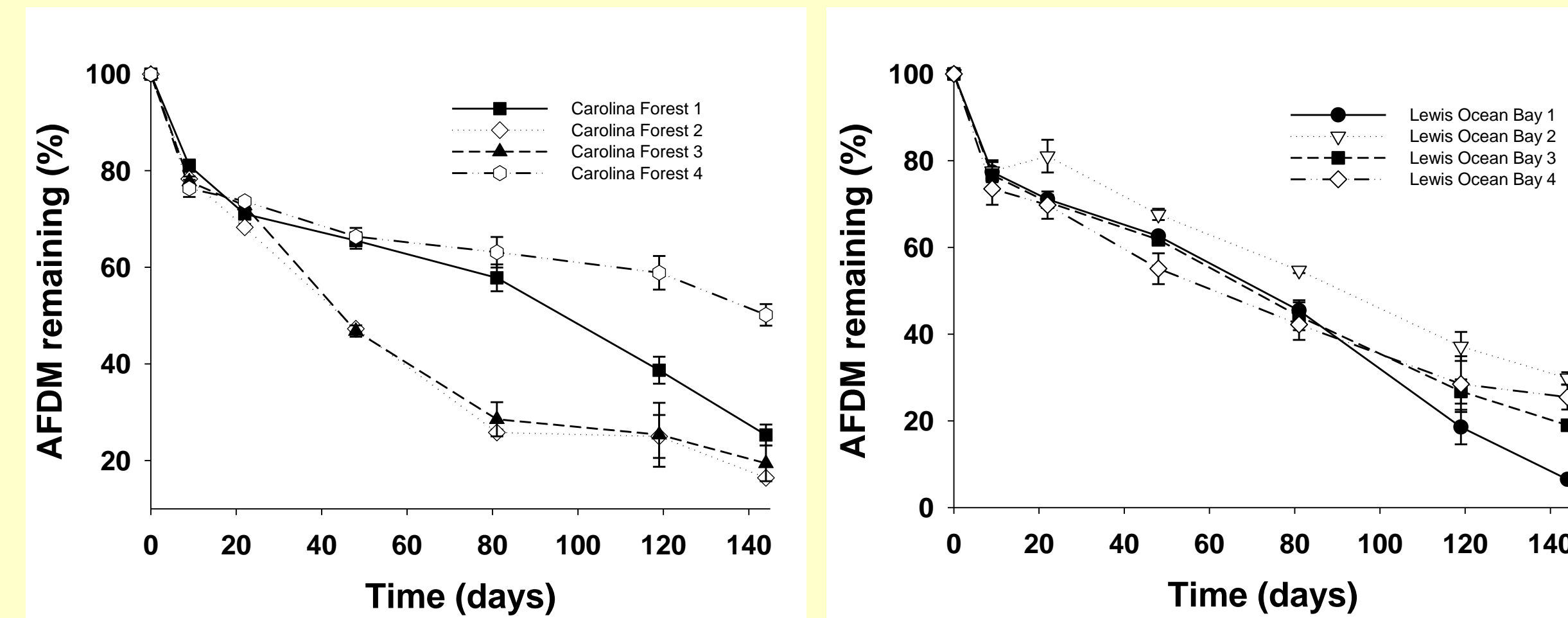
Methods

- Structural and functional parameters were measured at four 100-m long sites in each of two forested blackwater streams in South Carolina (total $n=8$ sites). The two streams include Socastee Swamp in the Carolina Forest Wildlife Refuge, Myrtle Beach; and Tilly Swamp in Lewis Ocean Bay Heritage Preserve, Conway. Lewis Ocean Bay Heritage Preserve is a managed 4050 ha preserve. Although prescribed fires are used to manage the preserve, the riparian zone is not burned. Owned by Wildlife Action as a wildlife corridor, Carolina Forest Wildlife Refuge is approximately 200 ha. The wide, forested floodplain within the Refuge is surrounded by housing development.
- Pre-weighed red maple (*Acer rubrum*) leaves in coarse-mesh bags were sampled monthly from December 2008-April 2009.
- Breakdown rates ($-k$) of leaf packs were estimated by linear regression of ln-transformed data, using a negative exponential model, $X=Ce^{-kt}$ (Petersen and Cummins 1974).
- Benthic macroinvertebrates were sampled once using protocols developed for calculating the Coastal Plain Macroinvertebrate Index (CPMI; Maxted et al. 2000). A 100-count subsample was identified primarily to genus and counted. Also, macroinvertebrate biomass was estimated using published length-mass regressions for each taxon (Benke et al. 1999). Mean macroinvertebrate taxa tolerance values for each site were calculated using values in Maxted et al. (2000).
- 5 random leaves were collected from each site during CPMI sampling (March 2009) and additional leaves were collected on a single day to measure fungal biomass (calculated from ergosterol extractions; Gulis and Suberkropp 2003).
- Breakdown rates were regressed against the structural metrics (i.e., fungal biomass during CPMI sampling and on a single day, and % Shredders based on abundance and biomass).



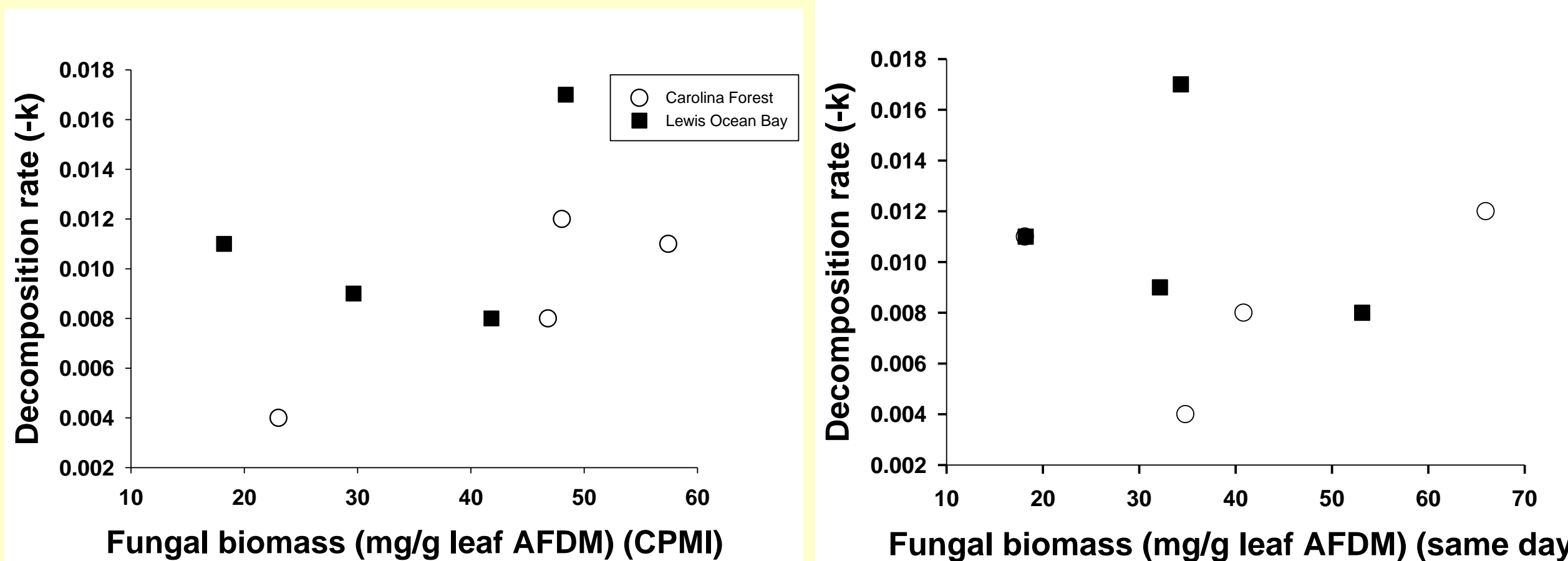
Results

Leaf breakdown



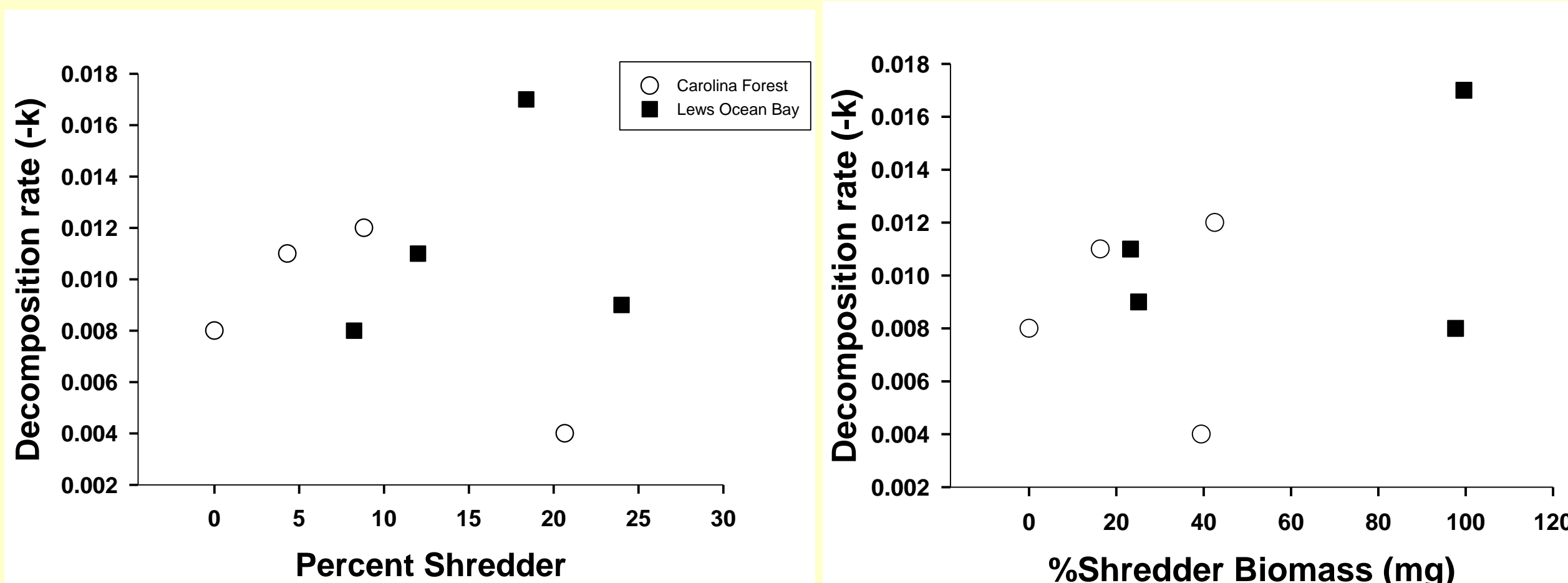
- Leaf breakdown rates varied significantly among sites, with $-k$ values ranging from 0.004 to 0.017 d^{-1} .
- Most breakdown rates ($-k$) were in the 'medium' category (0.005-0.10) (Petersen and Cummins 1974, Webster and Benfield 1986).

Breakdown vs. fungal biomass



- Fungal biomass (mg/g leaf AFDM) measured during either collection was not significantly related to leaf breakdown rates.

Breakdown vs. % Shredders



- Percent shredders based on either abundance or biomass collected during CPMI sampling was not significantly related to breakdown rates.

Shredder taxa

Shredders collected at each stream, listed from most to least abundant

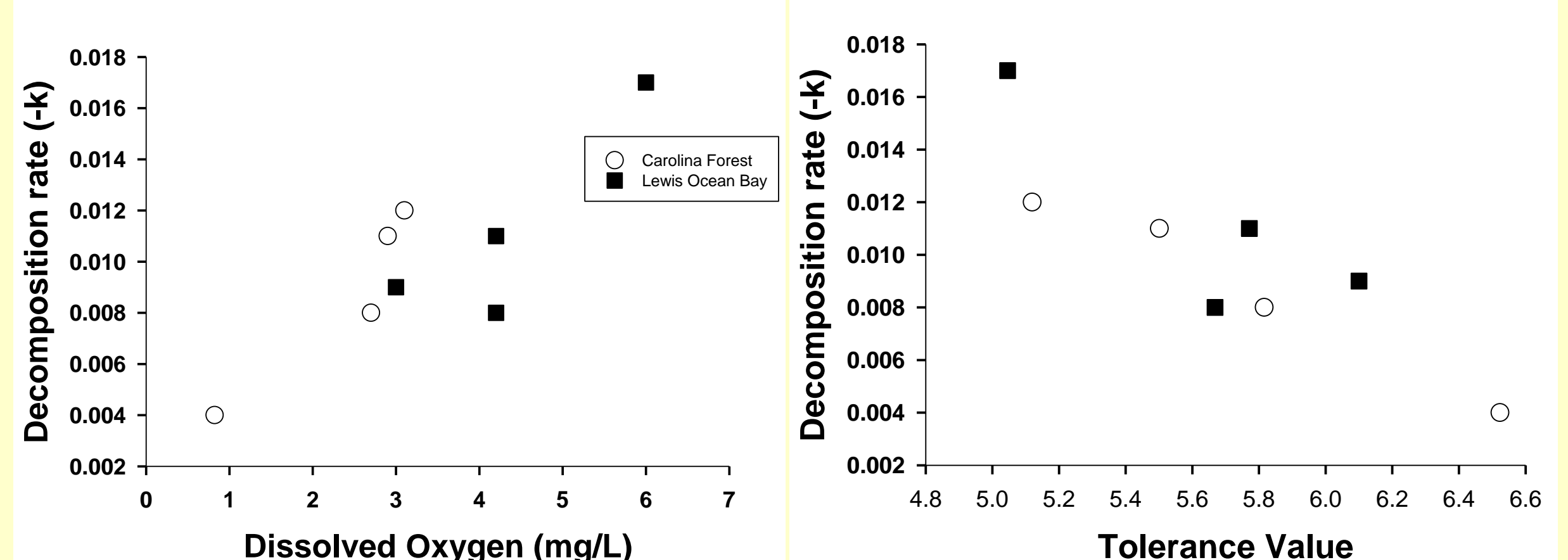
Carolina Forest	Lewis Ocean Bay
<i>Crangonyx</i> (Amphipoda: Crangonyctidae)	<i>Caecidotea</i> (Isopoda: Asellidae)
<i>Caecidotea</i> (Isopoda: Asellidae)	<i>Paraleptophlebia</i> (Ephemeroptera: Leptophlebiidae)
	<i>Lirceus</i> (Isopoda: Asellidae)
	<i>Crangonyx</i> (Amphipoda: Crangonyctidae)
	<i>Procambarus</i> (Decapoda: Cambaridae)
	<i>Amphinemura</i> (Plecoptera: Nemouridae)

Abiotic Data

- Sites at Carolina Forest had lower dissolved oxygen (mg/L), while Lewis Ocean Bay sites had lower conductivity ($\mu S\ cm^{-1}$) and turbidity (NTU). All sites had low flow (m/s).

Location	Site	Mean pH	Mean DO (mg/L)	Mean conductivity ($\mu S\ cm^{-1}$)	Mean turbidity (NTU)	Flow (m/s)
Lewis Ocean Bay	1	5.2	6.0	55.6	2.0	0.001
	2	4.7	4.2	57.4	3.3	0
	3	4.6	4.2	55.3	1.7	0.009
	4	6.9	3.0	56.0	4.9	0
Carolina Forest	1	4.5	2.7	71.2	2.3	0
	2	4.6	3.1	95.1	12.9	0.005
	3	5.1	2.9	87.7	14.8	0.004
	4	5.0	0.8	87.5	7.4	0

Breakdown vs. other variables



- Dissolved oxygen (mg/L) was positively related to breakdown rates ($-k$) ($p=0.008$, $R^2=0.719$).
- Mean macroinvertebrate tolerance values were significantly related to breakdown rates ($-k$) ($p=0.004$, $R^2=0.779$). Low tolerance values indicate higher stream integrity.

Conclusions

- The short-term structural metrics tested (i.e., % Shredders and fungal biomass) did not predict longer-term ecosystem functioning (i.e., leaf litter breakdown).
- Instead, breakdown rates increased in sites with higher dissolved oxygen concentrations. Furthermore, sites with rapid leaf breakdown had higher stream integrity as indicated by macroinvertebrate tolerance values.
- Our study showed that Coastal Plain blackwater stream ecosystem function was dominated by the strong abiotic filter of oxygen availability and that this filter appeared to overwhelm our short-term measures of community composition and microbial biomass.

References

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Acknowledgments

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