Ecological effects of biochar on stream communities

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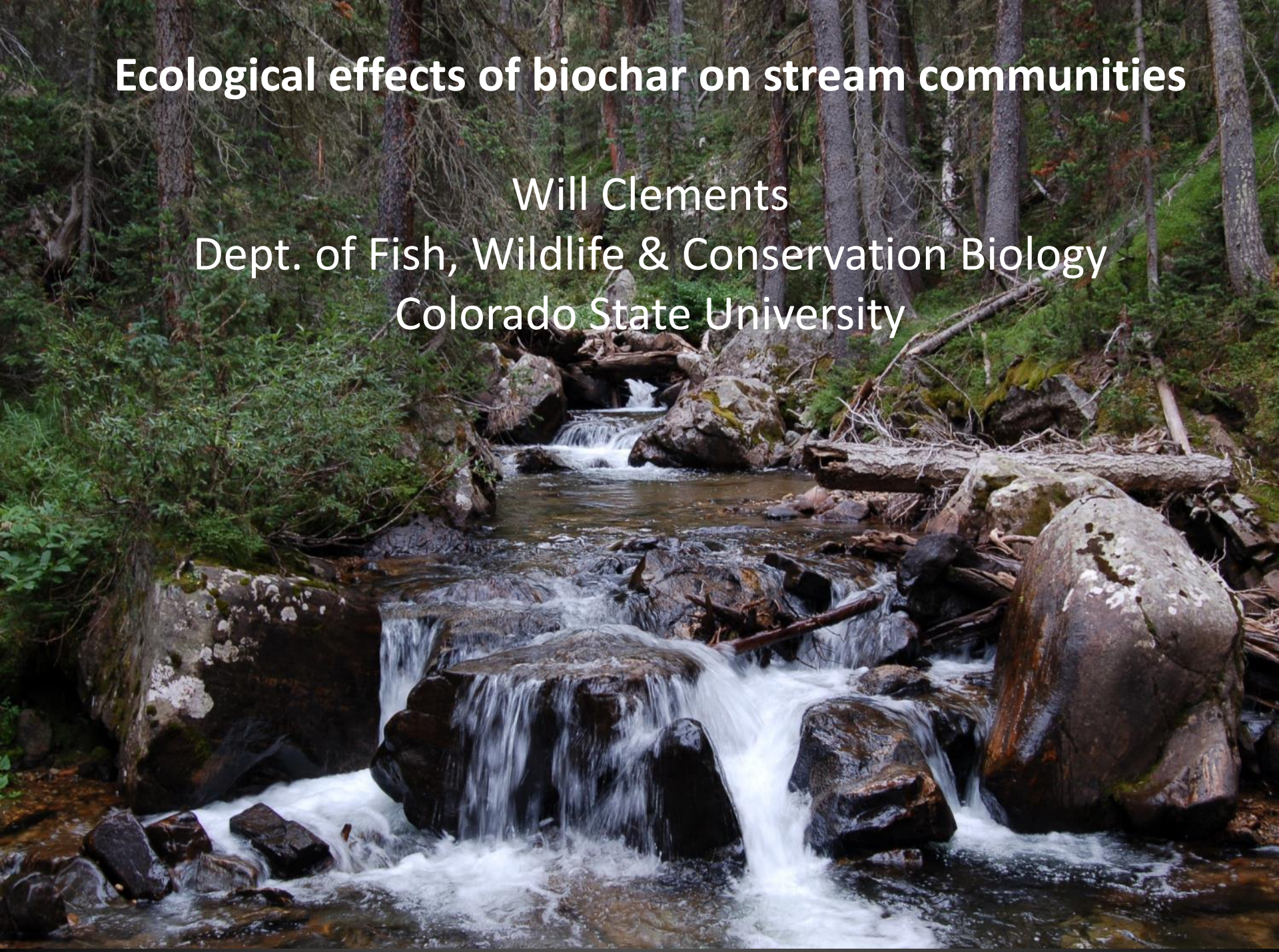

Motivation for the research

- Beneficial effects of biochar and activated carbon (AC) are well established in the literature; however,
- ~20% of studies have reported negative effects
  → growth, behavior and survival (Janssen et al. 2013)
- Contaminant (e.g., PAHs) release, loss of interstitial space, alterations in food resources, clogging of respiratory surfaces
- Most previous research conducted in terrestrial ecosystems; little focused on community or ecosystem processes

Objectives

- Assess effects of Biochar on macroinvertebrate communities and stream ecosystem processes
- Quantify combined and interactive effects of 2 size classes of Biochar
- Compare Biochar effects to those of a reference toxicant (Cu)

Experimental Approach

1. Field colonization study
   Colonization with and without Biochar

2. Stream microcosm experiments
   - Effects of large versus small Biochar
     Control
     Large (1 - 5 mm)
     Small (< 1 mm)
     Both
   - Biochar & reference toxicant (Cu)


South Fork of the Michigan River, Colorado

1. Macroinvertebrate Colonization Experiment

Diverse Range of Taxa & Functional Feeding Groups (~ 40 taxa)

Mayflies	Stoneflies	Caddisflies	Dipterans	Other Taxa
BAETIS	CAPNIA	BRAAME	CHIRON	HETCOR
DIPHET	ZAPADA	MICRAS	TANYTA	HYDRAC
DRUDOD	TAENIO	GLOSSO	ORTHOC	NEMATO
DRUGRA	SWELTSA	ARCGRA	TANYPO	OLIGOC
SERRAT	HESPAC	LEPIDO	BEZZIA	POLYCEL
CINYGM	ISOPERLA	RHYACOP	EMPIDI	
RHIHAG	MEGSIG	ALLOYM	CHELIF	
PARALEP	SKWALA		PERICO	
AMELET	PTEBAD		SIMULI	
			ANTOCH	
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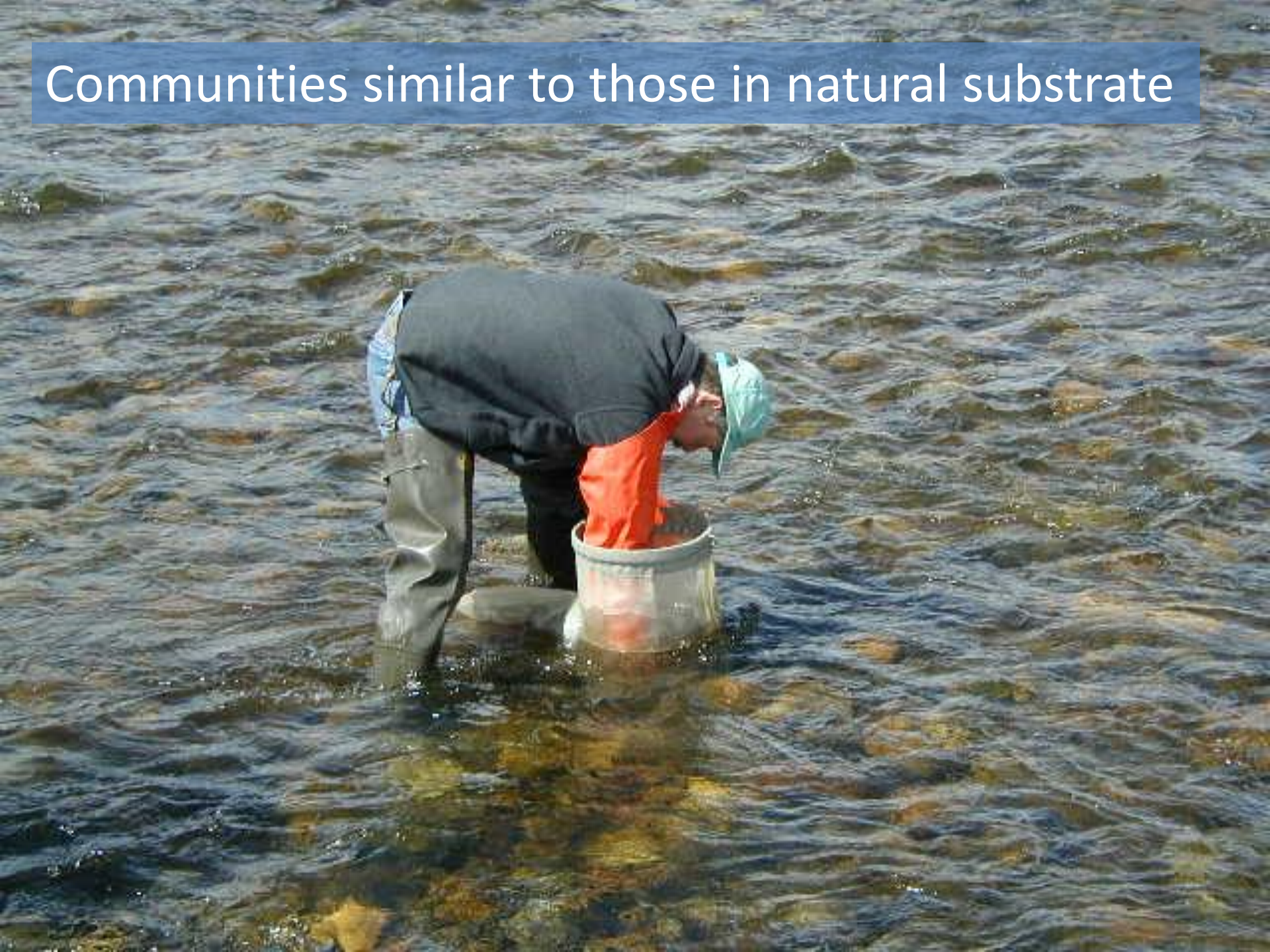
Communities similar to those in natural substrate

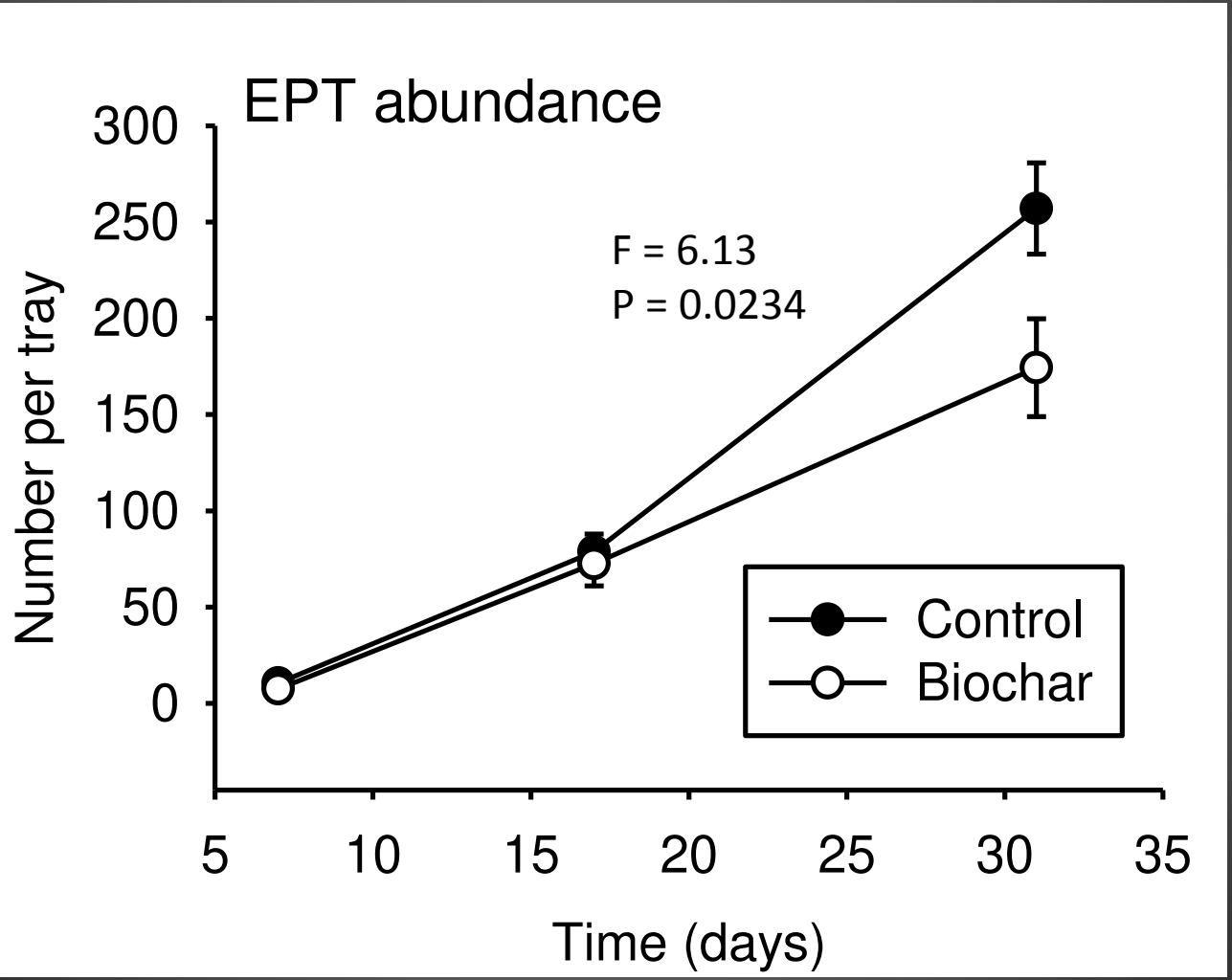


Mesh bags filled with either Biochar or small gravel substrate

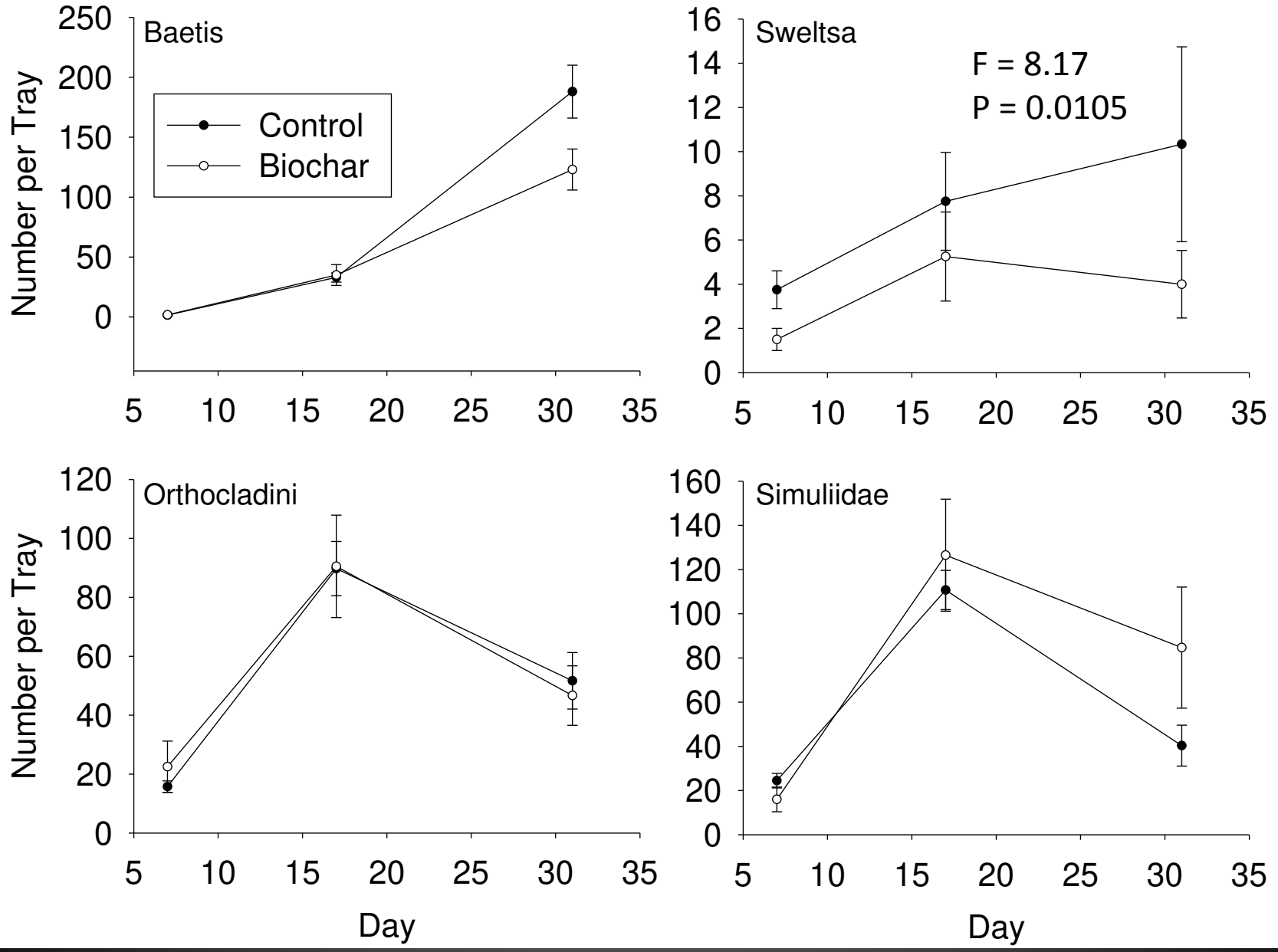
Covered with small cobble

- Deployed in the field
- Collected after 7, 17 & 31 d

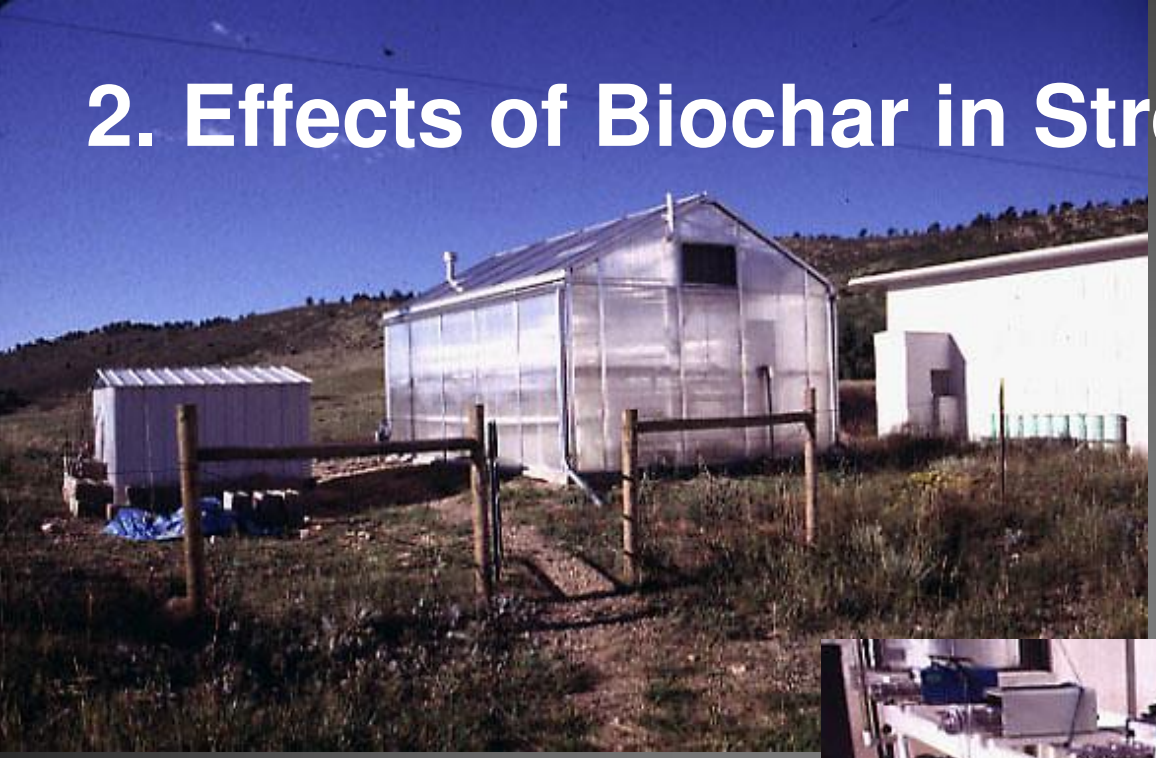
Colonization of mayflies, stoneflies and caddisflies in trays with and without Biochar



Colonization by Dominant Taxa

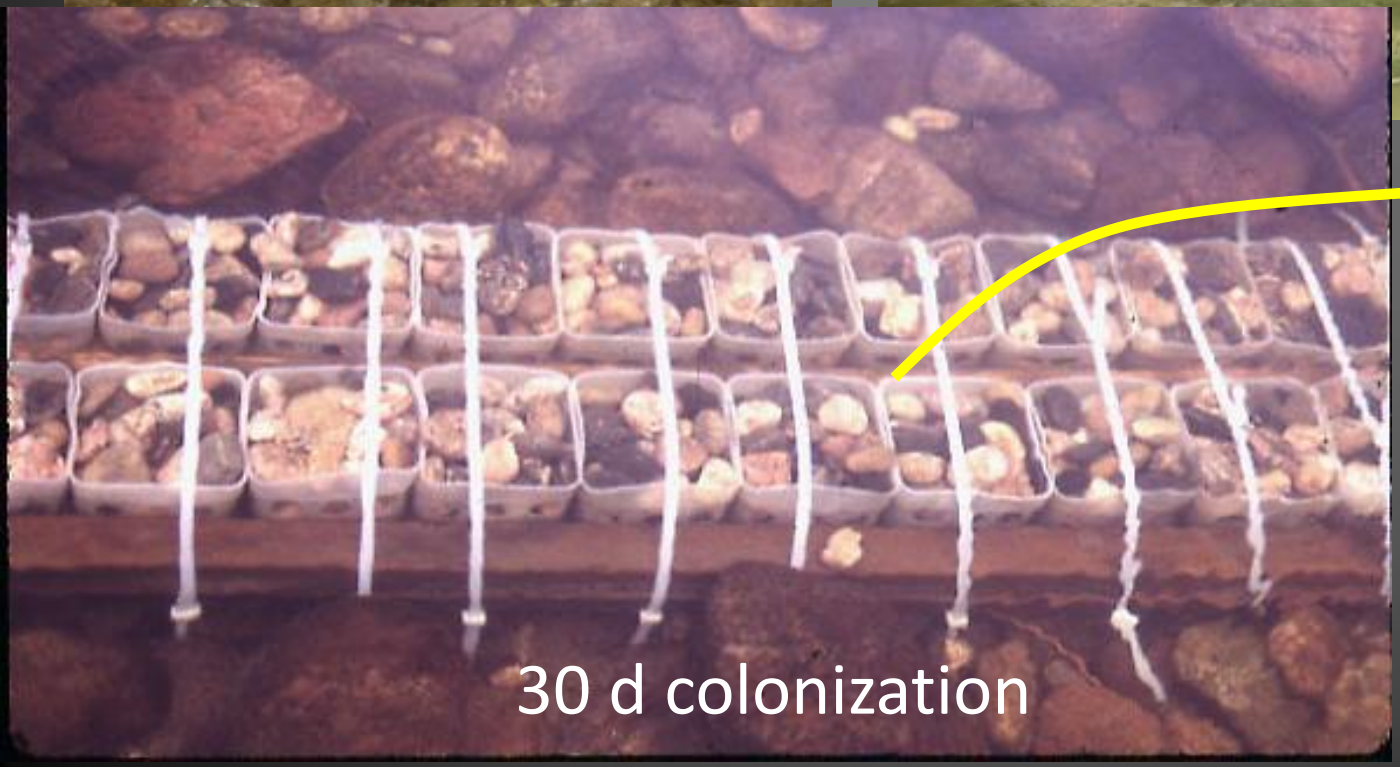


2. Effects of Biochar in Stream Microcosms

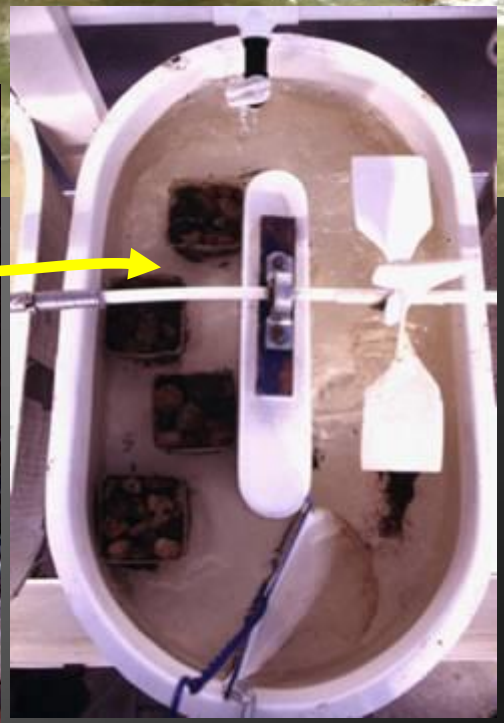


CSU Stream Research Laboratory

Natural water source
(oligotrophic reservoir)
Natural sunlight
18 20-L microcosms
Flow through systems



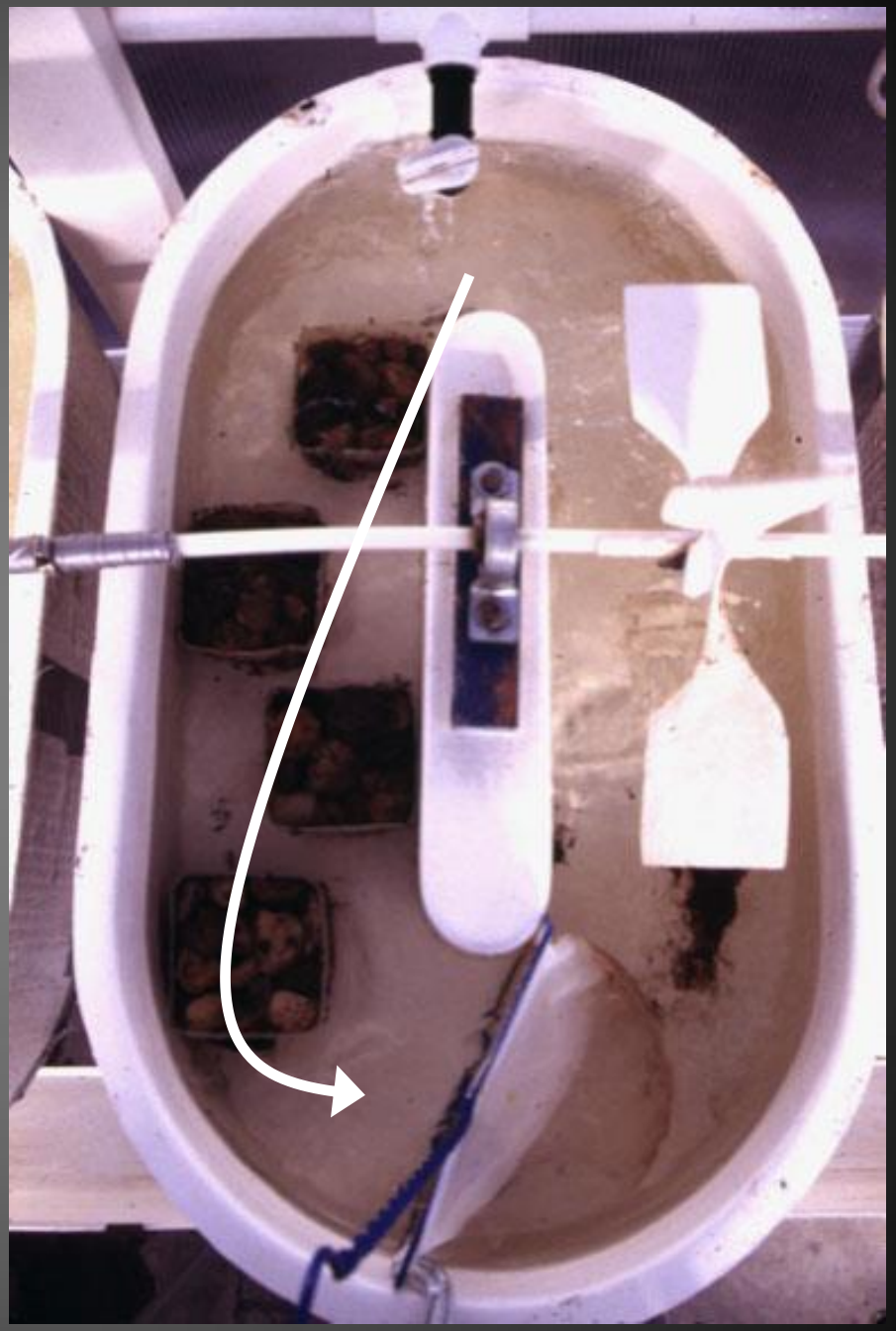
30 d colonization



10 d exposure

Endpoints Measured

- Macroinvertebrate drift
- Survival
- Community composition
- Community metabolism

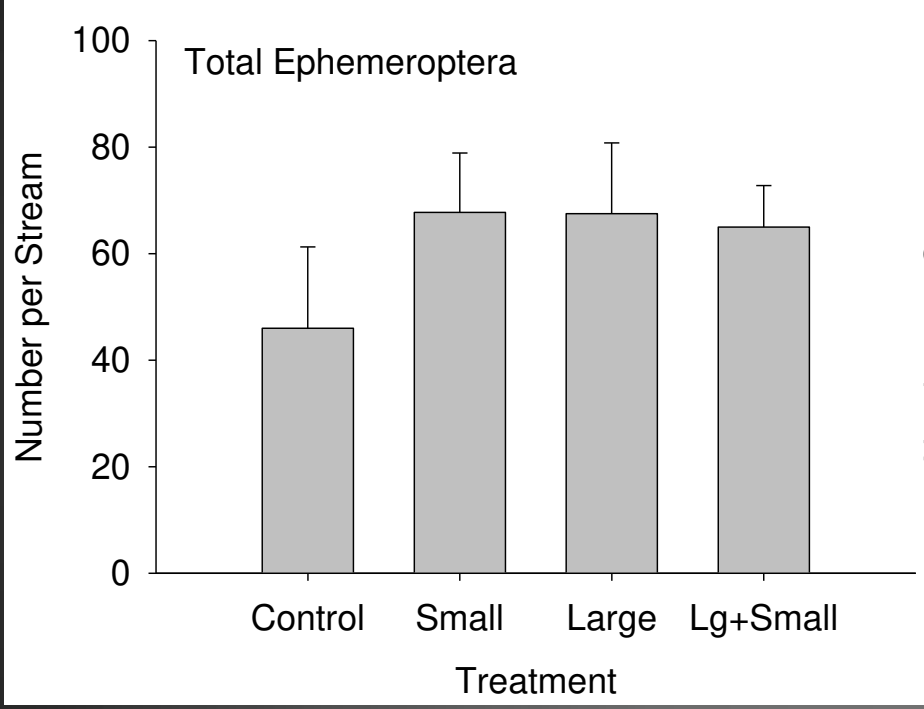


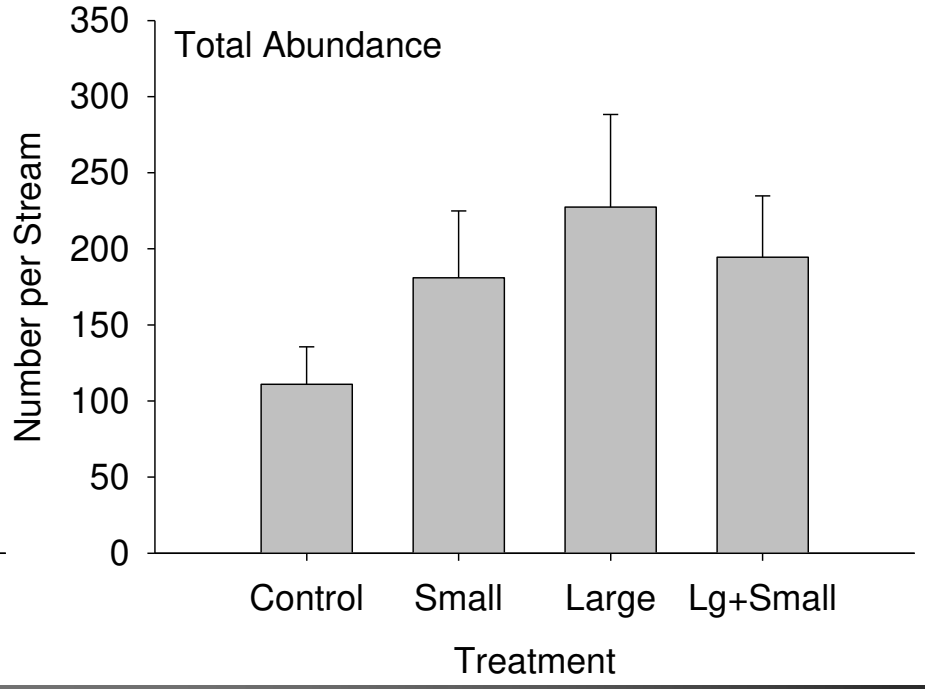
1.0 L container
350 µm mesh

<u>Biochar Treatments</u>:
Large: 750 ml Biochar
Changed every 2 d
Small: Biochar added as slurry

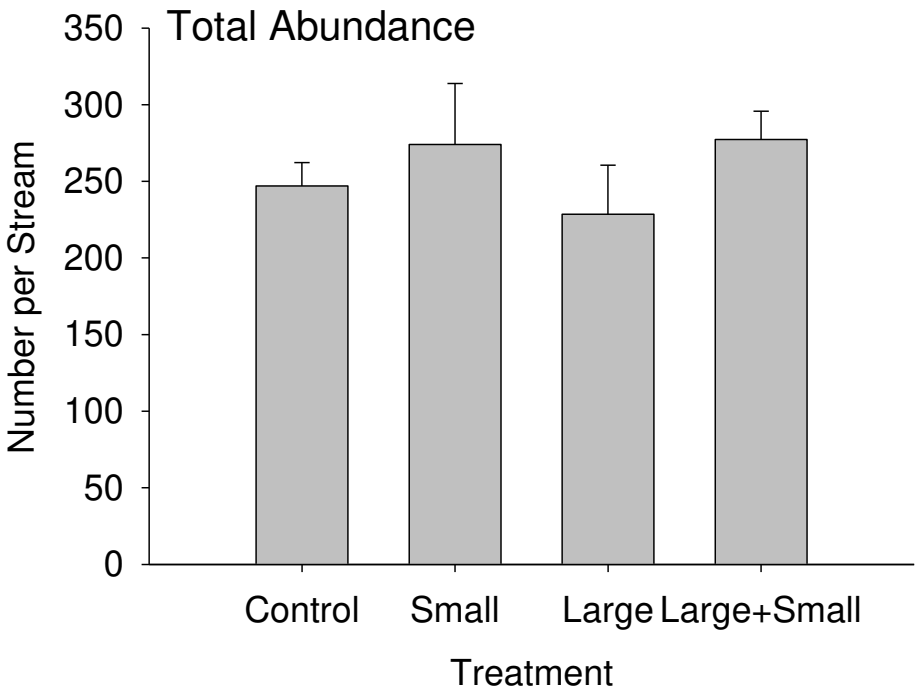
Experiment 1: Effects of Biochar

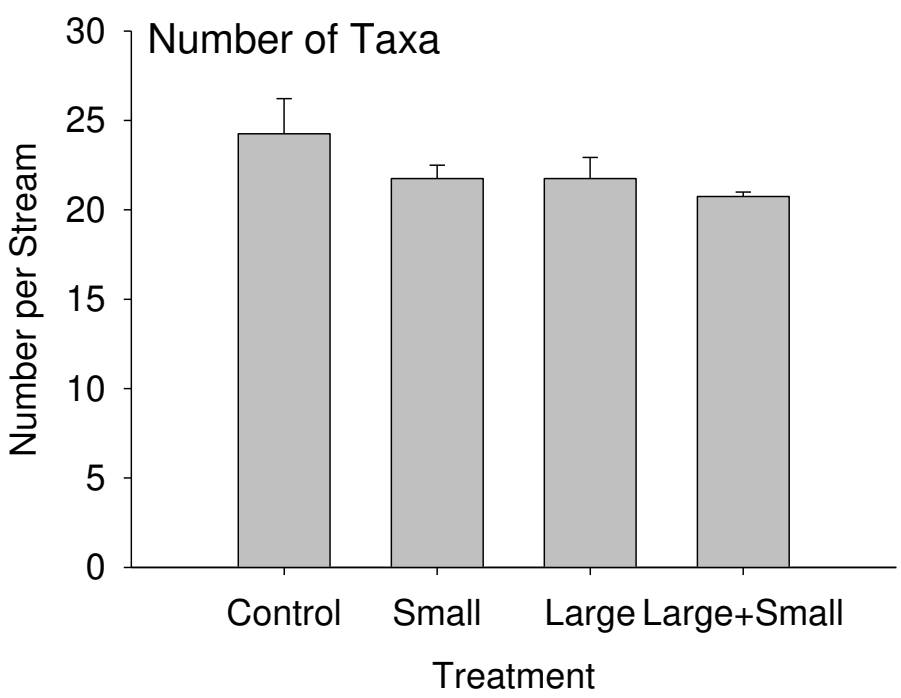
Drift of aquatic insects in stream mesocosms



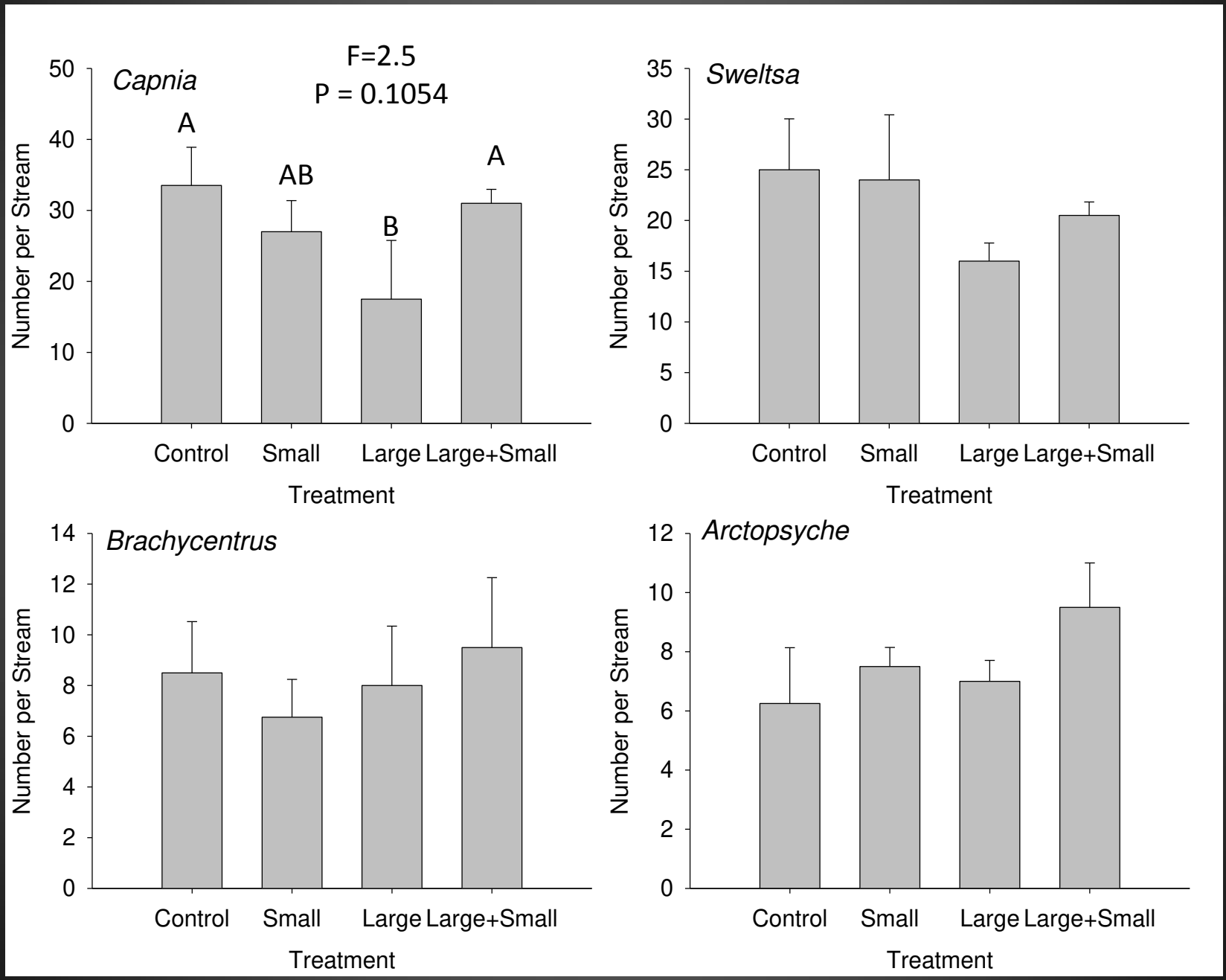


Effects of biochar on abundance & species richness after 10 d exposure to biochar

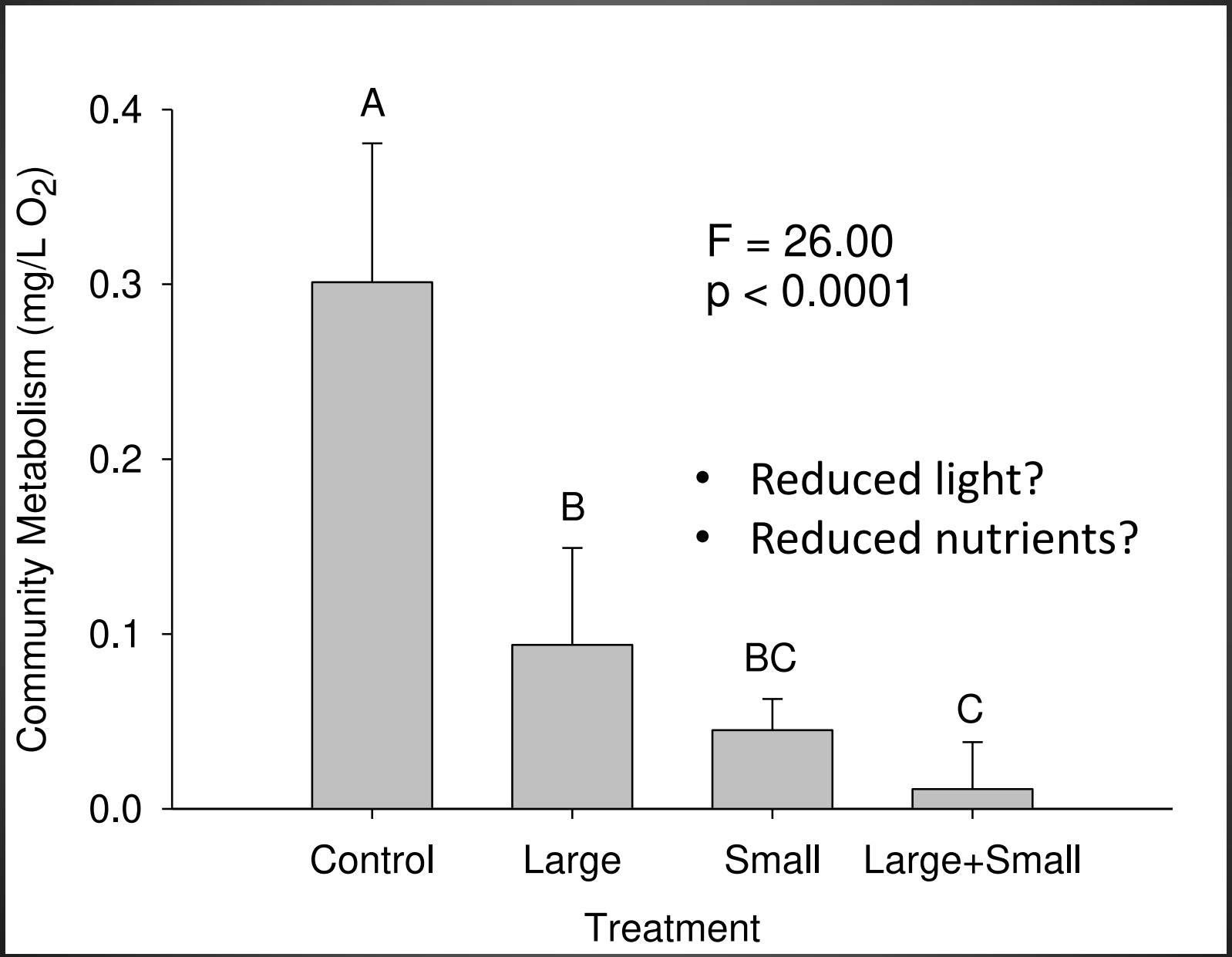




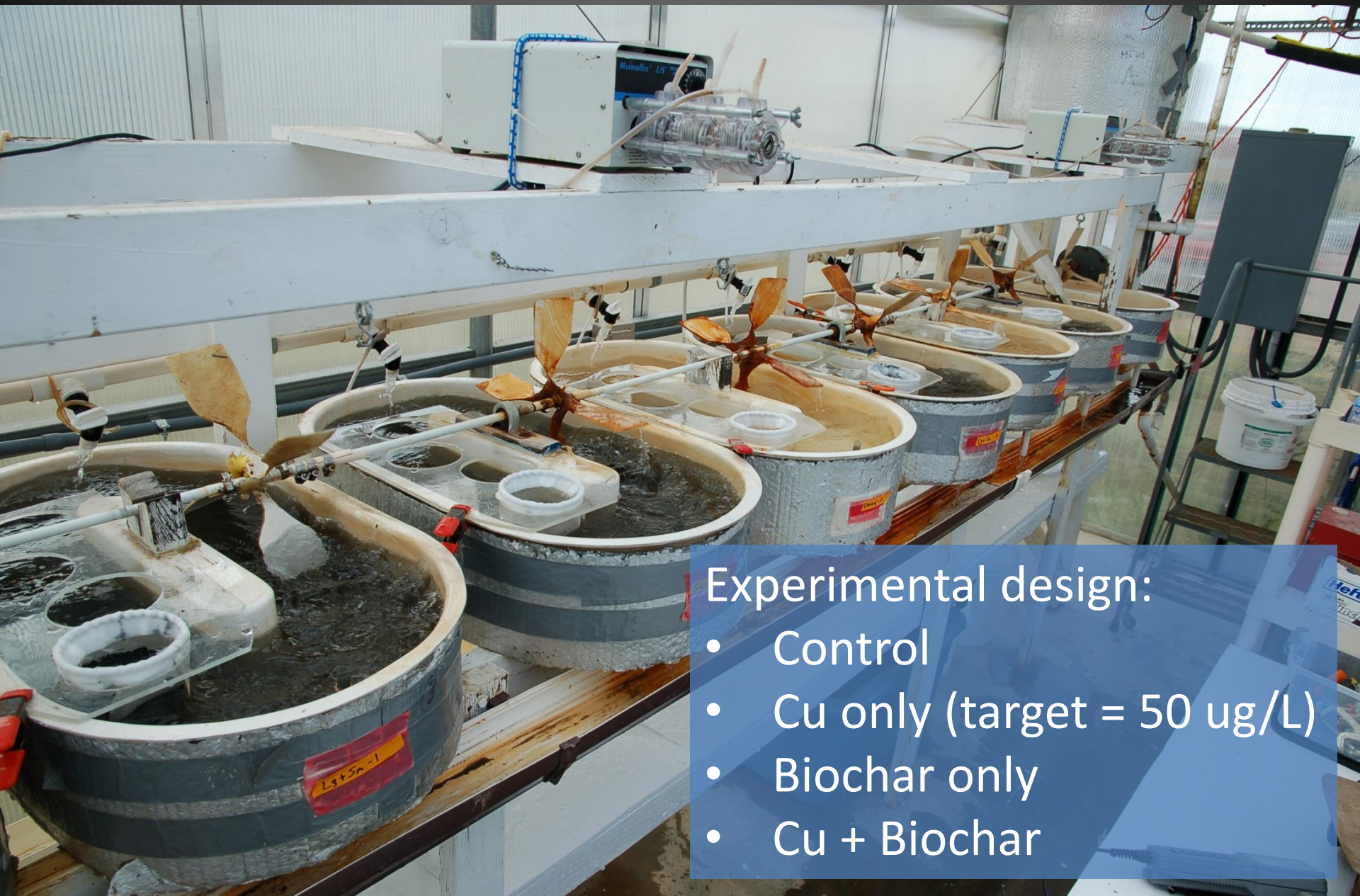
Effects of biochar on stoneflies and caddisflies



Highly significant effect on community metabolism



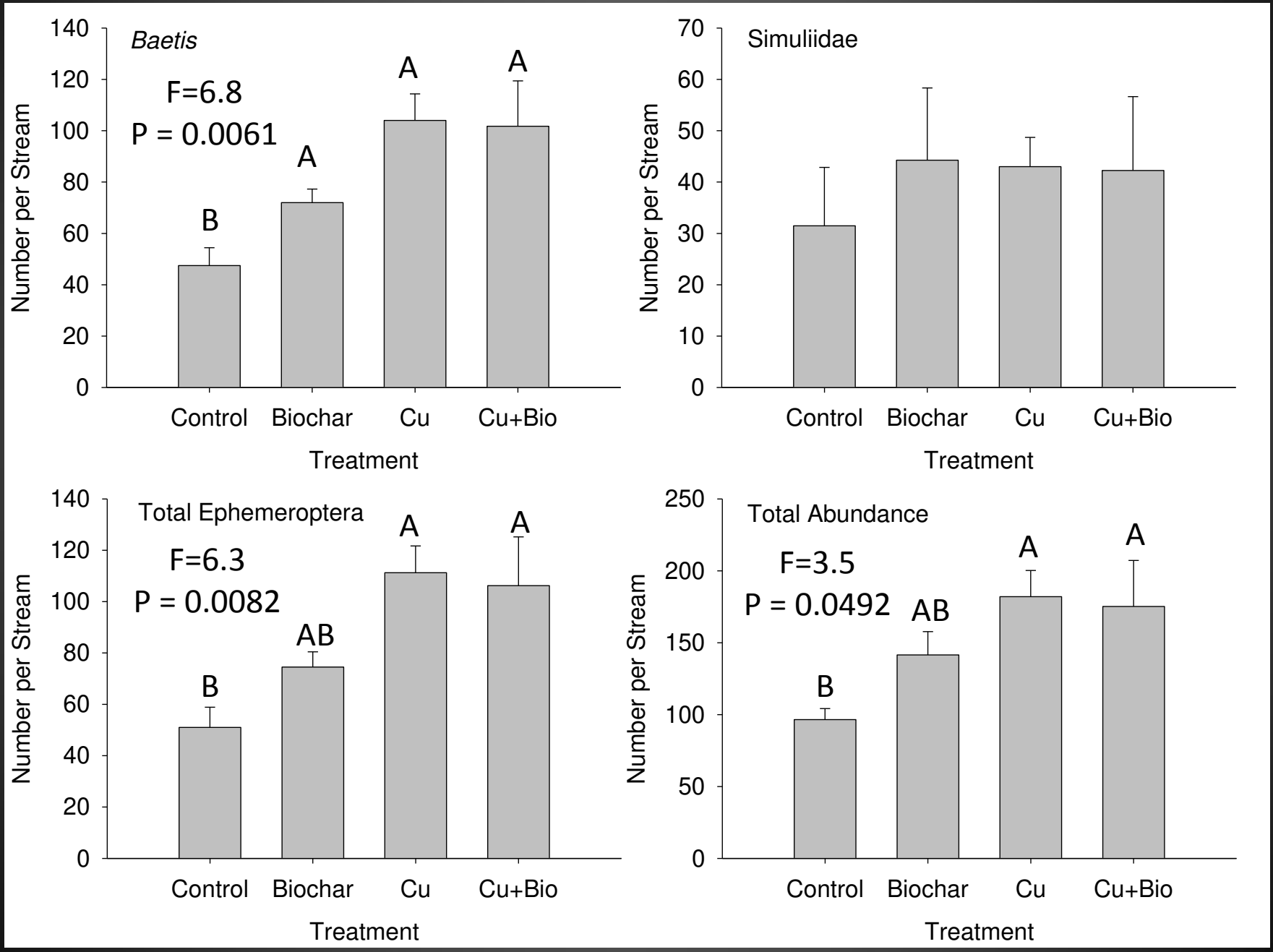
Experiment 2: Combined Effects of Biochar & Cu



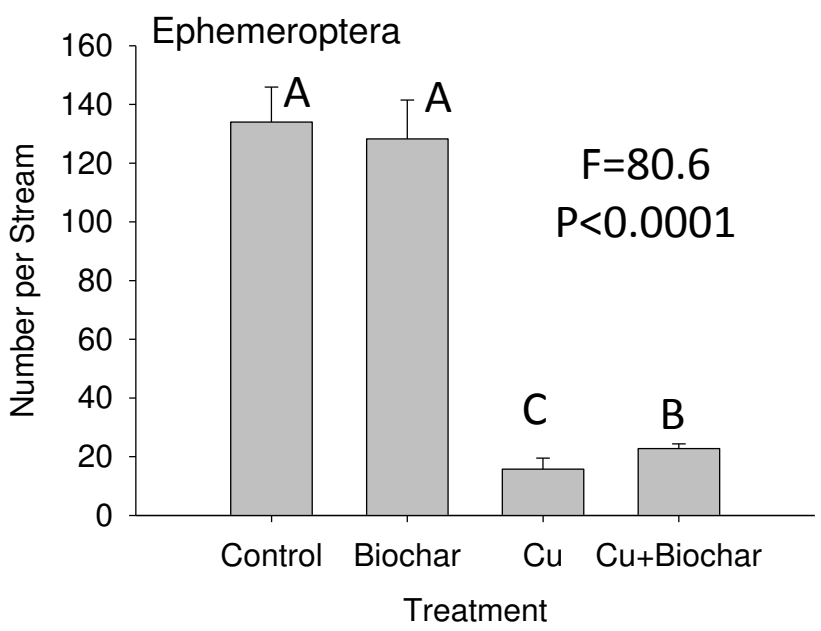
Experimental design:

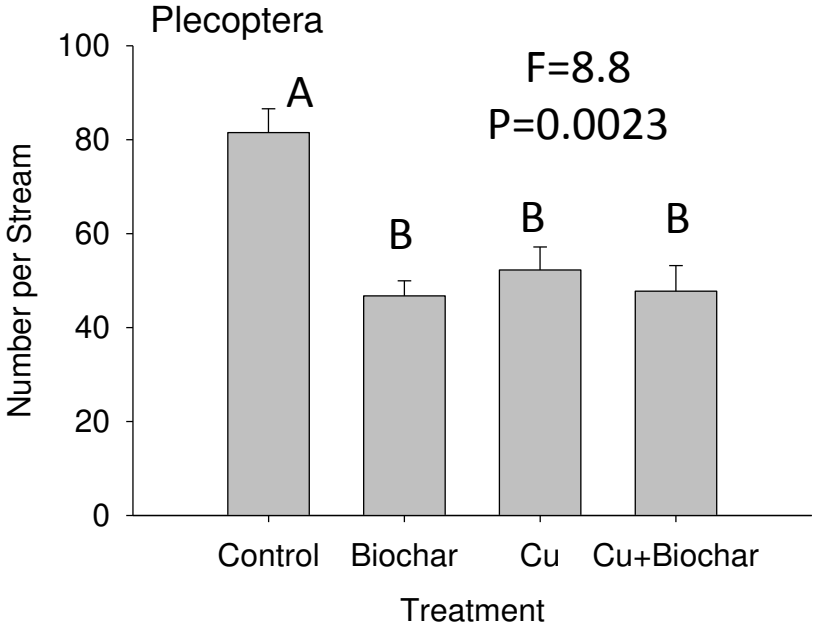
- Control
- Cu only (target = 50 ug/L)
- Biochar only
- Cu + Biochar

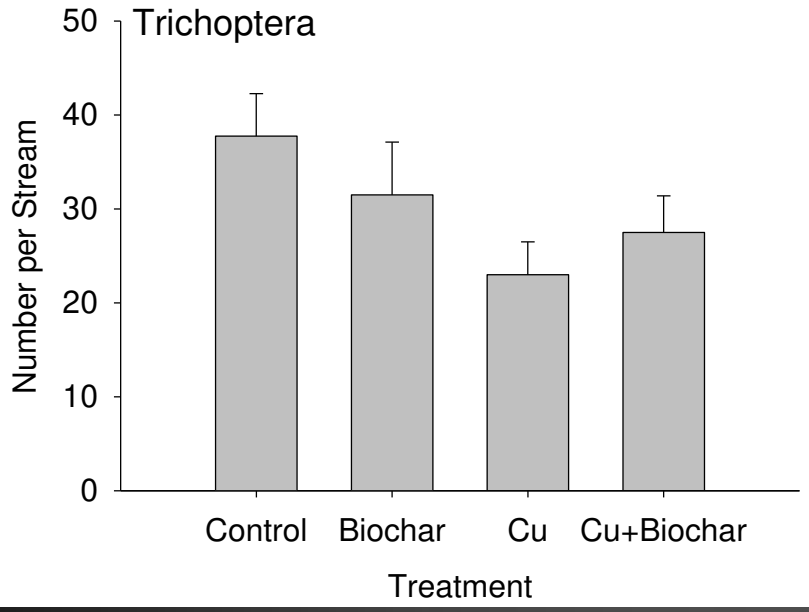
Macroinvertebrate drift

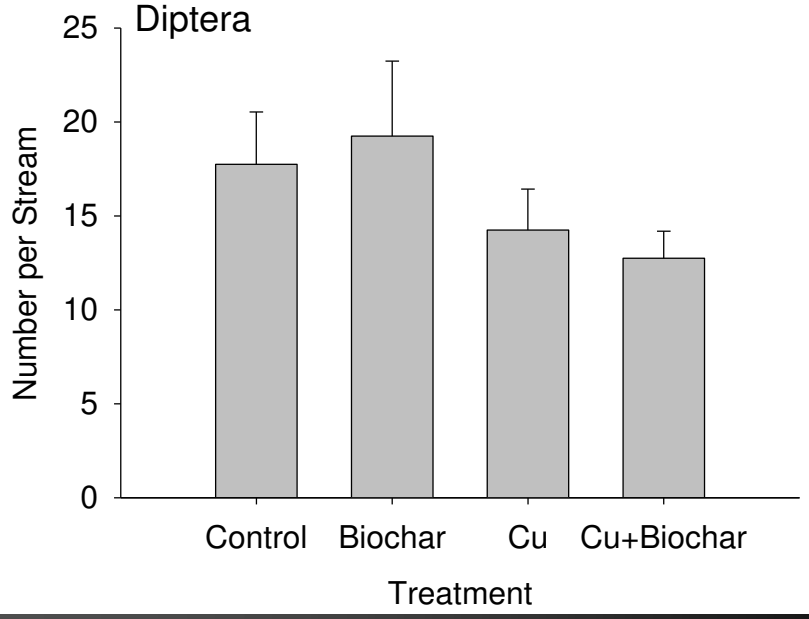


Effects of biochar & Cu on community composition

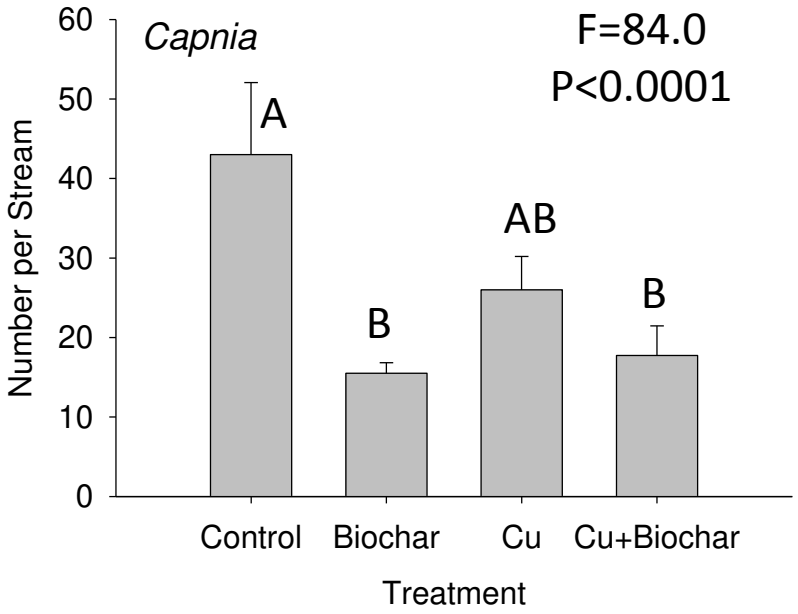


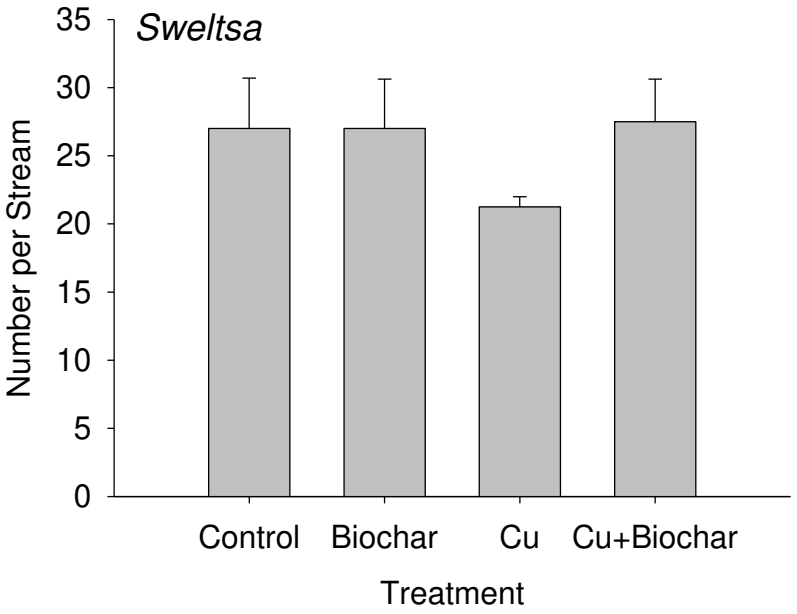


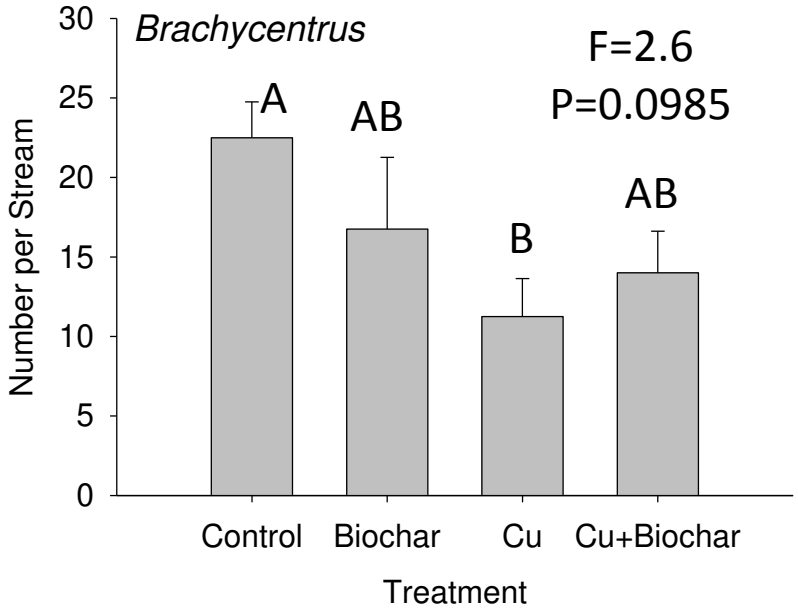


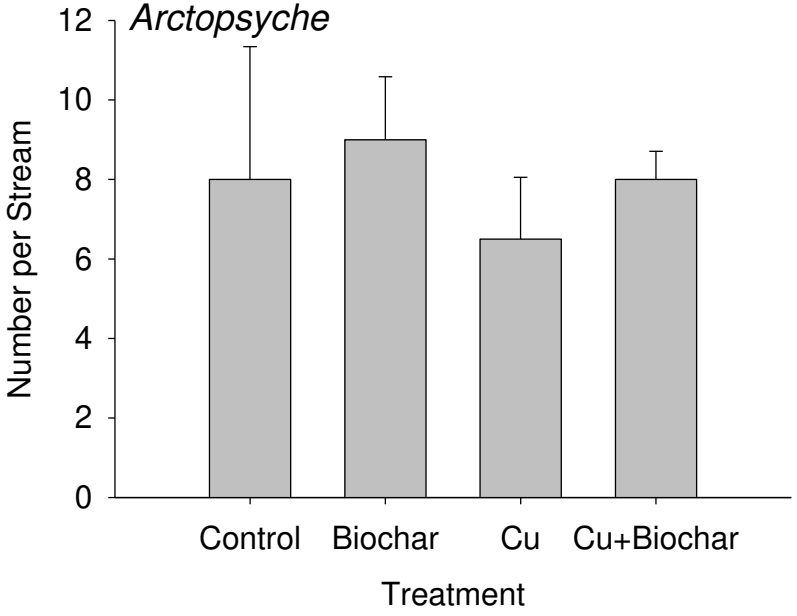


Dominant stoneflies & caddisflies

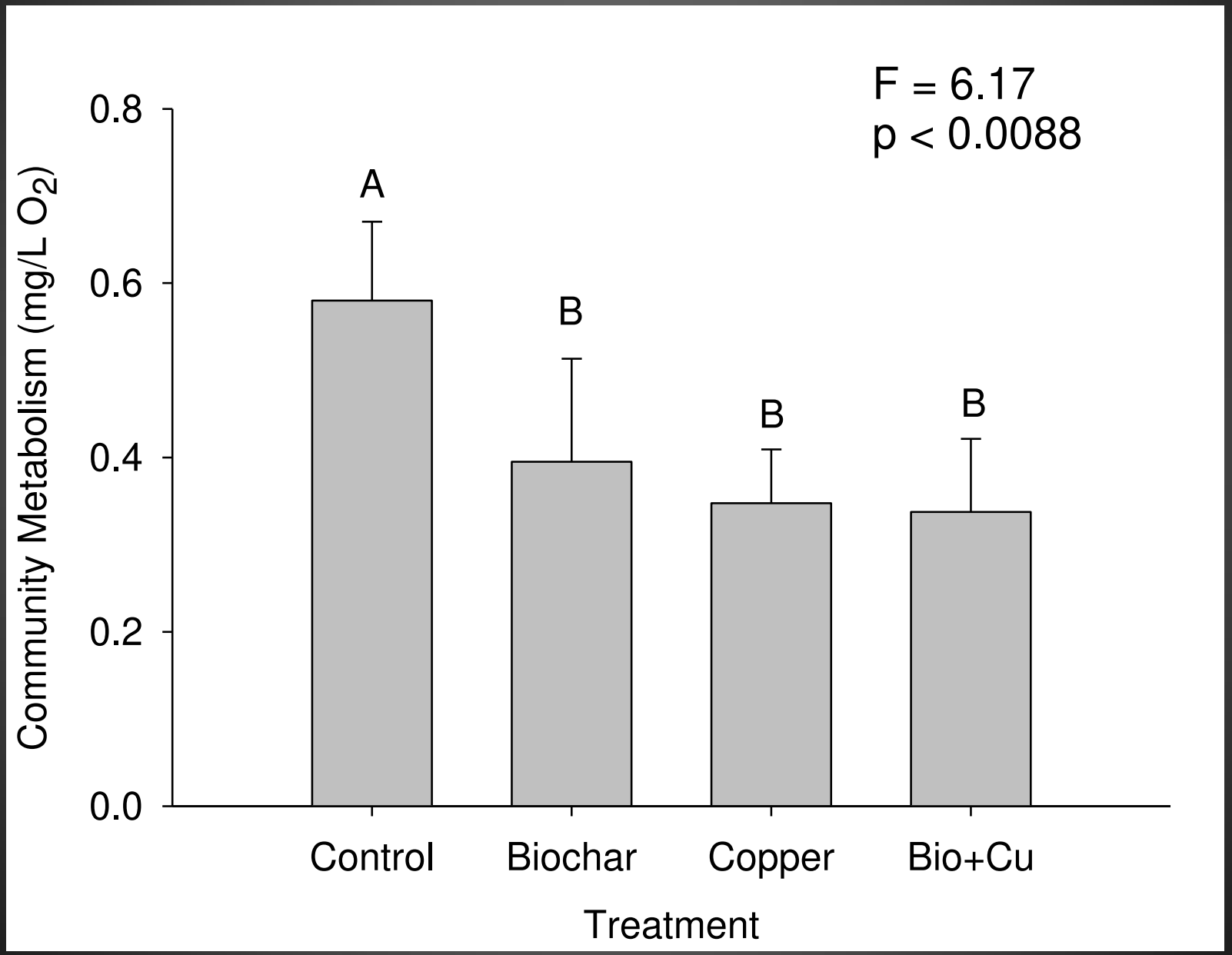




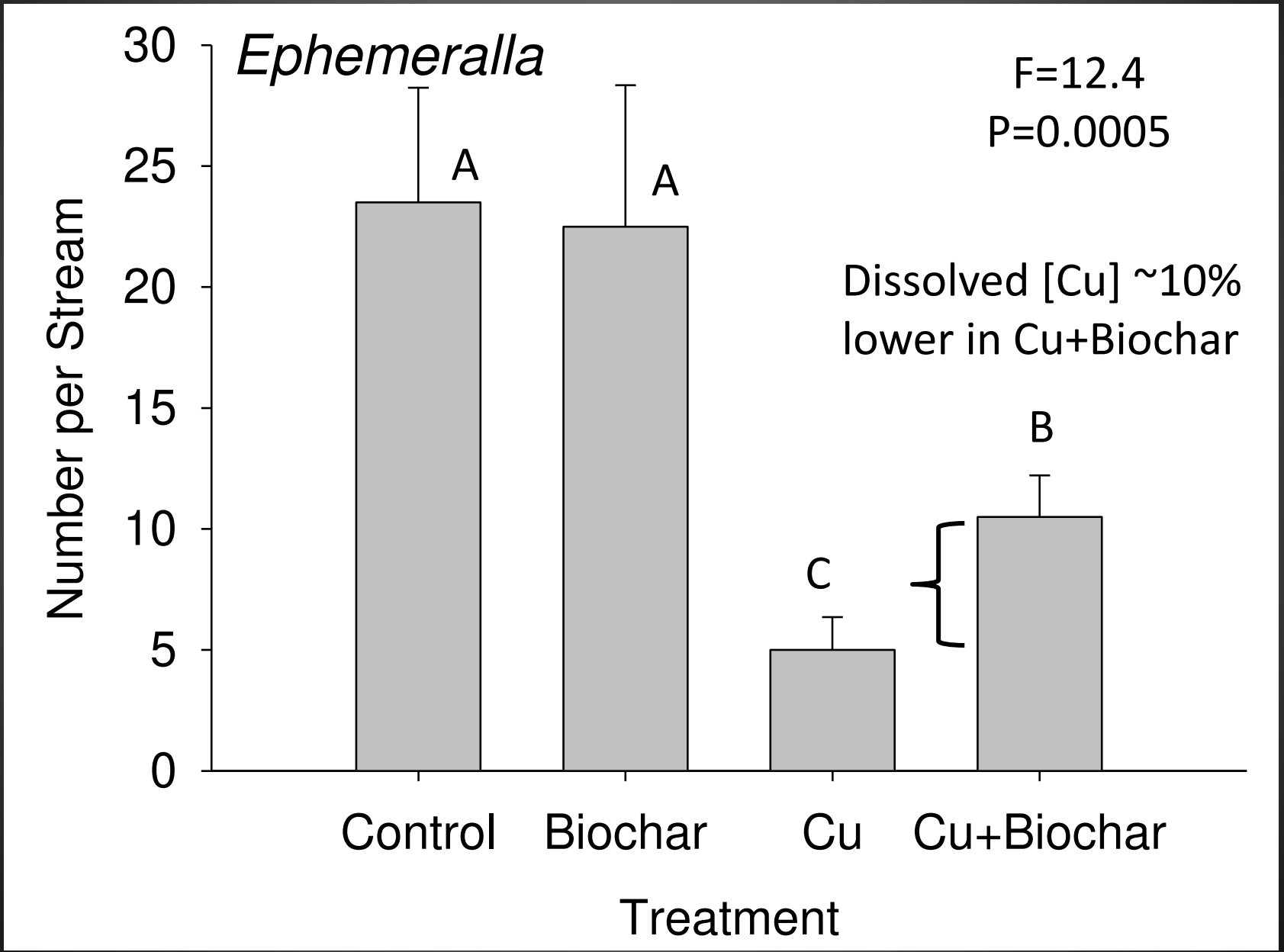




Community metabolism



Was there a protective effect of biochar?



Summary

- Colonization of stoneflies in the field was significantly lower in trays containing Biochar
- Biochar increased macroinvertebrate drift and reduced community metabolism in stream microcosms
- Effects of Biochar in stream microcosms were generally limited to stoneflies (especially early instars)
- Negative effects of Biochar should be evaluated within the context of benefits associated with reduced contaminant bioavailability

Next Steps:

- Develop a better understanding of the mechanisms responsible for biochar effects → Why stoneflies?
- Identify optimal biochar application rates and size distributions to maximize contaminant sorption but minimize effects on benthic communities