Food web and ecosystem connections between forests and streams

Photo by A. Marcarelli

Dr. Amy M. Marcarelli
Biological Sciences

MI SAF 2017

Coauthors:

Casey Huckins, Sue Eggert (Salmon Trout River)

Colden Baxter, Masashi Murakami, Kurt Fausch, Joe Benjamin, Yo Miyake, Shigeru Nakano (Horonai Stream)

Intellectual Support/Influential Collaborators:

Bob Hall, Madeleine Mineau, Wayne Minshall, Mark Wipfli, students and members of the Stream Ecology Center at Idaho State University and the Huckarelli Lab at Michigan Tech

Thank you **Jenny Cornell and Fuyuki Goto**, faculty and staff of Tomakomai Experimental Forest

Photo by A. Marcarelli

Streams – the most open of ecosystems

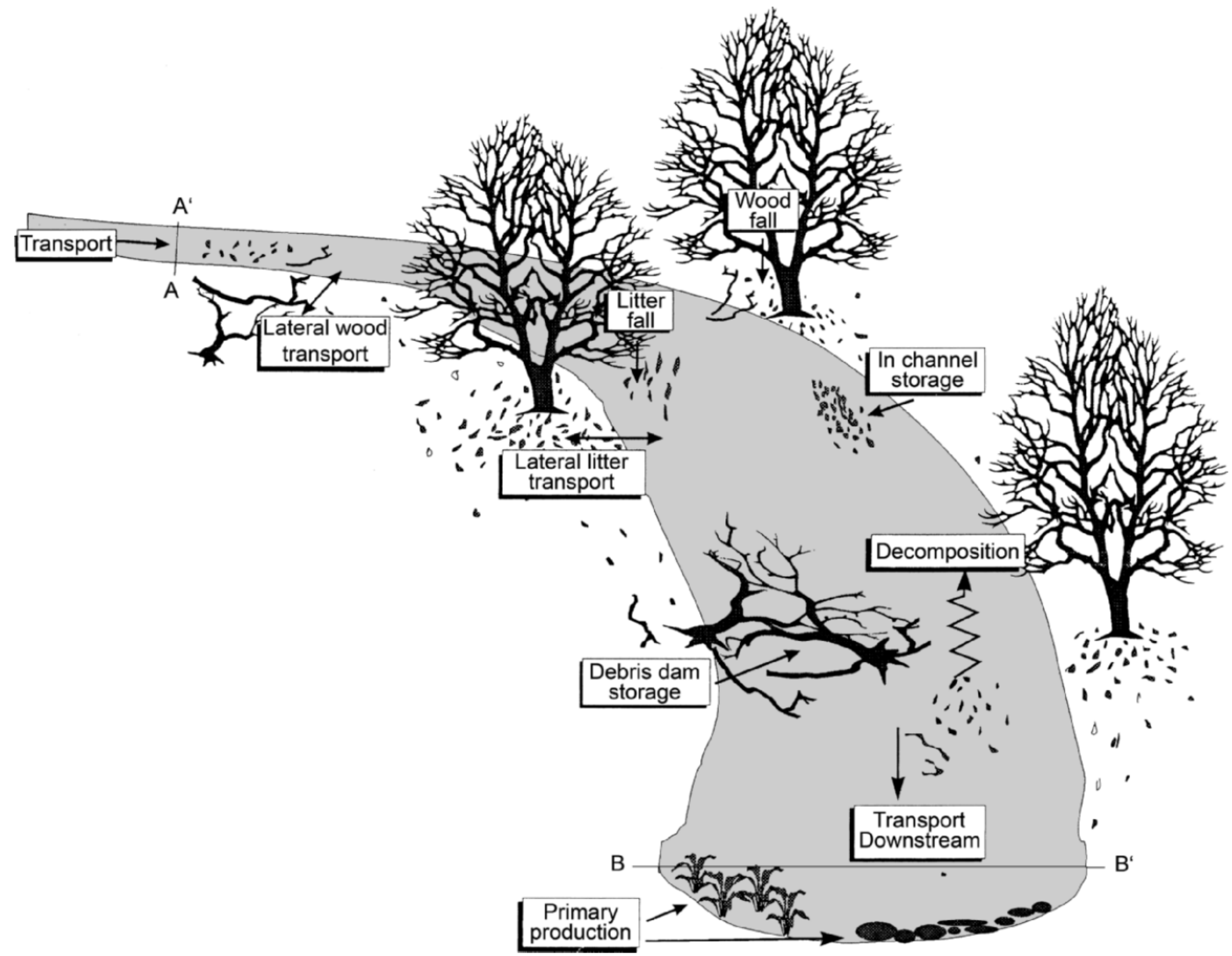

FIGURE 12.10 Inputs, outputs, and standing stocks of organic matter for a forest stream segment defined by the transects A-A′ and B-B′. (Reproduced from Minshall 1996.)

Allan and Castillo 2007, *Stream Ecology* Ch 12

Photo by A. Marcarelli

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Organic Matter breakdown

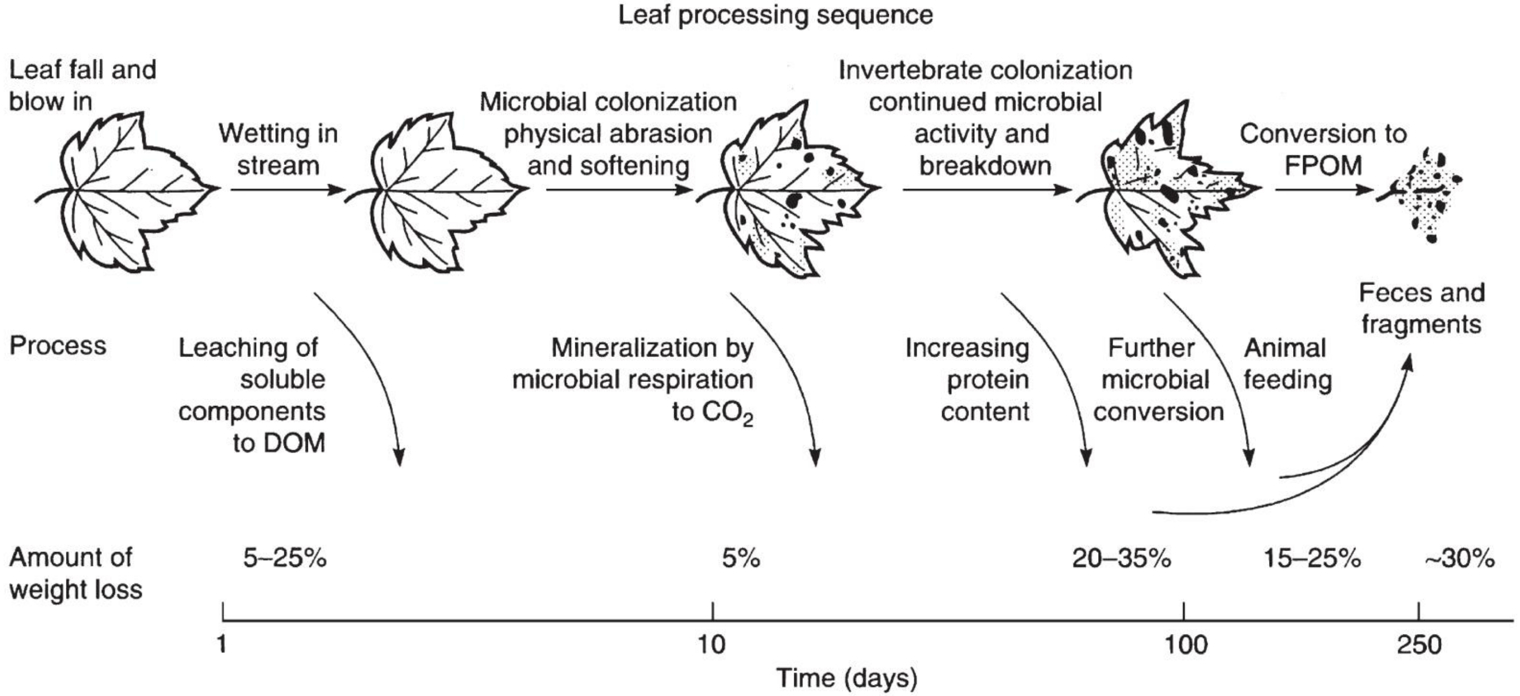


FIGURE 7.3 The processing or "conditioning" sequence for a medium-fast deciduous tree leaf in a temperate stream. Leached DOM is thought to be rapidly transferred into biofilms by microbial uptake.

Allan and Castillo 2007, *Stream Ecology* Ch 7

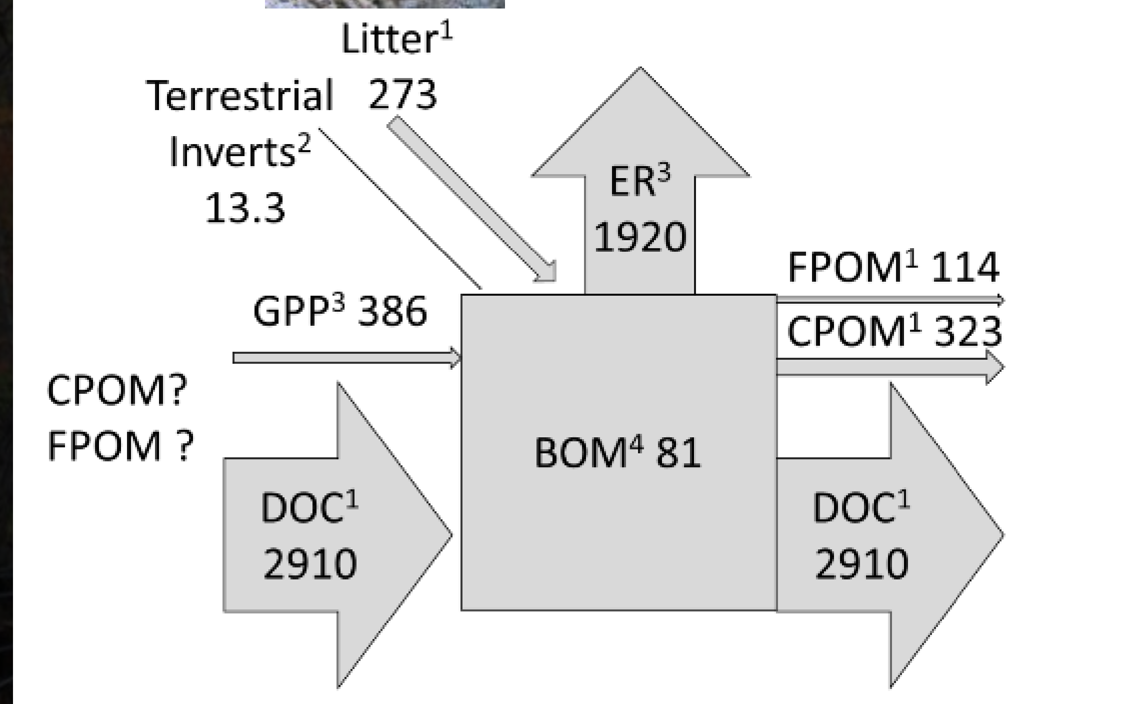
Photos by C. Baxter

Presque Isle River
Aug 2013

Photos by A. Marcarelli

Terrestrial organic matter subsidies drive aquatic ecosystem processes because they are delivered in large QUANTITIES

Organic Matter Budget for Horonai Stream, Hokkaido, Japan



Marcarelli, et al. In Prep

1975 – "The stream and its valley" H. B. N. Hynes

"One recent appreciation – we must not call it a discovery as it has been known since the early days of this Society… – is that streams are basically heterotrophic. The derive most, often nearly all, of their energy from uphill."

Verh. Internat. Verein. Limnol. | 19 | 1—15 | Stuttgart, Oktober 1975

Edgardo Baldi Memorial Lecture

The stream and its valley

H. B. N. HYNES

With 4 figures and 2 tables in the text

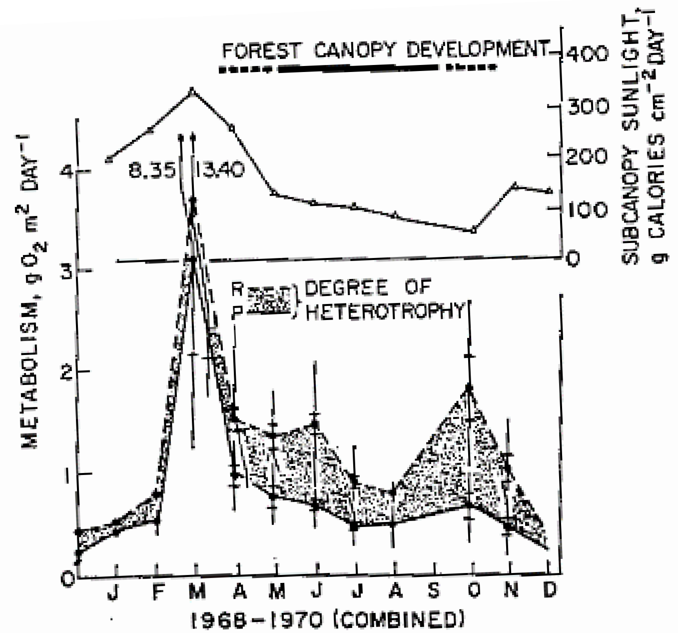
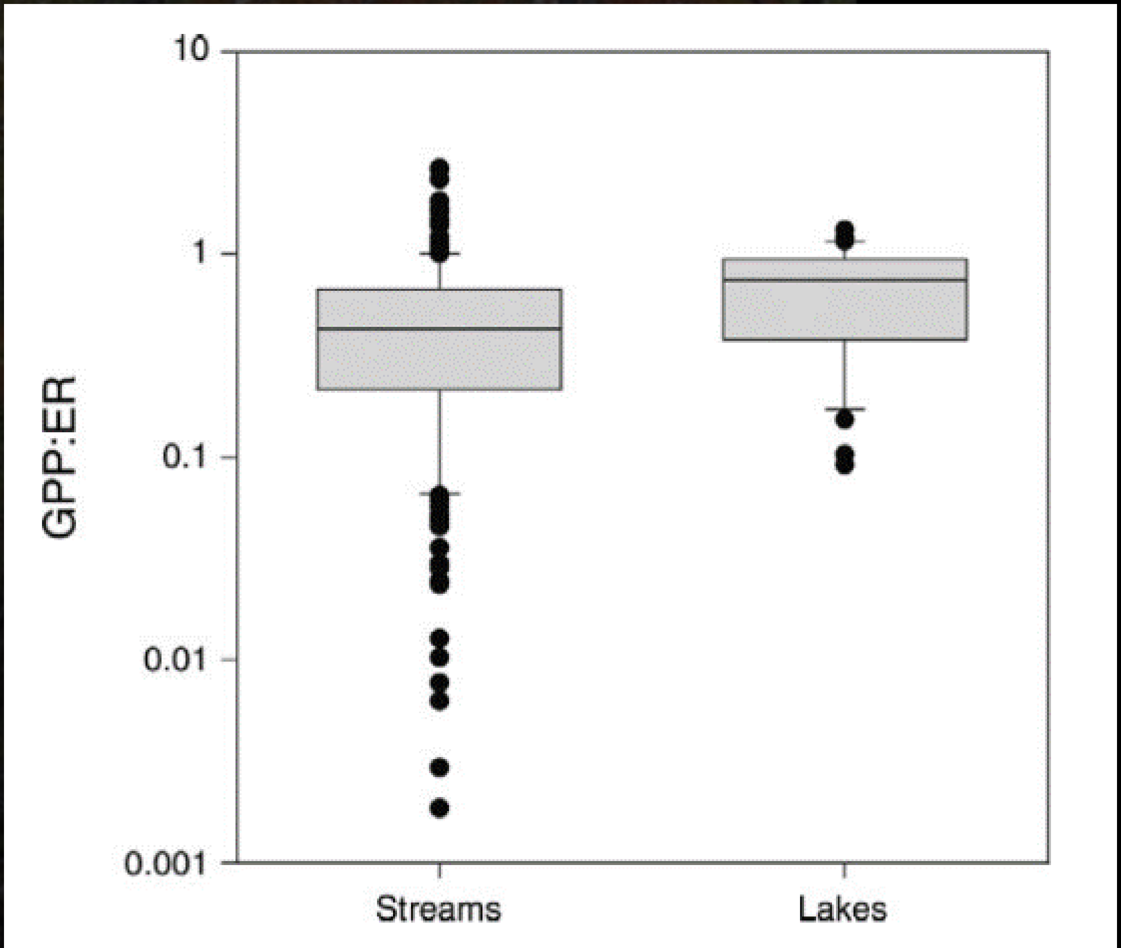


Fig. 1. The oxygen production (P), community respiration (R) and the sunlight recorded month by month at a station on New Hope Creek, North Carolina. The points are mean values, vertical bars are the range of values and horizontal bars are one standard error from the mean. Modified from HALL (1972).

Terrestrial organic matter subsidies drive aquatic ecosystem processes because they are delivered in large QUANTITIES

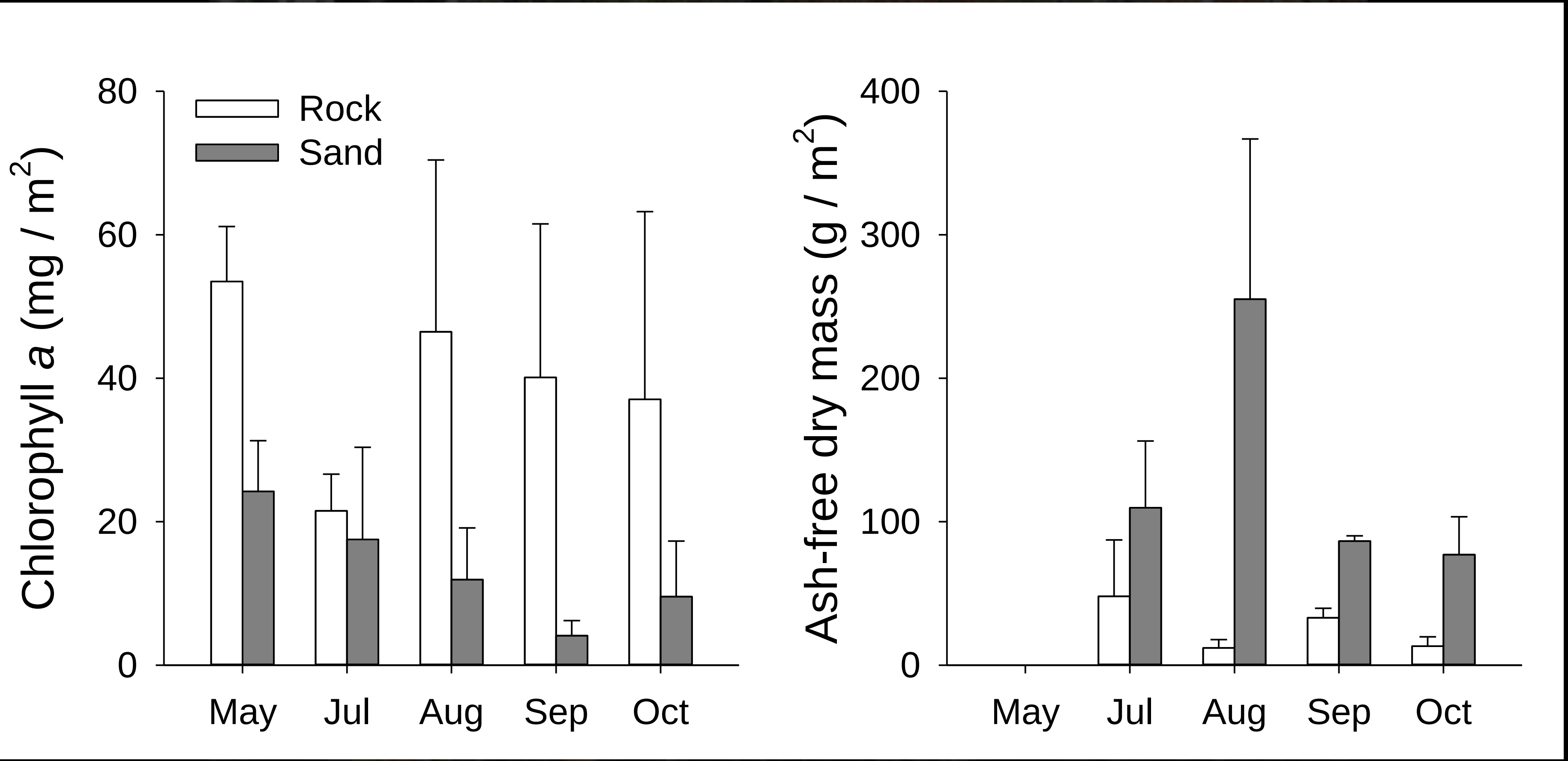


Marcarelli et al. 2011 *Ecology*

Photo credits: C. Huckins

Photo credits: C. Huckins

Sand accumulations change biofilm and organic matter standing crops

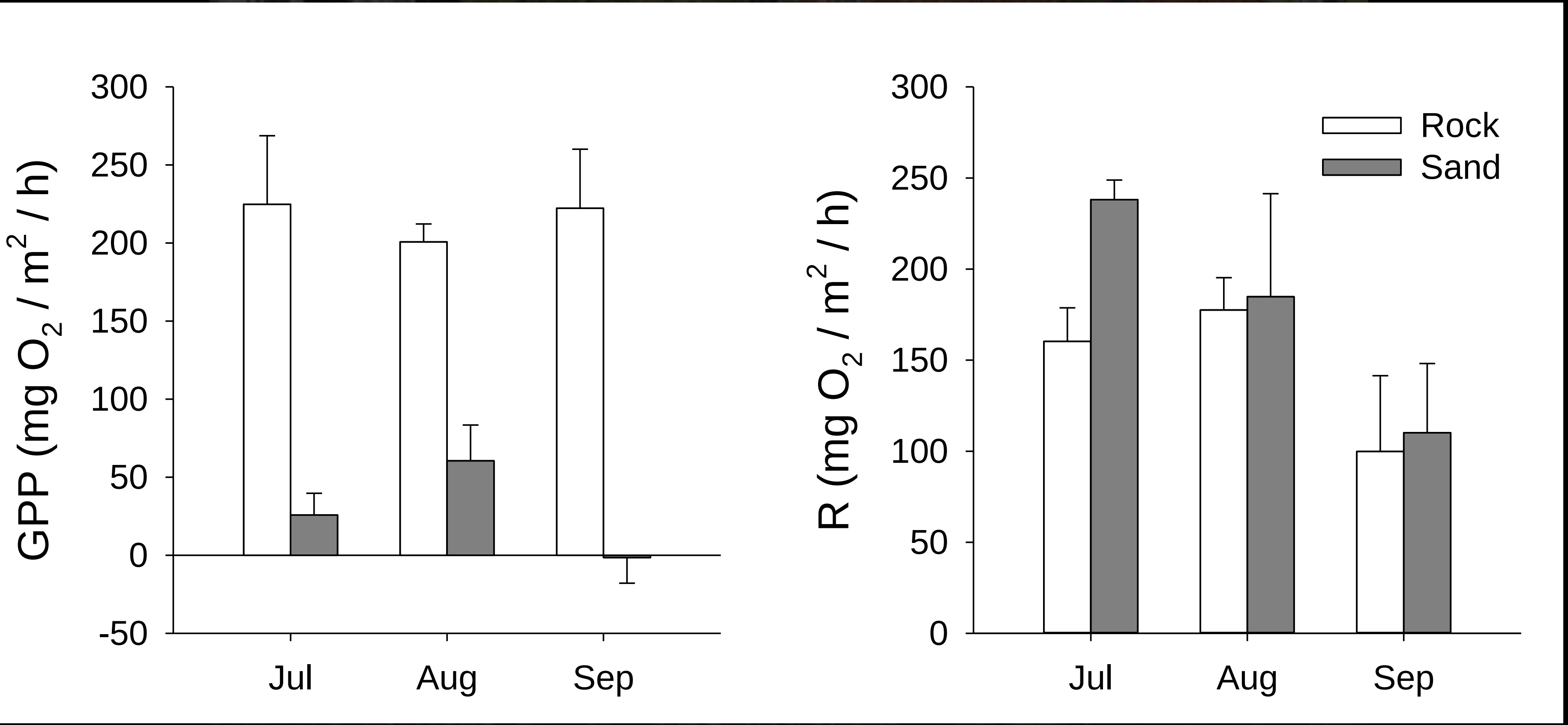


RM-ANOVA date $F_{4, 8} = 3.3$, $p = 0.07$

RM-ANOVA substrate $F_{1, 2} = 8.4$, $p = 0.10$

Marcarelli et al. 2015 *Journal of Great Lakes Res.*

Sand accumulations change metabolism rates

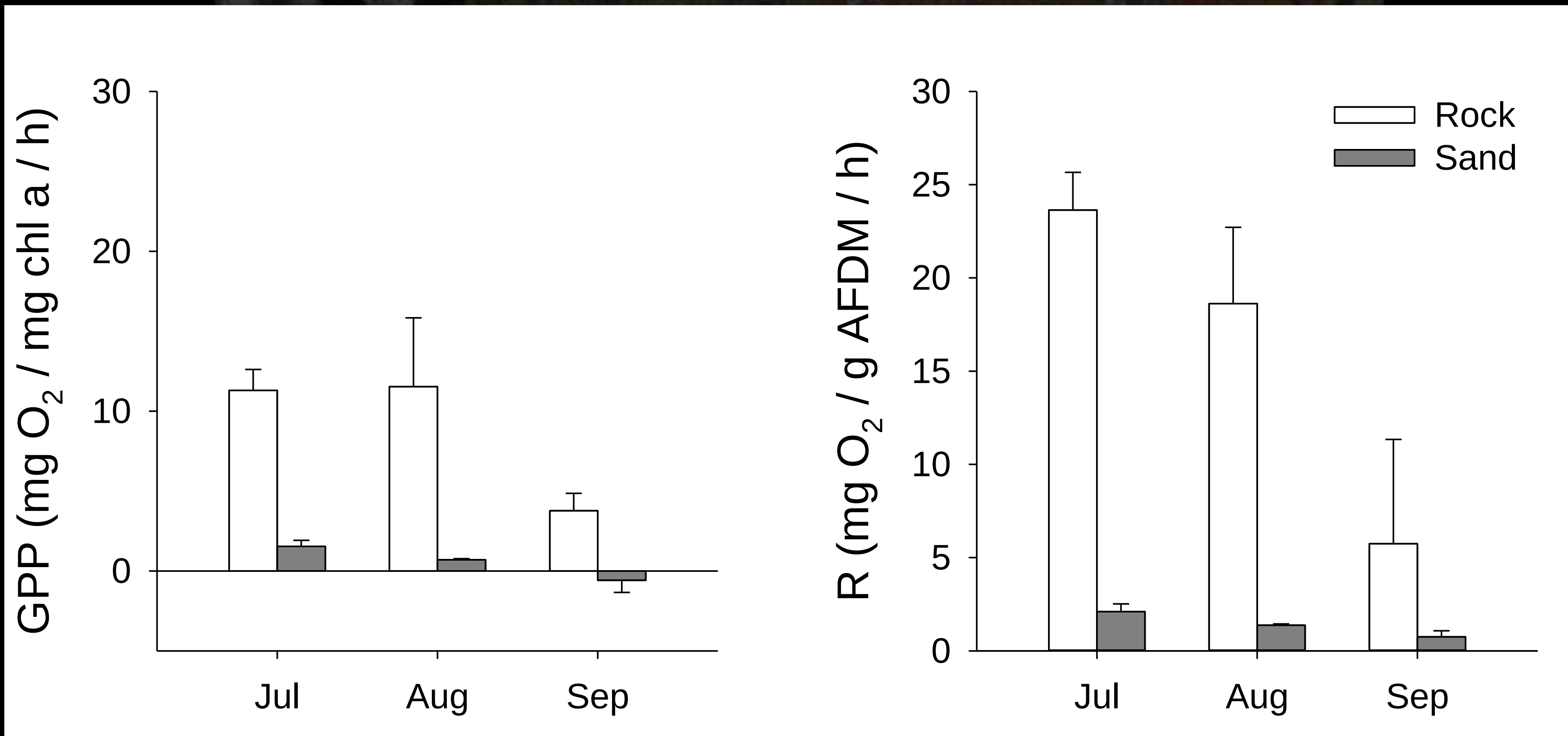


RM-ANOVA substrate*date $F_{2,4} = 5.8$, $p = 0.06$

RM-ANOVA date $F_{2,4} = 7.0$, $p = 0.05$

Marcarelli et al. 2015 *Journal of Great Lakes Res.*

Sand accumulations change metabolism rates



RM-ANOVA substrate $F_{2, 4}$ = 37.6, p = 0.03

RM-ANOVA substrate $F_{1, 2}$ = 6475.2, p < 0.001

Marcarelli et al. 2015 *Journal of Great Lakes Res.*

Photo credit: A. Marcarelli

Stream habitat changes

- Riffle/pool frequency altered
- Velocity distribution simplified
- Substrate heterogeneity reduced
- Surface area increased, but permeability reduced

Resource availability changes

- Primary producers reduced
- Organic matter processing reduced
- Change in use of terrestrial vs. aquatic resources

Photo credits: C. Huckins

Photos by C. Baxter and S. Collins

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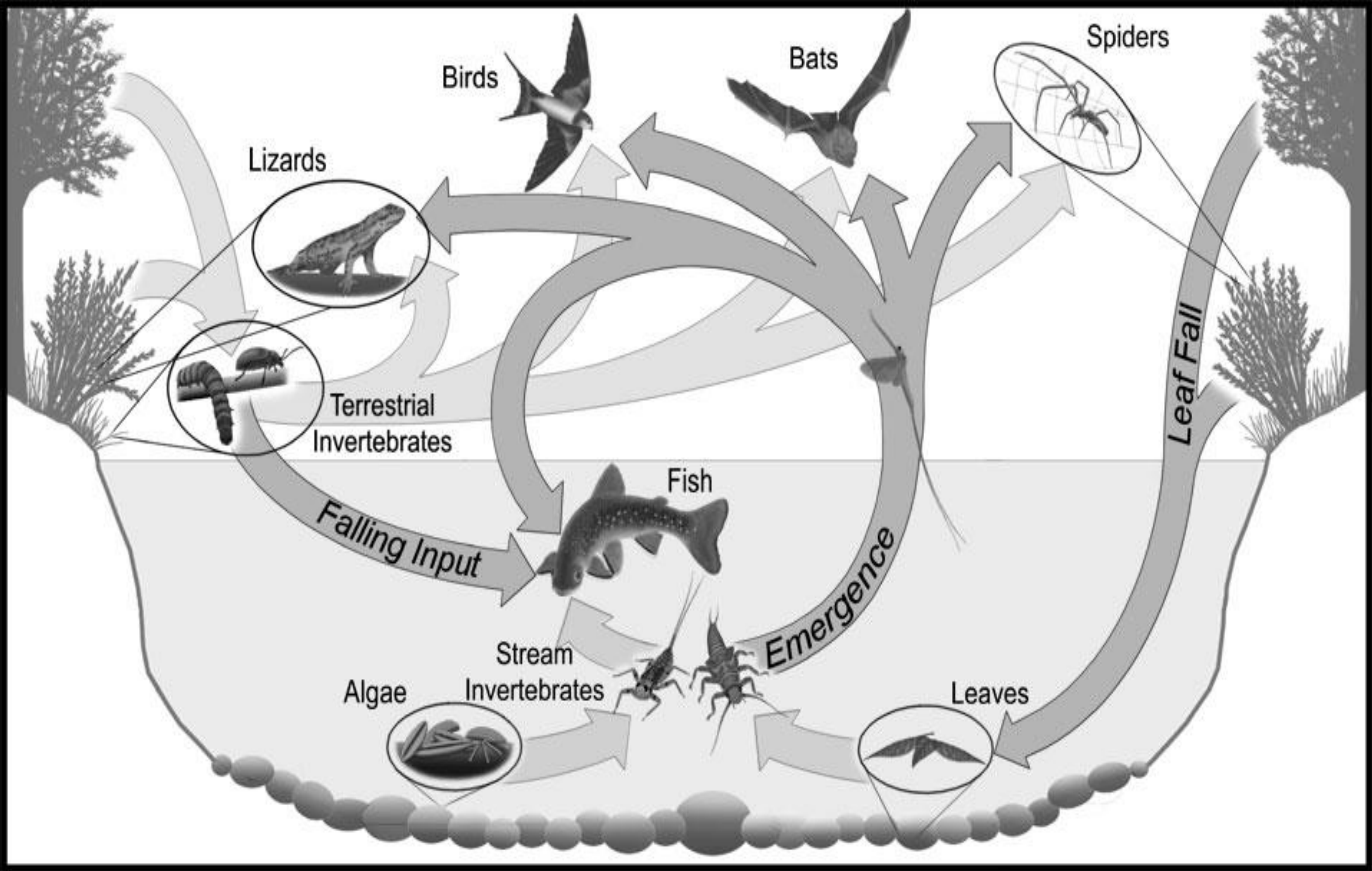
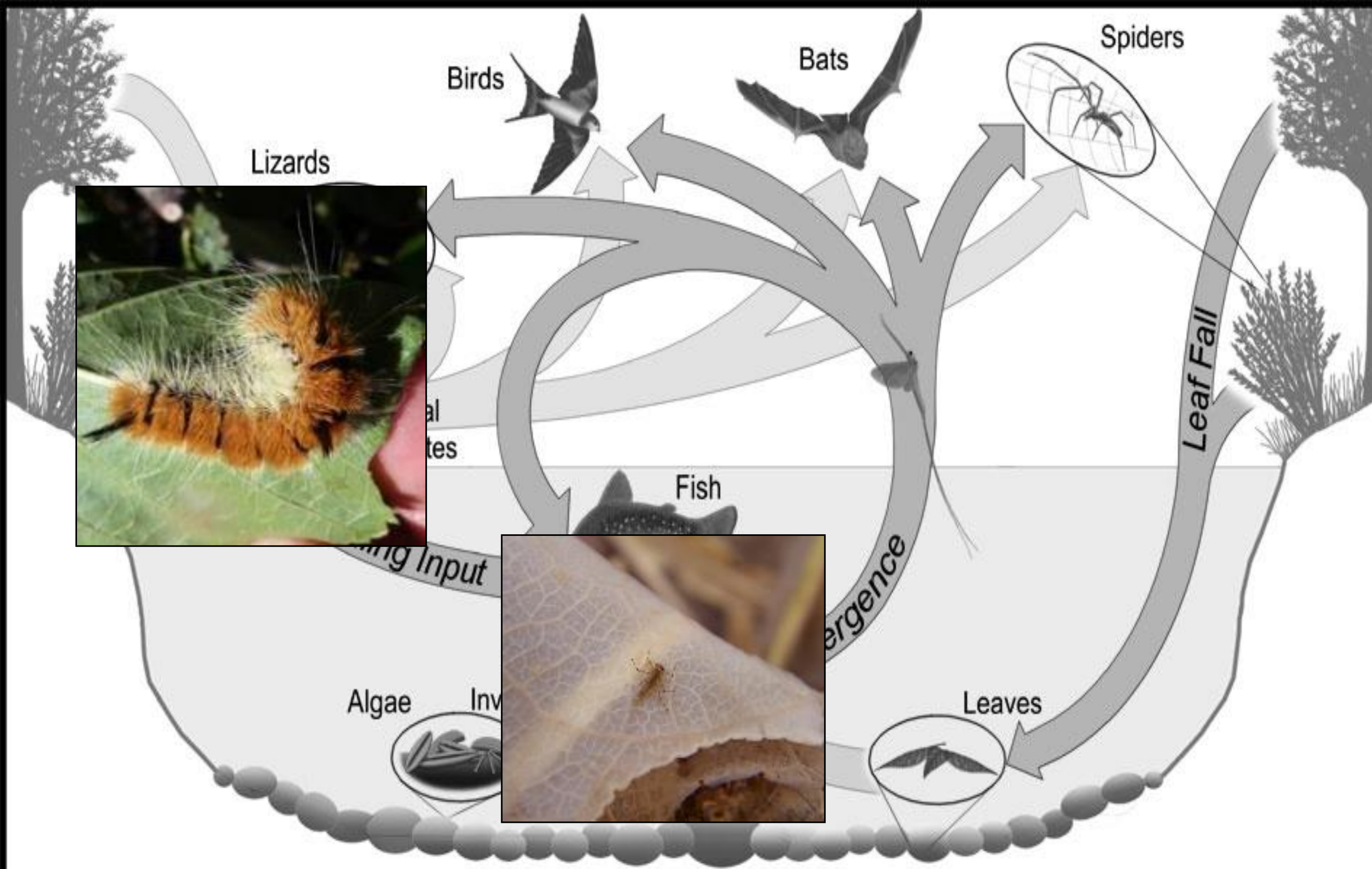
Reciprocal linkages between stream and terrestrial ecosystems



Baxter et al. 2005 *Freshwater Biology*, Illustration by Jeremy Monroe

Reciprocal linkages between stream and terrestrial ecosystems



Baxter et al. 2005 *Freshwater Biology*, Illustration by Jeremy Monroe

Horonai Stream: iconic studies of terrestrial subsidies

Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs

Shigeru Nakano*† and Masashi Murakami‡§

TERRESTRIAL–AQUATIC LINKAGES: RIPARIAN ARTHROPOD INPUTS ALTER TROPHIC CASCADES IN A STREAM FOOD WEB

SHIGERU NAKANO,[1,4] HITOSHI MIYASAKA,[2] AND NAOTOSHI KUHARA[3]

FISH INVASION RESTRUCTURES STREAM AND FOREST FOOD WEBS BY INTERRUPTING RECIPROCAL PREY SUBSIDIES

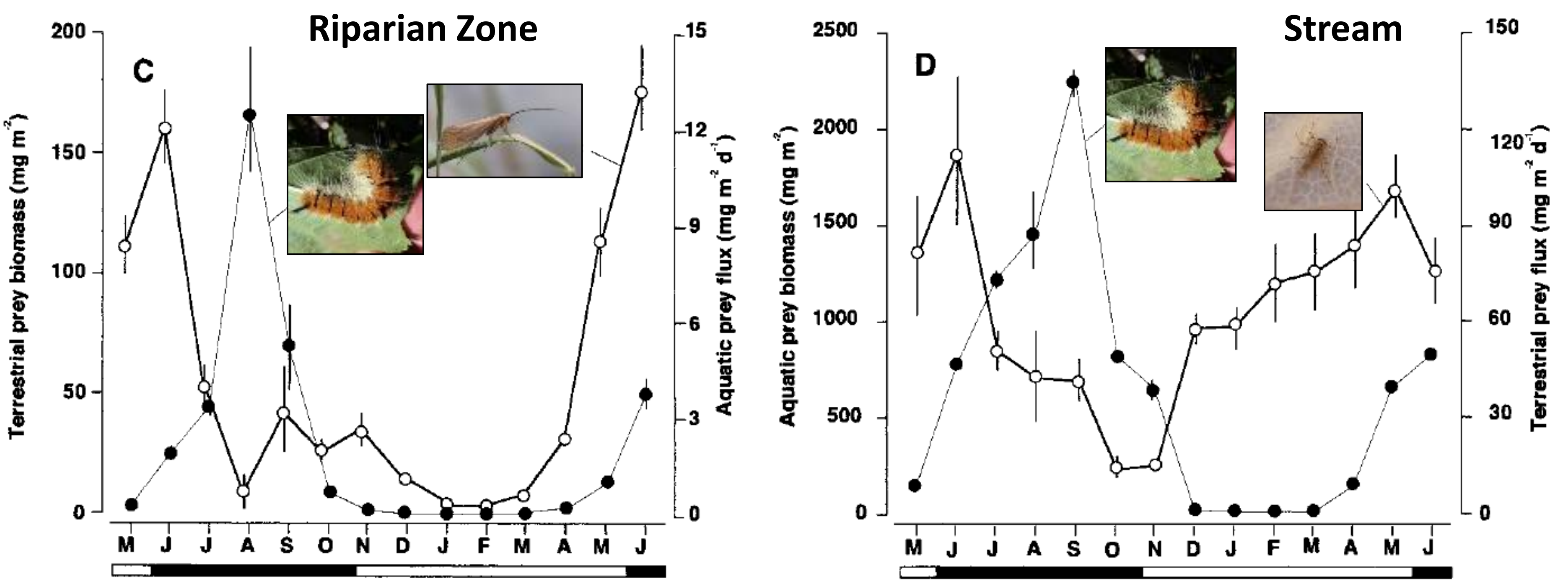
COLDEN V. BAXTER,[1,4] KURT D. FAUSCH,[1] MASASHI MURAKAMI,[2] AND PHILLIP L. CHAPMAN[3]

Horonai Stream: iconic studies of terrestrial subsidies

Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs

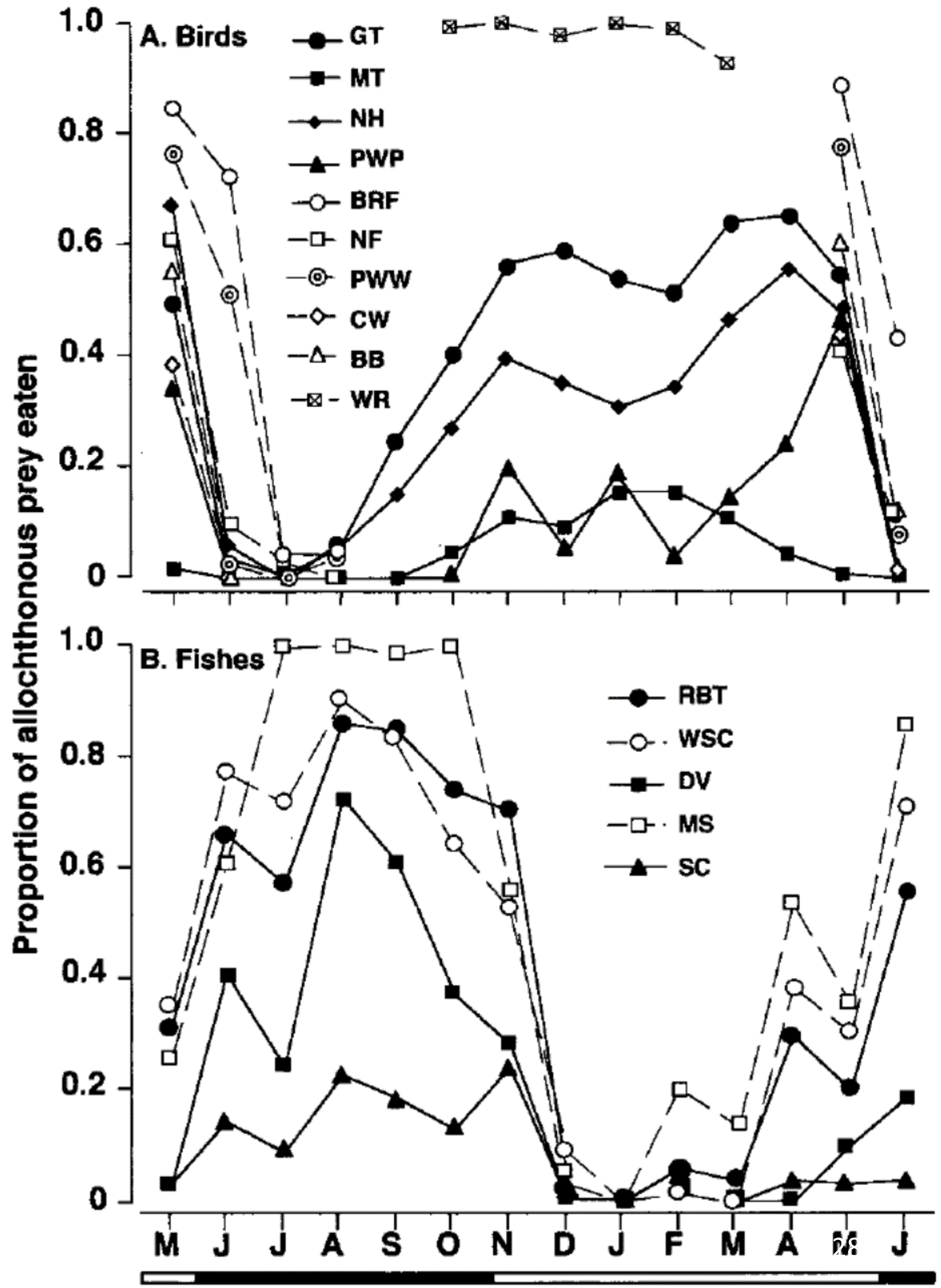
Shigeru Nakano*† and Masashi Murakami‡§

Terrestrial and aquatic prey cross boundaries between streams and forests



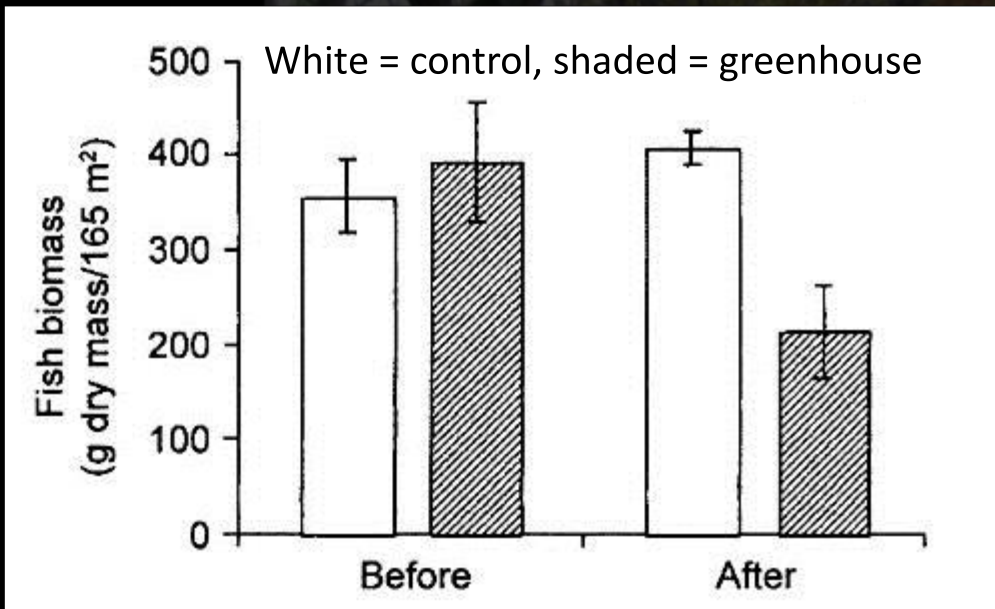
Nakano and Murakami 2001 *PNAS*

Fish and birds eat a lot of prey from the other ecosystem… when they're available

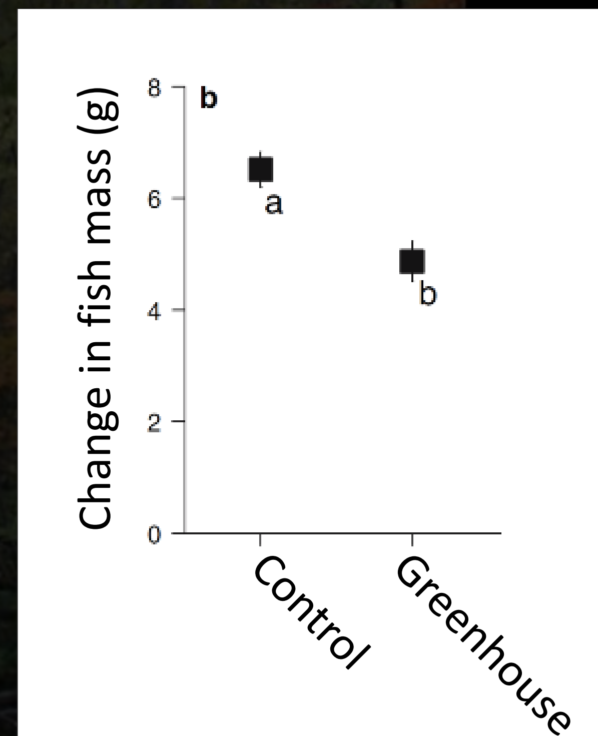


Nakano and Murakami 2001 *PNAS*

When fish eat terrestrial invertebrates…they grow more!



Cutting off terrestrial invertebrate subsidy reduces fish growth by 25% and induces emmigration

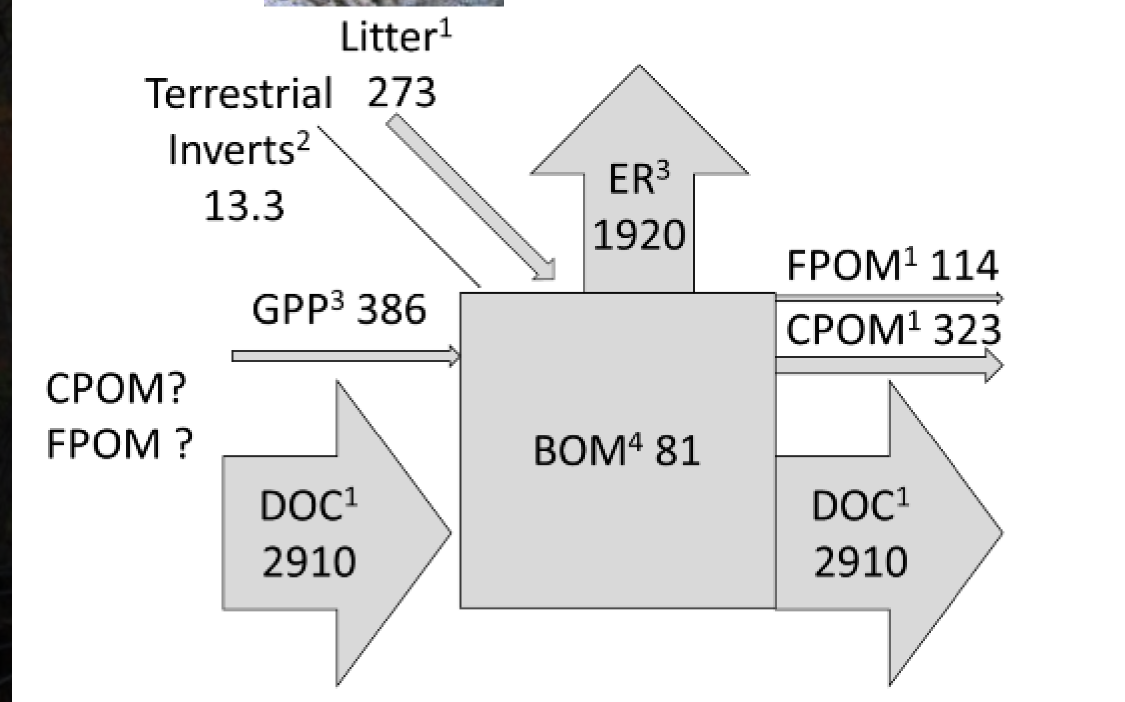


chi et al. 2003. Ecology

Baxter et al. 2007 Oecologia

BUT, relative to terrestrial organic matter, there aren't many terrestrial invertebrates that fall into the stream…

Organic Matter Budget for Horonai Stream, Hokkaido, Japan



Marcarelli et al. In Prep

OBJECTIVE: Construct a combined food web and ecosystem perspective of terrestrial subsidies

Subsidy fluxes

Primary, secondary & fish biomass & production

Food web linkages

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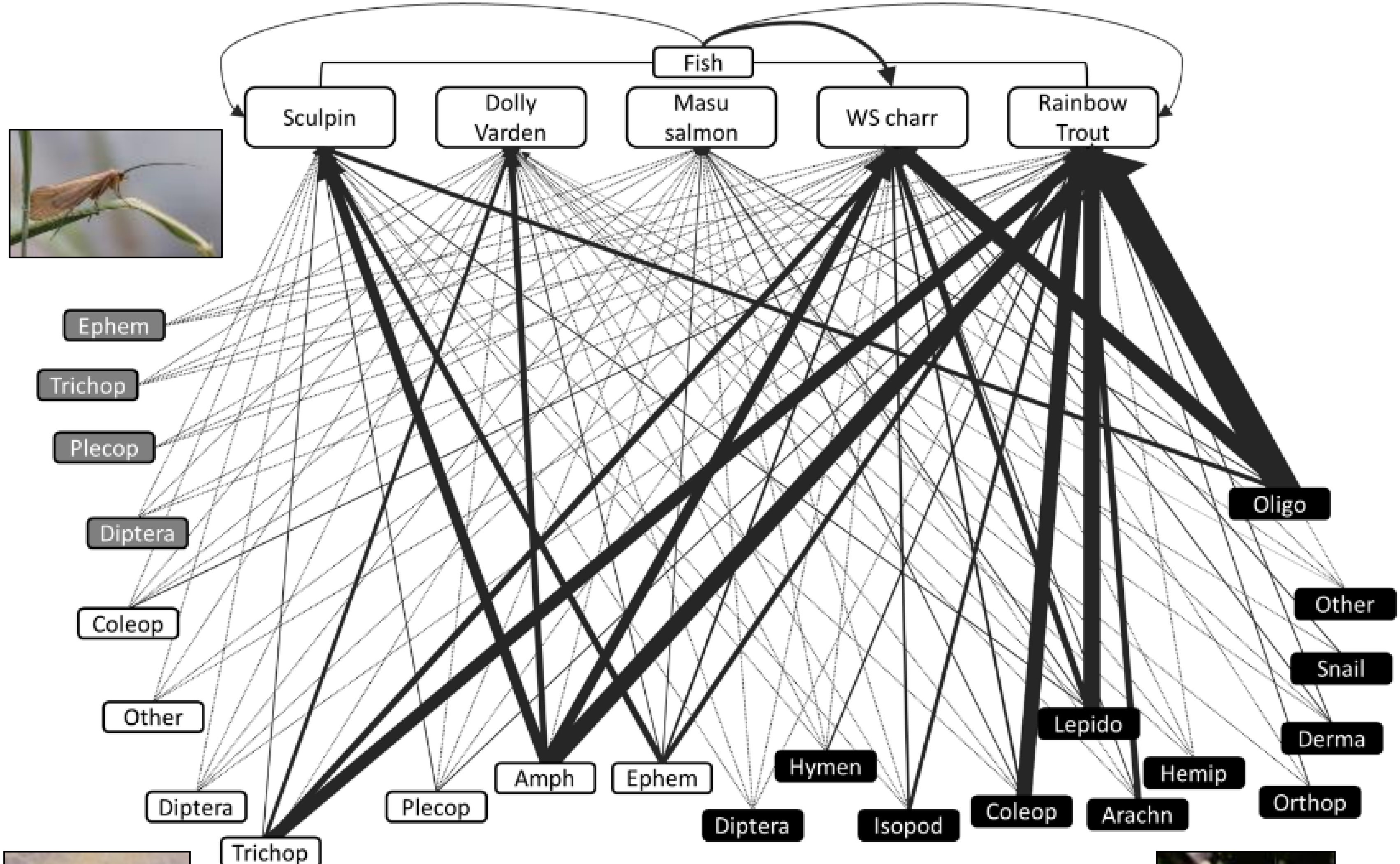
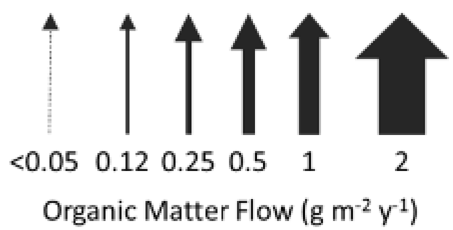
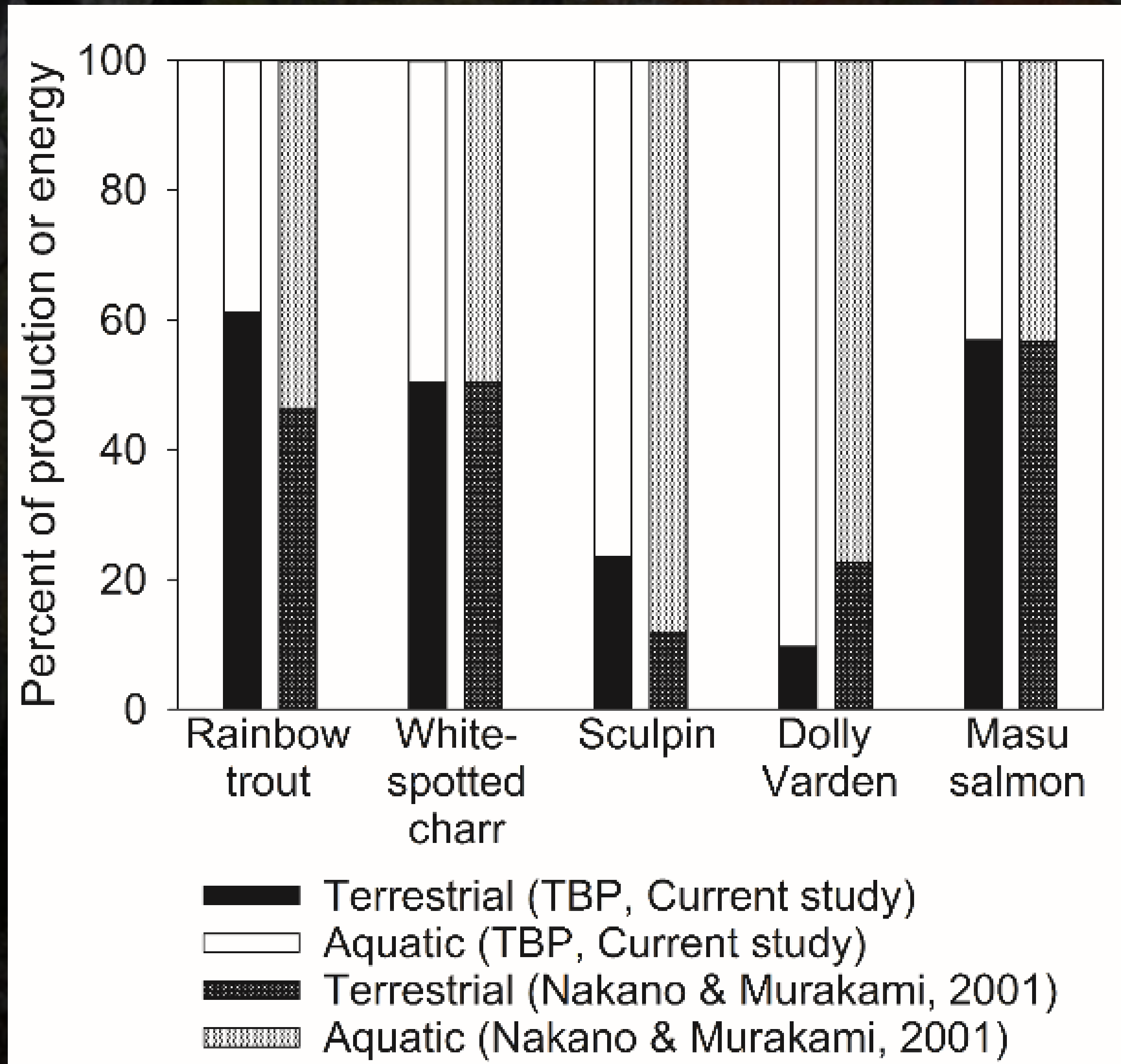


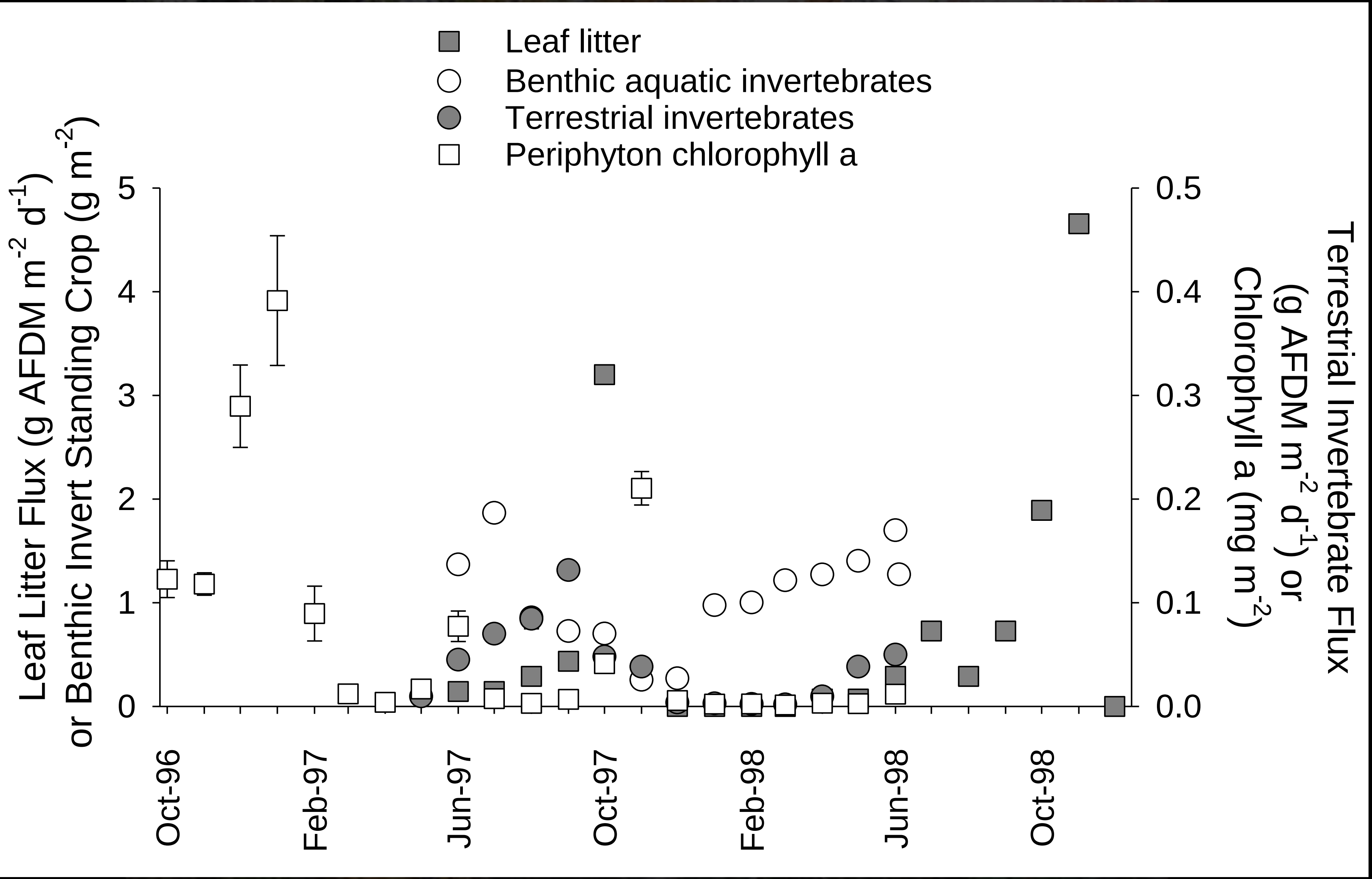


Marcarelli et al. In Prep

Terrestrial invertebrates contribute 10-60% of annual energy budget to fish



Marcarelli et al. In Prep



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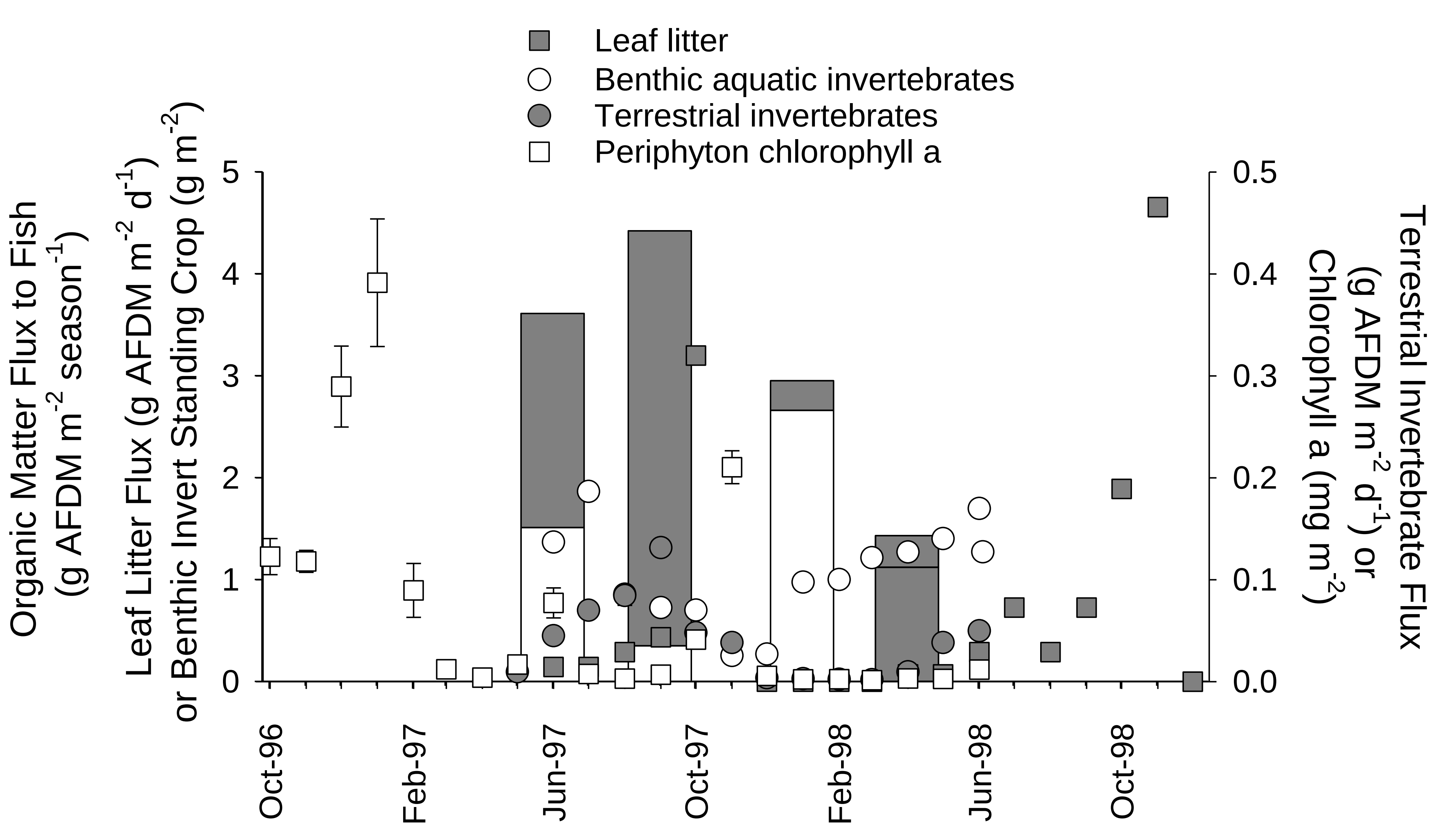
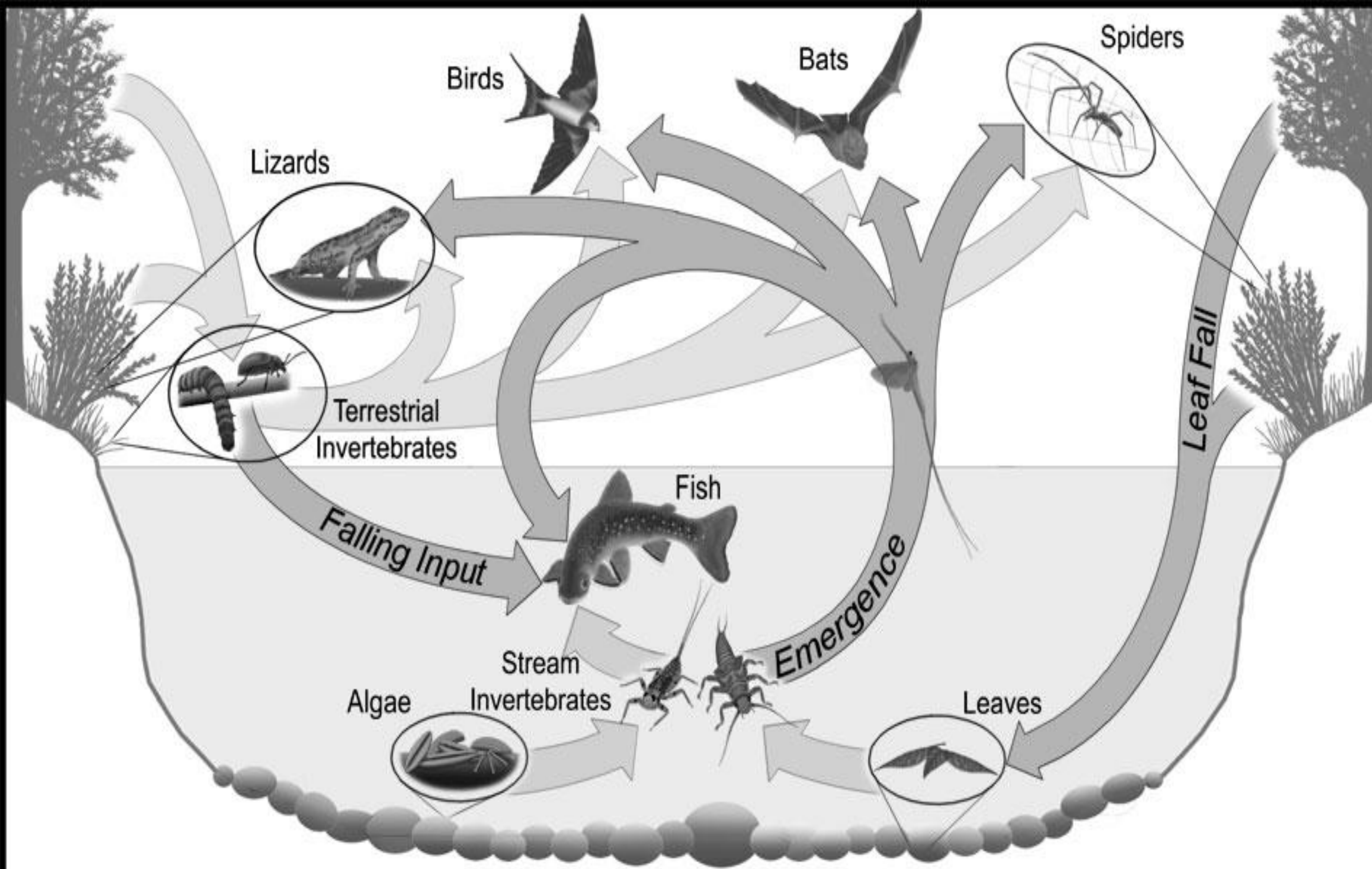


Marcarelli et al. In Prep

Reciprocal linkages between stream and terrestrial ecosystems



Baxter et al. 2005 *Freshwater Biology*, Illustration by Jeremy Monroe

Questions?

Email ammarcar@mtu.edu, Twitter @AmyMarcarelli

Aquatic Ecosystem Ecology at Michigan Tech

Small fluxes of C and N in streams and rivers

Macrophyte management and detection in lake littoral zones

Terrestrial-stream-lake interactions

Ecosystem insights on stream restoration

http://marcarelli-lab.bio.mtu.edu/

1980 – "The River Continuum Concept"

PERSPECTIVES

The River Continuum Concept[1]

Robin L. Vannote

Stroud Water Research Center, Academy of Natural Sciences of Philadelphia, Avondale, PA 19311, USA

G. Wayne Minshall

Department of Biology, Idaho State University, Pocatello, ID 83209, USA

Kenneth W. Cummins

Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331, USA

James R. Sedell

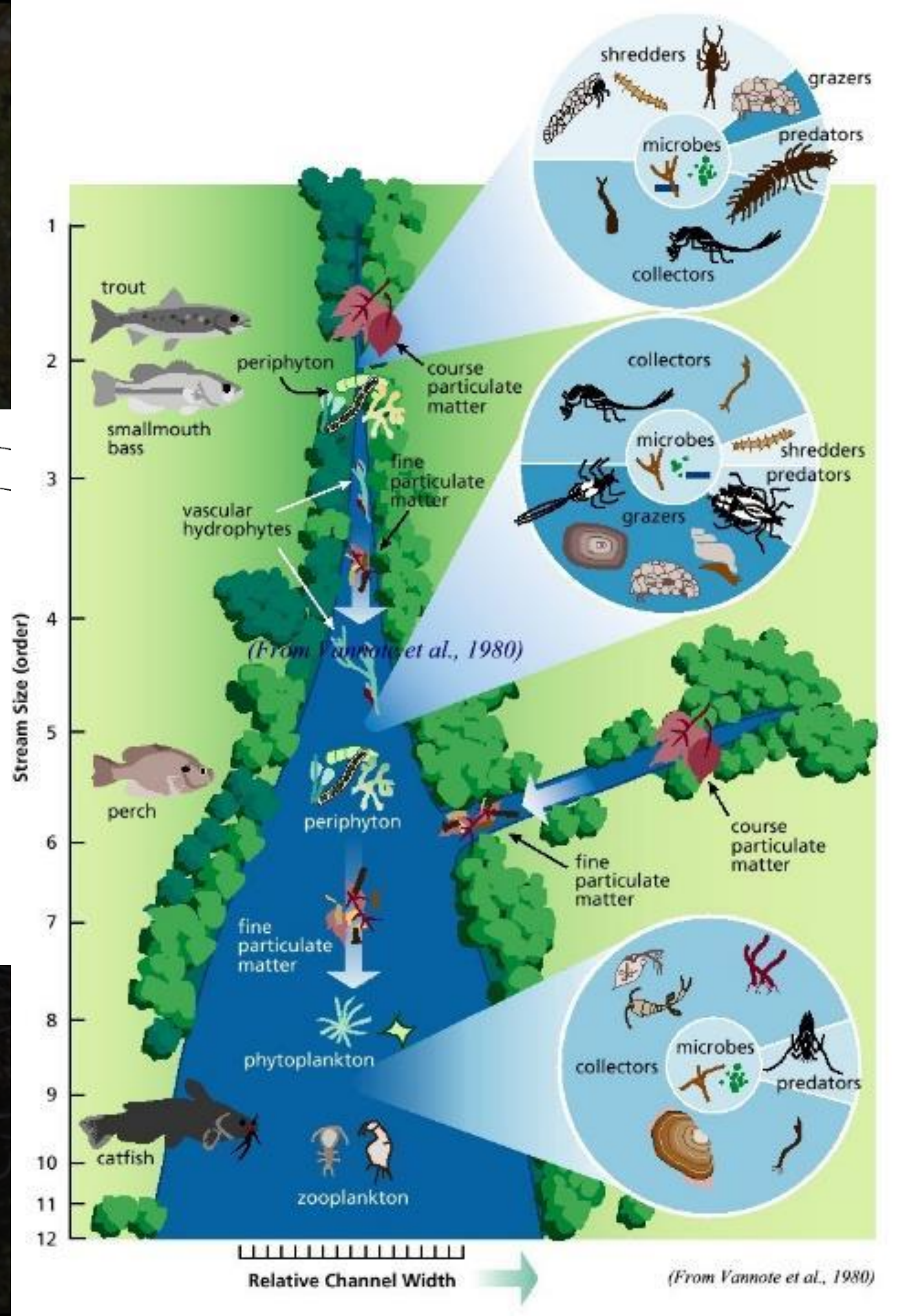
Weyerhauser Corporation, Forestry Research, 505 North Pearl Street, Centralia, WA 98531, USA

and Colbert E. Cushing

Ecosystems Department, Battelle-Pacific Northwest Laboratories, Richland, WA 99352, USA

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37: 130–137.

From headwaters to mouth, the physical variables within a river system present a continuous gradient of physical conditions. This gradient should elicit a series of responses within the constituent populations resulting in a continuum of biotic adjustments and consistent patterns of loading, transport, utilization, and storage of organic matter along the length of a river. Based on the energy equilibrium theory of fluvial geomorphologists, we hypothesize that the structural and functional characteristics of stream communities are adapted to conform



Measuring Ecosystem Production

Light-dark bottles or chambers

Change in light chamber: **Net Primary Production** (GPP – R = NPP)

Change in dark bottle: **Respiration** (R)

Change in light bottle + change in dark bottle : **Gross Primary Production** (NPP + R = GPP)

1885