Forest Succession and Terrestrial-Aquatic Biodiversity in Northern Forest Watersheds: Relationships, Causes, and Implications for Management

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- Terrestrial invertebrate biomass and diversity is greater in early successional forest habitats, but increasing the percent of early successional habitat in watersheds does not influence the magnitude of this subsidy, or use by brook trout.
- In-stream productivity can influence the relative importance of terrestrial resources to aquatic consumers, like brook trout.

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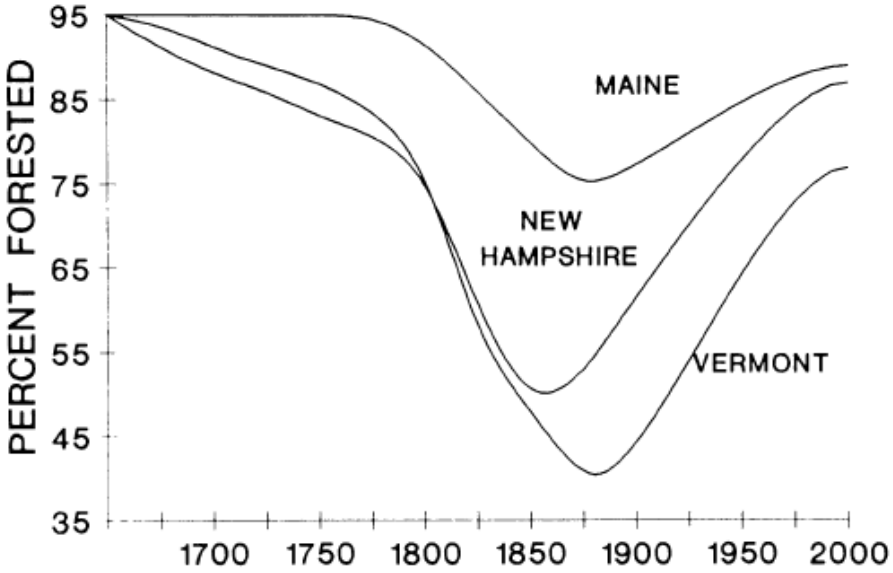
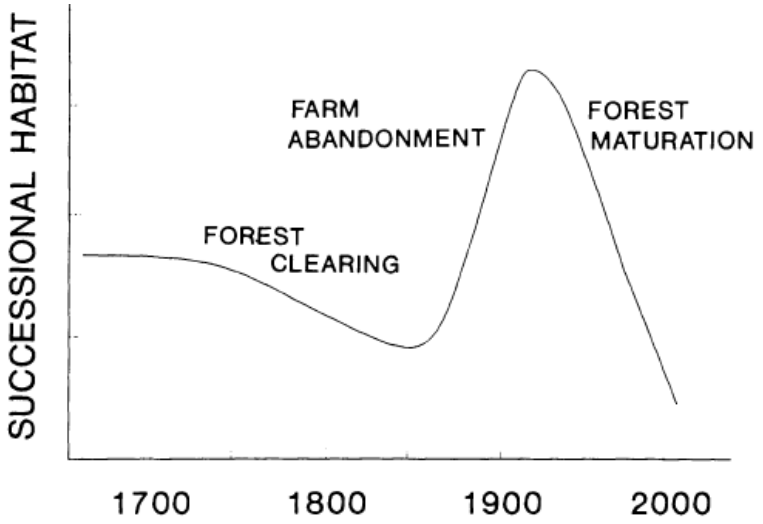
http://www.nsrcforest.org

Project Summary

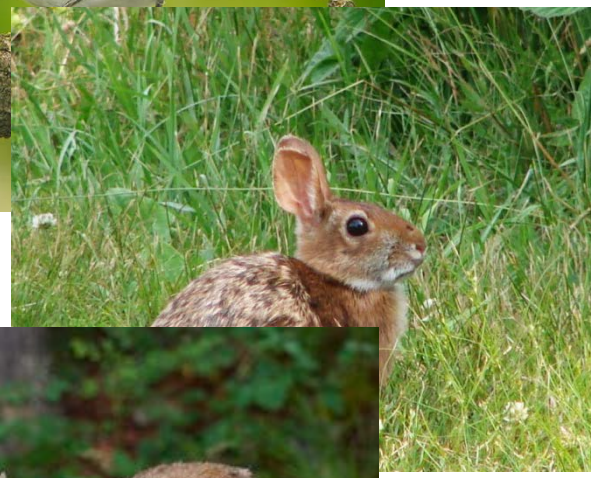
- Terrestrial subsidies are important resources for organisms in receiving habitats, particularly when production in those habitats is low. Terrestrial invertebrates provide a critical subsidy for trout, including eastern brook trout (*Salvelinus fontinalis*), but we have limited understanding of what causes input and use of these subsidies to vary among streams.
- We predicted that forest successional stage would be an especially important driver of variation in terrestrial invertebrate subsidies to brook trout in headwater streams due to differences in terrestrial invertebrate biomass in early and late successional habitats. Specifically, we expected biomass of aerial invertebrates, those capable of dispersal to the stream, to be greater in early successional habitat than late successional habitat due to the nutrient rich, herbaceous vegetation typical of early successional habitat.
- We measured aerial terrestrial invertebrate biomass in early and late successional habitats, input to streams and use by resident brook trout in 12 first and second-order watersheds in northern New Hampshire, U.S.A. The study watersheds represented a range of early successional habitat coverage (0 - 51.5%). We also measured a suite of reach-scale variables that might influence terrestrial invertebrate input and use by brook trout, including riparian forest conditions and benthic invertebrate biomass.
- Within study watersheds, aerial terrestrial invertebrate diversity, biomass, and abundance were significantly higher in early successional habitats than late successional habitats. However, terrestrial invertebrate input to streams and use by brook trout were unrelated to percent early successional habitat in the watershed, and to other watershed and riparian forest characteristics. These results indicate that management for upland early successional habitat has little effect on terrestrial invertebrate subsidies to headwater streams and fish.
- Surprisingly, benthic invertebrate biomass was the one significant predictor of percent terrestrial invertebrates in brook trout diets. Use of terrestrial invertebrate subsidies declined with increasing benthic invertebrate biomass, suggesting that productivity in the aquatic environment influences the degree to which brook trout use terrestrial subsidies. Although subsidy inputs are controlled by the donor system, this study shows that use of these subsidies by consumers can be determined by conditions in the recipient habitat.

Background and Justification





Background and Justification



Background and Justification

Forest Condition

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Insect Input to Streams

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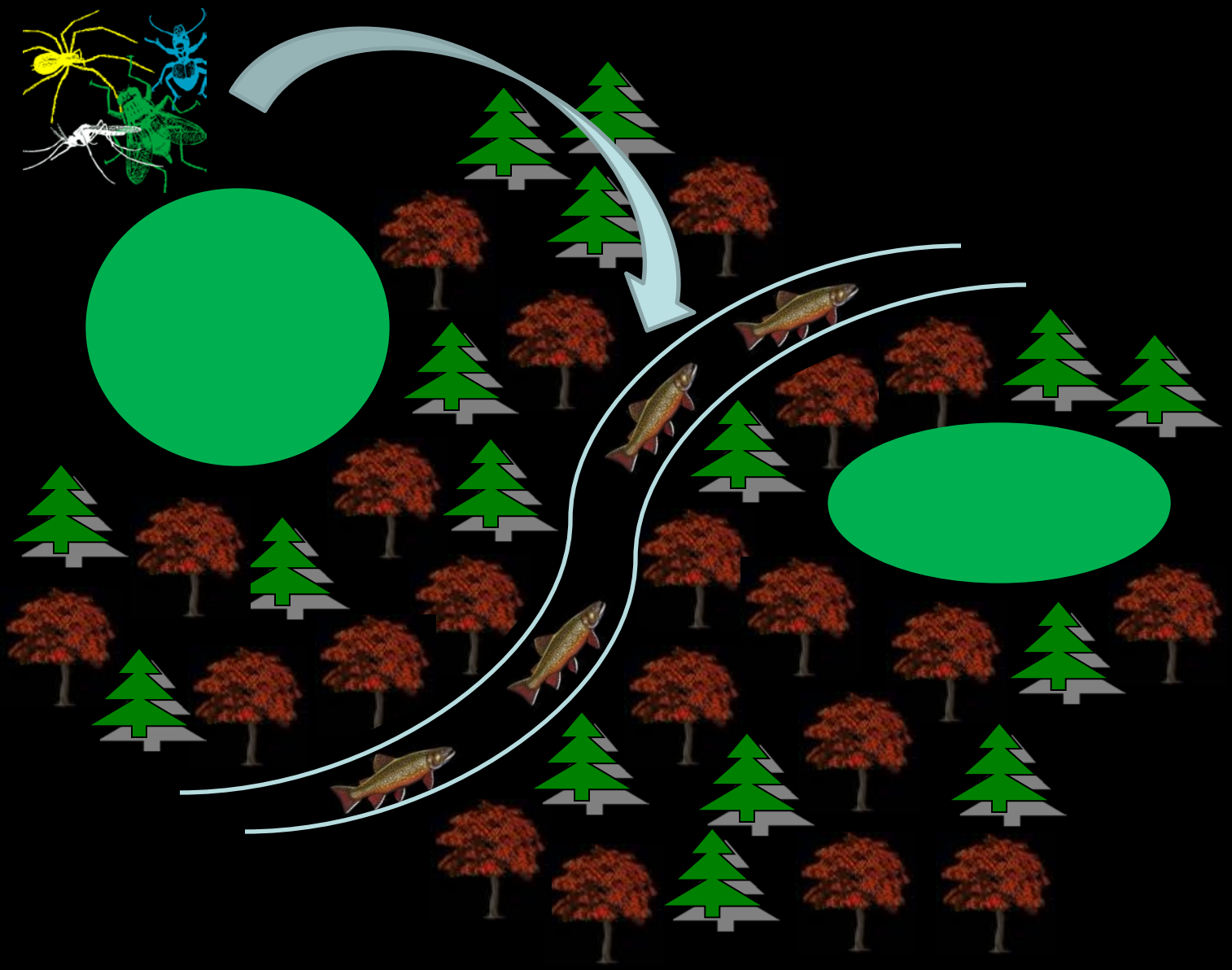
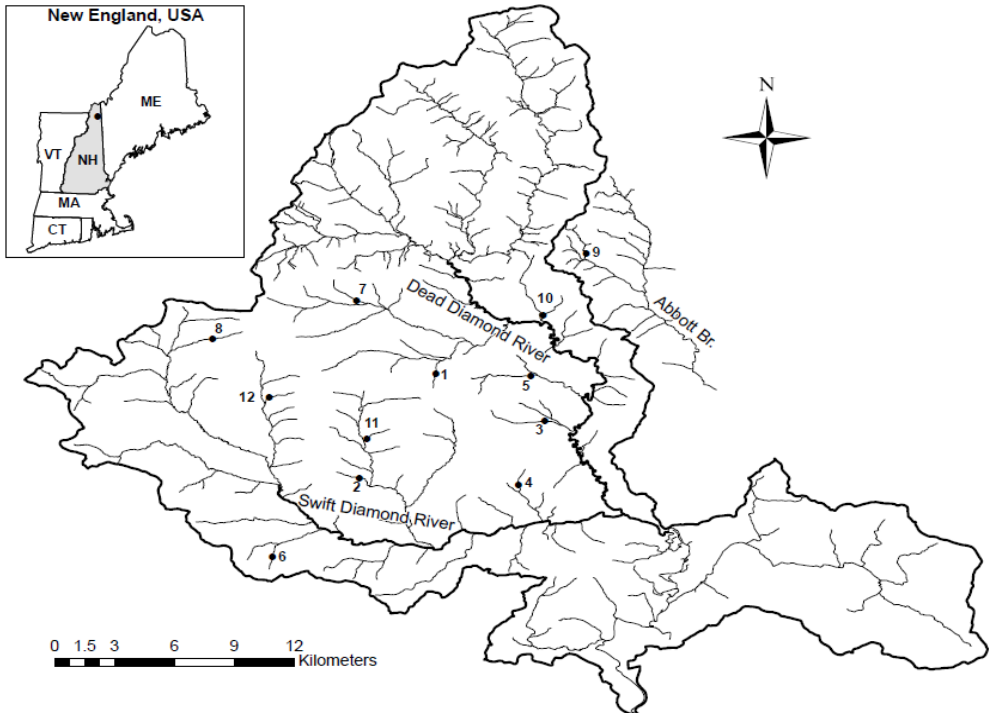
Brook Trout Diet

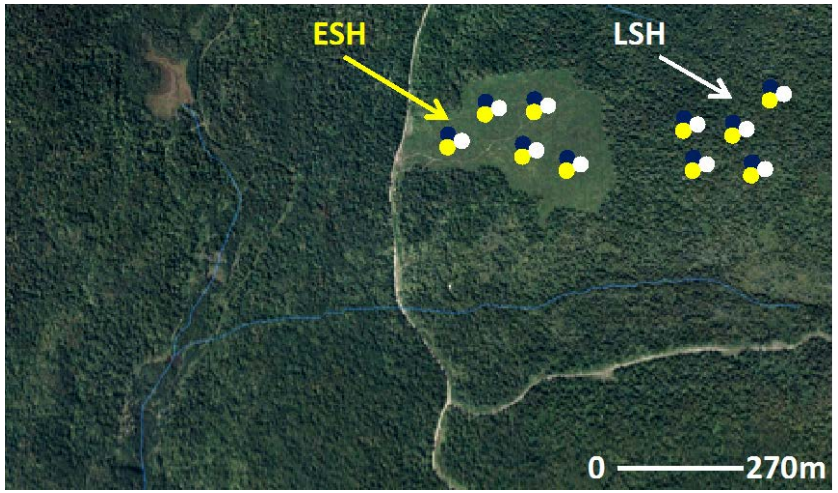
Research Questions



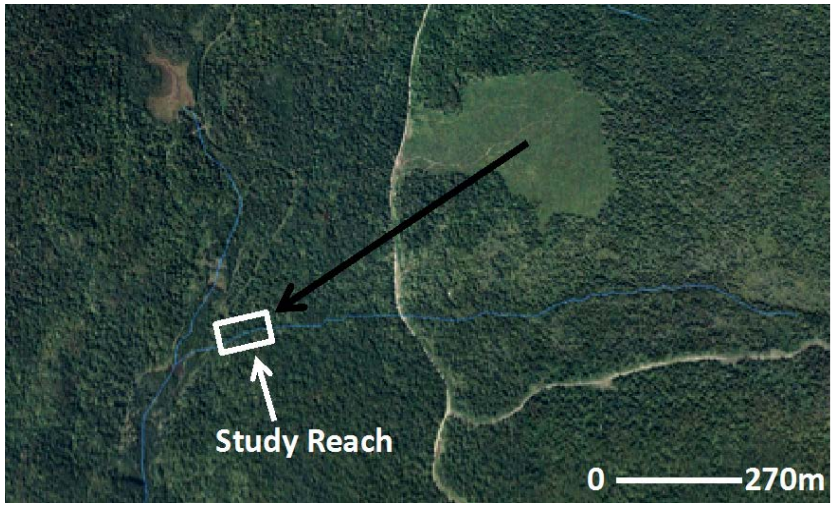
Research Sites



Terrestrial Sampling



Aquatic Sampling



Sampling Methods

Terrestrial Insects

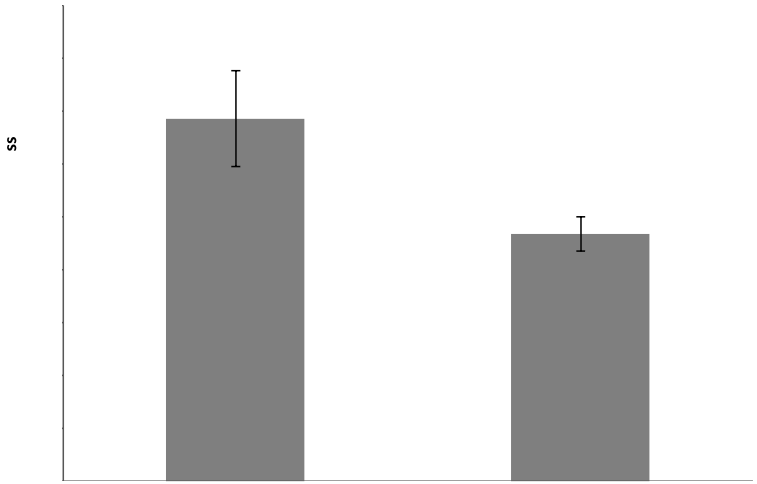
Stream Insects

Terrestrial Inputs to Streams

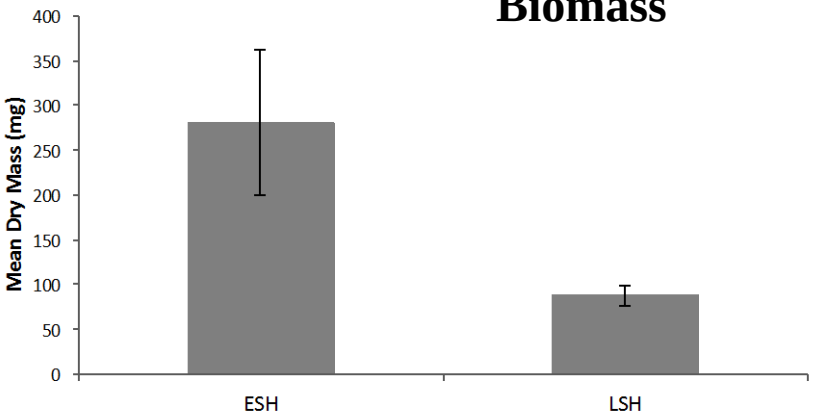
Brook Trout Diet

Results – Terrestrial Insects

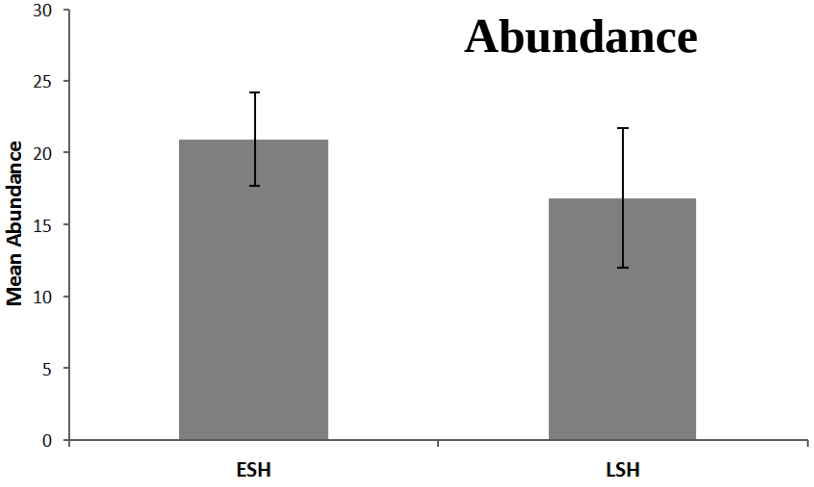
Family Richness



Biomass



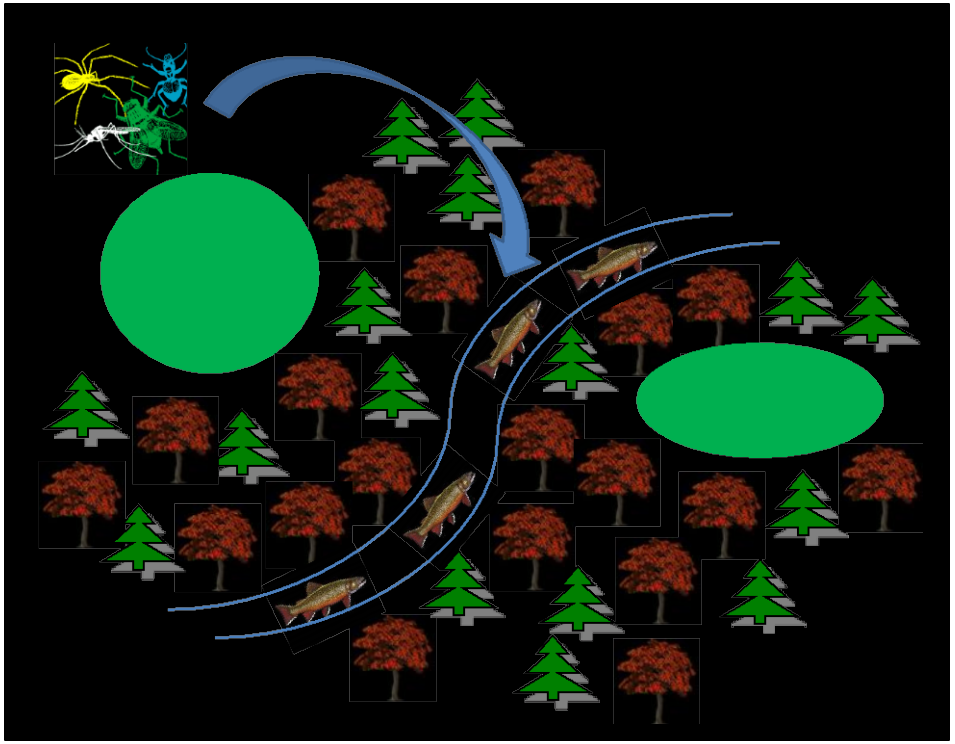
Abundance



Results – Terrestrial Inputs to Streams and Trout

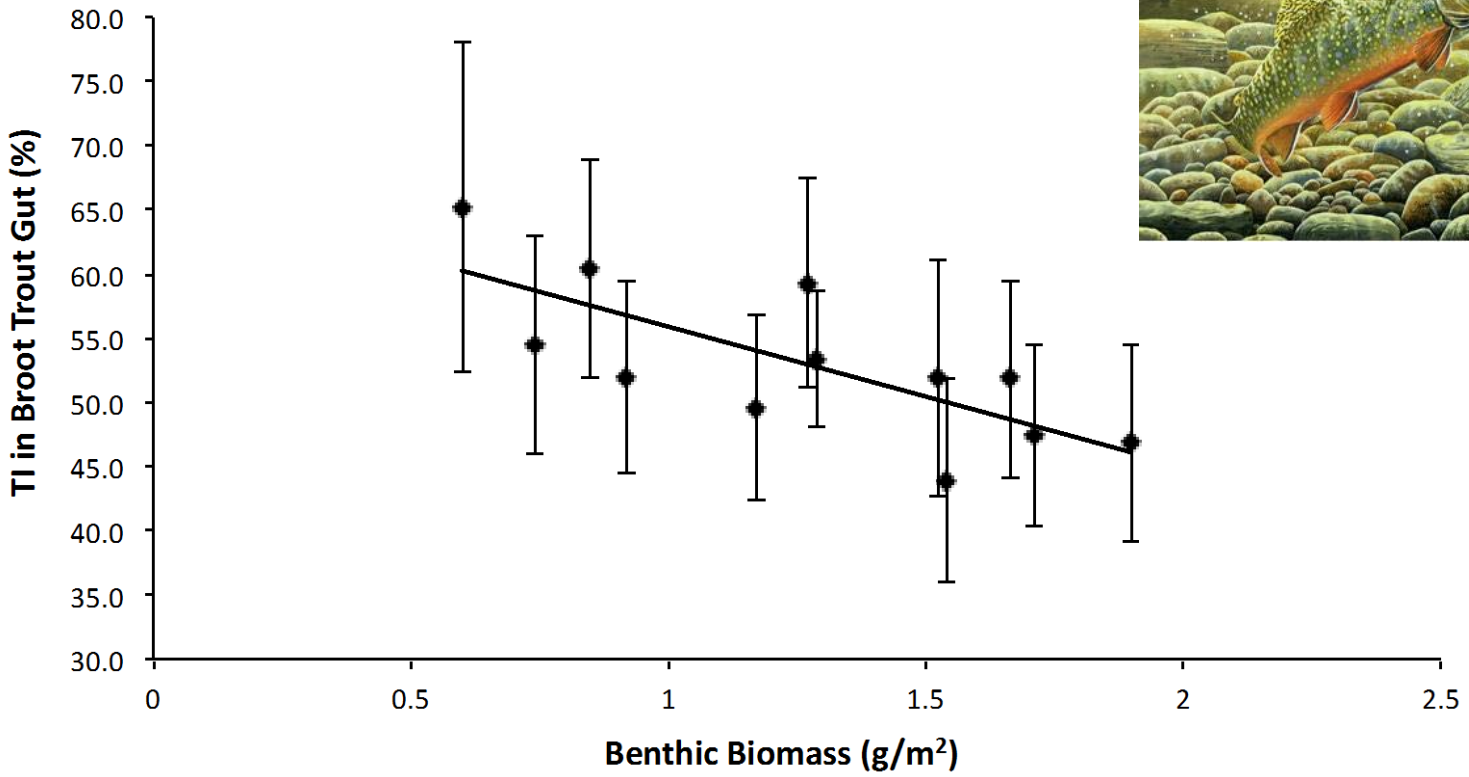
- Terrestrial invertebrate input was unrelated to watershed and riparian forest characteristics.

- % Terrestrial invertebrate mass in brook trout diet was unrelated to terrestrial invertebrate input.



Results – Terrestrial Inputs to Streams and Trout

- % Terrestrial invertebrate mass in brook trout diet was related to benthic invertebrate biomass



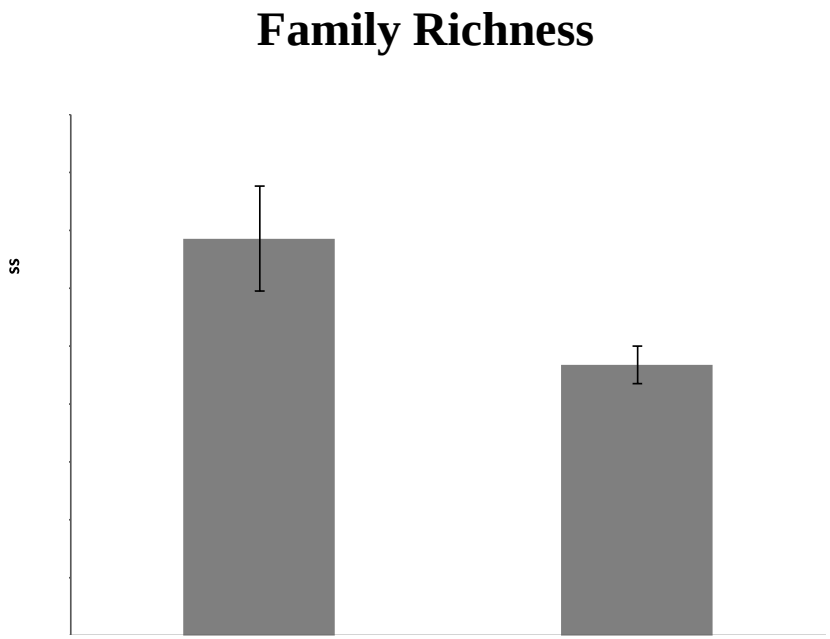
Implications

- Consumption of terrestrial invertebrates by brook trout may be mediated by availability of aquatic invertebrates
- Increasing %ESH coverage in a watershed does not increase terrestrial invertebrate inputs to streams
- Maintaining healthy streams and aquatic invertebrate communities is important for brook trout
- The importance of a cross-boundary resource to a receiving consumer may be dictated by conditions in the recipient habitat

Implications and Applications in the Northern Forest region

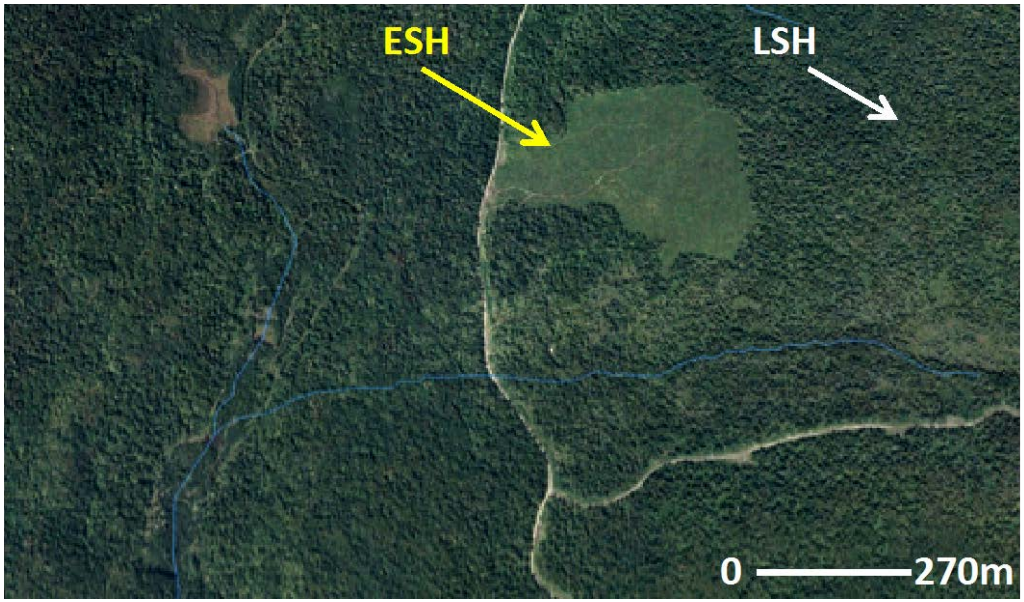
Future Directions

- How is insect diversity in ESH related to diversity in vertebrate consumers, or invertebrate pollinators?



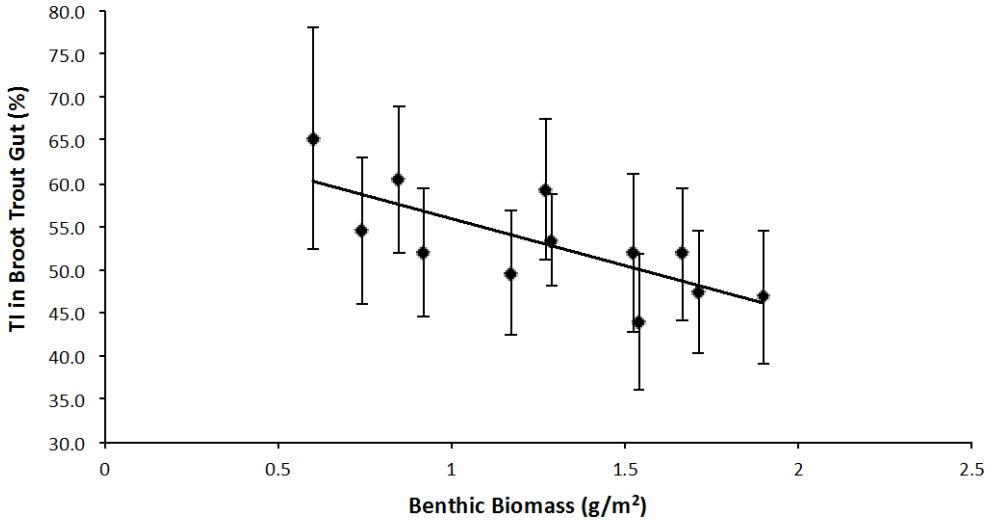
Future Directions

- How much ESH is needed in the Northern Forest region to support invertebrate and vertebrate diversity?



Future Directions

- What controls aquatic invertebrate productivity in headwater streams of the Northern Forest region?



List of products

- **Peer-reviewed publications**
  - Wilson, M.K., W.H. Lowe, and K.H. Nislow. *In review*. Invertebrate richness and biomass in early and late successional habitats of northeastern forests.
  - Wilson, M.K., W.H. Lowe, and K.H. Nislow. 2014. What predicts terrestrial invertebrate subsidy use by brook trout (*Salvelinus fontinalis*) in headwater streams? *Freshwater Biology* 59:187-199.
  - Brooks, R.T, K.H. Nislow, W.H. Lowe, M.K. Wilson, and D.I. King. 2012. Forest succession and terrestrial-aquatic biodiversity in small forested watersheds: a review of principles, relationships, and implications for management. *Forestry* 85:315-328.

- **Other publications**
  - Wilson, M.K. 2012. What predicts terrestrial invertebrate subsidy use by brook trout (*Salvelinus fontinalis*) in headwater streams? M.S. Thesis, Wildlife Biology Program, University of Montana, Missoula, MT.

- **Conference presentations**
  - American Fisheries Society Meeting, UMT Student Chapter, May 2011, Missoula, MT. M.K. Wilson and W.H. Lowe. The influence of watershed-scale forest characteristics on the supply of terrestrial prey to eastern brook trout (*Salvelinus fontinalis*).
  - Wildlife Biology Seminar Series, April 2010, Missoula, MT. M.K. Wilson. The influence of watershed-scale forest characteristics on the supply of terrestrial prey to eastern brook trout (*Salvelinus fontinalis*).