Environmental and Biotic Drivers of Food-web Structure in Ohio Streams

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ABSTRACT

Food webs are a type of ecological network that provide important information about biotic interactions and energy pathways in ecosystems. The determinants of key characteristics of ecological trophic networks are still not well understood. Here, we examine relationships between network structure and physical, chemical, and biotic characteristics of streams draining through multiple land uses in the upper Ohio River Basin. Preliminary evidence suggests that land use, nutrient stoichiometric relationships, and number of species were correlated with network properties such as connectance and linkage density. We anticipate that results will provide a better understanding of the environmental and biological drivers of aquatic invertebrate network structure in modified landscapes, which can in turn play a significant role in the health and stability of stream ecosystems.

BACKGROUND

Ecological networks describe complex interactions among organisms.[1]

- Food webs represent one type of ecological network, and describe trophic links between organisms within an ecosystem.[1]
- Representing trophic interactions as an ecological network allows us to quantify species interactions and their effect on the environment.[2,3]

There is evidence to suggest that food-web structure and functioning is affected by biological and physical stream characteristics including, for example:

- Number of species in food web[4]
- Watershed land use[5]
- Natural disturbance[6]

Food-web structure affects communities' ability to cope with anthropogenic perturbations.[7]

- e.g., more compartmentalized food webs are less affected by species removal.[7]

However, the effects of many types of environmental characteristics on food-web structure remains unresolved.

The **objective** of this study is to determine the associations between *stream nutrient and physical characteristics and benthic macroinvertebrate food-web structure in Ohio streams.*

STUDY SYSTEM

Figure 1. Study area in Ohio includes catchments with variable land-use types:

A. Forest (Burr Oak, *n* = 4)
B. Agriculture (Indian Lake, *n* = 4)
C. Mixed Use (Hoover, *n* = 4)

METHODS

Macroinvertebrate Collection

- Shallow streams = Surber sampler
- Deeper streams= Ekman sampler
- Identified to lowest possible taxonomic unit

Nutrient Concentrations

- Bulk water grabs
- Analyzed for total N (TN) and total P (TP)

Physical Characteristics

- Depth & bankfull width
- Turbidity & dissolved oxygen
- Pebble count & QHEI assessment

Network/Food-web Matrices

- Diets determined based on published literature, including:
  - Meritt et al. 2008[8]
  - Poff et al. 2006[9]

Food \ Species	*Branchiura sowerbyi*	*Microtendipes*	*Zavrelimyia*
Phytoplankton	1	1	0
Diatoms	1	1	0
Periphyton	1	1	0
Macrophytes	0	0	0
Detritus	1	1	0
Zooplankton	0	0	1
Branchiura sowerbyi	0	0	1
Microtendipes	0	0	1
Zavrelimyia	0	0	1

Figure 2. Example of a food-web matrix with the species present (top row) and available food (left column). A value of 1 represents a species that eats that food item.

Network/Food-web Metrics

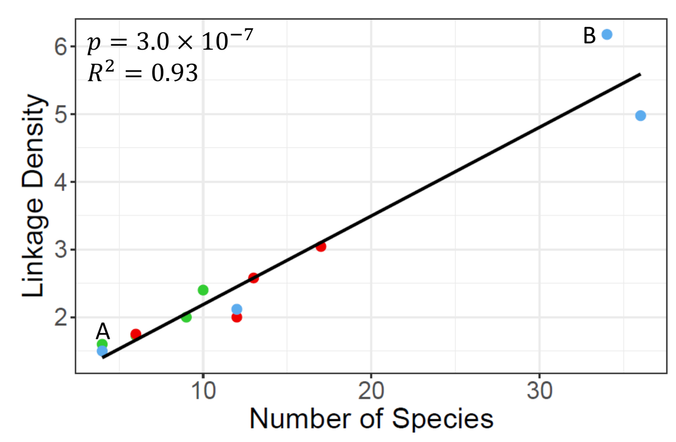
Linkage density = the average number of links per species[2]

Connectance = the density of interactions in the food web/network[2]

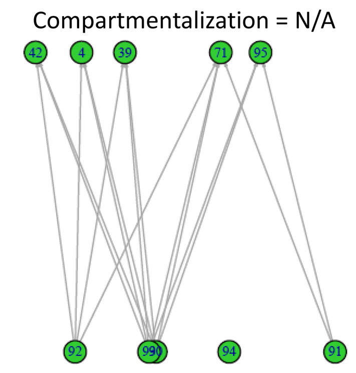
Compartmentalization = the degree to which groups of species interact with one another more than they interact with species outside of that group[7]

RESULTS

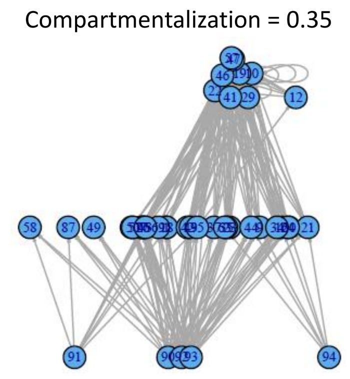
As the number of species increases, networks exhibit greater linkage density.



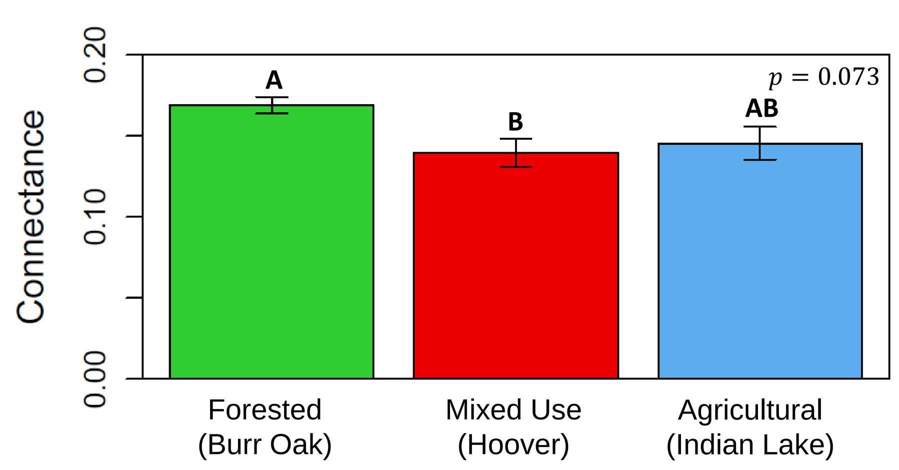
Site A
Linkage Density = 1.6
Connectance = 0.18
Compartmentalization = N/A



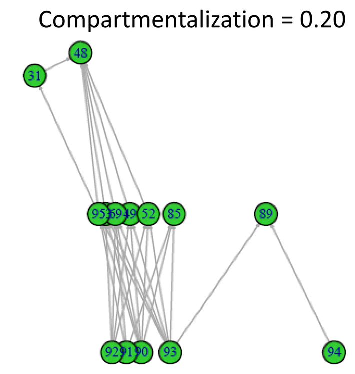
Site B
Linkage Density = 6.2
Connectance = 0.16
Compartmentalization = 0.35



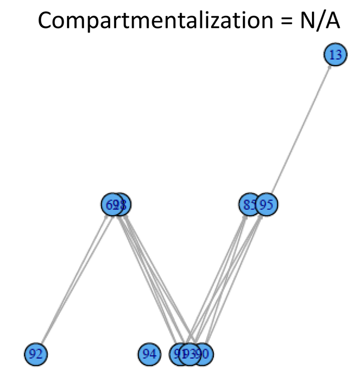
Connectance and compartmentalization are associated with land use and nutrient levels.

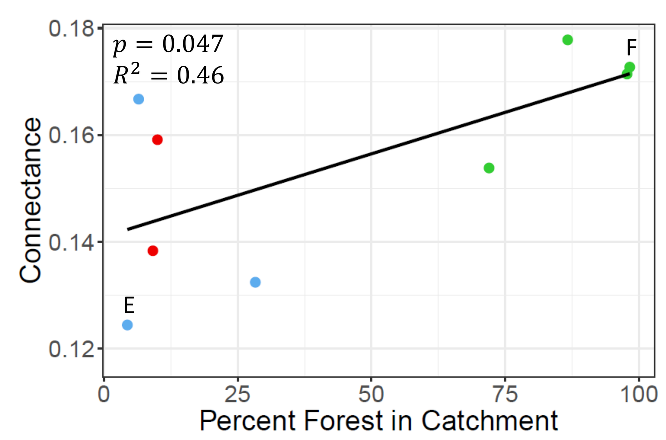


Burr Oak (Site C)
Linkage Density = 2.0
Connectance = 0.15
Compartmentalization = 0.20

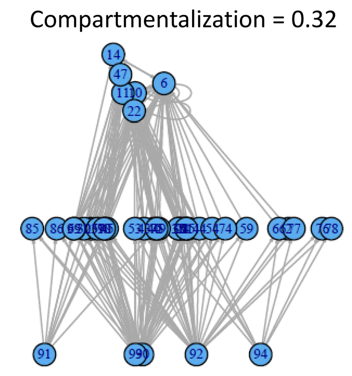


Indian Lake (Site D)
Linkage Density = 1.5
Connectance = 0.17
Compartmentalization = N/A

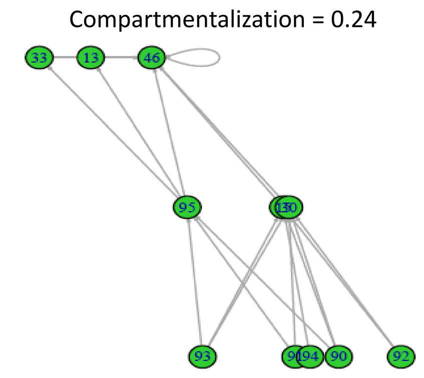


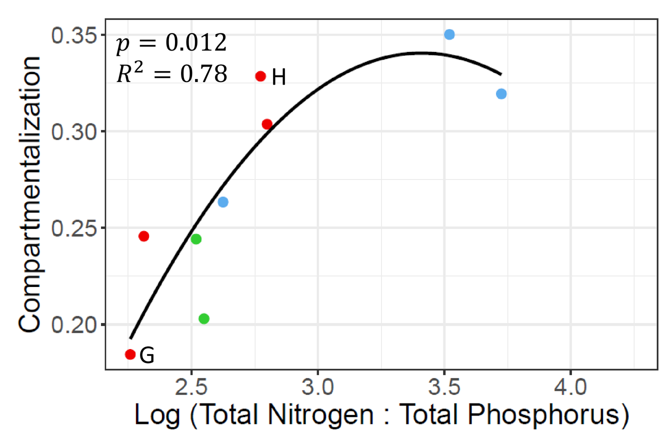


Site E
Linkage Density = 5.0
Connectance = 0.12
Compartmentalization = 0.32

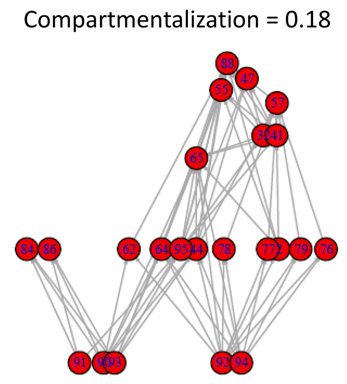


Site F
Linkage Density = 1.7
Connectance = 0.17
Compartmentalization = 0.24

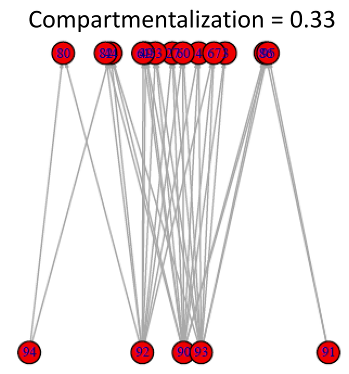




Site G
Linkage Density = 3.0
Connectance = 0.14
Compartmentalization = 0.18



Site H
Linkage Density = 2.0
Connectance = 0.12
Compartmentalization = 0.33



CONCLUSIONS

Preliminary data suggest:

- Networks with a greater number of species have a higher density of links per species.
- Forested streams have more connected food webs.
- Ratios of nutrient concentrations affect compartmentalization, with implications for community and ecosystem persistence.

Anthropogenic changes such as land-use change and nutrient enrichment can affect network structure, affecting stream communities' ability to cope with current and future perturbations.

Next steps:

- Add additional sites at each Ohio watershed and additional watersheds in Indiana, Kentucky, and Tennessee
- Link ecological network structure to ecosystem functions such as stream metabolism

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