The Effects of Stream Fragmentation on Fish Communities

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INTRODUCTION:

No single factor has been a greater cause of population decline in wildlife communities than loss of habitat due to fragmentation. Habitat fragmentation is usually associated with terrestrial environments and is defined as the breaking up of contiguous areas of land into smaller, more isolated patches. However, one of the major questions facing stream biologists is to determine if habitat fragmentation can occur within a stream.

What is Stream Habitat Fragmentation?

- lack of connectivity between upstream and downstream populations

which occurs when:

1) the longitudinal continuum is disrupted

and/or

2) when lateral connections are severed between the stream channel and adjacent wetlands or riparian zones

How are streams fragmented?

land-use changes:

- -Deforestation of riparian and floodplain areas
- -Urban development
- -Livestock grazing
- -Conversion of floodplain and riparian areas into cropland for agricultural use

In Illinois, agricultural practices have deforested over 70% of native vegetation that have resulted in the loss or simplification of near-stream vegetation and a reduction in the physical environment of streams.

physical changes caused by riparian fragmentation:

- -increased sedimentation
- -increased water temperature
- -decreased dissolved oxygen levels
- -increased pollution levels
- -decreased habitat diversity within streams

The combined effect of riparian zone fragmentation and associated changes in stream abiotic factors may be detrimental to stream fish communities.

possible changes in fish populations:

- -reduced diversity of fish
- -decreased complexity in size structure of fish populations
- -decline in fish specialists
- -increased abundance of omnivores and detritivores
- -greater temporal variability in fish abundance

OBJECTIVES:

Since land use practices can cause stream habitat fragmentation along both a lateral and a longitudinal gradient, one would expect that fragmentation might lead to the creation of distinct patches within a stream. To date few studies have investigated the response of stream fish communities to in-stream patch formation caused by habitat fragmentation.

Therefore the objectives of the study were to:

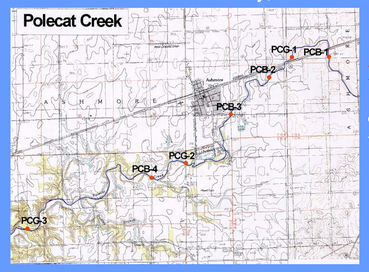
1) determine if habitat fragmentation causes distinct in-stream patch formation

2) determine the effects of patch formation on stream fish communities.

METHODS:

Sites

7 sites, in various stages of riparian zone disturbance were sampled along Polecat Creek in Coles County, Illinois during 1998 and 1999.



Reaches

Reaches ranged from 360-650 ft and contained at least one riffle/pool sequence when possible

Habitat Assessment (In Stream Patch Formation):

At each site the Stream Habitat Assessment Procedure (SHAP) was used to evaluate stream habitat based on the following 15 metrics:

METRIC	Excellent	Good	Fair	Poor
Substrate and Instream Cover				
Bottom Substrate	16-20	11-15	6-10	1-5
Deposition	10-12	7-9	4-6	1-3
Substrate Stability	13-16	9-12	5-8	1-4
Instream Cover	10-12	7-9	4-6	1-3
Pool Substrate	16-20	11-15	6-10	1-5
Channel Morphology and Hydrology				
Pool Quality	13-16	9-12	5-8	1-4
Pool Variability	13-16	9-12	5-8	1-4
Channel Alteration	7-8	5-6	3-4	1-2
Channel Sinuosity	10-12	7-9	4-6	1-3
Width/Depth	13-16	9-12	5-8	1-4
Hydrolic Diversity	10-12	7-9	4-6	1-3
Riparian and Bank Features				
Canopy Cover	10-12	7-9	4-6	1-3
Bank Vegetation	13-16	9-12	5-8	1-4
Immediate Land Use	7-8	5-6	3-4	1-2
Flow-Related Refugia	10-12	7-9	4-6	1-3

Six individuals subjectively assessed each metric along each stream reach and assigned metrics to one of four categories using guidelines established by the IEPA. The total score of 15 metrics forms the basis of overall habitat quality for the reach.

Fish Community Assessment

To evaluate the effects of patch formation on stream fish communities, the seven sites previously identified on Polecat Creek were sampled using electroshocking techniques. Upon shocking, fish were collected with drift nets and placed into buckets. After fish identification, stream quality within each site based on the fish community was determined through the following techniques:

1) Index of Biotic Integrity (IBI) using the following metrics

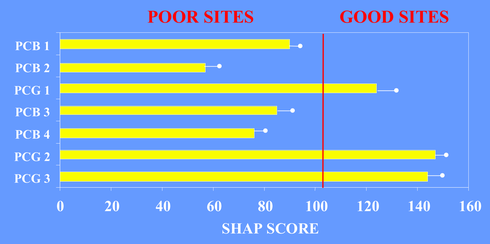
Category	Metric
Species Richness and Composition	Total number of fish species
	Number and identity of darter species
	Number and identity of sunfish species
	Number and identity of sucker species
	Number and identity of intolerant species
	Proportion of individuals as green sunfish
Trophic Composition	Proportion of individuals as omnivores
	Proportion of individuals as insectivorous cyprinids
	Proportion of individuals as piscivores (top carnivores)
Fish Abundance and Condition	Number of individuals in sample
	Proportion of individuals as hybrids
	Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies

2) Species Richness

- number of species collected at each site

RESULTS:

Habitat Assessment:



- An analysis of variance showed a significant difference in SHAP scores between sites ($p<0.001$). To determine where the differences occurred a Tukey's HSD was performed. The results indicated that the seven sites could be placed into two distinct groups; sites with good quality habitat (PCG 1,2 and 3) and sites with poor quality habitat (PCB 1,2,3,and 4).

- In Poor Quality Habitats, the loss in overall habitat quality was due to

Increase In: Deposition and Top of Bank Land Use

Loss In: Bottom Substrate Stability, In-Stream Cover, Bank Vegetation and Pool Quality

Fish Community Assessment:

General Results:

- A total of 4273 fish were collected from the 7 sites.
- Fish from 32 species representing 8 families were collected.
- Cyprinidae (minnow and carp) and Percidae (darters and perch) were the most common families with 11 and 6 species respectively.
- 11 cyprinid species composed 3334 individuals or 78% of the total number collected.

Index of Biotic Integrity:

Reasons for Differences in Mean IBI Scores

Decreased number of intolerant species in poor sites

Good sites had 10 intolerants, poor sites had only 6

Examples: northern hogsucker and silver redhorse

Increased proportion of omnivores in poor sites

12.55% in good sites, 31.65% in poor sites

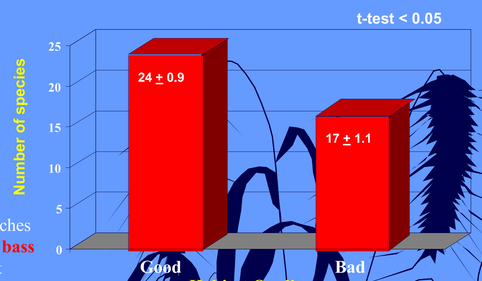
Examples: bluntnose minnow, common shiner

Reduction in carnivore proportion in poor sites

1% in good sites, 0.05% in poor sites

Examples: spotted and largemouth bass

Reduction in the number of trophic levels present in poor sites



2 Major Types of Fish Lost:

Top carnivore populations were reduced in poor patches

-loss of spotted bass and largemouth bass

Decrease in the number of intolerant species present

-loss of northern hogsucker and tangail darter

CONCLUSIONS:

- **SHAP scores varied in association with land use, with increased land use leading to a decline in habitat quality.**
- **Fragmentation of riparian zone vegetation can cause the formation of distinct patches within a stream system.**
- **Poor patches had reduced in-stream cover and pool quality as well as increased deposition and top of bank land use.**
- **Poor patches had reduced biotic integrity and species richness as well as a reduction in the number of trophic levels.**

These results suggest that restoring native riparian zone vegetation is an essential element for the management of stream ecosystems.