# Landscape Ecology of Mississippi River Mussels: Multiple Scale Metapopulation Perspective in Unionid Population Biology

**Principal Investigator:** John A. Downing
**Student Investigator:** Daelyn Woolnough (Ph.D.)
**Collaborators:** Teresa Newton, USGS, Upper Midwest Environmental Sciences Center
**Duration:** September 2002 to September 2006
**Funding Source(s):** U. S. Geological Survey, Upper Midwest Environmental Sciences Center

**Goals and Objectives:**

- To determine whether unionid populations in the Upper Mississippi River function as metapopulations
- To determine whether fish host populations in the Upper Mississippi River function as metapopulations
- To determine whether one species of fish host could contribute to population connectivity of unionid species or if multiple species are necessary to provide connectivity of populations

**Progress:**

Explanations for patterns observed in local assemblages of unionids are frequently sought with reference to interactions between host fish species. We compared the ability of a spatial model to reproduce the fish-mediated movement of larval unionids and examine host fish data from the Upper Mississippi River (UMR) in comparison with this model. The models focus on the condition of mussel beds (species richness, species abundance, mussel bed size, and size classes) and four measures of host fish connectivity. Hypotheses were tested to determine the importance of host fish in structuring unionid populations and communities in large rivers.

To test these hypotheses, GIS coverages for Pool 8 (P8) of the UMR were developed that incorporated literature values of home ranges of host (n=57) and non-host (n=31) fish. Kriging analyses were performed to create host-fish and non-host fish probability surfaces for the entire P8 and pool thirds. Kriging analyses were based on home range, abundance, and location of fish and reflect movement of fish in P8. Euclidean path analyses were performed among mussel beds to create a matrix of potential paths among all mussel beds in P8. From these path analyses, potential connectivity measurements of fish were performed among mussel beds by overlaying the path analyses with the Kriging of fish data. Overall connectivity among mussel sites based on communities and species of mussels were calculated. Mussel bed condition was summarized for each mussel bed and incorporated into the spatial coverages. These analyses were all performed on two grid sizes ($10m^2$ and $100m^2$) and for the entire P8 (~38km) as well as pool thirds (~12km).

We showed that host fish populations have greater connection than non-host fish among mussel beds (F-test; $p=0.03$) and that the connection provided by the entire host fish community would be similar among pool thirds. Individual unionid host fish provide the greatest connectivity in the upper and middle pool thirds. Connectivity increased with greater mussel bed condition, as expected, but then decreased at very high mussel bed condition. Literature values of home ranges for fish species varied substaintially so a literture review was performed and submitted for peer-review. The results of the home range analysis will be used in the final analyses of these data.

Using Ripley's K-function we determined that the distribution of host fish species indicate spatial clustering at multiple scales which reflects the spatial clustering of mussel beds in the UMR. This spatial clustering lends itself to metapopulation analysis with host fish providing the connection between populations of unionids; we present a metapopulation equation for unionids and suggest reasons why unionid populations are predisposed to metapopulation analysis. Spatial clustering of fish at multiple scales reflects the spatial clustering of mussel beds in the UMR. The Levins' classic 1969 metapopulation model is not an appropriate metapopulation model for these data because the connectivity host-fish provide among mussel beds varies. Therefore we suggest that a metapopulation model similar to Hess's 1997 model is more appropriate for this system because varying connectivity can be incorporated.

**Future Plans:**

In the future, we will determine spatial autocorrelation of data through the use of variograms and determine connectivity matrices for each host fish species using a sinuosity index which will contribute further information to the present euclidean path connectivity analyses. We will incorporate information on mussel species generalist or specialist host fish use and determine which mussel sites are most similar by ordination of mussel sites and pool thirds.