COMMUNITY CLASSIFICATION AND DISTRIBUTUION PATTERNS OF FRESHWATER MUSSELS IN THE STRAWBERRY RIVER, ARKANSAS

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INTRODUCTION

- Freshwater mussels of the families Unionidae and Margaritiferidae represent the greatest species richness in North America with nearly 300 taxa
  - More than 60% of these 300 taxa threatened or endangered (Williams et al.1993; William and Neves 1995; Ricciardi et al. 1998 and Elderkin et al. 2007).
  - Among these species , 269 - found in the Southeast US (Neves et al. 1997)
  - Within Arkansas, 22 species- conservation concern, 20 species (24%) - special concern, 5 species (6 %)- threatened, 19 species (22%) -endangered and 1 -extirpated (Harris et al. 2009)
- Still a large knowledge gap in the large scaled distribution pattern of freshwater mussels
- Previous study in Buffalo River (Matthews et al. 2009) showed 3 distinct freshwater mussel communities along the river gradient

OBJECTIVES

1. Determine if there are distinct freshwater mussel communities from headwaters to mouth of Strawberry River.
2. Determine if there are any environmental variables associated with freshwater mussel distribution

STUDY AREA

- Strawberry River Watershed **(Fig. 1.)**
  - Central Plateau ecoregion of the Ozark Mountains in northcentral AR
  - Total area of ~1500 km^2
  - Geology
    - Dolomite (Ge1) ~50.6%, Sandstone (Ge2) ~43.3%, Alluvium (Ge3) ~2.4%
  - Soils
    - Ozark Highland Soil (So1) ~ 96.4%), Southern Mississippi valley silty Up (So3) ~ 2.5%, Southern Mississippi valley Alluvium (So4) ~1%
  - Land cover/use
    - Deciduous forest (Lu41) ~ 41%, Pasture/hay (Lu81) ~ 29%, Mixed forest (Lu43) ~ 14%, Cultivated crops (Lu82) ~ 1%
  - Between1800 and 1900 many irrigation companies took water from Strawberry River to the lower valleys changing the local communities and ecology
- Strawberry River
  - ~145 km long
  - Qualitative and quantitative mussel surveys in 1990's and 2000's
    - 57 sites and 38 species

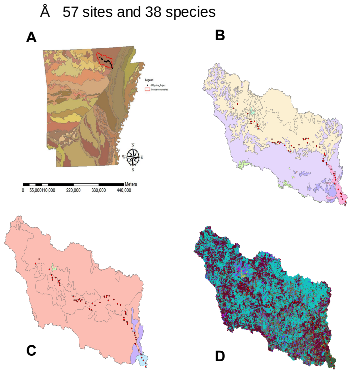

Figure 1. Strawberry River (with 57 sampling sites) A). Arkansas with major ecoregions. Strawberry River lies in Central Plateau (level IV ecoregion) B) Major Geology types C) Major Soil types D) Major Landuse types. (Ecoregion Source: EPA http://www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm)

METHODS

- **Freshwater Mussel Data**
  - Quantitative and qualitative surveys from 1990's and 2000's
  - 38 species of freshwater mussels
  - 57 sites with mussels
- **Environmental Data**
  - Arc GIS
    - Calculated sub-watershed drainage area for each of the 57 sites
    - Calculated environmental variables for each site at the regional **sub-watershed (Sw)** and **local scale (Lo; 100 m buffer)**
    - Total number of variables = 82
      - Landuse, Soil type, Geology and Soil Texture .
      - Slope will be added in future
- **Statistical Analysis**
  - PCA (PC-ORD version 5; McCune and Mefford 2006)
    - Two matrices populated
      - Mussel main matrix (species presence/absence)
      - Environmental secondary matrix

RESULTS

- Mussel Data
  - Axes 1 and 2 of mussel PCA explained ~30% of variability, while axes 1 and 3 explained ~25% (**Table 1**.).
  - None of the axes combinations (1vs.2, 1 vs.3, and 2 vs. 3) plots appear to show the expected distinct dominant community structure along the river gradient **(Fig. 2.)**

RESULTS continued

- Species /axes correlations (τ >0 .25) -significant **(Table 2.)**
  - 15 of 38 species correlated with axis 1
  - 16 of 38 species correlated with axis 2
  - 2 of 28 species correlated with axis 3

Table 1. Eigenvalue, % variance explained, cumulative % variance, and broken stick eigen value for axes 1-3 for presence/absence freshwater mussel data matrix.

Axis	Eigen value	% of variance	Cumulative %Variance	Broken-stick Eigenvalue
PCA1	6.506	17.120	17.120	4.228
PCA2	5.119	13.472	30.592	3.228
PCA3	3.153	8.299	38.891	2.728

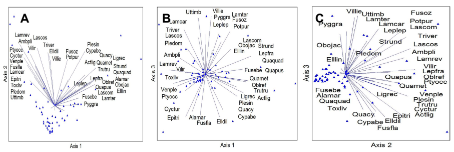

Figure 2. Axis 1 versus axis 2 (A), axis 1 versus 3 (B), and axis 2 vs. 3 (C) scatterplot of sites and species showing species vectors (blue).

Table 2. Significant species correlations with axes 1-3.

Species	Axis 1 (r value)	Axis 2 (r value)	Axis 3 (r value)
Actlig	0.242	0.278	
Ambpli	-.733	0.292	
Fusfla	0.114	0.723	
Quamet	0.198	0.427	
Quapus	0.478	0.547	
Toxliv		-0.488	-0.537
Ligsub	-0.394	0.275	0.301
Lamsil	-0.527	0.517	
Fusebe	0.352	0.268	
Lamter	0.356	0.339	
Lepfra	0.310	0.341	
Oblref	0.459	0.393	
Quamet	0.198	0.427	
Trutu	0.318	0.263	
Cyctub	0.605	0.359	
Lascos	-0.531	0.509	

RESULTS continued

- Environmental Data
  - Axes 1 and 2 of variables PCA explained ~ 42 % of variability while axes 1 and 3 explained ~ 30% of variability **(Table 3.)**
- Mussel and Environmental Interactions
  - Axes 1 and 2 **(Fig. 3A.)**
    - Sandy loam (LoSalo), Gravelly sandy loam (LogSalo), Sandy loam (SwSalo), Very cherty loam (LoVcl), Gravelly sandy loam (SwGsalo), Alluvium (SwGe3, LoGe3), Southern Mississippi valley alluvium (SwSo4), Fine sandy loam (LoFsalo) Portia fine sandy loam (LoPfsalo), silty loam (LoSl), Wideman fine sand (LoWfs), Moko-Rock outcrop complex (LoMRoc), Agnos very cherty loam (LoAvcl), Cultivated crops (SwLu82)
  - Axes 1 and 3 **(Fig. 3B.)**
    - Developed open space (SwLu21), Dolostone (LoGe1), Very cherty silty loam (SwVcsl), Water (SwWater), Sandy loam (LoSalo, SwSalo), Gravelly sandy loam (SwGsalo, LoGsalo), Agnos very cherty silty loam (Avcsl), Moko-Rock outcrop complex (LoMroc), Alluvium (SwGe3, LoGe3), Southern Mississippi valley alluvium (SwSo4), Wideman fine sand (LoWfs), Portia fine sandy loam (LoPfsalo), Cultivated crops (SwLu82)
  - Axes 2 and 3 **(Fig. 3C.)**
    - were not informative for the dominant environmental variables
- Dominant Environmental Variables
  - **Geology:** Sandstone (SwGe2) positive along all 3 axes, Alluvium (SwGe3) significantly positive with axis 1 (r>0.5), No Significant dominant variables in local scale
  - **Soil types:** Southern Mississippi valley silty up (SwSo3) with all 3 axes, Southern Mississippi valley alluvium (Swso4) significantly positive with axis1 (r>0.5)
  - **Soil textures:** Cherty silty loam (SwCsl), Silty loam (SwSl) positive with axes 1-3,Sandy loam (SwSalo) significantly positive with axis 1 (r>0.5)
  - **Landuse:** Mixed forest (LoLu43, SwLu43) positive with axes 1-3, Pasture/hay positive (LoLu81) with axes 1-3, Developed open space (SwLu21) positive with axes 1-3 and Cultivated crops (SwLu82) significantly positive with axis 1 (r>0.5)

Table 3. Eigenvalue, % variance explained, Cumulative % Variance and Broken Stick Eigen value for axes 1-3 for 82 different environmental variables.

Axis	Eigen value	% of variance	Cumulative % Variance	Broken-stick Eigenvalue
PCA1	19.953	24.333	24.333	4.990
PCA2	14.693	17.918	42.252	3.990
PCA3	10.190	12.426	54.678	3.490

Table 4. Dominant geology types (% of entire watershed) and relationship with axes 1-3 .

Geology (%)	Sub-watershed level (Sw) relationship
Dolomite (Ge1; 50.6%)	
Sandstone (Ge2; 43.3%)	+
Alluvium (Ge3; 2.4%)	r>0.5 with axis 1

Table 5. Dominant soil types along axes 1-3.

Soil types (%)	Subwatershed level (Sw)
Ozark Highland soil (96.4%)	
Southern Mississippi valley silty up (2.5%)	+
Southern Mississippi valley alluvium (1.0%)	r>0.5 with axis 1

Table 6. Dominant Soil texture types along axes 1-3.

Soil texture (%)	Subwatershed level (Sw)
Cherty silty loam	+
Silty loam (24%)	
Gravelly sandy loam (16%)	
Rock outcrop (11%)	
Fine sandy loam (6%)	
Silt loam (5%)	+
Sandy loam (2%)	r>0.5 with axis 1

Table 7. Dominant Land use types along axes 1-3.

Landuse (%)	Subwatershed level (Sw)	Local level (Lo)
Deciduous forest (Lu41,44%)		
Pasture/hay (Lu81,29%)		+
Mixed forest (Lu43,14%)	+	+
Cultivated crops (Lu82,1%)	r>0.5 with axis 1	
Developed open space (Lu21, 4%)	+ with axes 1-3	

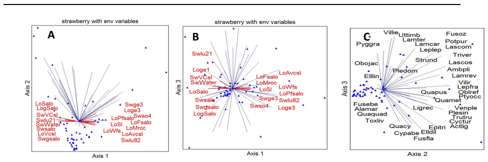

Figure 3. Axis 1 vs. axis 2 (A), axis 1 vs. axis 3 (B) and axis 2 vs. axis 3 (C) scatterplots of sites (blue triangles), species vectors (blue), and environmental vectors (red).

DISCUSSION

- Significant correlation with some of the environmental variables and species distribution: Southern valley alluvium soil(SwSo4) , Landuse with cultivated crops (SwLu82), Very cherty silty loam (SwVcl), Agnos very cherty silty loam (LoAvcsl), Portia fine sandy loam (PFsalo), Moko-Rock outcrop (LoMroc), Sandy loam (LoSalo) and Gravelly sandy loam (LoGsalo)
- The correlation of the species distribution with alluvium - similar to the results of Iowa River (Arbuckle and Downing ,2002)
- Unlike the Buffalo River (Matthews et al. 2009), there seem to be no clumping and gradient present in Strawberry River
- Subwatershed level environmental variables -more important than local level variables

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