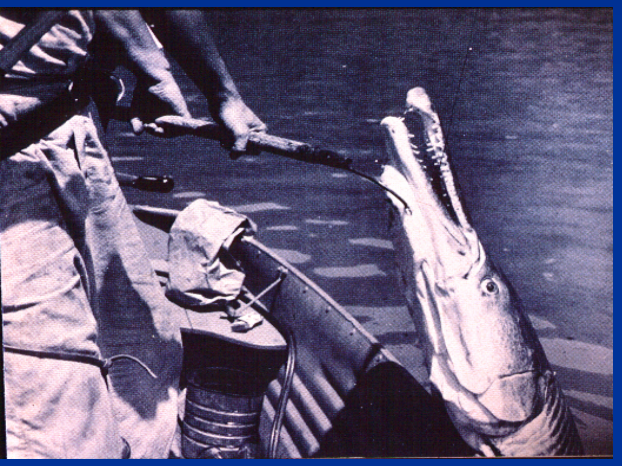
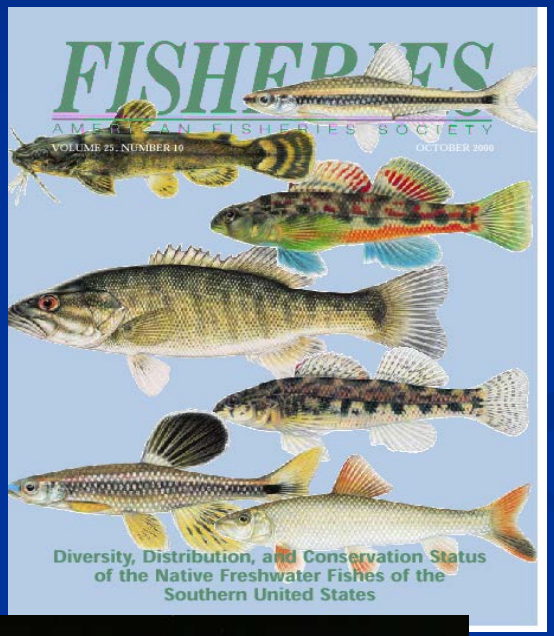
Fish Faunal Regions of the Southern United States: Isolation by Distance as a Structuring Mechanism





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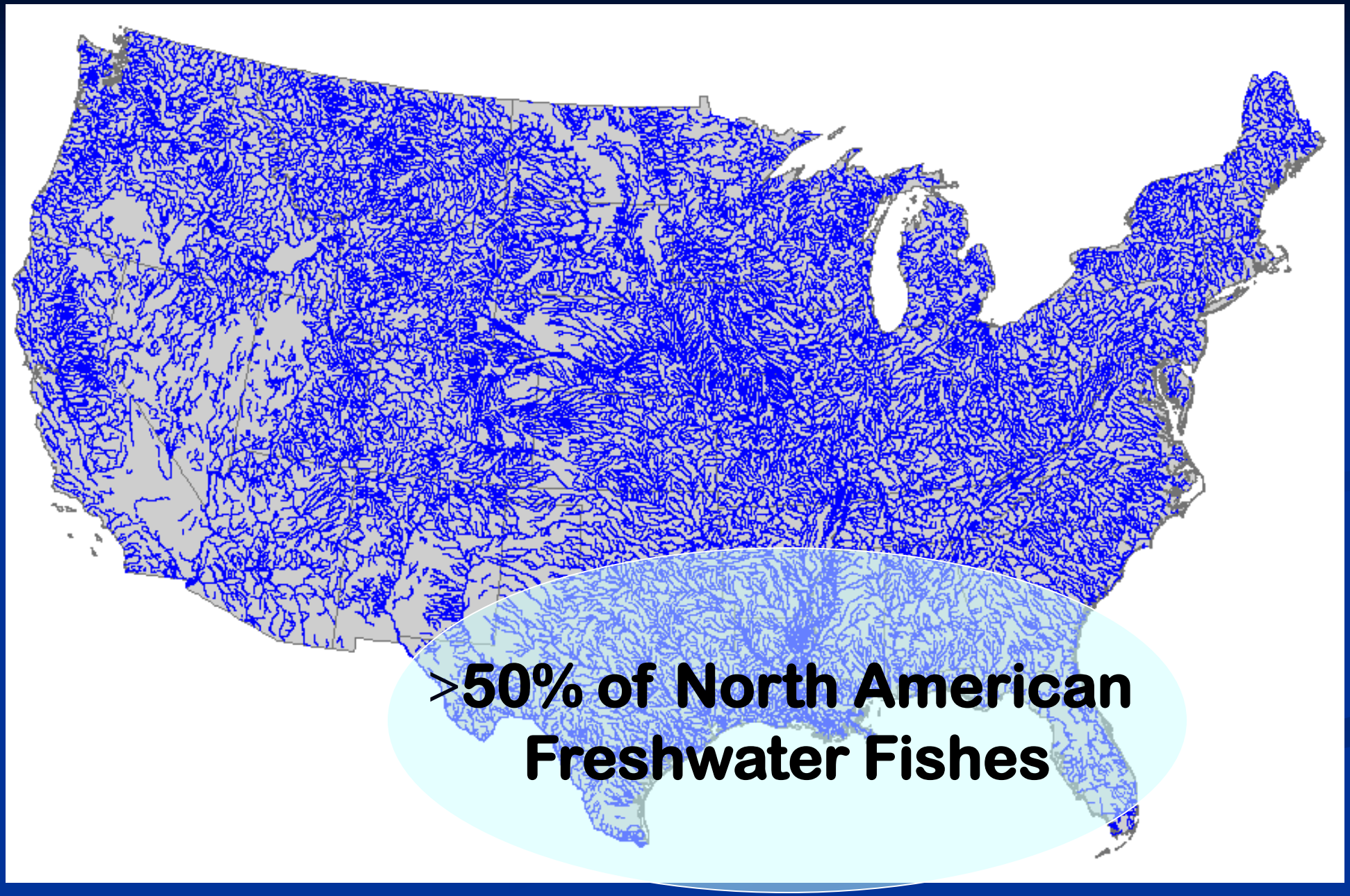
North America ~1100+ freshwater fishes

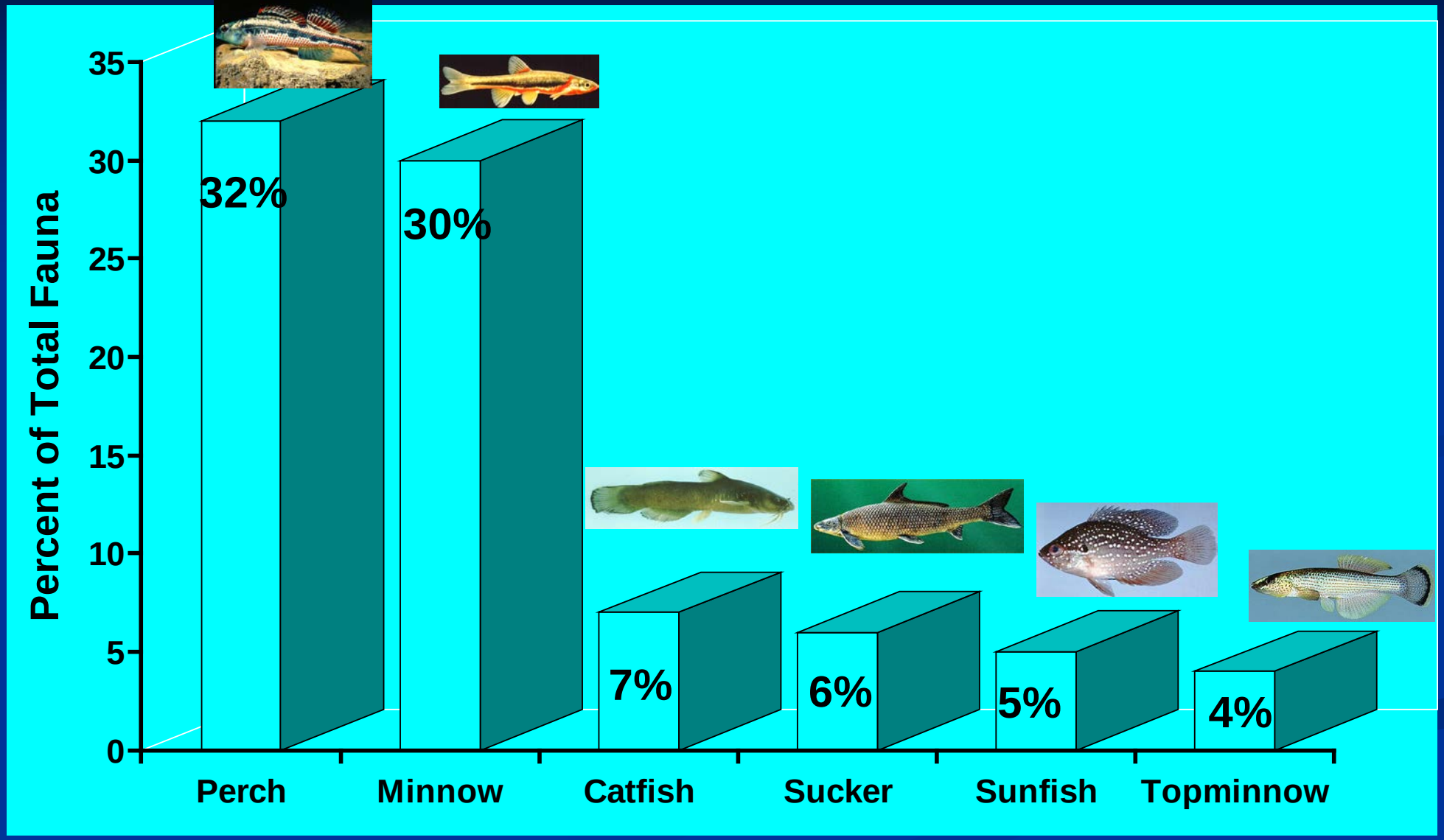
Two salient features of southern U.S. fish fauna:

High Diversity

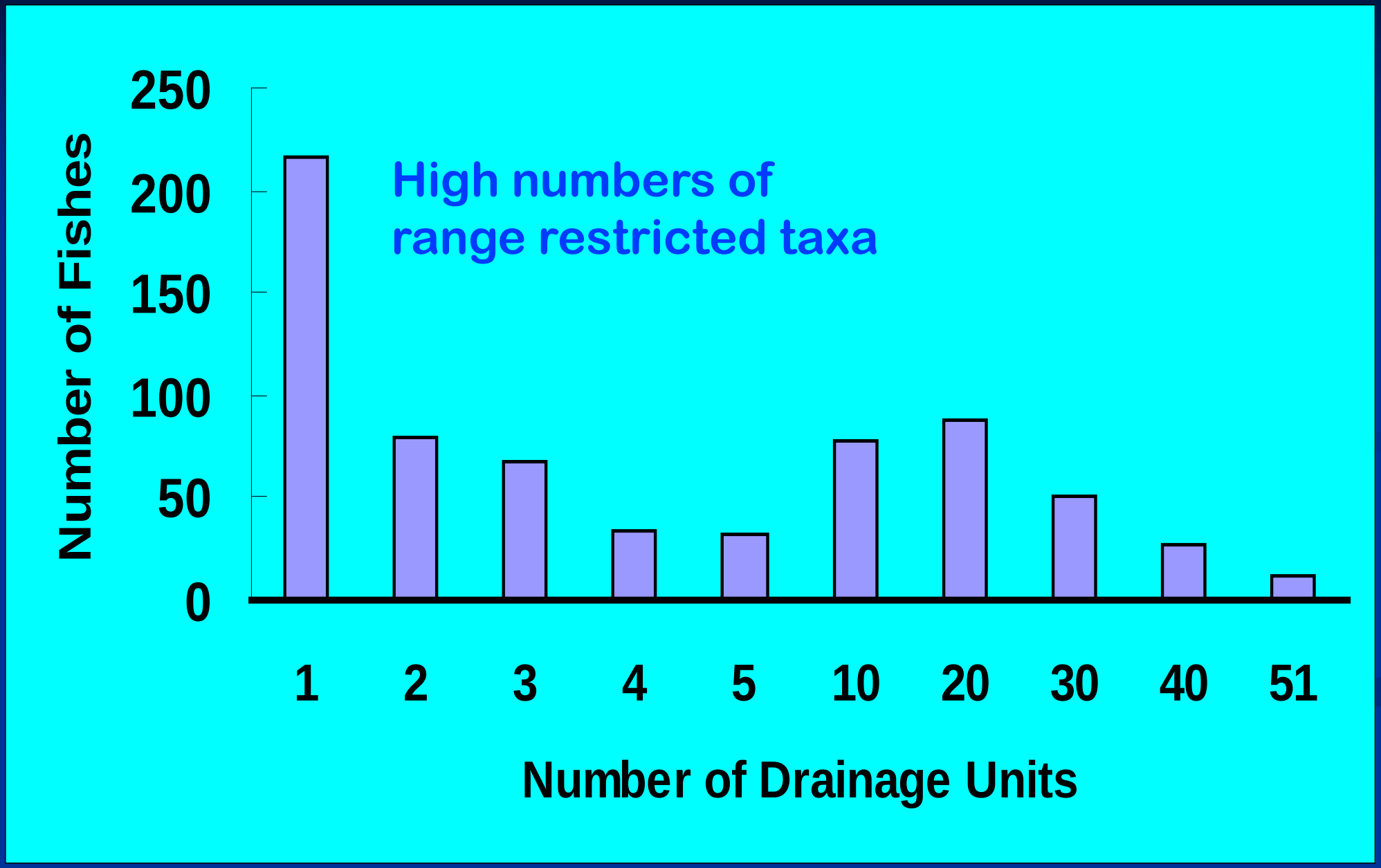
Range-restricted taxa


>50% of North American
Freshwater Fishes

Predominant Fish Families in Southern Waters



Range Extent of Fish Taxa

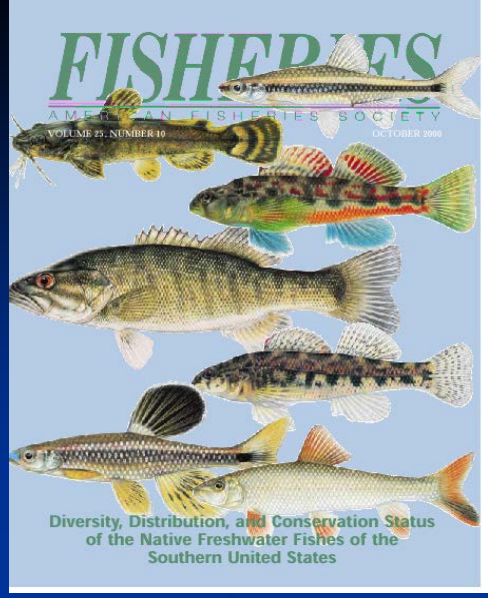


Objectives

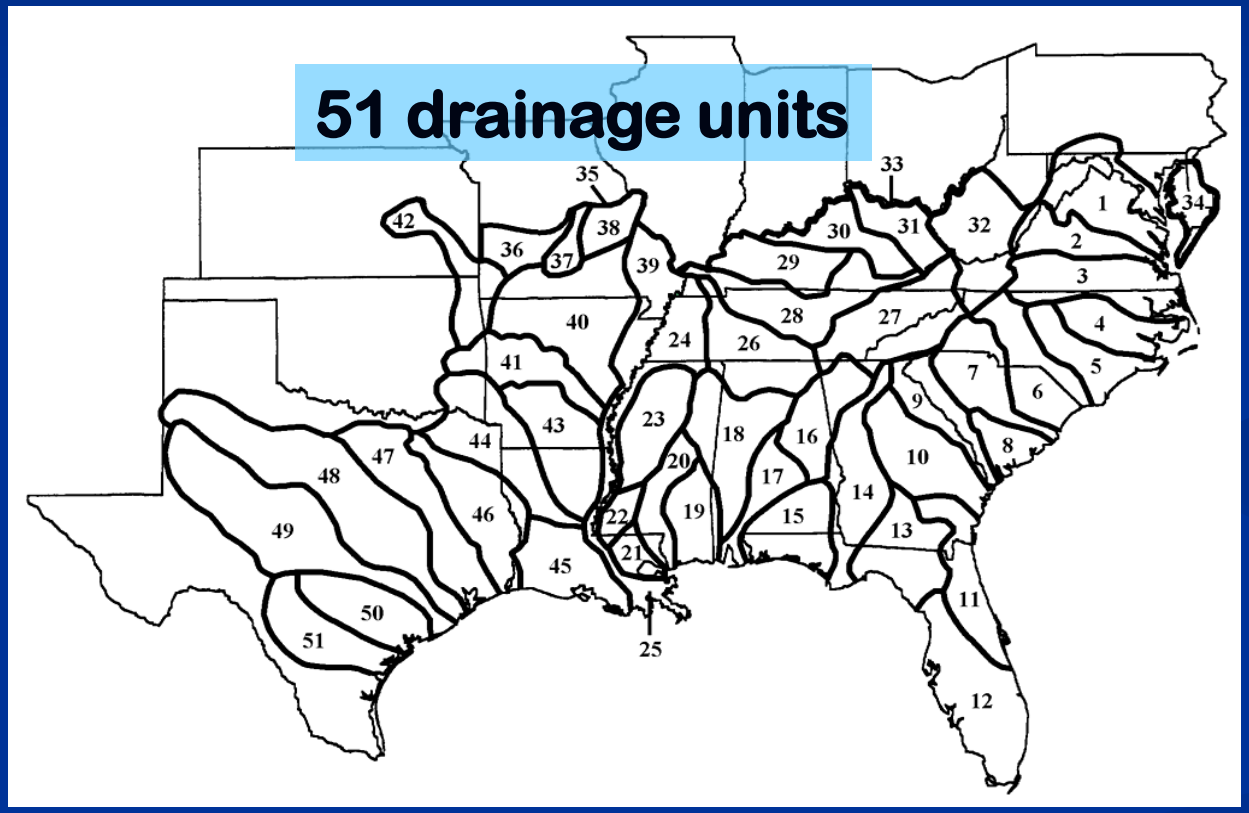
Delimit fish faunal regions objectively and test for distinctiveness

Determine importance of isolation-by-distance (i.e., drainage interconnectivity) in the geo-spatial structuring of the fauna

THE DATABASE



All native fish taxa (685) assigned as present or absent in each drainage unit.



NATIVE SUBSETS

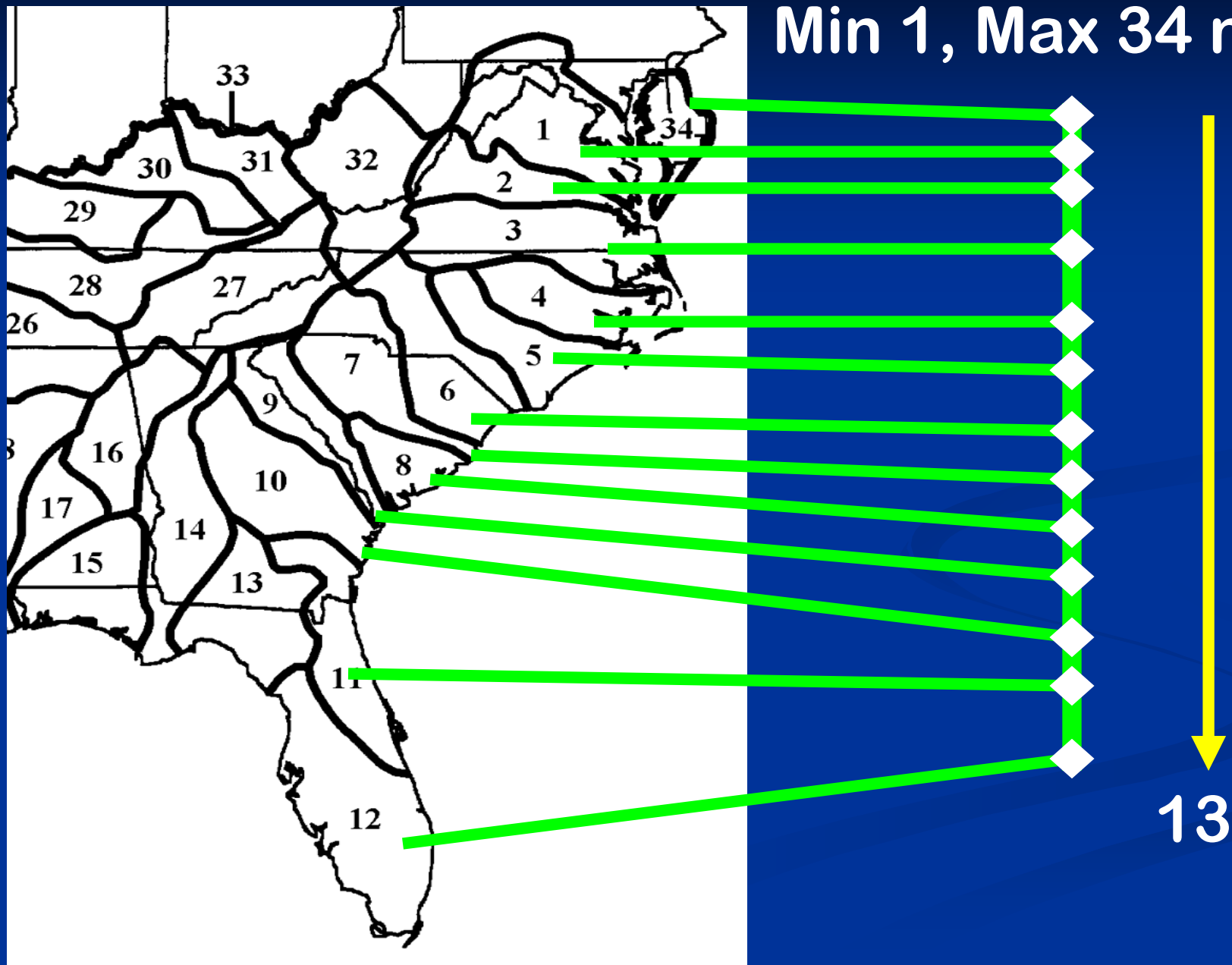
- Darter taxa (218)
- Minnow taxa (209)
- Catfish taxa (46)
- Sucker taxa (44)

Methods

- 5 pairwise faunal distance matrices of drainage units (Jaccards distance, UPGMA clustering):
  - all native fishes
  - subsets of the native fauna (darters, minnows, suckers, catfishes)
- NMS (Non-metric Multidimensional Scaling) as independent test of adequacy of cluster-derived faunal regions (Sorenson distance)
- Internodal drainage distance matrix
- Mantel tests to test structural similarity between distance matrices

Internodal Distances Between Drainages

Min 1, Max 34 nodes



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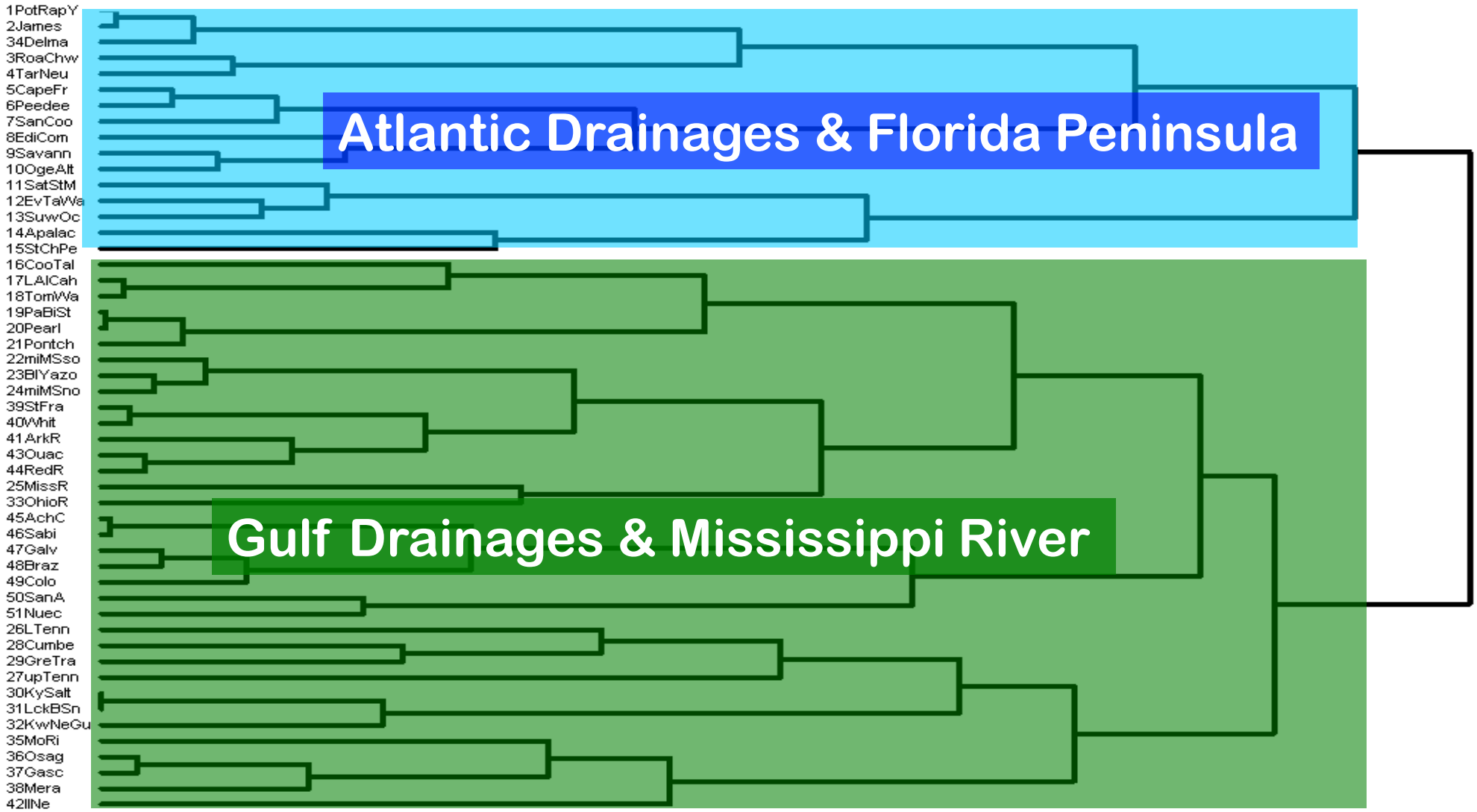
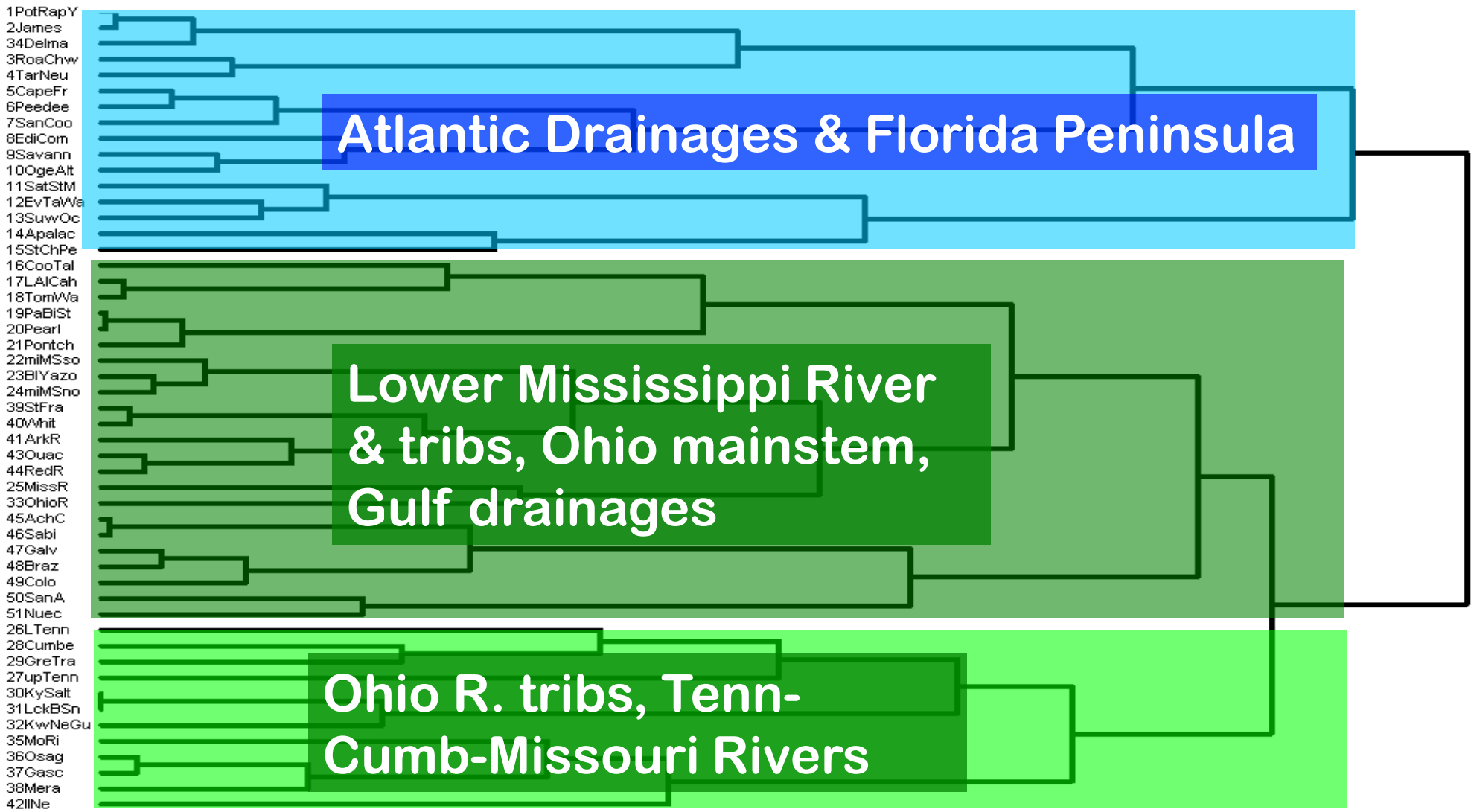
Drainage Similarity All Native Fishes

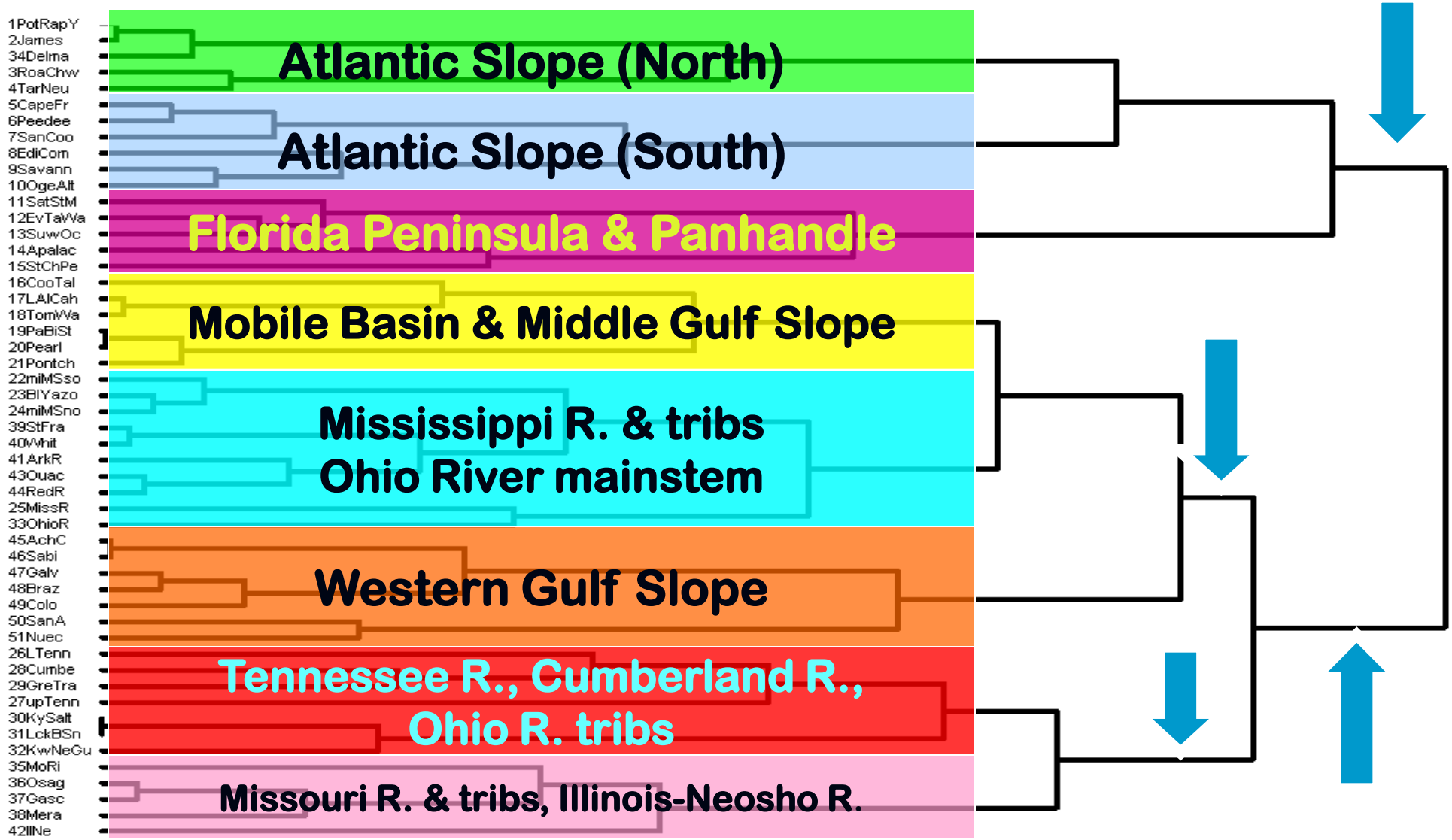
(chaining= 3.59%)

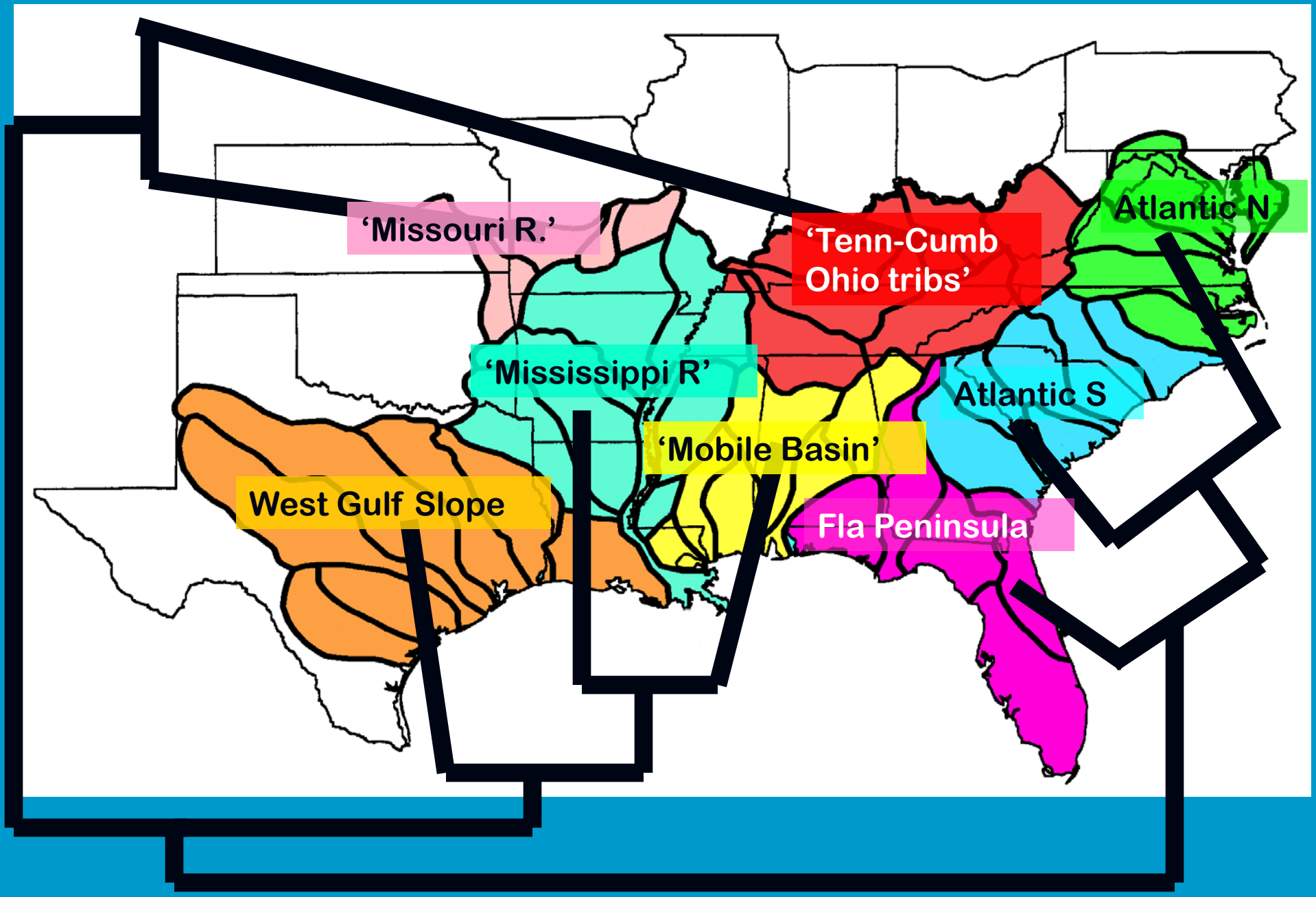


Drainage Similarity All Native Fishes

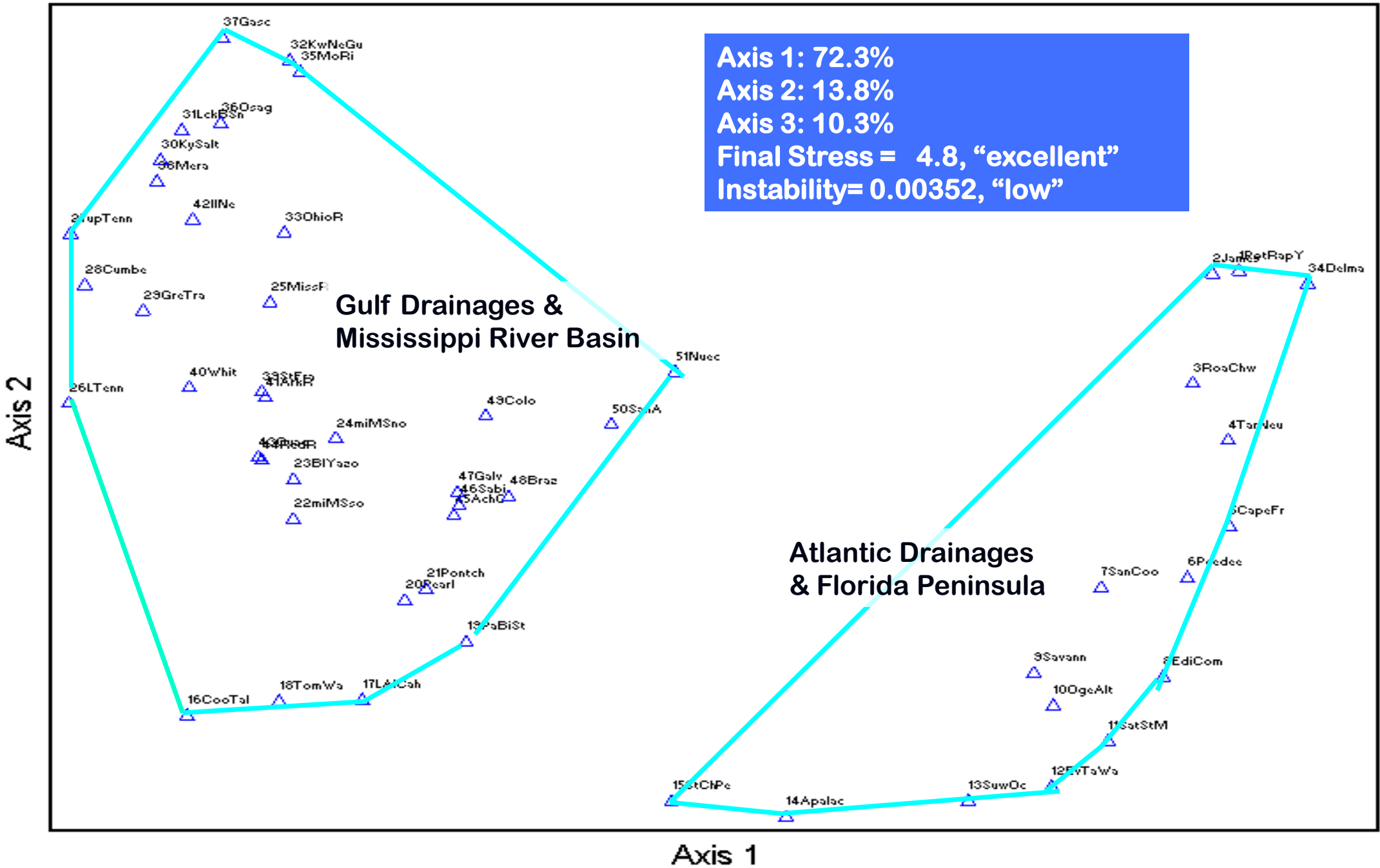


Drainage Similarity (Jaccards) All Native Fishes

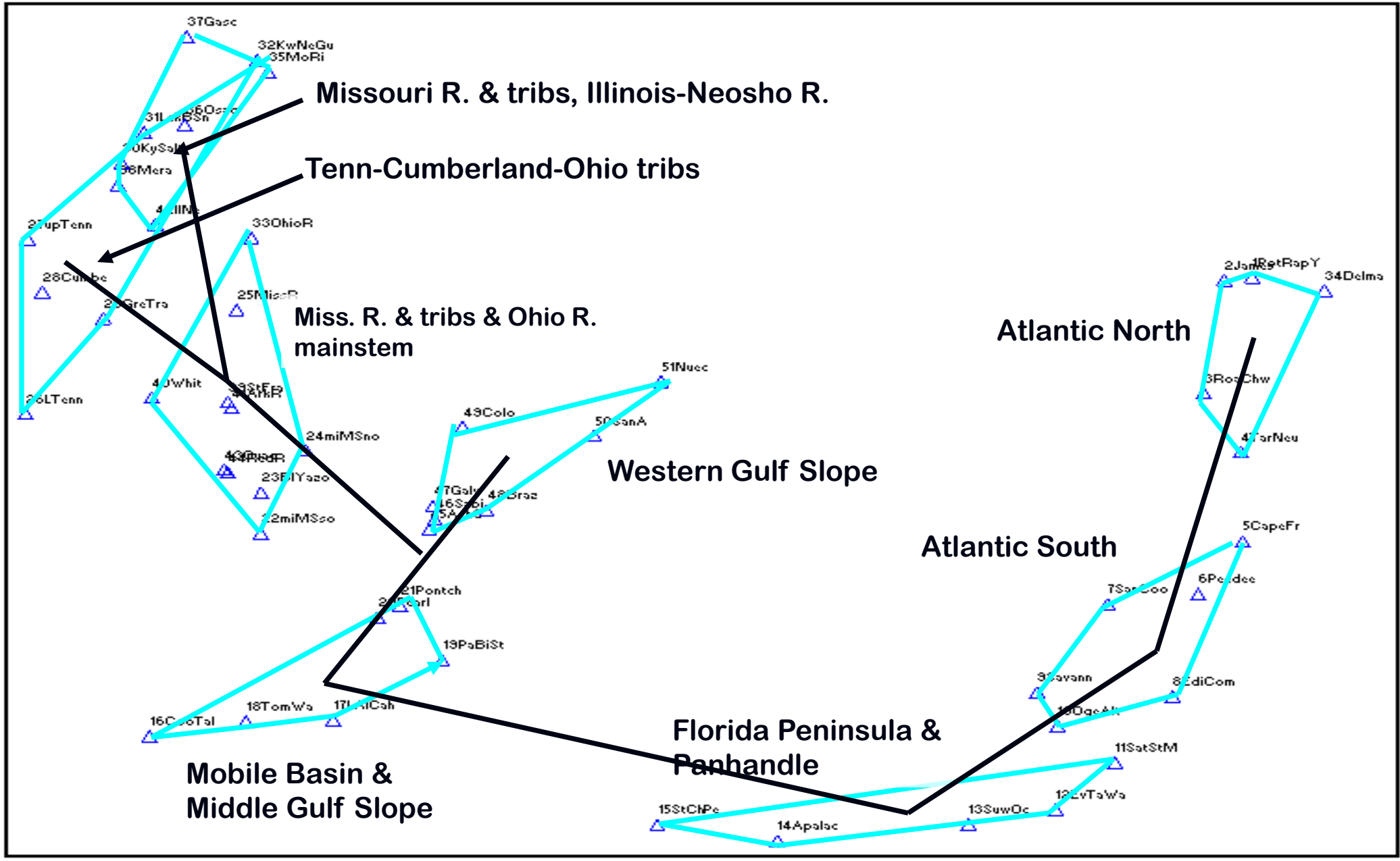



'Missouri R.'
'Tenn-Cumb
Ohio tribs'
Atlantic N
'Mississippi R'
Atlantic S
'Mobile Basin'
West Gulf Slope
Fla Peninsula

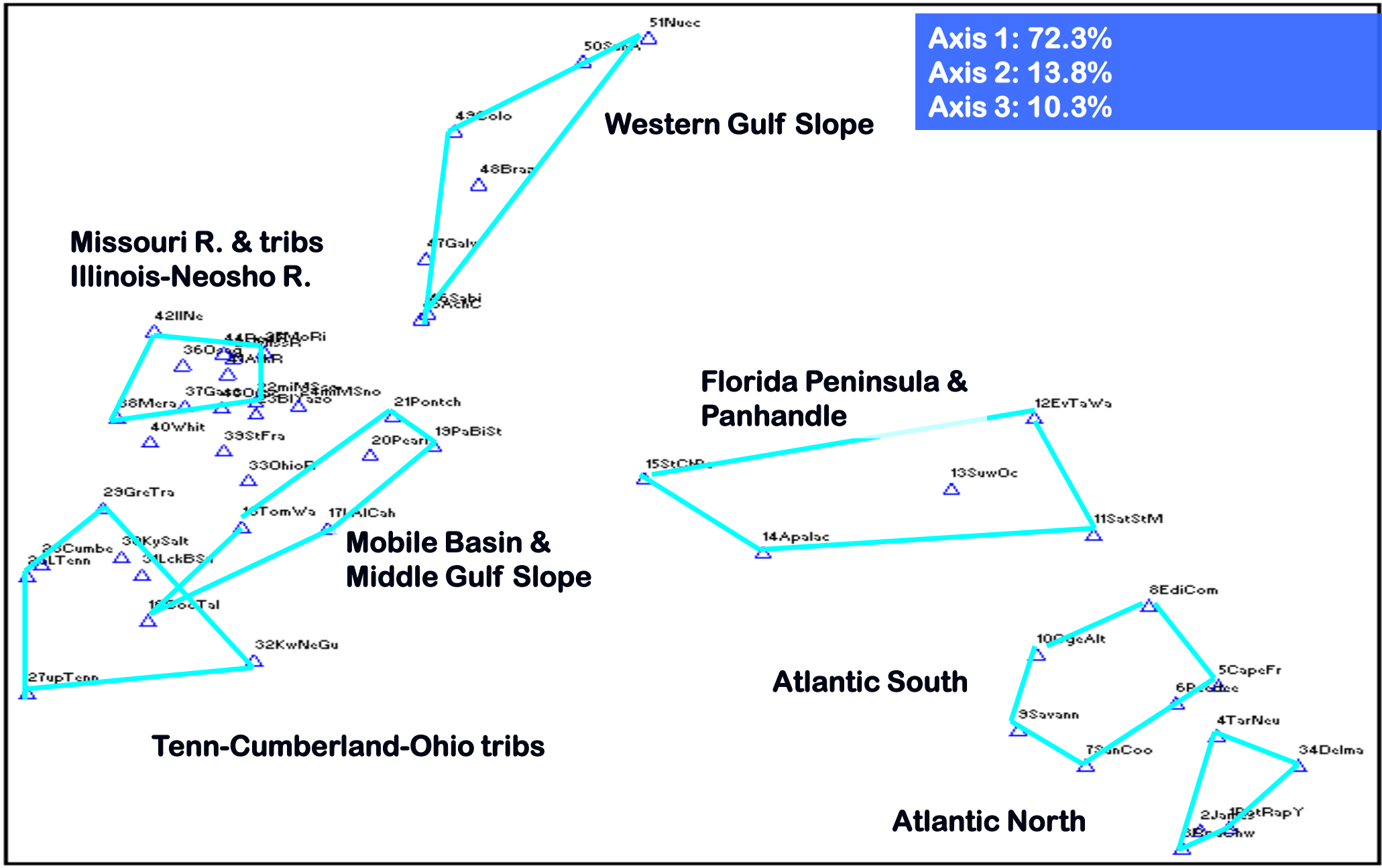
NMS 3-D all native fishes run Sorensen presence absence



NMS All Native Fishes



NMS All Native Fishes



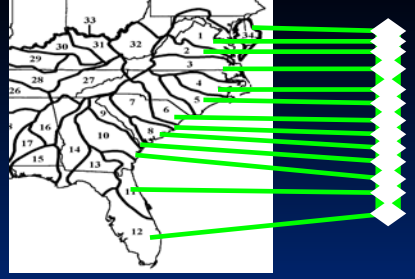
All Natives & Subsets

(Mantel tests)

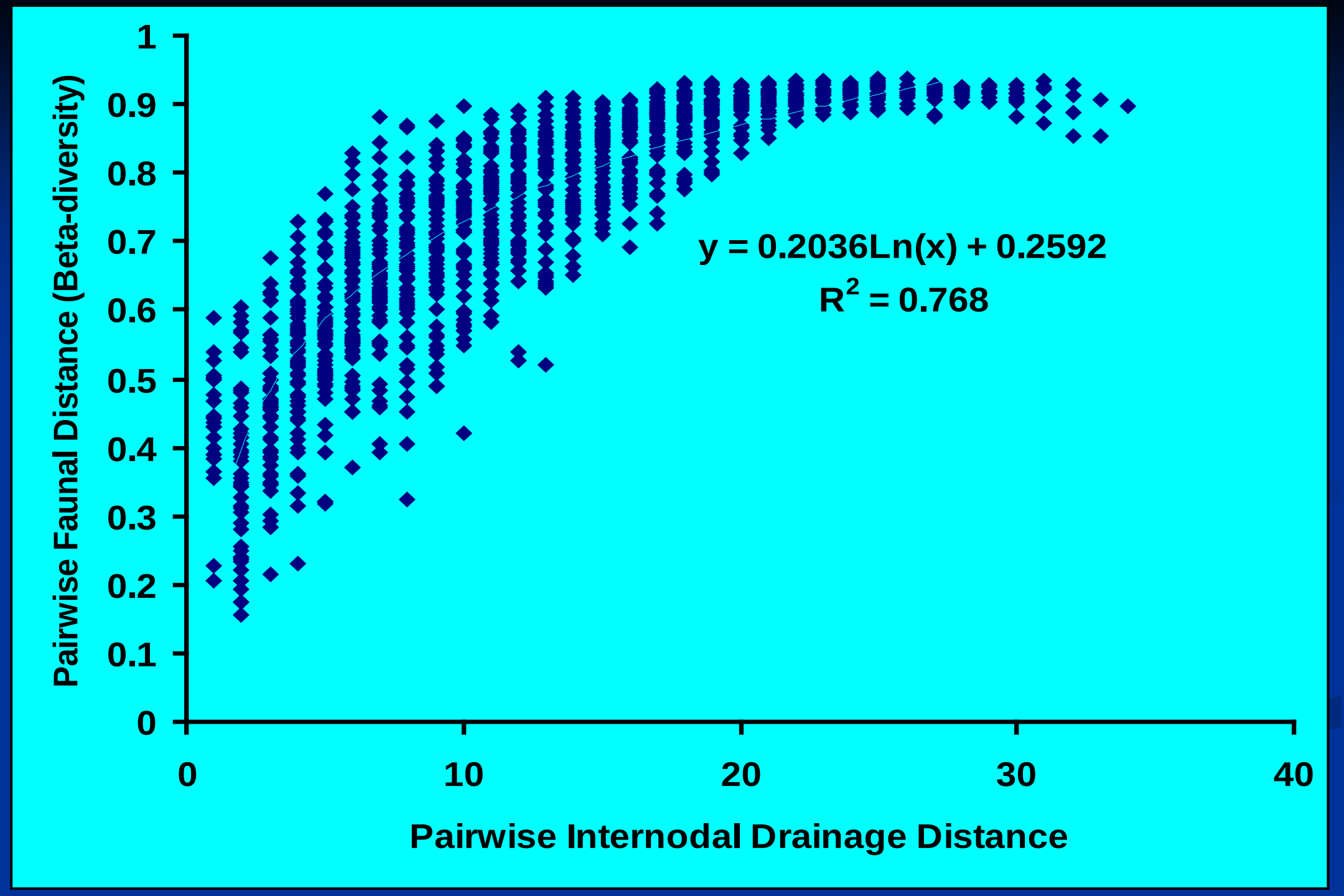
	All	Darter	Minnow	Sucker	Catfish
All	__	0.912	0.944	0.815	0.878
Darter		__	0.869	0.712	0.737
Minnow			__	0.837	0.786
Sucker				__	0.658

All significant $p < 0.001$

Fish & Internodal Drainage Distance Matrices



	Internodal Drainage Matrix	
	Mantel r	p<
Fish Matrix		
All native fishes	0.827	0.001
Darters	0.685	0.001
Minnows	0.715	0.001
Catfishes	0.764	0.001
Suckers	0.641	0.001


Pairwise Faunal Distance (Beta-diversity)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
y = 0.2036Ln(x) + 0.2592
R2 = 0.768
0
10
20
30
40
Pairwise Internodal Drainage Distance

Summary

- A set of highly distinctive faunal regions emerged from the analyses-.
- Faunal geo-spatial structure is highly congruent with drainage interconnectivity across the entire fauna and all major families.
- Simple model of hierarchical, isolation-by-distance accounts for most of the faunal structure.

Summary

- Geo-spatial structuring in the native fauna is very strong, producing highly distinct faunal regions.

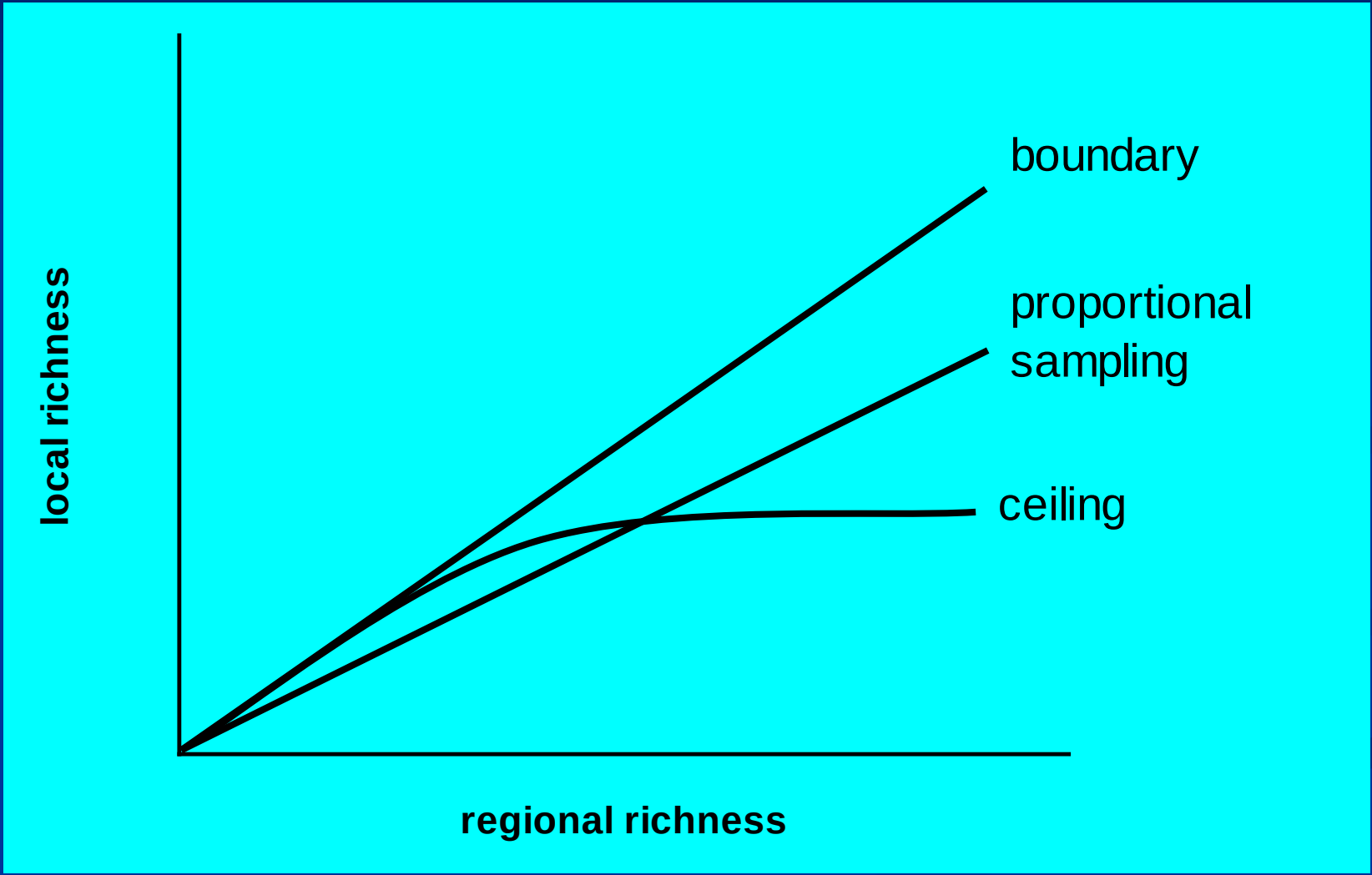
- Structure is highly congruent with drainage interconnectivity for all major families.

- Drainage faunas are "samples of regional faunas," appear "undersaturated," and likely are strongly affected by increased isolation from regional faunas.

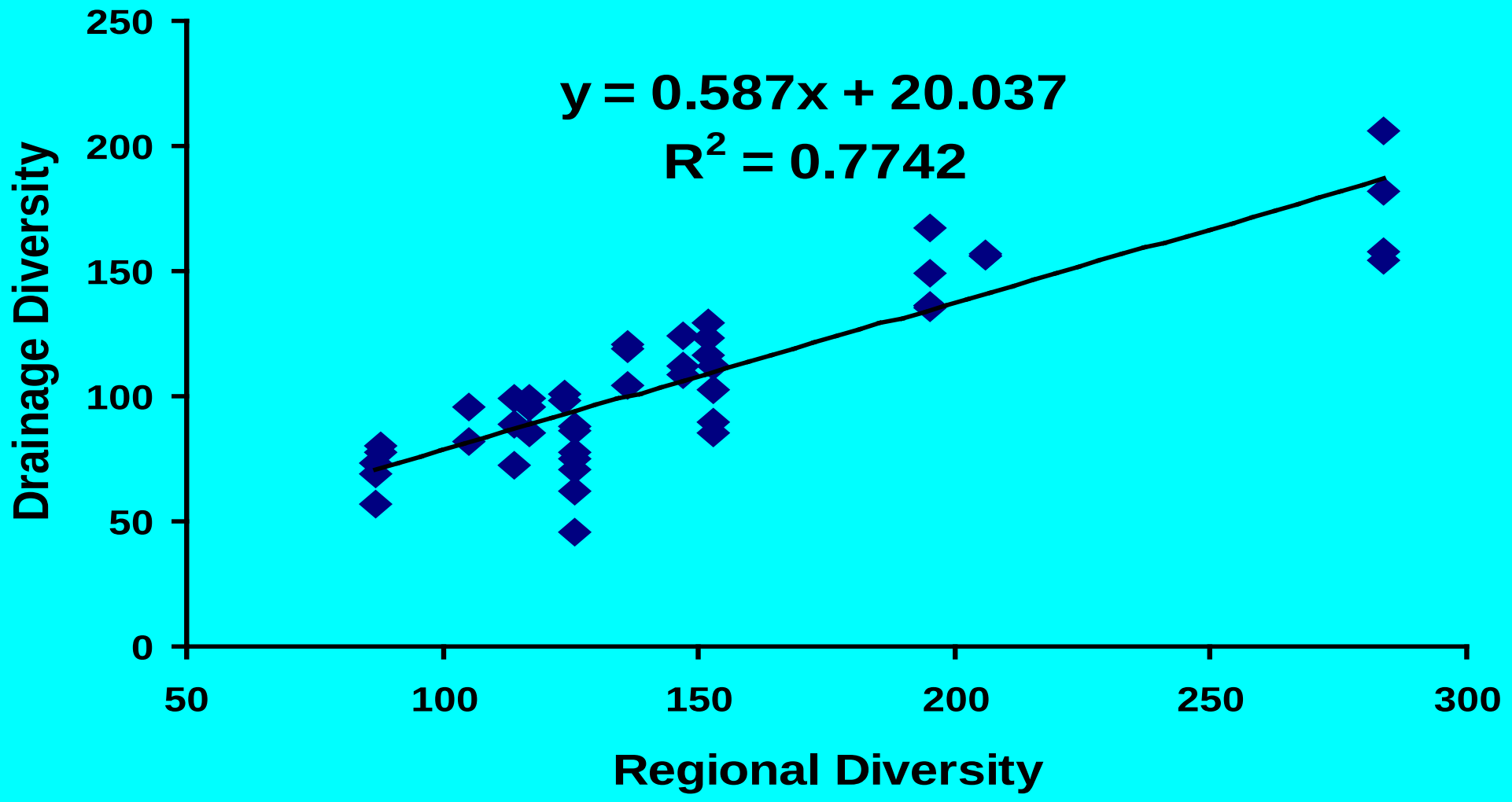
Drainage- and Regional-scale Diversity

How is drainage-scale native fish diversity related to regional-scale fish diversity?

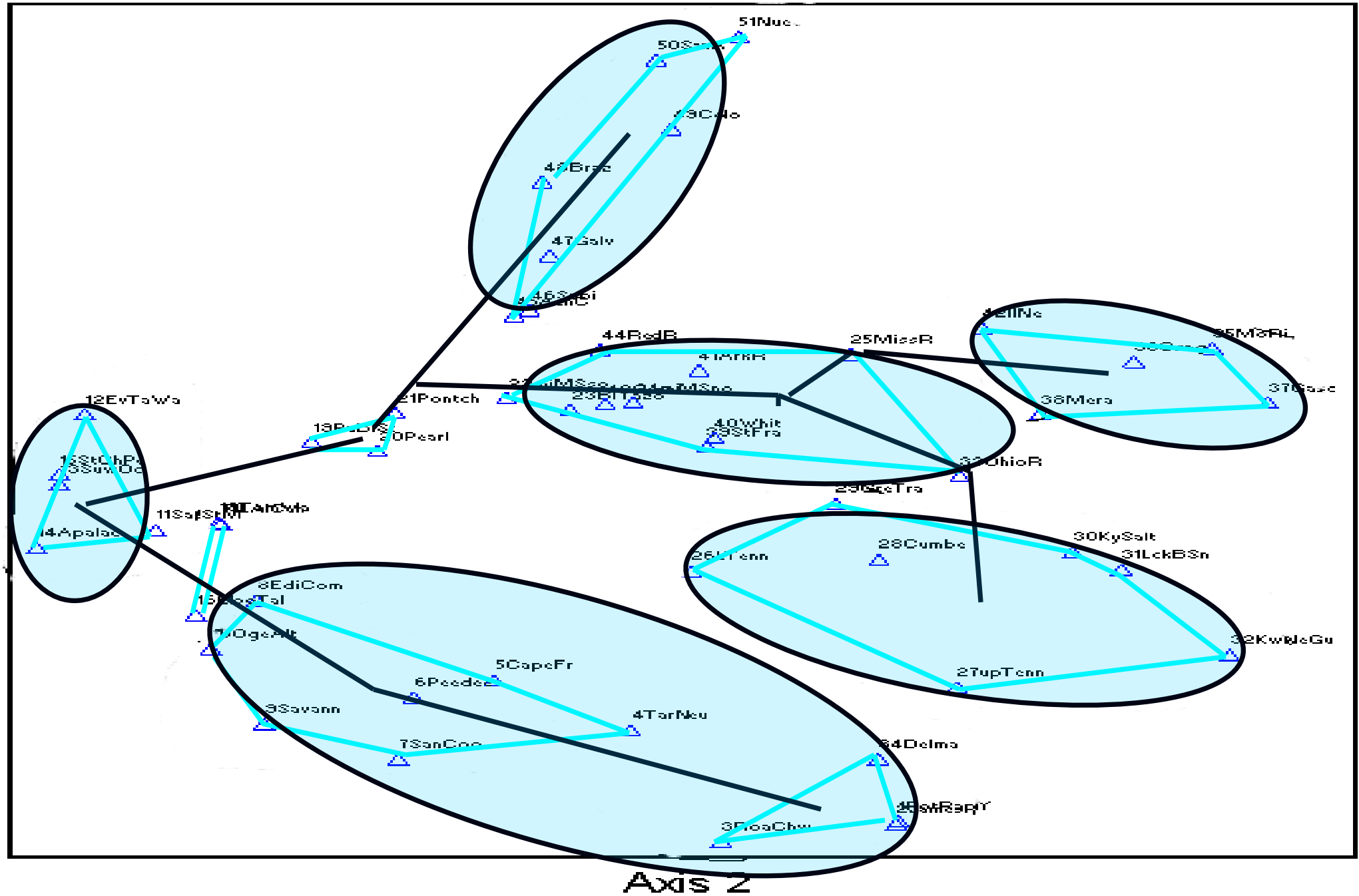
Theoretical Expectations for Regional Richness and Local Richness



Drainage & Regional Diversity

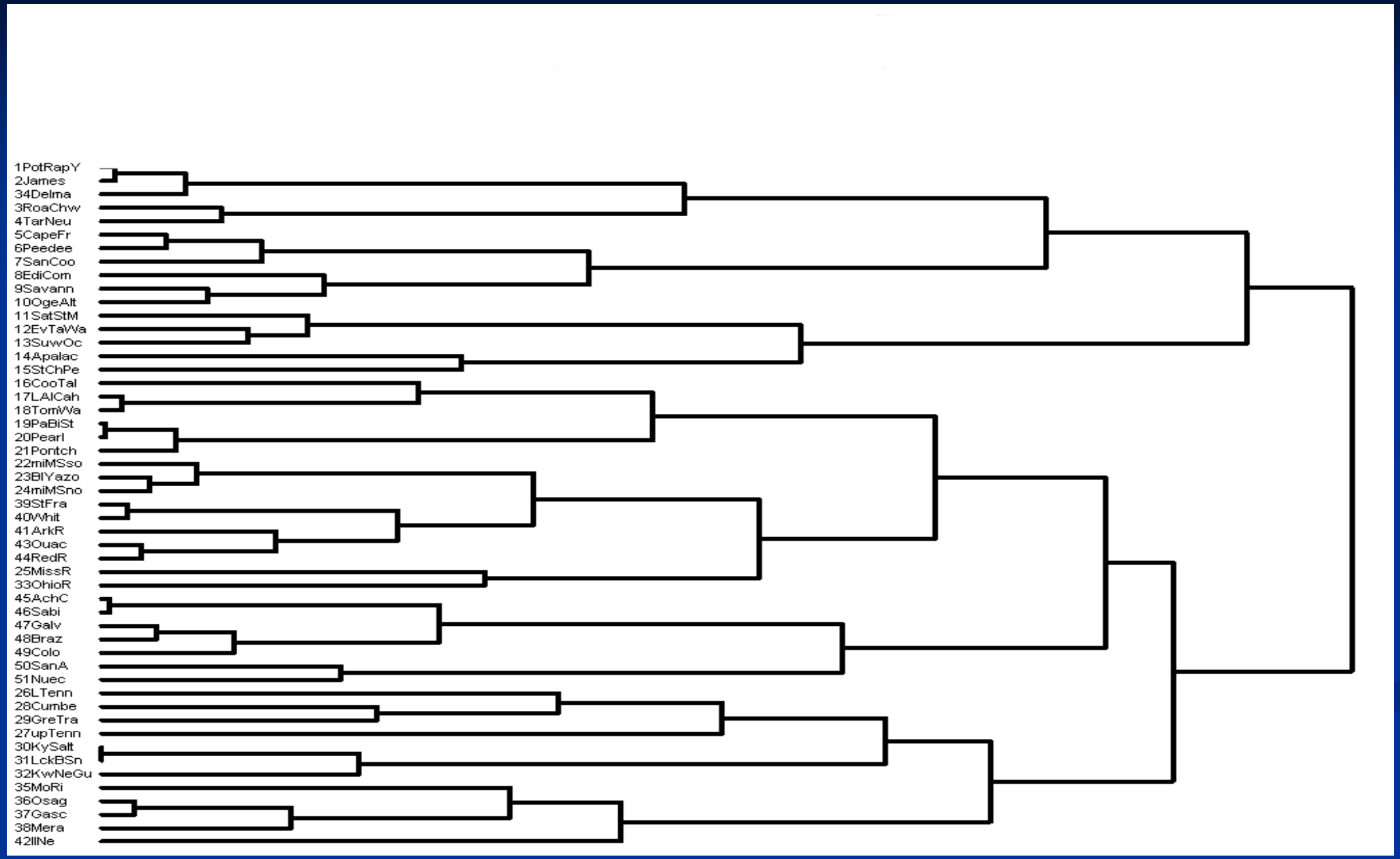


NMS 3-D all native fishes run Sorensen presence absenc



How is drainage-scale native fish diversity related to regional-scale fish diversity?

- Drainage-scale diversity related linearly, positively, and strongly to regional-scale diversity.
- So what?
- Implications for increased extinction risk from natural or human-induced fragmentation and isolation (e.g., coastal systems, dams, water quality) (Sheldon, 1987; Matthews and Robison 1998).
- Implications for faunal 'undersaturation' such that biotic and/or abiotic interactions have not limited drainage level fish diversity (e.g., Cornell, 1993).
- Implications for establishment of non-indigenous fishes.
- Emphasizes strong role of 'historical contingency' in assembling the fauna.


1PotRapY
2James
34Delma
3RoaChw
4TarNeu
5CapeFr
6Peedee
7SanCoo
8EdiCom
9Savann
10OgeAlt
11SatStM
12EvTaWa
13SuwOc
14Apalac
15StChPe
16CooTal
17LAlCah
18TomWa
19PaBiSt
20Pearl
21Pontch
22miMSso
23BlYazo
24miMSno
39StFra
40Whit
41ArkR
43Ouac
44RedR
25MissR
33OhioR
45AchC
46Sabi
47Galv
48Braz
49Colo
50SanA
51Nuec
26LTenn
28Cumbe
29GreTra
27upTenn
30KySalt
31LckBSn
32KwNeGu
35MoRi
36Osag
37Gasc
38Mera
42IlNe