Alabama: The Aquatic State

Dr. Scot Duncan
Birmingham-Southern College

Photo: Hunter Nichols
Alabama’s Surprising Biodiversity

Which of the 50 states ranks #1 for aquatic species diversity in the US?
## States of the Union:
Ranking America’s Biodiversity

**April 2002**

NatureServe

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* Includes vertebrates, vascular plants, freshwater mussels, crayfishes, freshwater snails, large branchiopods, butterflies, underwing moths, tiger beetles, dragonflies, damselflies.

Alabama’s Freshwater Fish Data

- Ranked #1 state in the US for fish diversity
- #1 North American Hotspot for species
- 303+ species
- 38%+ of N. Am. species
- 20+ AL endemic species
- 120+ near-endemic species
Comparative Fish Diversity in the Cahaba River Watershed

- Colorado River Watershed
  - 33 Native Fish Species

- Cahaba River Watershed
  - 128 Native Fish Species

Slide courtesy of Dr. Paul Johnson, Alabama Aquatic Biodiversity Center
Alabama’s Freshwater Snails

- The #1 global hotspot ⁴
- #1 US state ¹
- 147 spp. ²
- 43% of N. Am. gill-breathing species ²

Mobile River Basin:
- Epicenter for N. Am. diversity³
- 93% of species are basin endemics!³

¹ Stein (2002); ² Lydeard and Mayden 1995; ³ Tolley-Jordan et al 2015; ⁴ Johnson 2009 VCE
Alabama’s Mussel Power!

- The #1 global hotspot! ¹
- 22% of the world’s species
- # 1 US state
- 182 species
- 34+% endemic/near-endemic
- 60% of N. Am mussel species

¹ USFWS 2015 url [here](#).
Alabama’s Crawfish/Crayfish/Crawdads/Mudbugs

- The #1 global hotspot
- #1 US state
- 84+ native species (+11 undescribed species)
- Poorly studied

1 Schuster et al 2011; 2 Crandall and Buhay 2008 Hydrobiologia
Alabama’s Aquatic Herp Diversity

- #1 in US for Freshwater Turtles (33 spp) \(^1\)
- Mobile-Tensaw Delta – highest turtle diversity on Earth! \(^1\)
- #2 in US for frogs (31 spp) \(^1\)
- Near top for salamander diversity \(^1\)

\(^1\) J. Stiles, pers. comm.
Question: Why do we have so many species?

Answer: Because we have so many ecosystems....
Alabama has 132,419 river and stream miles.
Question: Why are there so many ecosystems in Alabama?
1. Climate

Lots of Sunlight and Heat

Lots of rain

Lots of lightning
The Role of Climate in Alabama’s Biodiversity

US species diversity rankings
2. High geologic diversity
Spectacular variation in surface rocks and soils in Alabama
2. High geologic diversity

Geology influences:
- Surface bedrock
- Soils
- Topography

These factors create ecological diversity
2. Geologic Diversity
(thus, bedrock, topographic, and soil diversity)

Geologic map and “warm state” biodiversity rankings
3. Rich evolutionary past
Early Permian (290Ma)

Alabama

Appalachians

North America

South America

Africa
• Southern Appalachian Mountains provide...

• Topographic diversity
• Surface bedrock diversity
• Climate variation
• A landscape fractured into multiple watersheds...
- Populations of small aquatic animals become isolated in headwaters

- Over long periods of time they adapt genetically to local conditions and become new species

- No glaciation during ice ages to wipe them out
The Bad News...
The bad news...

- Alabama #2 for total extinction\(^1\)
  - #1 US state on continent
  - 2 fishes
  - 31 snails (+2 extirpated)\(^2\)
  - 11 mussels (+2 extirpated)\(^2\)

### Species Extinctions by State

<table>
<thead>
<tr>
<th>Rank</th>
<th>State</th>
<th>Total Extinct</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hawaii</td>
<td>217</td>
</tr>
<tr>
<td>2</td>
<td>Alabama</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>California</td>
<td>53</td>
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<td>4</td>
<td>Texas</td>
<td>27</td>
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<td>5</td>
<td>Georgia</td>
<td>26</td>
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<tr>
<td>6</td>
<td>Florida</td>
<td>23</td>
</tr>
<tr>
<td>7</td>
<td>Tennessee</td>
<td>22</td>
</tr>
<tr>
<td>8</td>
<td>Virginia</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>Kentucky</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>Ohio</td>
<td>15</td>
</tr>
</tbody>
</table>

\(^1\) Stein 2002; \(^2\) Lydeard and Mayden 1995
The bad news...

105 federally listed (T&E) species
- 81% freshwater aquatic species
- Ranked #2 in 2015 for number endangered animals, #2 overall
- Ranked #4 in 2002 for at risk species

### At risk species by State

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<tr>
<th>Rank</th>
<th>State</th>
<th>% at risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hawaii</td>
<td>63</td>
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<tr>
<td>2</td>
<td>California</td>
<td>29</td>
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<tr>
<td>3</td>
<td>Nevada</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>Alabama</td>
<td>14.8</td>
</tr>
<tr>
<td>5</td>
<td>Utah</td>
<td>14.7</td>
</tr>
<tr>
<td>6</td>
<td>Florida</td>
<td>14.3</td>
</tr>
<tr>
<td>7</td>
<td>Arizona</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>Georgia</td>
<td>13</td>
</tr>
<tr>
<td>9</td>
<td>Oregon</td>
<td>11</td>
</tr>
<tr>
<td>10</td>
<td>Tennessee</td>
<td>10</td>
</tr>
</tbody>
</table>

1 Stein 2002; 2 ECOS May 2016; 3 MNN 2015
The Good News...

...is that we can fix this.
Conservation Strategy

1. Safeguard biodiversity
2. Enable conservation
3. Empower with Education
4. Motivate with Inspiration
Priority regions for biodiversity conservation

Jenkins et al. 2015. US protected lands mismatch biodiversity priorities. PNAS
Protected lands

Jenkins et al. 2015. US protected lands mismatch biodiversity priorities. PNAS

Fig. 3. Protection status and ownership of lands in the lower 48 states. (A) Existing protected areas colored by IUCN category (41). (B) Ownership status of public, private, and Native American lands.
Safeguard Biodiversity: Species Recovery

Alabama Aquatic Biodiversity Center
Safeguard Biodiversity: Species Passage at Dams

Benefits of dams...

• Hydropower
• River Navigation
• Flood control
• Economic development
• Some forms of recreation
Safeguard Biodiversity: Species Passage at Dams

Negative impacts of dams on rivers...

Impacts of impoundments on river habitat

- Impounded river
  - Interruption of natural pool/riffle sequence
  - Loss of juvenile and spawning habitat
  - Accumulation of nutrients/pollutants
  - Uniform (slow) flow

- Un-impounded river
  - Greater habitat diversity
  - Greater biodiversity
  - Diverse depth
  - Diverse flow patterns
  - Uniform sedimentation
  - Barrier to fish migration and sediment transport

*Impoundments often create ‘weir pools’ downstream which provide holding habitat but at the expense of naturally-formed pools and riffle habitat
Safeguard Biodiversity: Species Passage at Dams

Passage facilitation

Bring down dead-beat dams

60 of Alabama’s fish species would benefit by restoring fish migration routes through our rivers.
Safeguard Biodiversity: Species Passage at Road Crossings

Bad  

Beautiful!

Patched pipe culvert; Eric Prowell, USFWS

Arch-span culvert; Will Duncan, USFWS
Safeguard Biodiversity: Tackle Sediment Pollution

- Greatest pollution threat
- Non-point source
- Negative effects:
  - habitat
  - plant growth
  - oxygen
  - feeding, mating
  - tissue abrasion
  - excessive nutrients
Safeguard Biodiversity: Tackle Sediment Pollution

Low-impact parking lots

Green Roofs

Soil Conservation in Agriculture

Reduce bank collapse caused by urban storm water runoff
Safeguard Biodiversity: Mitigate Climate Change

- Threats to river systems
  - Rising creek/river temperatures
  - Salt water wedging
  - Estuary erosion
  - Agricultural expansion to Alabama
Safeguard: Modernize Policies

Alabama needs a comprehensive water management plan

Protect water for...
- Drinking water
- Agriculture
- Fisheries
- Transportation
- Recreation
- Industry
- Biodiversity

All our neighbors have a water plan.
(Yes, even Mississippi.)

Shouldn’t we?

Courtesy of ARA
Alabama is blessed with many natural resources, but none is more important than water. Our rivers, lakes and streams sustain our communities, support industry and jobs, generate power, irrigate crops, provide critical transportation links, maintain wildlife and supply boundless opportunities for recreation.

When the Alabama territory was organized in 1817, Governor William Wyatt Bibb determined that the most suitable image for the official seal would be a map of our extensive rivers. Today, the Great Seal of Alabama continues to attest to the importance of these vital arteries.

Accustomed to an environment with abundant water, most of us assume that an adequate supply will be available to meet our needs. In recent years, however, large sections of our state have experienced periods of extreme drought, highlighting the need for responsible water management plans, which will help us ensure a plentiful supply in years to come.

As Alabama's population grows and our economy expands, so does the demand for water. Our water resources are substantial, but not limitless. As we harness this resource for the needs of today, we must do so with an eye toward tomorrow.
Conservation Strategy

1. Safeguard biodiversity
2. Enable conservation
3. Empower with Education
4. Motivate with Inspiration
2. Enable conservation

Alleviating basic insecurities (health, safety, economic) gives people a hopeful future, and this enables them to value and contribute to conservation efforts.
Conservation Strategy

1. Safeguard biodiversity
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3. Empower with Education
4. Motivate with Inspiration
3. Empower with Education
Ecosystem Services
Support Human Well-Being

Supporting Services
- Nutrient cycling
- Soil formation
- Photosynthesis

Provisioning Services
- Food, Fresh water
- Wood, Fiber, Fuel

Regulating Services
- Climate and Flood Regulation,
- Disease Control, Water Cleansing

Cultural Services
- Aesthetic, Spiritual,
- Educational, Recreational

Constituents of Well-Being
- Security
- Basic material for good life
- Health
- Good social relations
- Freedom of choice & action

Modified from Millennium Ecosystem Assessment
Ecosystem Services
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Ecosystems provide MORE and BETTER services when their native species are present

Modified from Millennium Ecosystem Assessment
3. Empower with Education

The *Coosa Moccasinshell* is endangered from human activities and is restricted to the Coosa and Cahaba Rivers. If you were to now learn it is now extinct, would you feel at least just a little sense of disappointment, loss, or sadness?

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<td>Coosa Moccasinshell</td>
<td>46%</td>
<td>54%</td>
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The Alabama Lampmussel, like all mussels, helps clean river water of pollution so it keeps river ecosystems healthier. Mussels provide cleaner waters for recreation, extraction for drinking water, both of which have economic value. If you were to learn it is now extinct due to human causes, would you feel at least just a little sense of disappointment, loss, or sadness?

a. Yes

b. No

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<td>76%</td>
<td>24%</td>
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3. Empower with Education

We need better statewide public education efforts about the importance of our aquatic resources...
Instead of this....
Alabama's Placate Rocksnail is headed for Extinction!

So What?
Visit www.youralasc prevent extinction.org
Conservation Strategy

1. Safeguard biodiversity
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4. Motivate with Inspiration

- Craft an *inclusive* vision of our *shared* future
- All people and species are healthy and prosperous
- Motivate people to work towards this goal
Cook Museum of Natural Science
Wheeler NWR
McWane Science Center
Cahaba Blueway Trail
Cahaba River NWR
Tennessee Aquarium River Journey
Little River Canyon
Chattahoochee River
Whitewater Park
Dauphin Island Sea Lab
Five Rivers Delta Resource Center
Alabama Aquatic Biodiversity Trail
Autumn Duncan, age 4, spontaneously dancing in Turkey Creek
Solar System’s Aquatic Biodiversity Hotspot: NEEDS YOUR HELP!
Predicted climate changes for Alabama this century

- Summer maximum temperatures will increase 3–7° F.
- Winter minimum temperatures will increase 5–10° F.
- Relative sea level will rise 15-44 inches.
- Tropical cyclones will be more powerful.
- Droughts will be more frequent and longer.
- Marine waters will acidify, endangering marine ecosystems.

How will these change affect our native species?

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1 Sources: Twilley, 2001; Davenport, 2007; and Primack, 2010.
### Alabama’s Eventual Ranking?

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Alabama’s fishes

85+ species of shiner (Cyprinidae)
Alabama’s fishes

80+ species of darter (Percidae)

Vermilion Darter
Alabama’s fishes

Two species of cavefish (f. Amblyopsidae)
Alabama’s fishes

19+ species of catfish (f. Ictaluridae)

Frecklebelly Madtom

Courtesy of: http://www.flmnh.ufl.edu
Alabama’s Carnivorous Plant Diversity

#1 in US and global hotspot for carnivorous plants.
Alabama’s Herp Diversity

# 3 in US for herpetological diversity

Eastern Diamondback Rattlesnake

Cave Salamander

1 ALAPARC
Impacts of impoundments on river habitat

Impounded river
- Interruption of natural pool/riffle sequence*
- Loss of juvenile and spawning habitat
- Uniform (slow) flow
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