Outline

1. Introduction & Context

2. Invasive Species & Freshwater Resources

3. The Need for Productive Partnerships & Creative Solutions
I. Introduction & Context

The pressures on freshwater (globally and in Arkansas)
Global Water Inventory

Saltwater
97.5%
1 365 000 000 km³

Freshwater
2.5%
35 000 000 km³

- 0.3% Lakes and river storage
- 30.8% Groundwater, including soil moisture, swamp water and permafrost
- 68.9% Glaciers and permanent snow cover

0.3% = 105 000 km³
30.8% = 10 780 000 km³
68.9% = 24 115 000 km³

Global Water-Use

1 m³ ~ 274 gallons

Image sources: http://chartsbin.com;
Data source: FAO
Pressures on Groundwater

Ground Water Use in Arkansas as of 2009 (Mgal/day)

Legend
- 0 - 1 Mgal/day
- Greater than 1 - 10 Mgal/day
- Greater than 10 - 100 Mgal/day
- Greater than 100 - 400 Mgal/day
- Greater than 400 - 1000 Mgal/day
- Total Use (Mgal/day): 6068.53

Data Obtained from United States Geological Survey

Total Ground Water Use (Mgal/day)

Year

Million Gallons Per Day
0 1000 2000 3000 4000 5000 6000 7000 8000

Source: Arkansas Natural Resources Commission
Generalized Areas with Cones of Depressions

Critical Ground Water Designations

Legend
- Green: Crowley's Ridge
- Yellow: Current Study Areas
- Red: Current Critical Areas
- Blue: County Seats
- Brown: County Boundaries

Source: Arkansas Natural Resources Commission
Section 1. Introduction & Context

ECONOMIC Contribution of Arkansas Agriculture 2012

$16,003,372,059

Agriculture accounted for $16.0 billion of value added to the Arkansas economy in 2010.

That’s more than 16 cents of every $1 of Value Added.¹

¹Value Added is the sum of employee compensation, proprietary income, other property-type income and indirect business taxes.


Computed using 2010 Arkansas database from MIG, Inc. (Latest year for which relevant data were available.)
2. Invasive Species & Freshwater Resources

The pressures on freshwater and associated economic assets in N. America (and Arkansas), from invasive species
GEOGRAPHICAL
ENVIRONMENTAL (LOCAL)
REPRODUCTIVE
DISPERsal
ENVIRONMENTAL DISTURBED VS. NATURAL
NOVEL/INVADED RANGE

PREVENTION
CURE

REGULATION & QUARANTINE
ERADICATION FEASIBLE
CONTAINMENT POSSIBLE
MITIGATION NECESSARY
Invasive Species & Freshwater Resources

- Invasive species are widespread and common in freshwater
  - Freshwater is a relatively homogenous habitat
    - Geography is the most important barrier
  - If geography is overcome
    - Very few freshwater sites are unsuitable for many freshwater invaders
New Zealand Mud Snail: “Likely to find all shallower waters (<50 m depth) as suitable habitat”

- voracious herbivores capable of removing most aquatic vegetation, significantly impacting stream invertebrates and fish breeding habitat

Source: USGS; Loo et al. (2007)
## Numbers of Alien Invasive Species in Freshwater Habitats in N. America

<table>
<thead>
<tr>
<th>Category</th>
<th>From within N. America</th>
<th>From outside N. America</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants</td>
<td>20</td>
<td>114</td>
</tr>
<tr>
<td>Molluscs</td>
<td>19</td>
<td>31</td>
</tr>
<tr>
<td>Crustaceans</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>Other invertebrates</td>
<td>7</td>
<td>18</td>
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<tr>
<td>Fishes</td>
<td>314</td>
<td>116</td>
</tr>
<tr>
<td>Amphibians</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Reptiles</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>Mammals</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>419</strong></td>
<td><strong>323</strong></td>
</tr>
</tbody>
</table>

Source: USGS (2008); Strayer (2010)
Section 2. Invasive Species & Freshwater Resources

Source: USGS(2012); http://nas.er.usgs.gov/
Section 2. Invasive Species & Freshwater Resources

### Origin of Species Introduced in Arkansas

- **25** (25.25%) from North America
- **13** (13.13%) from Eurasia
- **12** (12.12%) from Asia
- **2** (2.02%) from South America
- **2** (2.02%) from Europe
- **2** (2.02%) from Africa
- **1** (1.01%) from AustralAsia
- **1** (1.01%) from Europe and Africa

### Introduction Pathways for Arkansas

- **39** (33.62%) stocked
- **8** (6.90%) unknown
- **6** (5.17%) aquaculture
- **6** (5.17%) aquarium release
- **2** (1.72%) bait release
- **2** (1.72%) hitch hiker
- **2** (1.72%) dispersed
- **2** (1.72%) escaped captivity
- **1** (0.86%) planted
- **1** (0.86%) shipping
- **1** (0.86%) released
- **1** (0.86%) pet release

Source: USGS(2012); http://nas.er.usgs.gov/
Molluscs

Invasion Sequence: 1986-2010

Sources: USGS; SUNY;
Impacts – Molluscs

Source: Bay View Compass; USACE; Malacological Society (UK)
Fish

Source: Associated Press; USGS; USFWS
Crustaceans

Source: USGS; Aquatonics Ltd.
Diseases

Section 2. Invasive Species & Freshwater Resources

Source: USDA; http://amphibianrescue.org; http://amphibianweb.org
Impacts on Invasive Plants on Water Resources

- **Quality**
  - Light ↓
  - Nitrate ↓
  - Phosphate ↓
  - Oxygen ↓
  - Macroinvertebrates ↑
  - Plant Biomass ↑

- **Quantity**
  - Evapotranspiration ↑
  - Invasive > Native
    - At the plant scale
      - 1-3 fold difference
    - Per unit ground area
      - 2-5 fold difference
    - Ecosystem scale
      - 0.5-2 fold difference

Source: Strayer (2010); Calveri & Sack (2010)
Freshwater-Dependent Assets

- Value of economic assets at risk
  - Wild-associated recreation
    - US ~$138 billion; Fishing & Hunting ~$87 billion
    - AR ~$1.8 billion; Fishing & Hunting ~$1.5 billion
  - Agriculture
    - AR ~$16 billion
      - Freshwater-dependent commodities: ~60-70%
- Other Human needs
  - Urban
- Value to the environment?

3. The Need for Productive Partnerships & Creative Solutions

In AR and beyond, how can we facilitate sustainable access to freshwater for humans, agriculture and the environment?
Demand Management

- Monitoring usage
  - Usage-based charges
    - For it to be effective needs
- Cap-and-trade
  - Catchment-wide cap on resource extraction
  - Catchment & inter-catchment scale trade of water rights
- Incentives for desirable use
- Education & Extension
- Regulation

Image Source: http://mdjunction.com
Water Stress in South Africa

Source: Dept. of Water Affairs (RSA); Dept. of Science & Technology (RSA)
Working for Water (S. Africa)

- Enhance Water Security
- Improve Ecological Integrity
- Restore the Productive Potential of Land
- Sustainable use of natural resources
- Invest in marginalized sectors of society

Source: Dept of Water Affairs (RSA)
WfW – Record of Achievement

- A focus on invasive plants
- Employment
- Outreach
- New economic incentives
Partnerships
What might a “Working for Water-Arkansas” look like?
“...the freshwater crisis is an early proxy of the twenty-first century's ultimate challenge of learning how to manage our crowded planet's resources in both an economically viable and an environmentally sustainable manner.”

Source: Harper Collins