2019 NCAFS Annual Meeting Continuing Education Workshop

Aquatic Nuisance Species in NC – where we are, where we are headed, and things we can do to help!

NORTH CAROLINA Wildlife RESOURCES COMMISSION

Introduction

Kevin Hining - NC Wildlife Resources Commission

Northern Mountain Regional Education Specialist

- Design and/or teach a variety of wildlife related workshops

- Conduct outreach events (festivals, schools, etc.)

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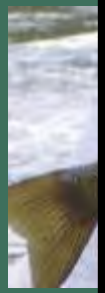

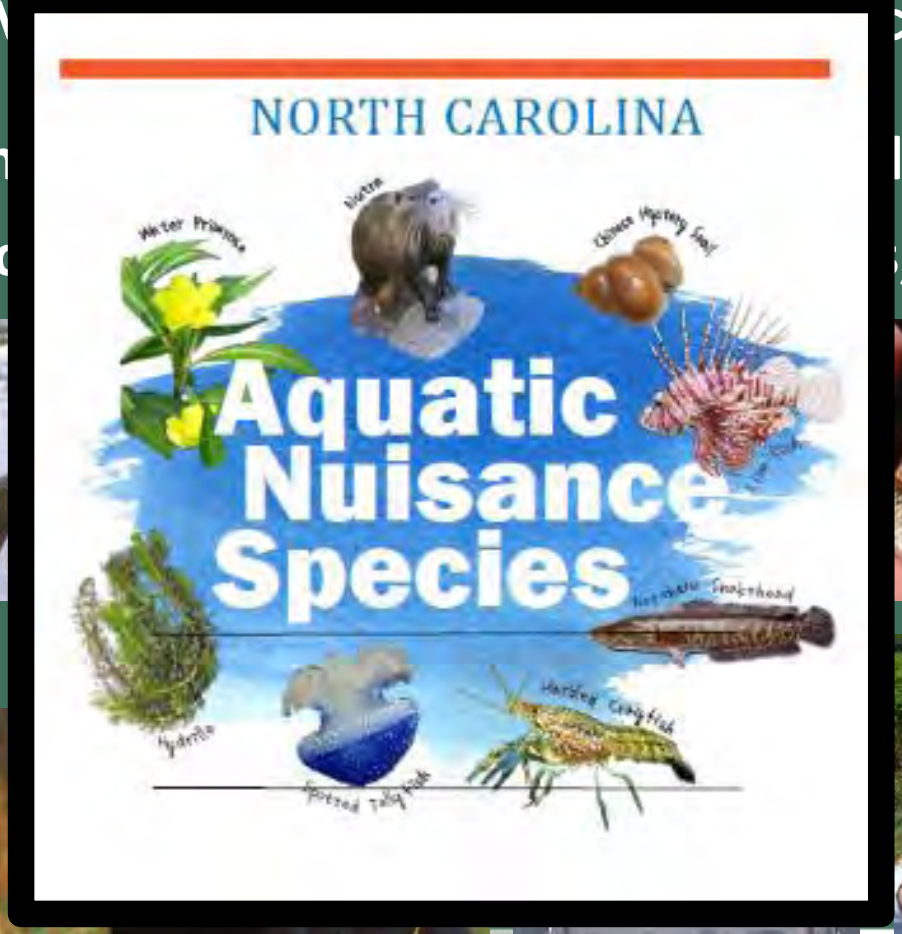

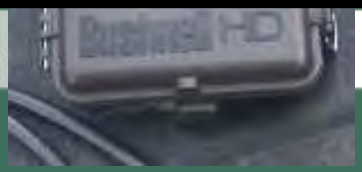

Workshop Layout

Chris Goudreau - introduce the NCANS Management Plan.

NCWRC & NCANS Management Plan Steering Committee member

Bryn Tracy - nuisance freshwater fish

Retired fisheries biologist (but not really retired…)

TR Russ - nuisance crayfish

Luke Etchison & Dylan Owensby - nuisance mollusks

NCWRC Aquatic Wildlife Diversity staff members

Erika Haug & Jessica Baumann - aquatic nuisance plants

NC State University Aquatic Plant Management Program

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Introduced species can be a major threat to biodiversity

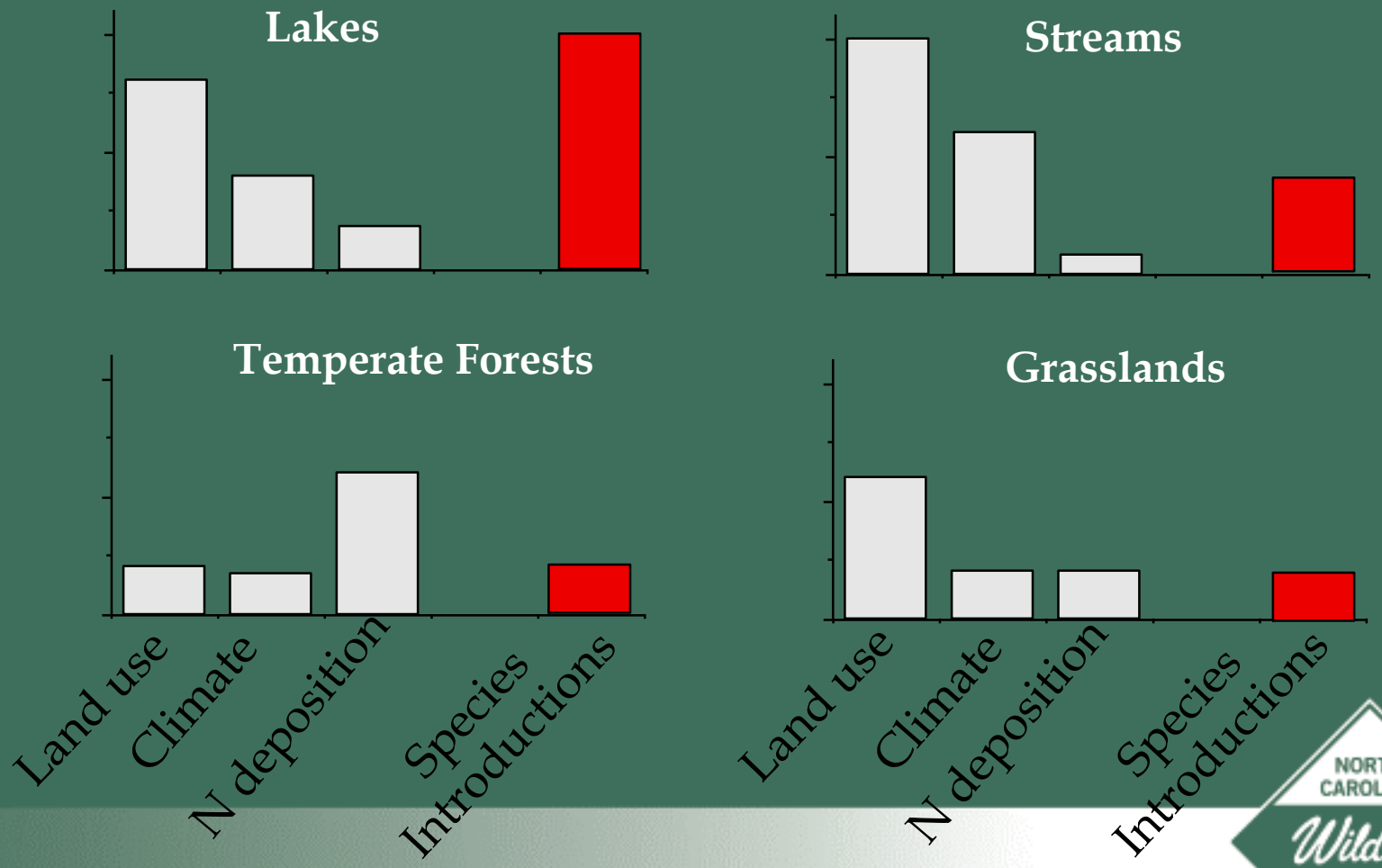
Prevention = best management

Public awareness needed about

-Impacts

-How they spread

Causes of Biodiversity Change



(Sala et al. *Science* 2000)

What is a Nuisance Species?

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What is a Nuisance Species?

Dragons!

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What is a Nuisance Species?

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What is a Nuisance Species?

Gremlins

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What is a Nuisance Species?

Two very different definitions, depending on who you ask…..

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May be native or nonnative, and may cause ecological and economic harm.

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What is a Nuisance Species?

An exotic or nonnative species that has been introduced and is causing ecological and/or economic harm

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Exotic = nonnative = nonindigenous = alien

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What is a Nuisance Species?

An exotic or nonnative species that has been introduced and is causing ecological and/or economic harm

Exotic = nonnative = nonindigenous = alien

Not all exotic species become nuisance species, but all nuisance species are exotic!

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Aquatic nuisance species **(ANS)** are aquatic nonnative organisms that have been introduced and are causing ecological or economic harm

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Aquatic nuisance species **(ANS)** are aquatic nonnative organisms that have been introduced and are causing ecological or economic harm

Top – Alewife (Illustration by Duane Raver)
Bottom – Blueback Herring (Illustration by Duane Raver)

White Perch (Illustration by Duane Raver)

Alewife, Blueback Herring, White Perch – in reservoirs

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Alewife, Blueback Herring, White Perch – in reservoirs

Blue Catfish

NORTH CAROLINA Wildlife RESOURCES COMMISSION

***Aquatic nuisance species* (ANS)** are aquatic nonnative organisms that have been introduced and are causing ecological or economic harm

Alewife, Blueback Herring, White Perch – in reservoirs

Flathead Catfish

Blue Catfish

NORTH CAROLINA Wildlife RESOURCES COMMISSION

***Aquatic nuisance species* (ANS)** are aquatic nonnative organisms that have been introduced and are causing ecological or economic harm

Asian Clam

Flathead Catfish

Alewife, Blueback Herring, White Perch – in reservoirs

Blue Catfish

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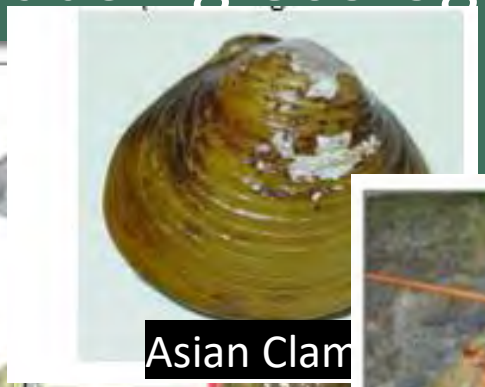

Alewife, Blueback Herring, White Perch – in reservoirs

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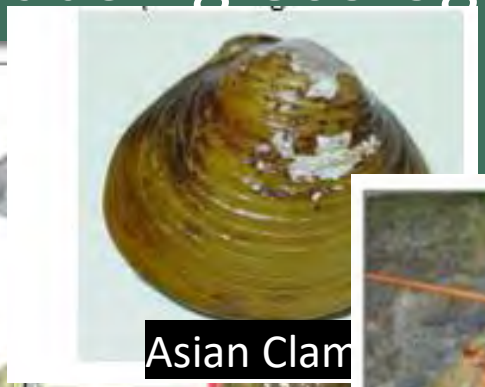

Asian Clam

Virile Crayfish

Hydrilla

Flathead Catfish

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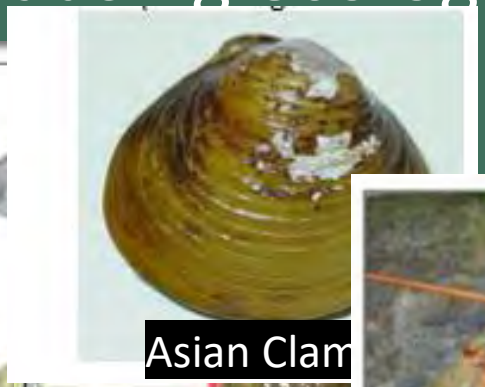

Asian Clam

Virile Crayfish

Flathead Catfish

Blue Catfish

The Good News.....

Not all exotic aquatic species will become a nuisance in North Carolina. Statistically, only a small percentage will become an issue.

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Threadfin Shad

Grass Carp

The Bad News…..

The movement of any organism from one waterbody to another can cause problems……..

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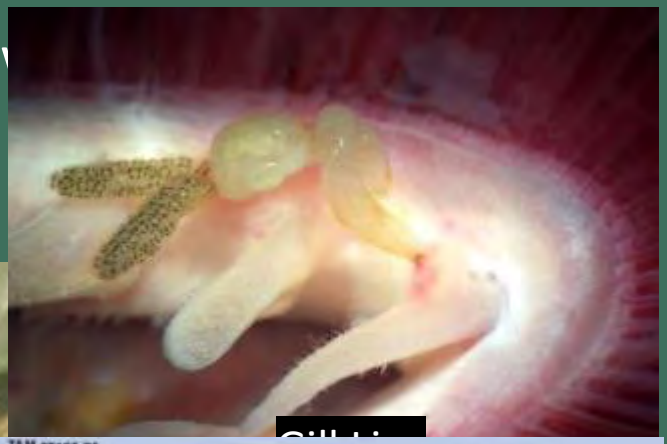

Whirling Disease

The Bad News…..

Aquatic Nuisance Species affect:

The Bad News…..

Aquatic Nuisance Species affect:

- <u>the survival and diversity of our native plants and animals</u>
  predation, competition, disease, interbreeding

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The Bad News…..

Aquatic Nuisance Species affect:

- the survival and diversity of our native plants and animals

- <u>natural ecosystem functions</u>
  decreases water flow, oxygen issues

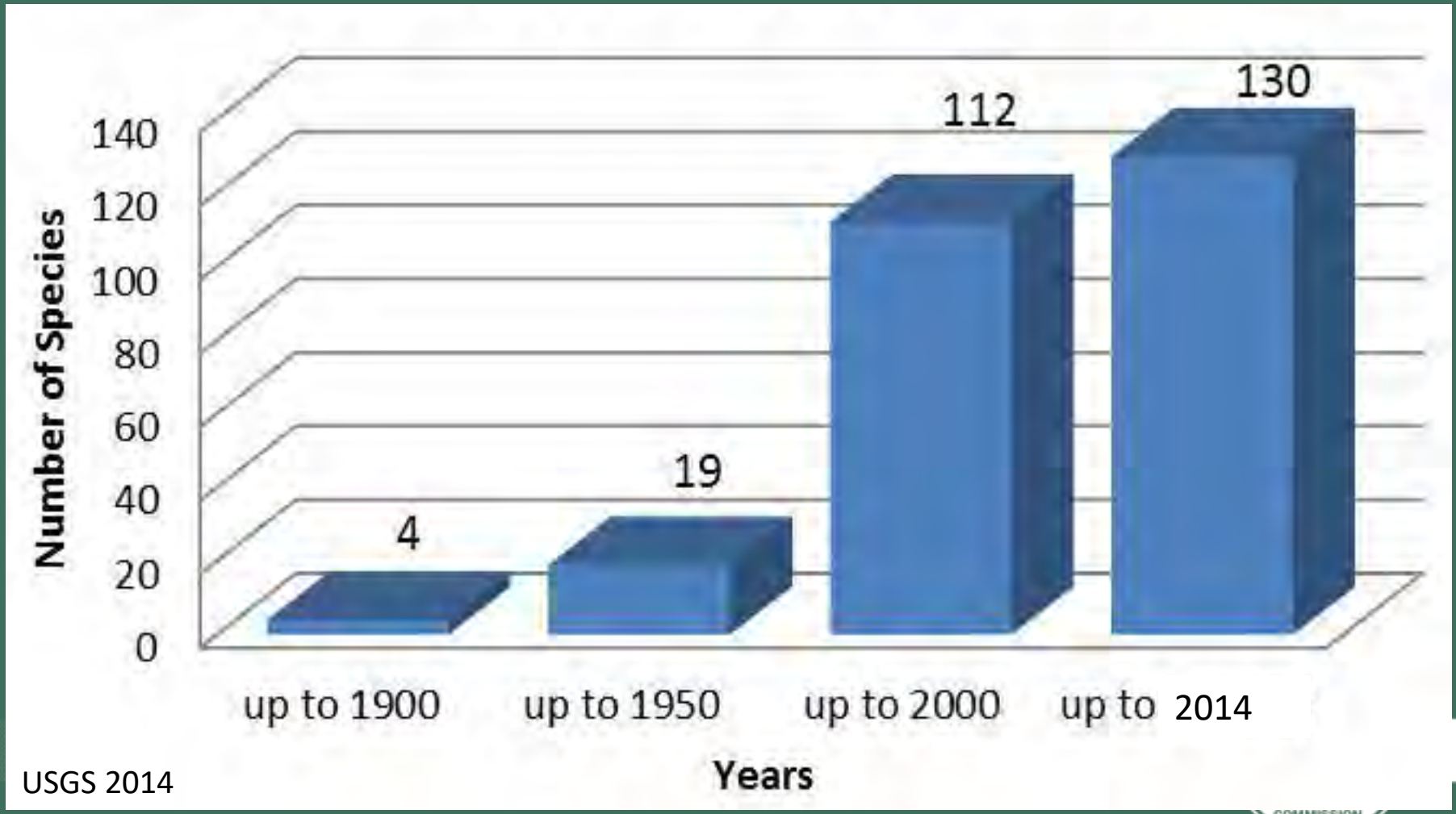
The Bad News…..

Aquatic Nuisance Species affect:

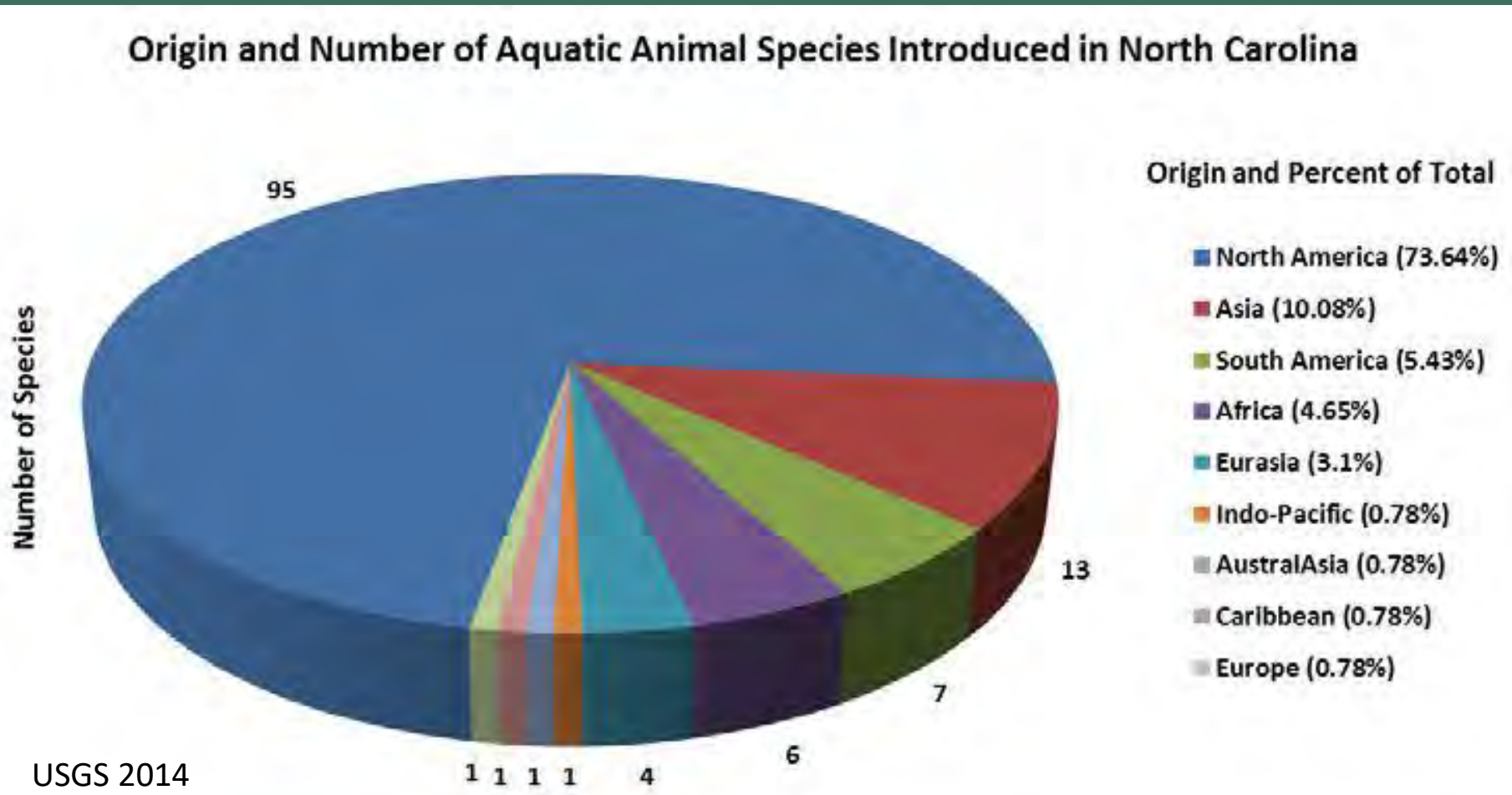
- the survival and diversity of our native plants and animals
- natural ecosystem functions
- the use of our waterways for recreational, commercial, and industrial activities.

Steve Hoyle, NCSU Crop Science

Cumulative number of aquatic animal species introduced to North Carolina waters



USGS 2014



USGS 2014

Origin and number of nonnative aquatic animals introduced in North Carolina (USGS 2014).

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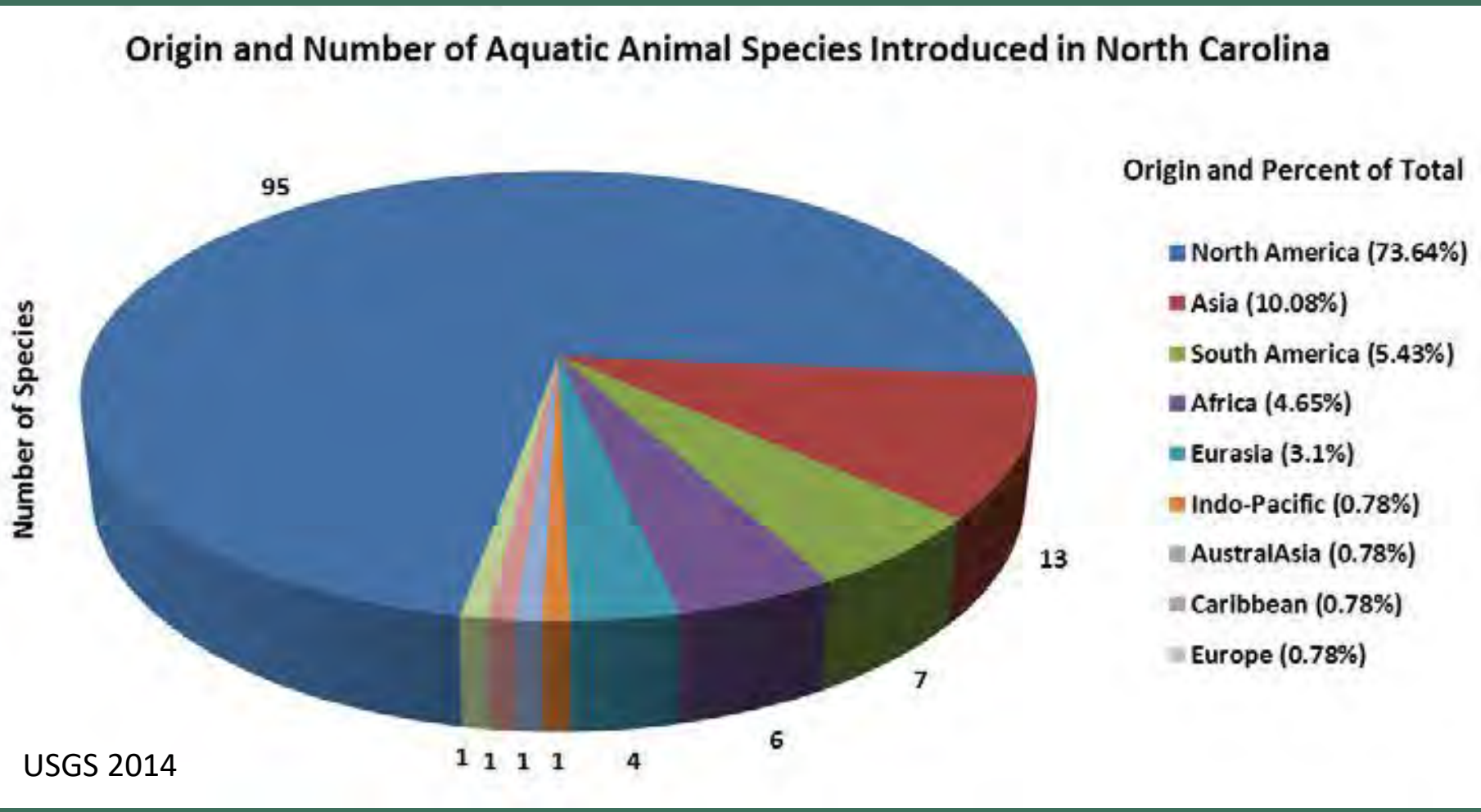


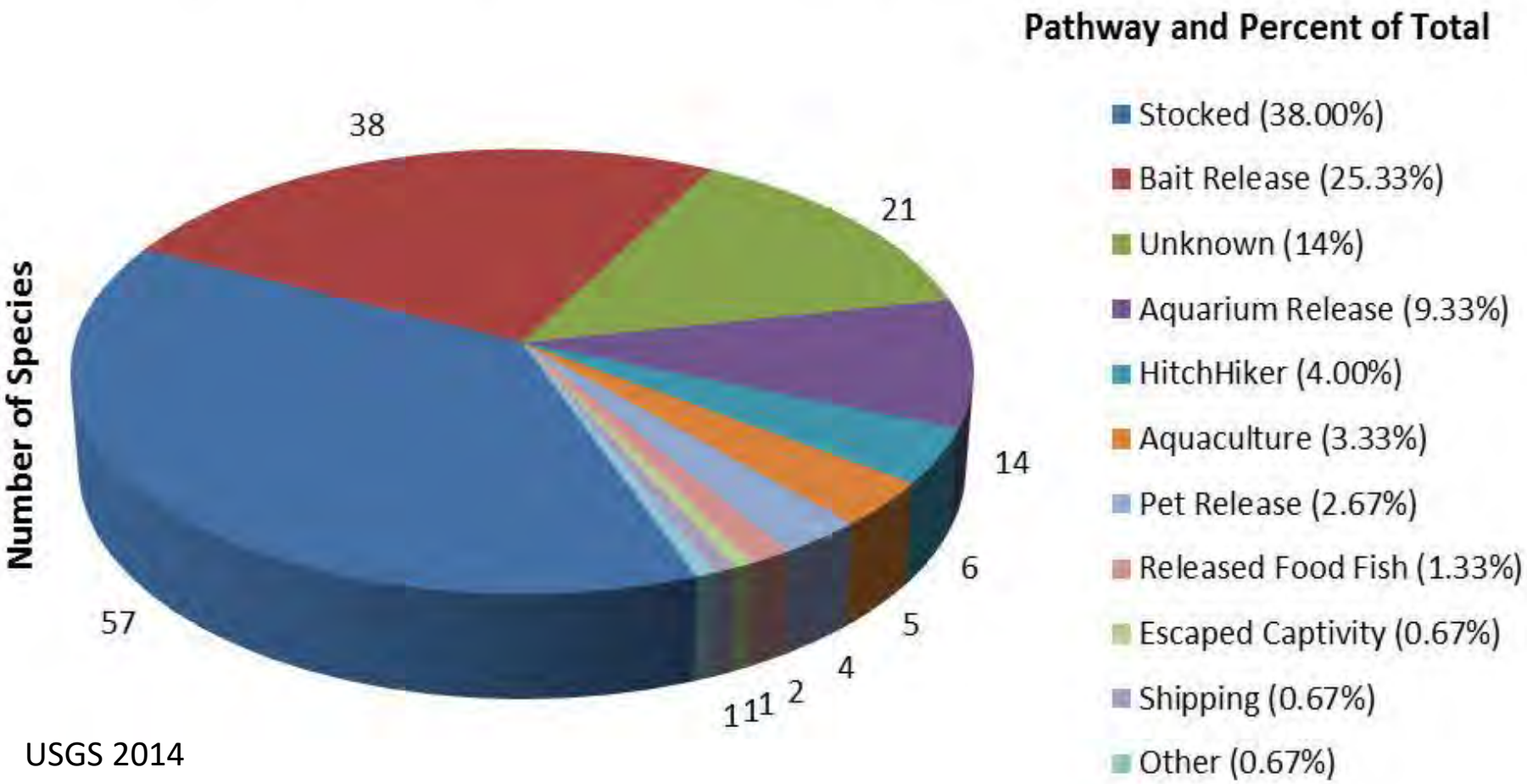
USGS 2014

- Nearly 75% of the introduced aquatic animal species found in NC, were introduced from other locations in North America.

- Humans have played a key role in introducing the majority of these nonnative species, either unintentionally or intentionally.

How Did They Get Here?

Aquatic Animal Introduction Pathways for North Carolina



USGS 2014

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What Can We Do To Help?

Prevention = Best Management Option!

Educate!

Prevent unintentional spread (think small)

Use native species

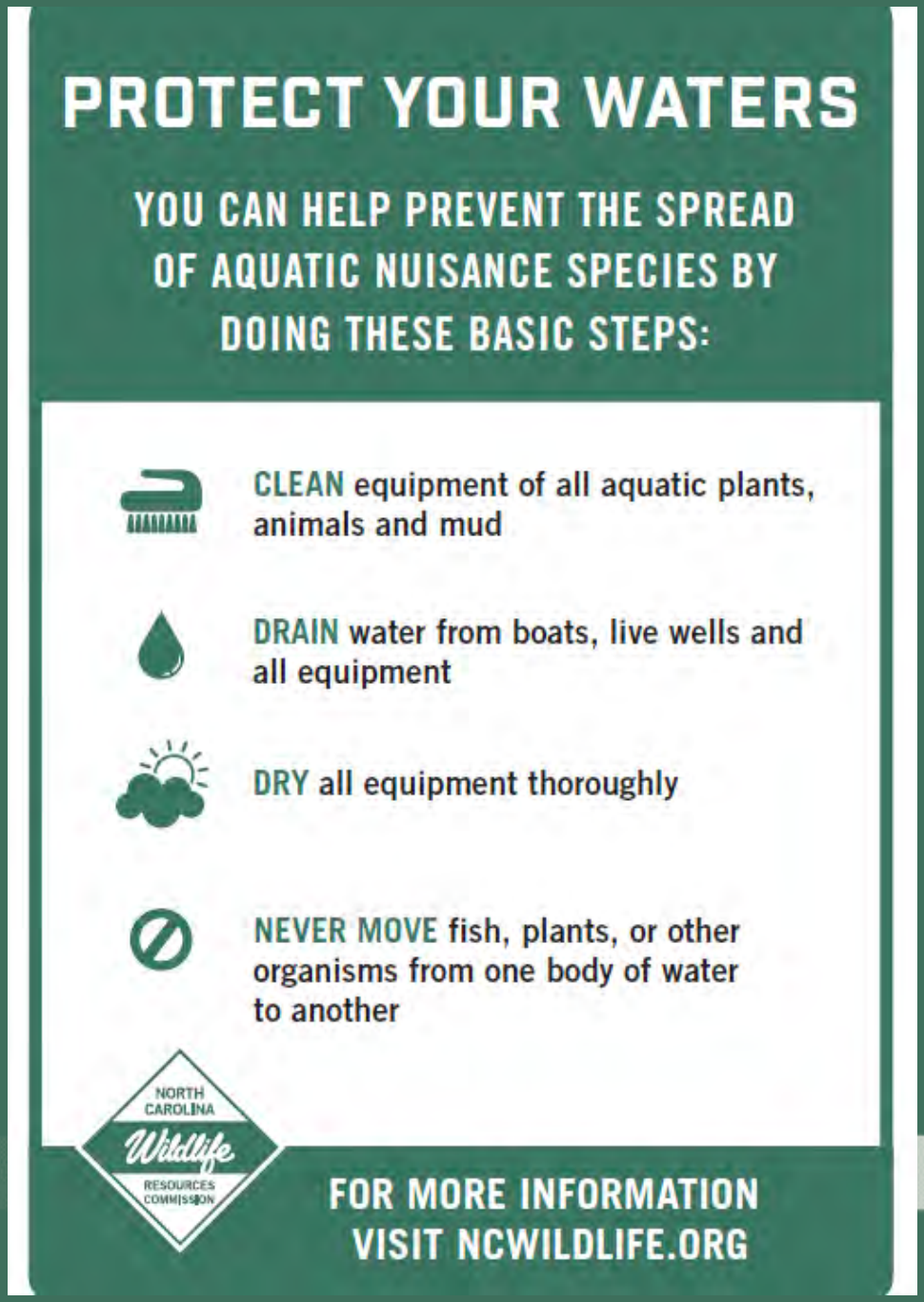
Do not release pets

Spread the word

Educational Programing →

Eradicate!

Early detection is key



[NCWRC Aquatic Nuisance Species webpage]

NCWRC ANS Committee (Todd Ewing, Chair)

NORTH CAROLINA Wildlife RESOURCES COMMISSION

STOP AQUATIC HITCHHIKERS!™
Be A Good Steward. Clean. Drain. Dry.

CLEAN DRAIN DRY

[NC Extension Aquatic Weed Management]

[Center for Aquatic and Invasive Plants]

[NCDEQ Aquatic Weed Control Program]

[Freshwater Mollusk Conservation Society]

[NC Aquatic Nuisance Species Management Plan]

[USDA aquatic invasive species education]

[Aquatic Invasive Species Education Program]

Play Clean Go

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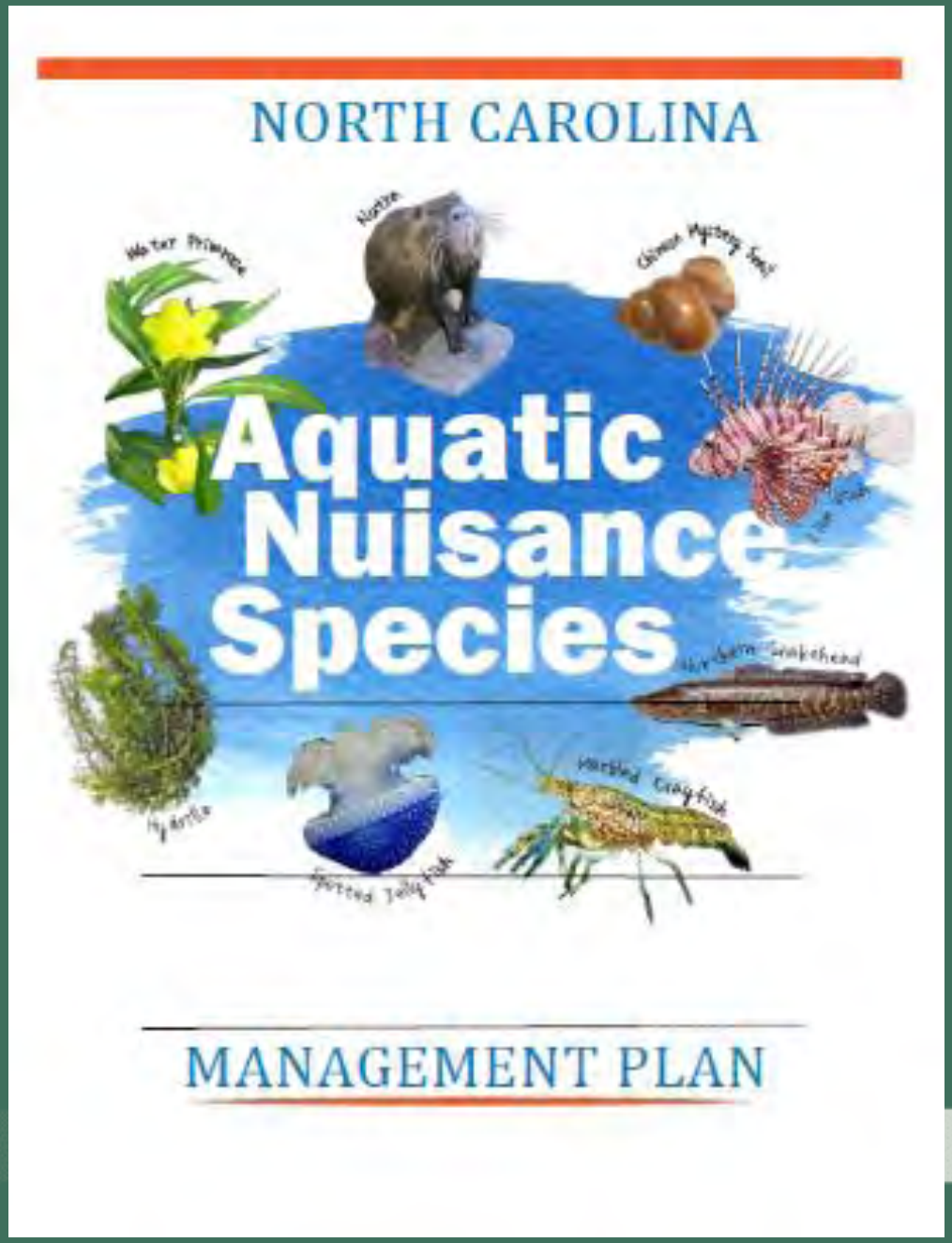


NC Aquatic Nuisance Species Management Plan

NORTH CAROLINA Wildlife RESOURCES COMMISSION

North Carolina Aquatic Nuisance Species Management Plan

February 20, 2019

Chris Goudreau

Hydropower & Special Projects Coordinator

North Carolina Wildlife Resources Commission

Presentation Outline

- Background
- ANS Plan Development
- Plan Components
- Next Steps

Rusty Crayfish

Water Primrose

Alewife

Asian Clam

Nutria

Background

- What are ANS?
  - Aquatic non-native organisms that have been introduced and are causing ecological and/or economic harm
- Why are ANS an issue?
  - Cost $120 B/yr in damages and management in US (2005 data)
- National Invasive Species Act of 1996
  - Directed states to create ANS plans
  - Established federal ANS Task Force
- NC status and forcing factors
  - One of last states without a plan
  - Hydrilla in Lake Waccamaw – listed species, state park, $$$

Red Swamp Crawfish

Status of State ANS Plans

Plan Development

- Steering Committee
  - NCDA&CS
  - NCDEQ – DCM, DMF, DWR
  - NCSU
  - NCWRC
  - USFWS
- Facilitation and support by NCDEQ
- Time frame
  - June 2014 – Sept. 2015

Water Hyacinth

Apple Snail

Plan Development

Northern Snakehead

- Federal guidance on plan components
- Discussion and agreement on approach and ground rules
- Challenging and complex issues
  - Underlying interests – commerce, recreation, environment
  - Jurisdictions
    - To raise or possess a species might require a permit or consultation with 2-3 agencies
    - Some species don't squarely fit into one jurisdiction (e.g., diadromous spp.)
  - Existing conditions – clean lists, prohibited lists, existing non-natives
- Plan sections assigned to team members

Japanese Mysterysnail

Plan Components

- Introduction
- Problem Description
- Pathways of Introduction
- ANS Species of Concern
- Jurisdiction and Responsibilities
- Management Goals and Objectives
  - Strategies and Actions
- Species Lists
- Species Fact Sheets

Alligatorweed

Zebra Mussel

Species Lists

White Perch

- Compiled:
  - NC and federal prohibited, noxious, injurious or invasive species lists
  - Lists from aquatic nuisance management plans of adjacent states
- Removed duplicates and those species not pertinent to NC
- Added known invasive or nuisance species in the state
- Reviewed for accuracy and adjusted based on current knowledge

Hydrilla

Species Lists

Bighead Carp

Eurasian Watermilfoil

1. Nuisance – extant and causing harm (Hydrilla)
2. Invasive – extant and likely to cause harm (Green Sunfish)
3. Nonnative – extant but no evidence of significant impacts or have been part of ecological landscape for many decades (Rainbow Trout)
4. Not extant but high risk of becoming a nuisance (Zebra Mussel)
5. Not extant but lower risk of becoming a nuisance (N. Pike)
6. Native NC species outside of original range considered nuisance in the introduced waters (Alewife)
7. Native NC species outside of original range considered invasive in the introduced waters (White Bass)
8. Species with questions as to origin, presence in NC, or nuisance potential (mostly marine species)

ANS Species of Concern

- Nuisance species were ranked by Steering Committee to determine species that should receive the most attention for action.
  1. Ecological Impacts
  2. Current Distribution and Status
  3. Trend in Distribution and Abundance
  4. Management Difficulty
  5. Economic Impact

Parrotfeather

- Rated (H, M, L) for each criterion. Mean rating calculated for each criterion. The five means for each species were summed to give a composite score. Scores then order ranked.

High Priority ANS

Lionfish

Scientific Name	Common Name	Taxa Group	Native Habitat	Rank
Hydrilla verticillata	Hydrilla	Plant	Freshwater	1
Pterois miles	Lionfish; Devil Firefish	Fish	Marine	2
Pterois volitans	Red Lionfish	Fish	Marine	2
Nymphoides peltata	Yellow Floating Heart	Plant	Freshwater	4
Phragmites australis australis	European Common Reed	Plant	Freshwater-Brackish	4
Orconectes rusticus	Rusty Crayfish	Crayfish	Freshwater	6
Procambarus clarkii	Red Swamp Crawfish	Crayfish	Freshwater	6
Alternanthera philoxeroides	Alligatorweed	Plant	Freshwater	6
Orconectes virilis	Virile Crayfish	Crayfish	Freshwater	9
Ictalurus furcatus	Blue Catfish	Fish	Freshwater	10
Lyngbya spp.	Blue-green Algae; Black Mat Algae	Cyanobacterium	Freshwater	11
Cipangopaludina chinensis malleata	Chinese Mysterysnail	Gastropod	Freshwater	12
Cipangopaludina japonica	Japanese Mysterysnail	Gastropod	Freshwater	12
Anguillicoloides crassus	Eel Swimbladder Nematode	Nematode	NA	12
Myriophyllum spicatum	Eurasian Watermilfoil	Plant	Freshwater	12

Fact Sheets

Freshwater Animals:

Alewife (*Alosa pseudoharengus*)
Blueback Herring (*Alosa aestivalis*)
When Introduced into Reservoirs

Taxa Group: Fish

Size: In reservoirs, up to 10 inches.

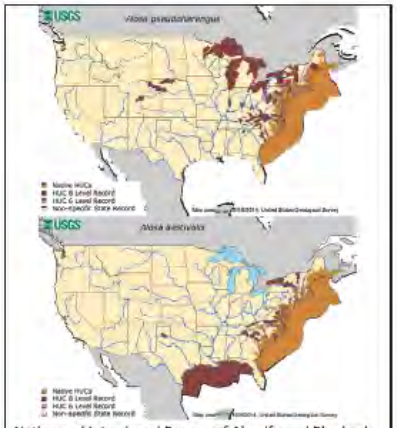
Distinctive Physical Characteristics: Both species are small herring with a dark dorsal side, bluish to greenish, and light sides with horizontal darker stripes. They are distinguished from other inland shad by the lack of an elongated posterior dorsal ray.

Habitat: Collectively referred to as "river herring," both species have anadromous spawning runs in coastal rivers and streams. Reservoir populations also use tributary streams for spawning. Both species prefer cooler water in summer in reservoirs.

Native Range: Atlantic coastal rivers and streams.

NC History: Native anadromous runs in coastal rivers; landlocked populations introduced in various reservoirs 1970-present.

Current NC Distribution: Widespread in impoundments of Atlantic Slope rivers throughout North Carolina. Blueback Herring have also been introduced in all major impoundments of the Hiwassee River and in Glenville Reservoir on the West Fork Tuckasegee River.



Native and Introduced Ranges of Alewife and Blueback Herring (U.S. Geological Survey)


Top – Alewife (Illustration by Duane Raver)
Bottom – Blueback Herring (Illustration by Duane Raver)

Pathway of Introduction: Bait bucket/live well transfer; some populations established by stocking.

Management and Control: None, once established; public education and signage have been used to discourage further introductions in reservoirs.

Impacts and Uses of Alewife and Blueback Herring

Ecological: Establishment of reservoir populations of river herring has been linked to recruitment failure of river-spawning sport fish, particularly Walleye.

Economic: River herring are an important fishery in their native range. In reservoirs they provide forage for larger fish and bait for anglers. However, they have a costly impact on Walleye fisheries that must be supported by hatchery culture and stocking once river herring become established.

Human Health or Human use: Native coastal river runs are harvested as food fish; in reservoirs, river herring are highly prized as bait fish for Striped Bass and other sport fish.

Sources:
Fuller, P., E. Maynard, D. Raikow, J. Larson, A. Fusaro, and M. Neilson. 2015. *Alosa pseudoharengus*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=490 Revision Date: 10/17/2012.

Fuller, P., G. Jacobs, J. Larson, A. Fusaro, and M. Neilson. 2015. *Alosa aestivalis*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=488 Revision Date: 6/14/2013.

Freshwater Plants:

Hydrilla
(Hydrilla verticillata)


Hydrilla. (©Bridget Lassiter)


Tar River Reservoir, NC. 2006. (©Rob Emens)

Taxa Group: Plant

Size: Depending on depth and water quality (a few inches to 8 feet+). Up to 20 feet in some reservoirs.

Distinctive Physical Characteristics: A submersed, rooted perennial with a very fast growth rate. Plants persist through the winter as subterranean tubers which sprout in the spring. Shoots grow laterally and vertically, often reaching the surface by late summer. Hydrilla is one of the most invasive plants found in NC. Leaves are oblong, sessile and whorled in groups of 4-8 around the stem. Leaf margins are serrated. Flowers are small, delicate and inconspicuous, often forming in late summer or autumn.

Habitat: Freshwater areas around the state, including rivers, lakes, and ponds.

Native Range: Asia

NC History: First discovered in 1980 in Wake County. From mid 1980s to late 1990s it spread to many Piedmont reservoirs where management was primarily done with triploid grass carp. Only recently has it become widespread in many of the water systems of the state.

Current NC Distribution: Statewide, from Mountains to Coastal Plain.

Introduced Distribution of Hydrilla. (EDDMapS, 2015)

Pathway of Introduction: Boaters and other recreationists and waterfowl/wildlife.

Management and Control: Herbicides and biological control with triploid grass carp.

Impacts and Uses of Hydrilla in NC

Ecological: Alters habitat by forming dense colonies which displaces and/or suppresses native submersed aquatic plants. Decrease in water flow contributes to sediment buildup. Extensive growth provides substrate for the causative agent of Avian vacuolar myelinopathy (AVM) that kills waterfowl and bald eagles.

Economic: Impedes navigation in waterways, impacts recreation activities and fouls water intakes and hydroelectric dams.

Human Health or Human use: Limited distribution as a nutritional supplement. Creates stagnant water which increases mosquito breeding habitat.

Sources:
Aulback-Smith, C. A. and S. J. de Kozlowski. Aquatic and Wetland Plants of South Carolina. 1996. SC DNR and SCAPMS.
Lassiter, B., R. Richardson, and G. Wilkerson. 2008. Aquatic Weeds: A Pocket Identification Guide for the Carolinas, NC Cooperative Extension.
EDDMapS. 2015. Early Detection & Distribution Mapping System. The University of Georgia Center for Invasive Species and Ecosystem Health. http:www.eddmaps.org/distribution/usstate.cfm?sub=3028. Acc. 9-19-15.

Goal and Objectives

Crested Floating Heart

Plan Goal – Prevent and control the introduction, spread and negative impacts of aquatic nuisance species in North Carolina.

1. Increase the coordination of aquatic nuisance species prevention and management activities.
2. Educate public and private stakeholders on the impacts of aquatic nuisance species.
3. Review existing federal and state legislation and regulations to identify inconsistencies and gaps.
4. Identify and secure new funding for aquatic nuisance species activities.
5. Monitor occurrence and spread of aquatic nuisance species.
6. Manage populations of aquatic nuisance species and manage other aquatic invasive species as appropriate to prevent their establishment and spread.
7. Identify and implement needed research on impacts and control of aquatic nuisance species.

Strategies and Actions

Water Lettuce

Objective 1: Increase the coordination of ANS activities.

Tactic	Description	Lead Agency	Cooperators	Funding Sources	Priority Level	Planned Effort			
						FY16	FY17	FY18	FY19
1A	Improve coordination between NCWRC, NCDENR and NCDA&CS	NCWRC, NCDENR and NCDA&CS	NCANSTF	None required	Medium	X			
1B	Establish ANS Task Force	NCWRC, NCDENR and NCDA&CS	various government agency staff, utilities, NGO's, academics, etc.	None required	High	X			
1C	Establish rapid response procedure for new introductions that have the potential for high levels of negative impact	NCANSTF	TBD – by organism and location	TBD – by organism and location	High	X	X	X	X
1D	Develop management plans for prevention, control, eradication of specific ANS	NCWRC, NCDENR and NCDA&CS	NCANSTF	Internal	High	X	X	X	X
1E	Participate on regional and national ANS panels and organizations	NCWRC, NCDENR and NCDA&CS	NCANSTF	Internal	Medium	X	X	X	X
1F	Coordinate ANS prevention and management with border states	NCWRC, NCDENR and NCDA&CS	NCANSTF	Internal and external	Medium	X	X	X	X
1G	Identify an ANSTF coordinator position	NCWRC, NCDENR and NCDA&CS	NCDENR, NCANSTF	Internal and external	High	X			

Try…

- Signed by NCWRC, NCDEQ, NC Ag. in early 2016
- Not sent to Governor or National ANS Task Force
- Considered requesting state budget funding and position

Purple Loosestrife

Redbelly Tilapia

Try Again

- Make minor updates
- Get agency and Governor signatures
- Send to National ANS Task Force for official approval
- Implement Strategies and Actions

Flathead Catfish

Spotted Jellyfish

Questions?

Marbled Crayfish

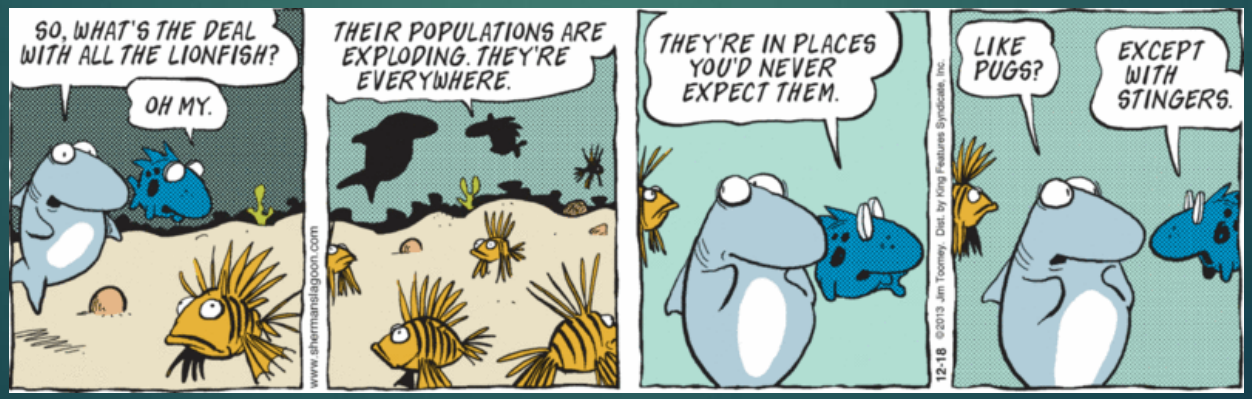
Nuisance Freshwater Fish Species in North Carolina

The Good, The Bad, & The Ugly - Past, Present, & Future

Bryn H. Tracy
NC Chapter AFS Member, Apex, NC

Aquatic Nuisance Species Workshop
30th Annual Meeting of the North Carolina Chapter
of the American Fisheries Society
February 19-21, 2019
Winston-Salem, NC

- "Non-native" Species in General and "Non-native" Species in North Carolina Specifically
- Common Language – Definition of Nuisance *vs.* Invasive Species
- Who is Our Audience?
- Invasion Phases and Impacts
- Gazing into the Crystal Ball
- What is Our Role?



I. PROLOGUE

Memorable Quotes

- "Biological pollutants"
- " . . . tropical Florida has become a biological cesspool of introduced life" (Lachner et al. 1970)
- Introducing fish species is a game of chance, and we run the risk of creating, like Dr. Frankenstein, a problem we cannot control (Moyle et al (1987) in Rahel (1997)).
- A Johnny Appleseed mentality that viewed the seeding of "barren" or "underpopulated" waters as a laudable activity yielding great benefit to humankind (Rahel 1997).
- Nonnative species invasions rank second to habitat loss as the major threat to biodiversity (E. O. Wilson and others)
- " We see illegal stocking as a problem born out of our own profession's historical behavior, and perpetuated by ineffective or conflicting message to the public regarding authorized and unauthorized fish stocking policy (Johnson et al. 2009).

Introductions were made in a social climate that viewed such agency-introductions as beneficial to society (Rahel 1997).

- Goldfish – *circa* early-mid 1600s
- Common Carp – (*circa* 1830s in US?), 1872 in CA, 1879 in NC
- Rainbow Trout and Brown Trout – 1880s
- Tench – 1891-1892
- Flathead Catfish – 1960s
- Brown Trout in the Sand Hills – 1960s

- The belief that game fish introductions into fishless waters was desirable and highly beneficial.

A Fistful of Dollars

The "Good"

The Bad

The Ugly

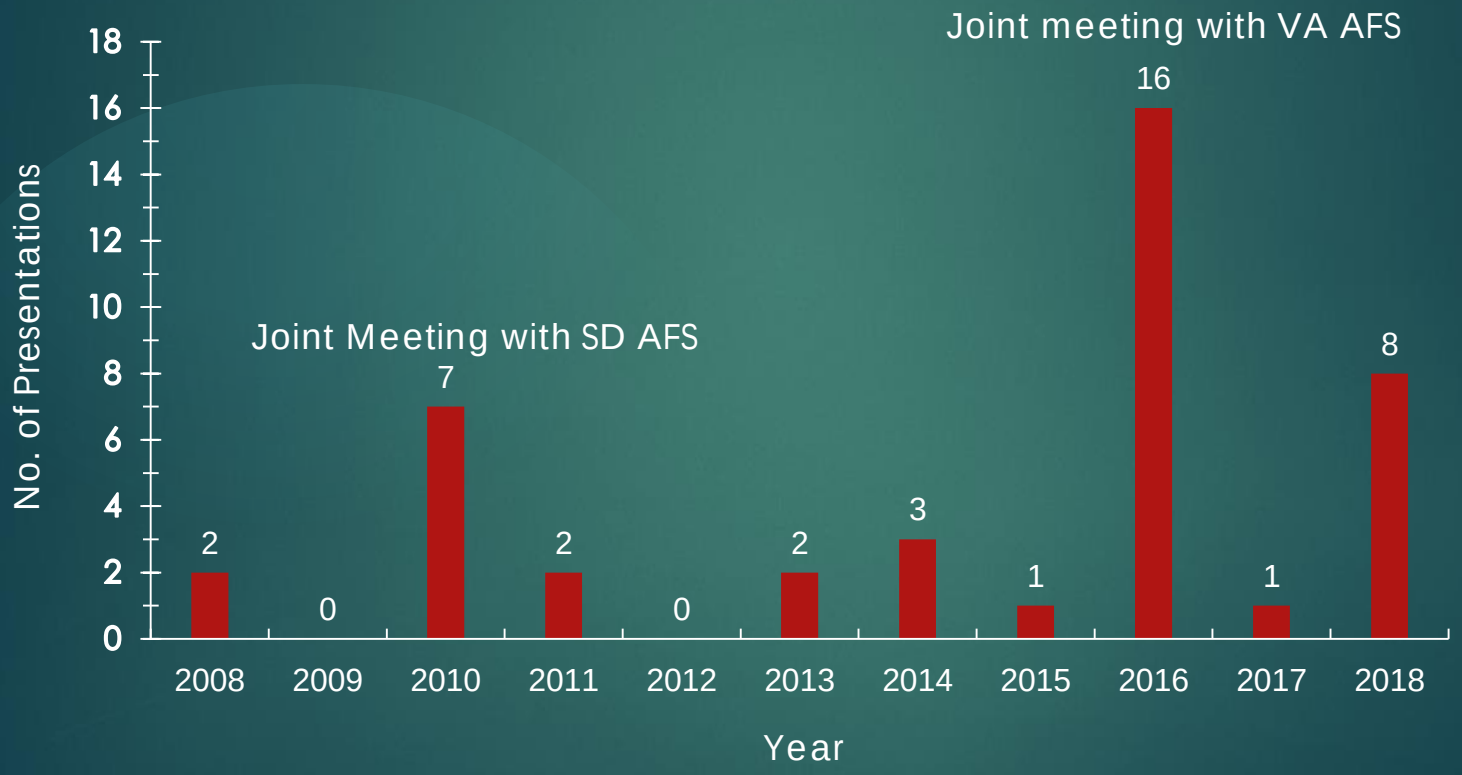
Back to the Future

Past

Present

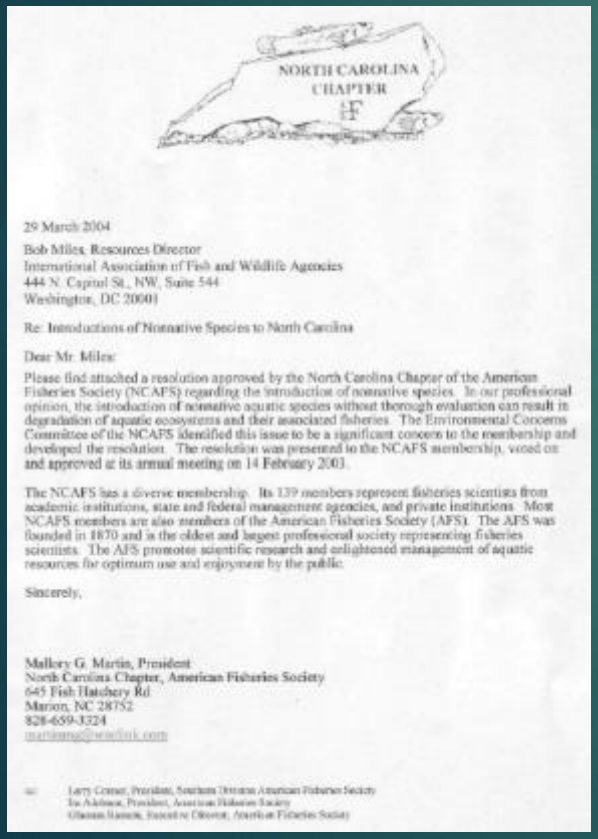
Future?

NC AFS Presentations on Invasive Species*



*excluding trout

2003 NC AFS Resolution On Introductions of Nonnative Aquatic Species



NORTH CAROLINA CHAPTER

29 March 2004

Bob Miles, Resources Director
International Association of Fish and Wildlife Agencies
444 N. Capitol St., NW, Suite 544
Washington, DC 20001

Re: Introductions of Nonnative Species to North Carolina

Dear Mr. Miles:

Please find attached a resolution approved by the North Carolina Chapter of the American Fisheries Society (NCAFS) regarding the introduction of nonnative species. In our professional opinion, the introduction of nonnative aquatic species without thorough evaluation can result in degradation of aquatic ecosystems and their associated fisheries. The Environmental Concerns Committee of the NCAFS identified this issue to be a significant concern to the membership and developed the resolution. The resolution was presented to the NCAFS membership, voted on and approved at its annual meeting on 14 February 2003.

The NCAFS has a diverse membership. Its 139 members represent fisheries scientists from academic institutions, state and federal management agencies, and private institutions. Most NCAFS members are also members of the American Fisheries Society (AFS). The AFS was founded in 1870 and is the oldest and largest professional society representing fisheries scientists. The AFS promotes scientific research and enlightened management of aquatic resources for optimum use and enjoyment by the public.

Sincerely,

Mallory G. Martin, President
North Carolina Chapter, American Fisheries Society
645 Fish Hatchery Rd
Marion, NC 28752
828-659-3324
martinmg@wildlink.com

cc: Larry Cotner, President, Southern Division American Fisheries Society
Ira Adelman, President, American Fisheries Society
Gharon Hamon, Executive Director, American Fisheries Society

Resolution of the North Carolina Chapter of the American Fisheries Society

On Introductions of Nonnative Aquatic Species[1]

Adopted 14 February 2003 by a membership vote of yes

Whereas: The introduction of nonnative aquatic species can serve as an important tool in achieving the first objective in the constitution of the American Fisheries Society (AFS): promotion of the conservation, development, and wise use of fisheries;

Whereas: Scientific reviews indicate that introduction of nonnative aquatic species can also result in the degradation of aquatic ecosystems and their associated fisheries, including the suppression and elimination of native species through competition and predation, the introduction of parasites and disease, hybridization, habitat alteration, and other negative impacts;

Whereas: The eradication of established populations of nonnative aquatic species can be infeasible and unacceptable to certain parties, while control efforts are often costly;

Whereas: The number of nonnative fish species introduced deliberately or unintentionally in some river basins in North Carolina is approaching 45 percent of the known species from these river basins[2];

Whereas: The Scientific Council on Fishes of the North Carolina Wildlife Resources Commission's (Commission) Wildlife Advisory Committee has tendered (6 November 2002) strong recommendations to the Commission on banning importation or further intrastate movement of ten species of nonnative fishes deemed actually or potentially injurious to native species and ecosystems;

Whereas: Recent reports of the collection of the snakehead (*Channa* sp.) from North Carolina waters and its possible establishment in nearby states, and the introduction of the spring viremia of carp virus to the Roanoke River Basin through a culture facility have drawn attention to the issue;

[1] Non-native aquatic species are defined, for the purpose of this document, as species that have been moved outside of their native range whether originating in a foreign country or from within the United States.

[2] Jenkins, R. E., and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland (and references cited therein); Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Non-indigenous fishes introduced into inland waters of the United States. American Fisheries Society, Special Publications 27, Bethesda, Maryland; North Carolina Division of Water Quality (unpublished data).

Therefore be it resolved that, based on the best scientific information available, it is the position of the North Carolina Chapter of the American Fisheries Society (NCAFS) which includes fisheries professionals from throughout North Carolina's academic institutions, state and federal management agencies, and private institutions that:

1. To reduce the threat posed by the establishment of nonnative aquatic species, the NCAFS encourages a thorough evaluation of proposed introductions according to the recommendations of the AFS Policy on the Introduction of Aquatic Species[3];
2. Existing state and federal regulations on the importation, culture, sale, and release of nonnative aquatic species must be effectively coordinated (intra- and inter-state), enforced, and made more stringent where existing regulations have failed;
3. Actions should be taken by state and federal agencies to identify established populations of nonnative aquatic species not otherwise regulated or managed by said agencies, and critically review or develop management strategies to restore ecosystems degraded by the presence of established nonnative species;
4. The NCAFS will actively participate in the education of the public and private entities regarding the potential risks of nonnative introductions and provide guidance on how to reduce those risks.

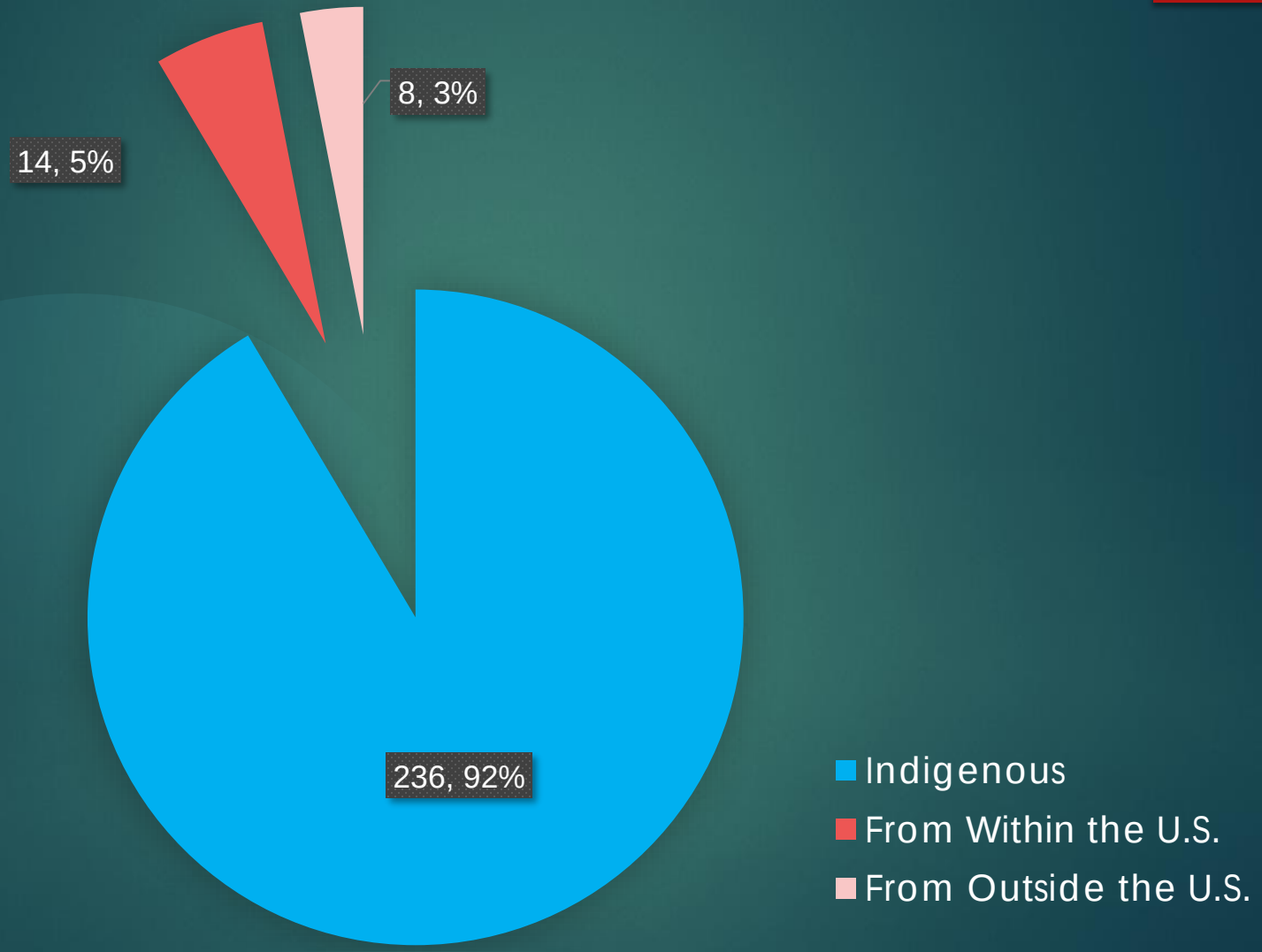
[3] See: http://www.fisheries.org/Policy_Affairs/Policy_Statements/index_policy_statements.shtml, accessed January 2001

North Carolina

- Most widely distributed nonindigenous species
  - Common Carp in 21 river basins
  - Grass Carp in 17 river basins
- Indigenous introductions (transplants) - 63 species
  - Cyprinids – 19 species
  - Centrarchids – 11 species
- Most basins introduced
  - Channel Catfish – 11
  - White Crappie -- 10

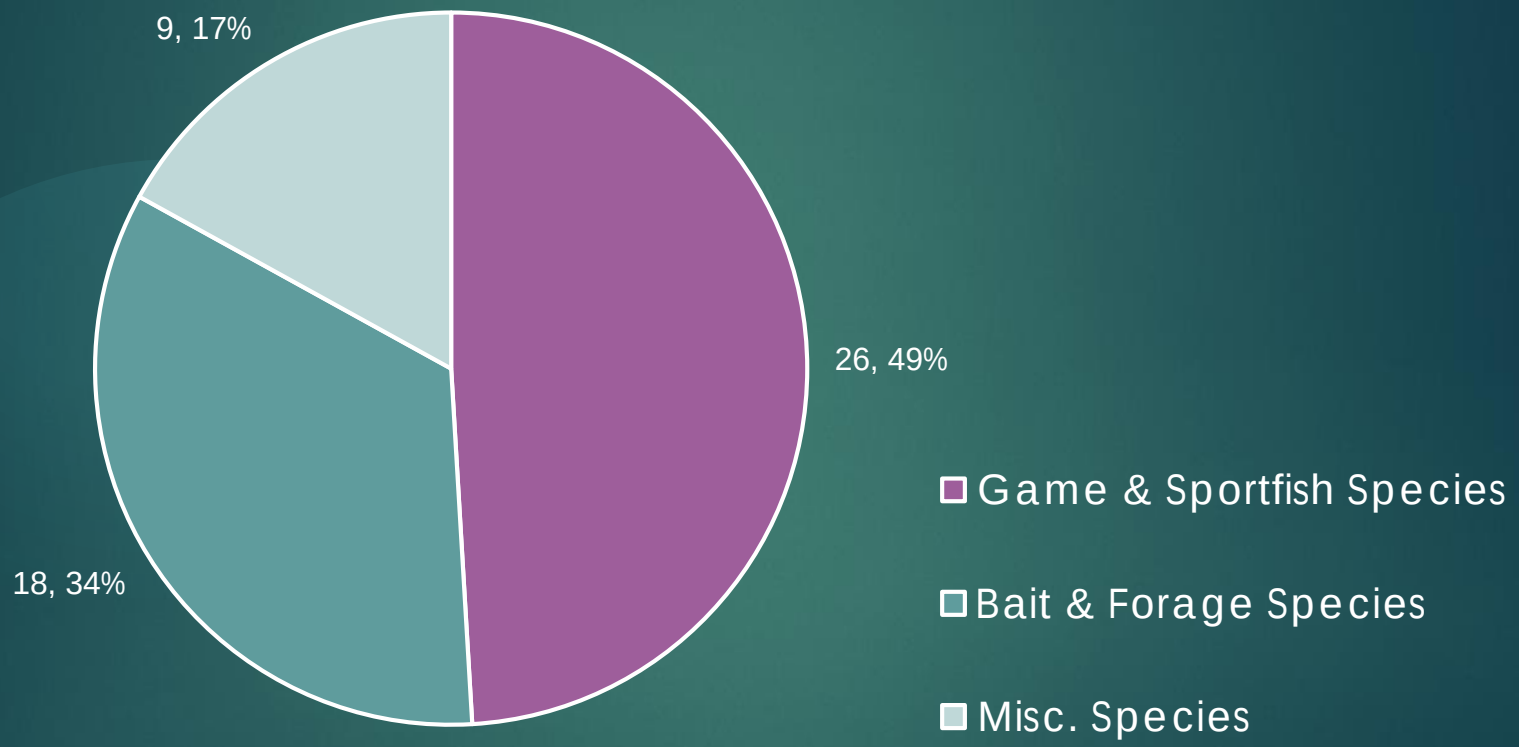
(Tracy, Rohde, and Hogue, unpublished manuscript)

Fish Species in North Carolina



(Tracy, Rohde, and Hogue, unpublished manuscript)

Approximately 20% of North Carolina's fish fauna have been introduced outside of their native ranges since Menhinick (1991).



The two most-widely introduced species were Fathead Minnow, found in nine additional basins, and Blue Catfish, found in seven additional basins.

(Tracy, Rohde, and Hogue, unpublished manuscript)

New River Basin in North Carolina

Pre-European Colonization

- Indigenous species - 28
- Top predators
  - Brook Trout
  - Flathead Catfish
  - Channel Catfish
- Game fish species - 2

2019

- Nonindigenous fish species added – 28
- Top predators
  - Brook Trout, Brown Trout, Rainbow Trout
  - Flathead Catfish, Channel Catfish
  - Muskellunge
  - Rock Bass, Smallmouth Bass, Largemouth Bass, Black Crappie
- Game fish added – 13
- Bait species added – 12
- Imperiled species - 8

Some of North Carolina's Nonindigenous Species

- Grass Carp
- Blue Catfish, Channel Catfish, Flathead Catfish
- Armored Catfish
- Blue Tilapia, Redbelly Tilapia
- Pacu
- Alewife, Blueback Herring
- Bigmouth Buffalo, Smallmouth Buffalo, Black Buffalo
- Freshwater Drum
- Northern Snakehead
- Lionfish

II. DEFINITIONS

Definitions (NC ANSMP 2015)

Aquatic Nonnative Species

An organisms that has been moved to a place, drainage system, ecosystem, or any aquatic system outside of its historic range

Mountain Redbelly Dace

Roanoke Hog Sucker

Aquatic Invasive Species

An aquatic invasive organism that has been introduced and is causing ecological and/or economic harm

Common Carp

Aquatic Nuisance Species

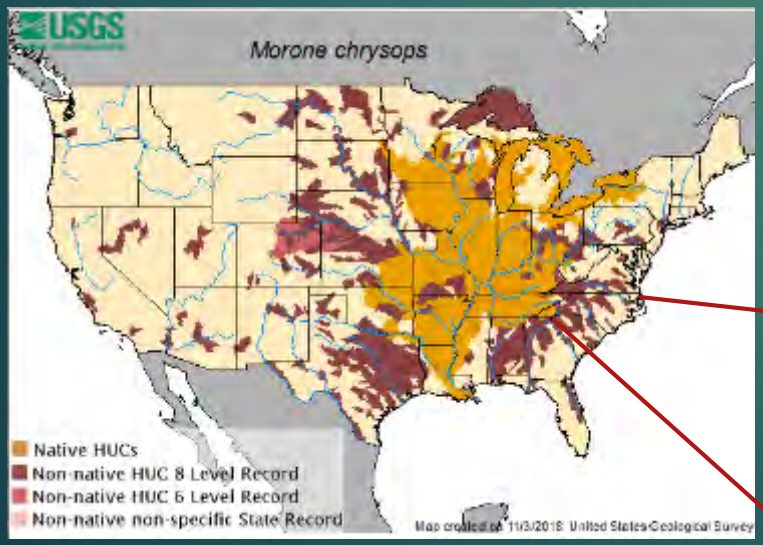
An aquatic organism that is likely to cause negative ecological and/or economic impacts when moved outside of its historical range

Silver Carp

Species Native to a Portion of North Carolina

Invasive Species Outside of Their Native Range

- White Bass – piscivorous habits?



Nuisance Species Outside Their Native Range

- Blueback Herring
- Alewife
- Smallmouth Buffalo
- White Perch
- Flathead Catfish

Non-native Nuisance Fish Species Currently in North Carolina (NCANSMP 2015)

Invasive Species

Goldfish

Oscar (?)

Nuisance Species

Blue Catfish

Spotted Bass (Alabama Bass)

Blue Tilapia

Redbelly Tilapia

Lionfish

Low Risk of Becoming a Nuisance Species

Stocked Gamefish

- Redear Sunfish
- Rainbow Trout
- Brown Trout
- Sockeye Salmon

Aquatic Plant Nursery Trade

- Bluefin Killifish (Special Concern)

Aquarium Release/Live Food Markets

- Oriental Weatherfish

Bait Fish

- Fathead Minnow

Nuisance Fish Species Not Currently in North Carolina (NC ANSMP 2015)

Non-native

Low Risk of Becoming a Nuisance Species

- Mexican Banded Tetra (?)
- Pacu – several species
- Brook Stickleback
- Freshwater Electric Eel
- Northern Pike
- Flagfish
- Ide
- Tench
- Asian Swamp Eel
- Yellow Bass
- Rainbow Smelt
- Vermiculated Sailfin Catfish
- Atlantic Salmon
- Candiru Catfish (?)

Non-native

High Risk of Becoming a Nuisance Species

- African Longfin Eel
- Snakehead – several species
- Walking Catfish – several species
- Ruffe
- Silver Carp
- Bighead Carp
- Black Carp
- Round Goby
- Mozambique Tilapia
- Nile Tilapia
- Tubenose Goby
- Piranha – several species
- Rudd

III. THE AUDIENCE

To Whom is the Species a Nuisance?

- NCWRC
  - Alewife, Blueback Herring *vs*. Walleye in Lake James, Hiwassee Reservoir
  - Rainbow Trout, Brown Trout *vs*. Brook Trout
  - Flathead Catfish *vs*. native sunfish, bullheads, and suckers
  - Alabama Bass (Spotted Bass) *vs*. Largemouth Bass
- Duke Energy
  - Alewife in Lake Norman
- US F&WS
  - Common Carp in Lake Mattamuskeet
- Dept. of the Interior - GSMNP
  - Rainbow Trout, Brown Trout *vs*. Brook Trout
  - Abrams Creek

What About other Users of the Aquatic Resources?

- Introduced as Forage
  - Alewife
  - Blueback Herring
  - Threadfin Shad
- Recreational Fishery
  - Bigmouth Buffalo
  - Flathead Catfish, Blue Catfish, Channel Catfish
  - Rainbow Trout, Brown Trout
  - Freshwater Drum
- Aquatic Plant Management
  - Grass Carp

State Record, 78 lbs.
Brian Newberger
Cape Fear River, 2005
(photo NCWRC)

Why Did They Get Here?

- "Conservation" purposes
- The desire for new
  - Forage fish
  - Sport/game fish
  - Sources of fish protein
- Biological control agents
  - Mosquito-borne diseases – Mosquitofish
  - Aquatic macrophyte management – Grass Carp, tilapia
  - Trematode (snail) infestations in catfish ponds – Black Carp
  - Phytoplankton control – Silver Carp and Bighead Carp

Differences Between Stockings and Introductions?

Authorized Stockings	Unauthorized Stockings
Legal	Illegal
Management tool by professionals	Management tool by "fishermen"
NCWRC and US F&WS approval	Approval not requested
Create a new or enhance an existing fishery	"Create a new or enhance an existing fishery"

What about Winter Stocking of Trout into Non-trout Type Waters?

- 24 small ponds and reservoirs in December 2018 from Jackson to Edgecombe counties
- What message does it send to fishermen regarding non-native introductions?
- How different is this "dumping of surplus" from dumping of surplus of yesteryear?
- Politically-driven motives?

IV.ARRIVAL

Biological Invasion Phases
(Garcia-Berthou 2007; Kolar & Lodge 2002)

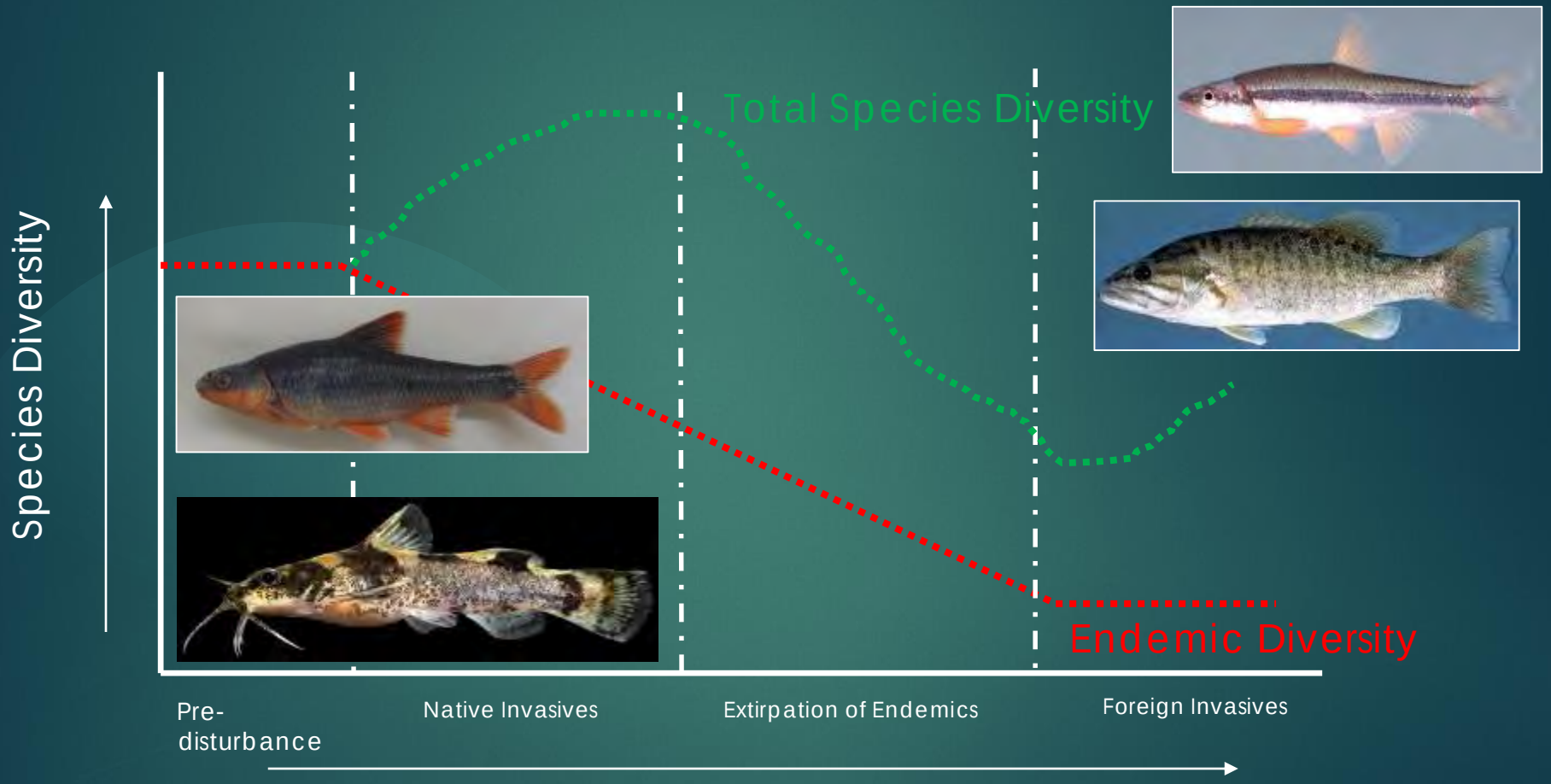
How Did They Get Here?

Factors Promoting & Pathways of Introductions

- Presence of large impoundments needing stockings
- Proximity to metropolitan areas & adjacent drainages
- Circumvention of natural or man-made barriers
- Diversion canals (ICW)
- Removal of barriers
- Live bait bucket and boat live well releases
- Coloration
- Colonial nesting & "seine ability"
- Live food fish markets
- Ethnic customs and religious practices
- Dumping of aquaria
- Failed aquaculture security systems
- Aquatic plant trade
- Ballast water of ships

(Jenkins & Burkhead 1994; Kerr et al. 2005; Rahel 2007)

What Happens When They Get Here?



Homogenization Timeline (from Scott & Helfman 2001)

Problems with Aquatic Invasives (modified from NCANSMP 2015)

- Spread easily through water
- Difficult to chemically or mechanically control
- Cross jurisdictional boundaries
- All communities are susceptible to invasion by introduced species regardless of native species diversity (Gido and Brown 1999)
- Habitat and water quality do not seem to be significant factors
- Reservoirs are artificial systems, anyway

Ecological Impacts of Nuisance Species

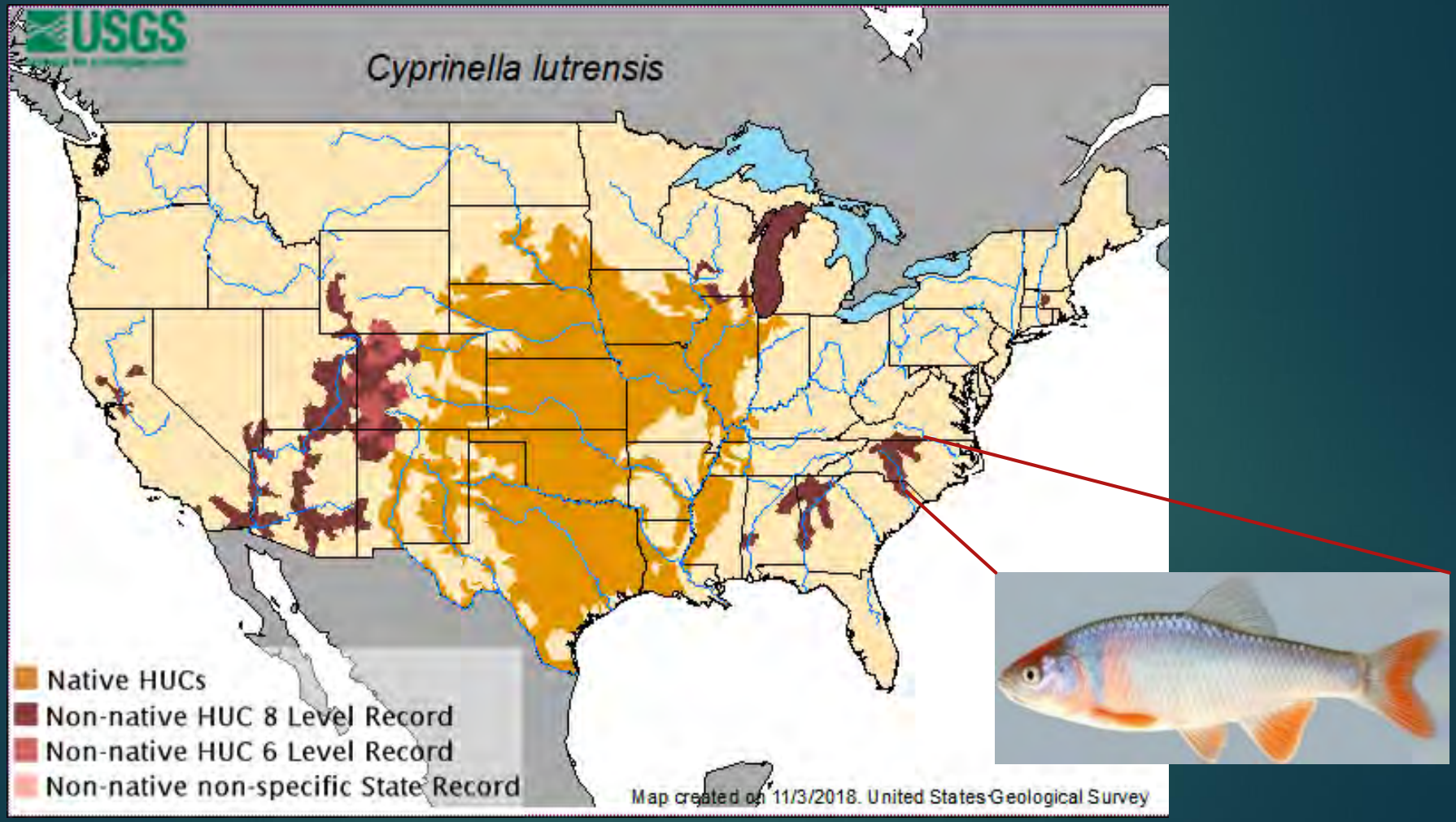
- Predation – Piscivory, Molluscivory, Ovivory, Planktivory
- Competition
  - Bluehead Chub in the French Broad River Basin?
  - Mountain Redbelly Dace in the New River Basin?
  - Green Sunfish in headwater Piedmont streams?
- Transfer of non-native fish-borne parasites and diseases to native fish species and/or humans
  - Gill lice in Brook Trout
  - Whirling disease in trout
- Gene pool deterioration - hybridization
- Habitat alteration and degradation
- Homogenization of the fauna – macro *vs.* micro scale
- Localized extirpation of endemic species
- Impact the recovery efforts for T&E species
  - Blue Catfish, Flathead Catfish, Smallmouth Buffalo *vs.* Robust Redhorse
  - Flathead Catfish and Blue Catfish *vs.* Carolina Madtom
  - Flathead Catfish and Blue Catfish *vs.* Atlantic and Shortnose Sturgeon

What's so Bad About these Species Already in North Carolina?

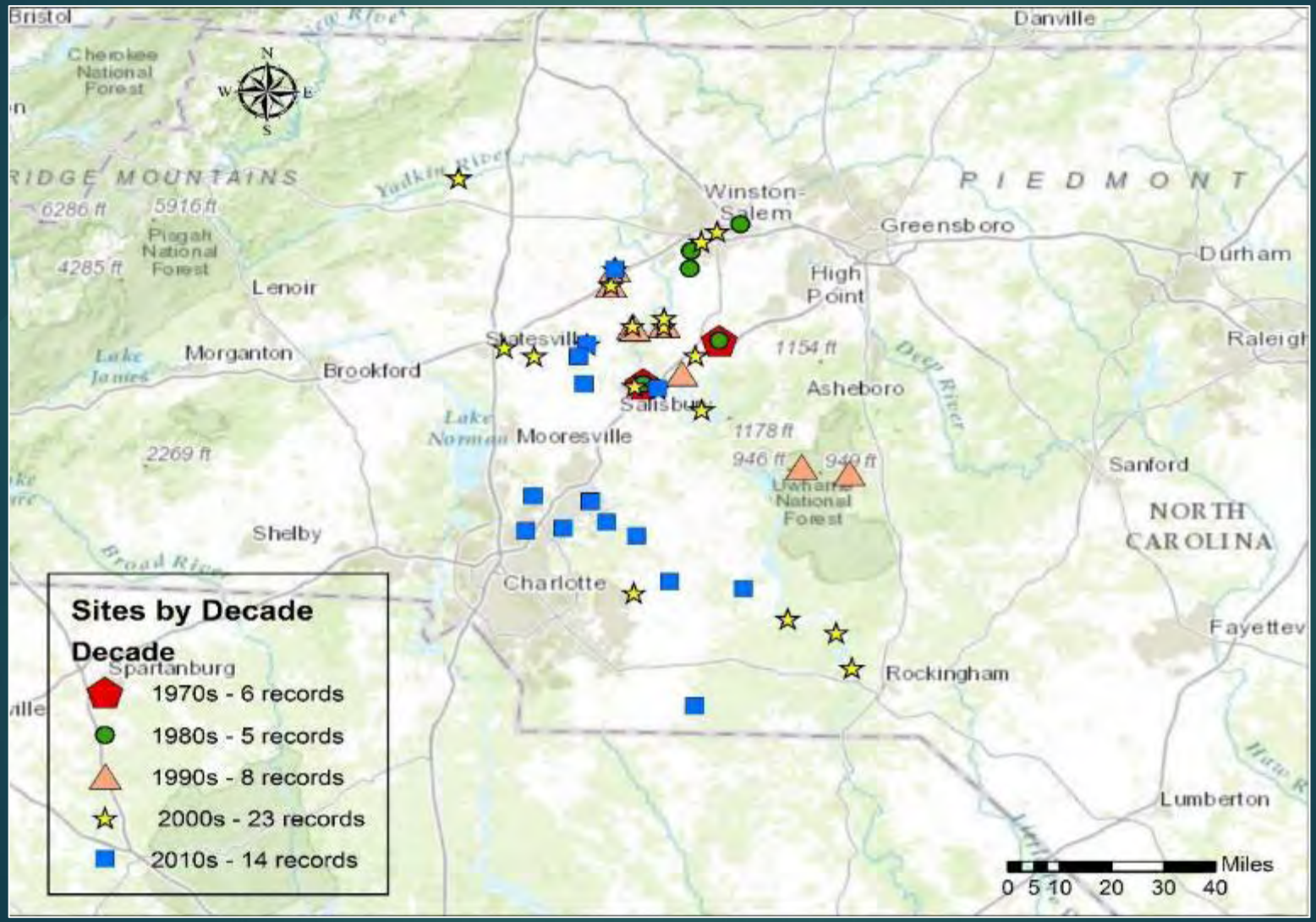
- Alewife & Blueback Herring – ovivory on and recruitment failure of Walleye
- Alewife – a contributor to fish kills of Striped Bass in Lake Norman
- Common Carp – habitat alteration
- Grass Carp – herbivory on native submerged aquatic vegetation
- Red Shiner – competition, hybridization
- Flathead Catfish – piscivorous on native sunfish and native bullheads
- Blue Catfish – predation on native molluscs, competition with game species for prey, displace native catfishes
- White Perch – ovivory, stunting of reservoir populations
- Alabama Bass/Spotted Bass – competition, hybridization
- Blue Tilapia and Redbelly Tilapia -- herbivory on native submerged aquatic vegetation

$\sum$ = Monies spent on nuisance species impacts could have been spent elsewhere

How Fast Can an Invasive Species Disperse Throughout a River Basin?



Yadkin-Pee Dee River Drainage Red Shiner



V. OUTLOOK

What Might Happen if These Species are Introduced?

Silver Carp & Bighead Carp

Alter native fish communities by feeding on zooplankton and phytoplankton

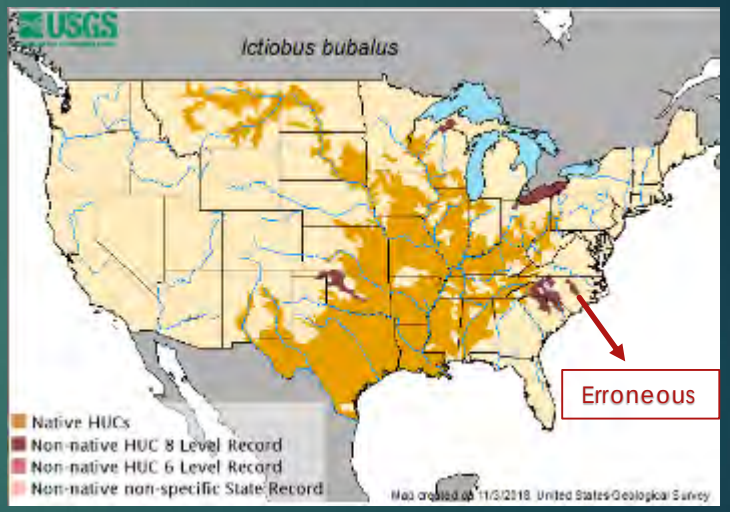
Silver Carp are capable of inflicting bodily injury to boaters when airborne

Snakeheads, *Channa* spp.

Highly piscivorous

Compete with Largemouth Bass

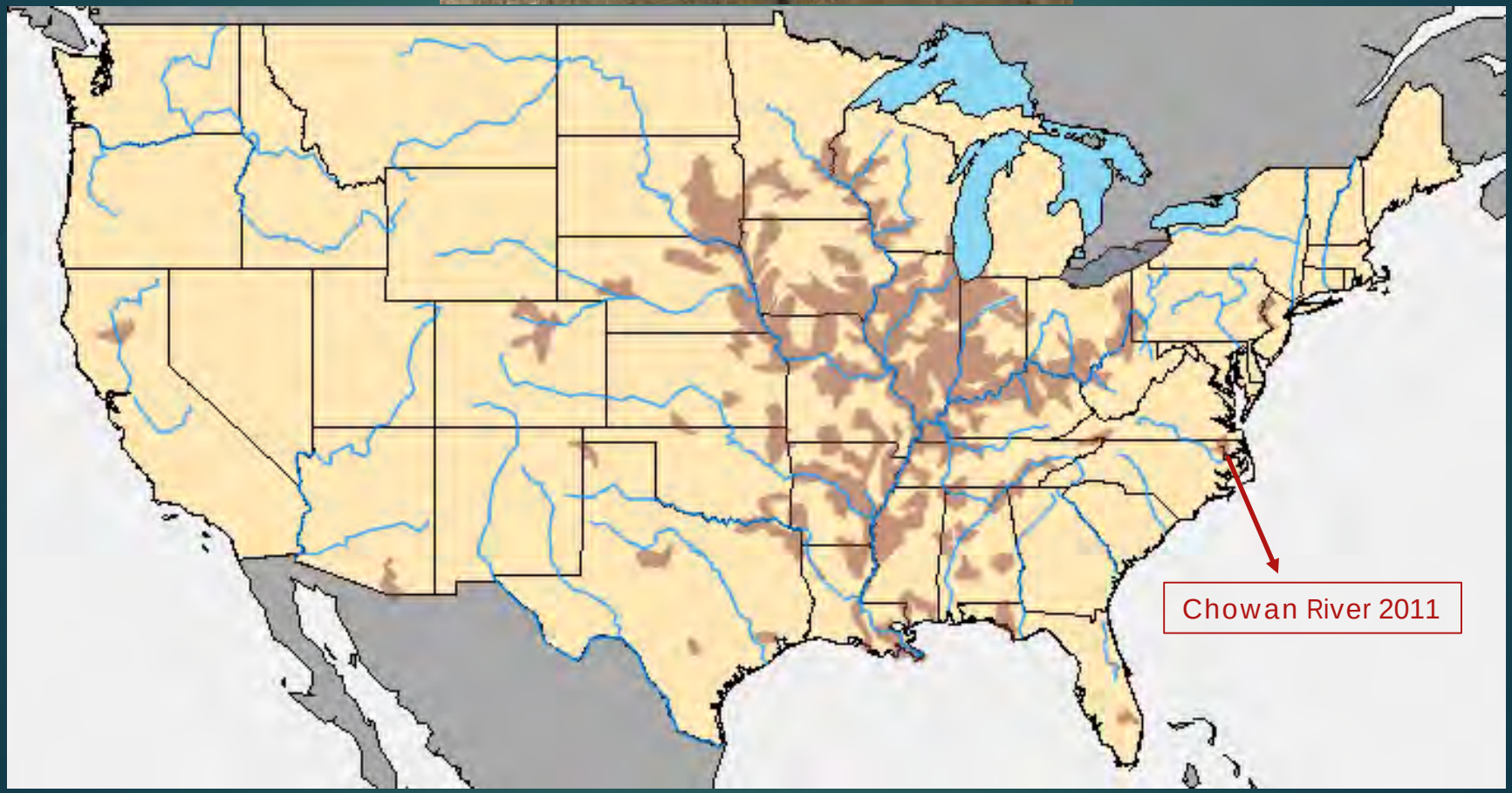
Smallmouth Buffalo



Potential to impact planktonic and benthic communities of Lake Waccamaw

Silver Carp

Bighead Carp



Northern Snakehead

Blotched Snakehead

VI. OPPORTUNITIES

Irreversible Changes "The Horse is Out of the Barn"

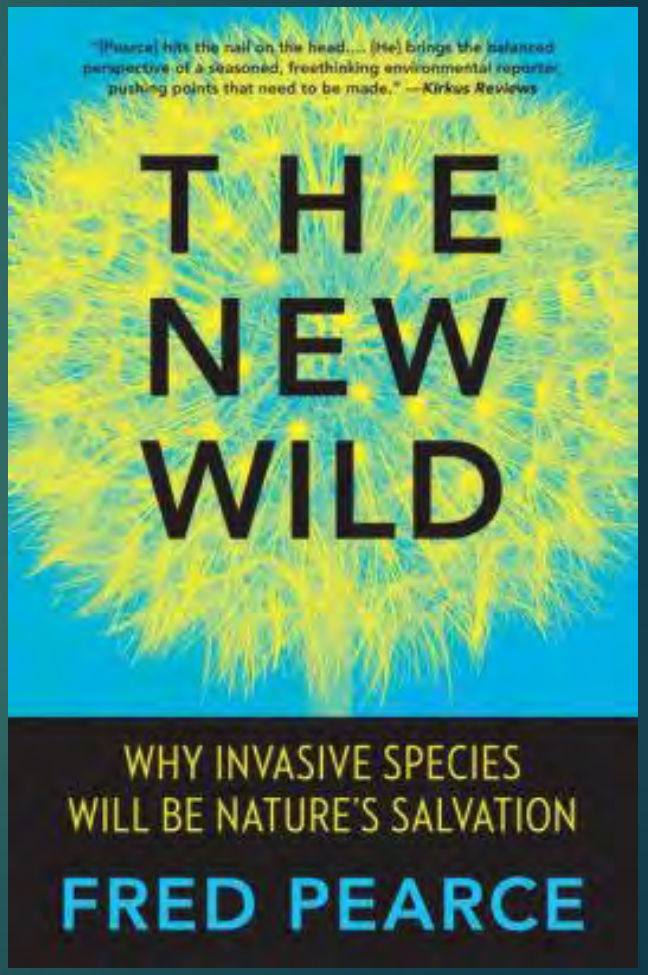
- Bighead, Silver, and Black Carp in the Midwest
- Lionfish off the East Coast
- Sea Lamprey and Alewife in the Great Lakes
- Grass Carp
- Snakehead in Virginia
- Blue Catfish and Flathead Catfish
- White Perch, Blueback Herring, and Alewife in Lake James
- Blueback Herring in Hiwassee Reservoir

What Do You Do? – Inactive

- Do nothing
- Learn to "live with it".
- Stop spending money trying to fix a problem that was caused illegally.
  - Lake James
  - Hiwassee Reservoir

Northern Snakehead

South Fork Catawba River
US 74
Gaston County
May 14, 2007



What Do You Do? - Reactive

- Eradication efforts are often ineffective for established populations
- Eradication efforts are very costly
  - 2002 dollars -- $15 million/year for Sea Lamprey control
  - 2001dollars -- $500 million spent annually by Canada on efforts to control invasive aquatic species in the Great Lakes
  - "Cost of keeping Asian carp from Great Lakes nearly triples" - $778 Million (https://www.apnews.com/0db5b0d04f6b4c588cc588a1e870c9a4)
- Don't reward "bad" behavior by instituting special fishing restrictions and trophy fisheries
  - Flathead Catfish in Tar River Basin
  - Blue Catfish in Lake Gaston
  - Catfish in the Pee Dee River downstream from Blewett Falls
- Encourage harvesting of invasive species
  - "Lionfish: If You Can't Beat 'em, Eat 'em!" (http://science.unctv.org/content/lionfish-if-you-cant-beat-em-eat-em)
  - "Invasive Asian Carp: An Expensive Menace but a Surprising Entrée" (https://www.pbs.org/newshour/show/invasive-asian-carp-an-expensive-menace-but-a-surprising-entree)
  - "Eat the Invaders - Fighting Invasive Species, One Bite at a Time" - http://eattheinvaders.org/

What Do You Do? - Proactive

- Enforce existing NCWRC and NCDA regulations
- Impose stiffer penalties for illegal introductions
- Propose new regulations
- Education
  - Of our Legislature
  - Of ethnic cultures
- Public outreach & media exposure
- Blog about it -- https://thefisheriesblog.com/2019/01/21/pet-fish-or-alien-invader/
- Advocate for more funding of NC ANSMP
- Advocate for more funding for Habitattitude - http://www.habitattitude.net/
- Report sightings to NAS - https://nas.er.usgs.gov/default.aspx

Habitattitude™
PROTECT OUR ENVIRONMENT

What Can Be Done?

Possession of Certain Fishes
(15A NCAC 10C .0211)

- It is unlawful to transport, purchase, possess, sell or stock in the public or private waters of North Carolina any live individuals of:

  1. Piranha,
  2. "walking catfish" , *Clarias batrachus*
  3. Snakehead fish, Family Channidae
  4. Black Carp, *Mylopharyngodon piceus*
  5. Bighead Carp, *Hypophthalmichthys nobilis*
  6. Silver Carp, *Hypophthalmichthys molitrix*
  7. Rudd, *Scardinius erythropthalomus*
  8. Round Goby, *Neogobius melanostomus*
  9. Tubenose Goby, *Proterorhinus marmoratus*
  10. Ruffe, *Gymnocephalus cernuus*
  11. Grass Carp, *Ctenopharyngodon idella*
  12. Asian Swamp Eel, *Monopterus albus* – a species complex of three genetically distinct clades
  13. Red Shiner, *Cyprinella lutrensis*

- A person may buy, possess or stock triploid Grass Carp only for the purpose of controlling aquatic vegetation under a permit issued by the Executive Director when the director determines that conditions of such possession or stocking provide minimal probability of escape and threat to sensitive aquatic habitat and that the carp is certified to be sterile by genetic testing at a federal, state, or university laboratory.

Transportation of Live Fish
(15A NCAC 10C .0209)

- (a) Fish Transport: It shall be unlawful for any person, firm, or corporation to transport live freshwater nongame fishes, or live game fishes in excess of the possession limit, or fish eggs without having in possession a permit obtained from the North Carolina Wildlife Resources Commission.

- (b) Fish Stocking: It shall be unlawful for any person, firm, or corporation to stock any life stage of any species of fish in the inland fishing waters of this State without having first procured a stocking permit from the North Carolina Wildlife Resources Commission.

- (c) Permits for stocking fish shall be issued as follows:
  - (2) Before issuing a stocking permit, the Executive Director shall review the application and determine, based on principles of wildlife management and biological science, that the proposed stocking will not:
    - (A) threaten the introduction of epizootic disease or
    - (B) create a danger to or an imbalance in the environment inimical to the conservation of wildlife resources.
  - (5) Based on the criteria in Subparagraph (2), no permit shall be issued to stock any of the following species in the areas indicated:

SPECIES	LOCATION
Salmonids except brown, brook, and rainbow trout	Statewide
Flathead catfish	Statewide

- (e) The release of more than the daily creel limit, or if there is no established creel limit for the species, more than five individuals of the species, shall constitute *prima facie* (legally sufficient to establish a fact or a case unless disproved) evidence of an intentional release.

Possession of Certain Fish

- Unlawful to possess, transport, or release live Alewife or Blueback Herring in the Little Tennessee River, including its tributaries and impoundments (proposed repealing in Winter 2019)

Alewife

- Unlawful to possess, transport, or release live White Perch in waters in and west of Haywood, Buncombe, and Rutherford counties

White Perch

(NCWRC 2018-2019 Fishing, Hunting & Trapping Regulations)

VII.EPILOGUE

"Unless some serious allocation of resources is devoted to the issue – something hard to foresee in [yesterday's] today's [and tomorrow's] economic climate - the problem will keep growing with some catastrophic consequences to many segments of the American economy and environment" (Zanetell and Rassam 2002 *in* Fisheries).

"Regulatory agencies, academic researchers, and both public and private sectors in North Carolina must identify ways to more effectively communicate and implement efforts to present the introduction and spread of aquatic invasive species before more of those species become a nuisance" (NCANSMP 2015)

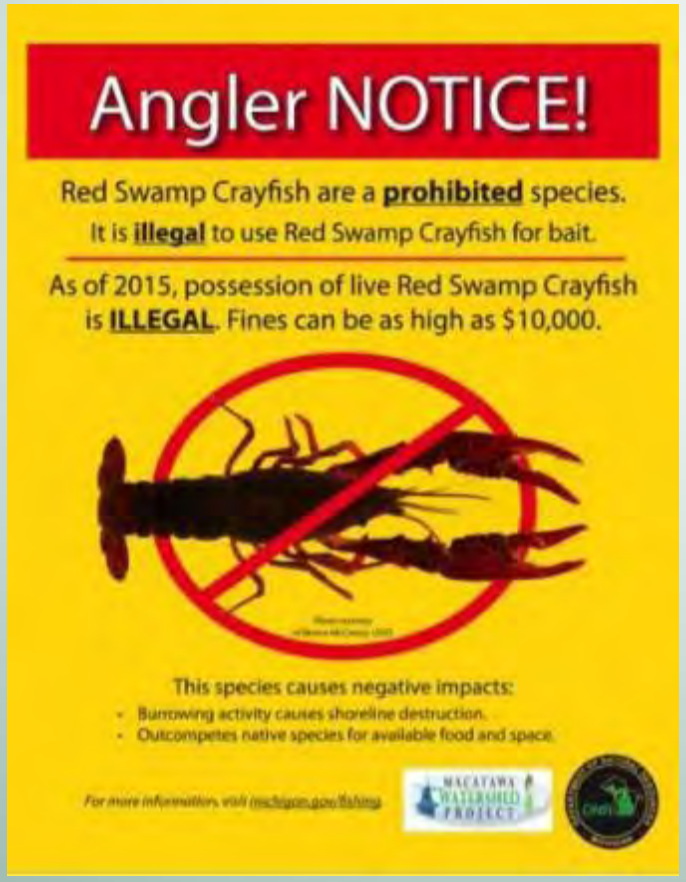
CREDITS

- Maps
  - USGS Aquatic Nuisance Species -https://nas.er.usgs.gov/default.aspx
- Photographs
  - Fritz Rohde
  - Scott Smith
  - Nate Tessler *via* NANFA
  - Mike Swing
  - Dave Coughlan & Mark Auten
  - Virginia Tech's Virtual Aquarium - https://efish.fishwild.vt.edu/
  - USGS Aquatic Nuisance Species
- Music
  - The Good, the Bad and the Ugly -- Ennio Morricone -
  - The Ecstasy of Gold---Ennio Morricone
- Museum Specimens
  - Gabriela Hogue, North Carolina Museum of Natural Sciences

Questions?

Mirror Koi, *Cyprinus carpio*, Dan River

Nuisance Crayfish in North Carolina



T.R. Russ

NORTH CAROLINA
Wildlife Resources Commission

Prioritization of ANS Species currently found in North Carolina. Species in bold have commercial or recreational value

Higher Priority | Medium Priority | Lower Priority

Scientific Name	Common Name	Taxa Group	Habitat	Rank
Hydrilla verticillata	Hydrilla	Plant	Freshwater	1
Pterois miles	Lionfish; Devil Firefish	Fish	Marine	2
Pterois volitans	Red Lionfish	Fish	Marine	2
Nymphoides peltata	Yellow Floating Heart	Plant	Freshwater	4
Phragmites australis australis	European Common Reed	Plant	Freshwater-Brackish	4
Orconectes rusticus	Rusty Crayfish	Crayfish	Freshwater	6
Procambarus clarkii	**Red Swamp Crawfish**	Crayfish	Freshwater	6
Alternanthera philoxeroides	Alligatorweed	Plant	Freshwater	6
Orconectes virilis	Virile Crayfish	Crayfish	Freshwater	9
Ictalurus furcatus	**Blue Catfish**	Fish	Freshwater	10
Lyngbya wollei	Giant Lyngbya	Cyanobacterium	Freshwater	11
Cipangopaludina chinensis malleata	Chinese Mysterysnail	Gastropod	Freshwater	12
Cipangopaludina japonica	Japanese Mysterysnail	Gastropod	Freshwater	12
Anguillicoloides crassus (= Anguillicola crassus)	Eel Swimbladder Nematode	Nematode	NA	12
Myriophyllum spicatum	Eurasian Watermilfoil	Plant	Freshwater	12
Myocaster coypus	Nutria	Mammal	Freshwater	16
Corbicula fluminea	Asian Clam	Bivalve	Freshwater	17
Micropterus punctulatus	Spotted Bass	Fish	Freshwater	17
Phyllorhiza punctata	Australian Spotted Jellyfish	Coelenterate	Marine	19
Lythrum salicaria	Purple Loosestrife	Plant	Freshwater	19
Lythrum spp.	Purple Loosestrife (any not native to NC)	Plant	Freshwater	19
Murdannia keisak	Marsh Dewflower; Asian Spiderwort	Plant	Freshwater	19
Ludwigia hexapetala (L. uruguayensis)	Uruguay Waterprimrose	Plant	Freshwater	23
Myriophyllum aquaticum	**Parrotfeather**	Plant	Freshwater	23
Polysiphonia breviarticulata	a red algae	Algae	Marine	25
Egeria densa	Brazilian Elodea	Plant	Freshwater	25
Najas minor	Brittle Naiad	Plant	Freshwater	25
Triadica sebifera	Chinese Tallow Tree	Plant	Freshwater	25
Tilapia zillii	**Redbelly Tilapia**	Fish	Freshwater	29
Ludwigia peploides peploides	Creeping Water Primrose	Plant	Freshwater	29
Codium fragile tomentosoides	Green Sea Fingers	Algae	Marine	31
Carcinus maenas	European Green Crab	Crab	Marine	31
Oreochromis aureus	**Blue Tilapia**	Fish	Freshwater	31
Eichhornia crassipes	**Water Hyacinth**	Plant	Freshwater	31
Ludwigia peploides montevidensis	Creeping Water Primrose	Plant	Freshwater	31
Pistia stratiotes	**Water Lettuce**	Plant	Freshwater	31
Potamogeton crispus	Curly Pondweed	Plant	Freshwater	37
Nasturtium officinale	Watercress	Plant	Freshwater	38

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Red Swamp Crayfish

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White River Crayfish

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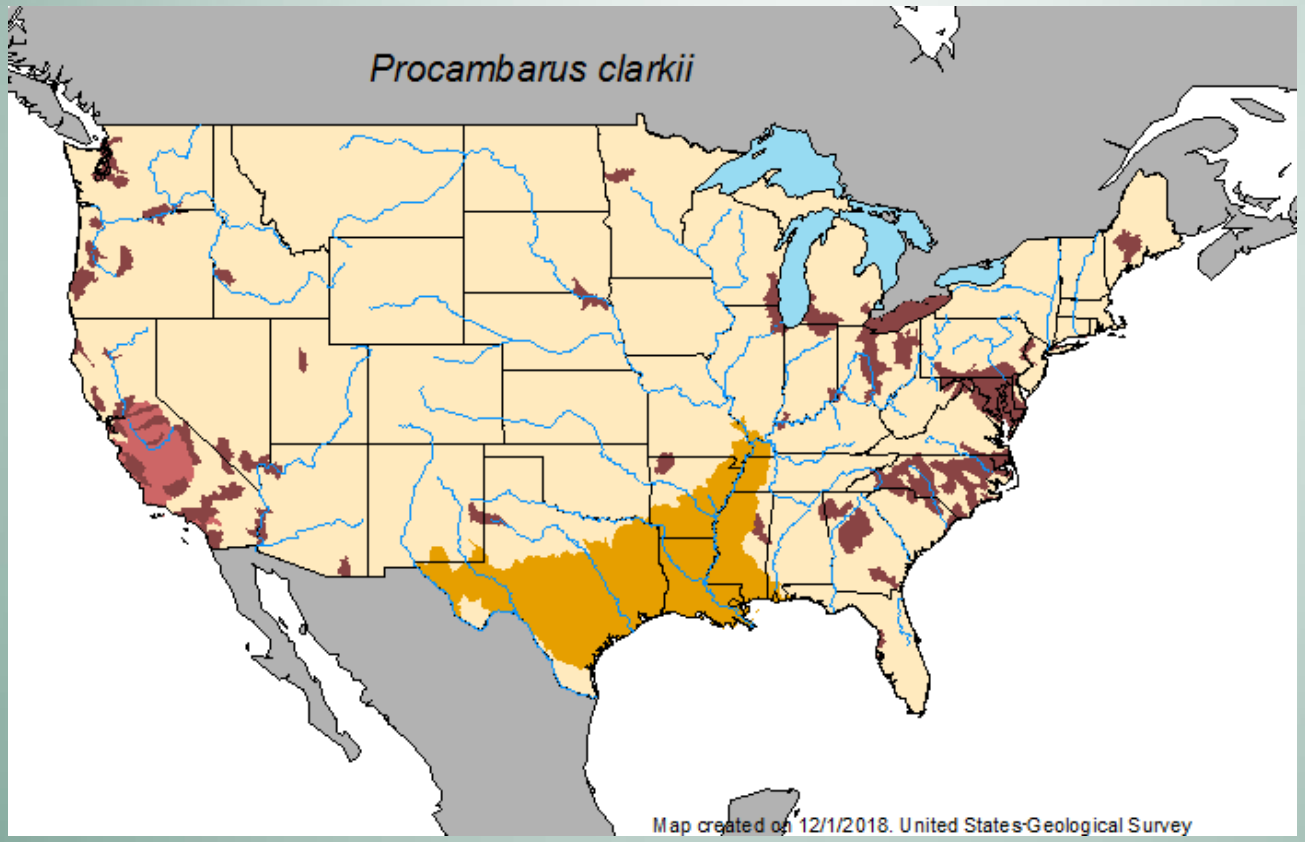

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Rusty Crayfish

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Rusty Crayfish

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Surgeon and Reticulate Crayfish

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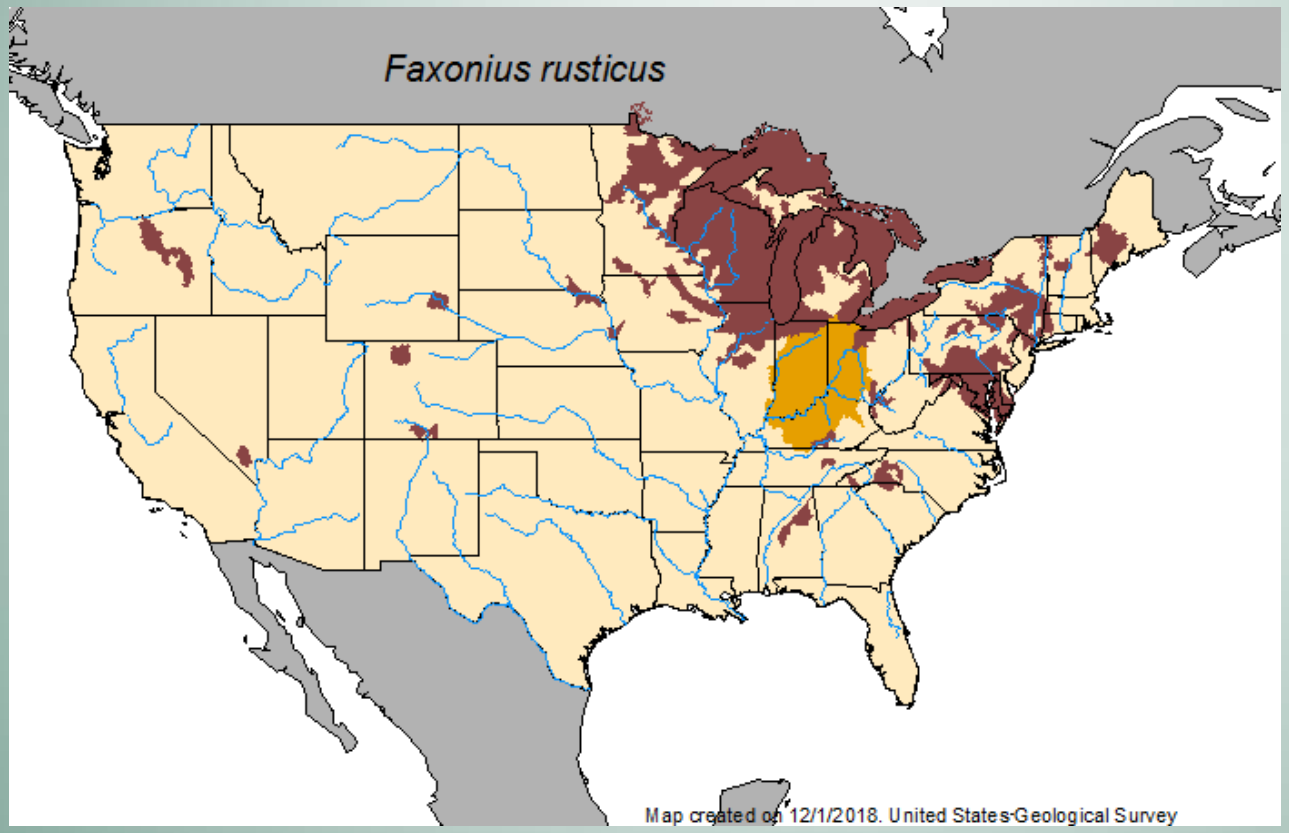

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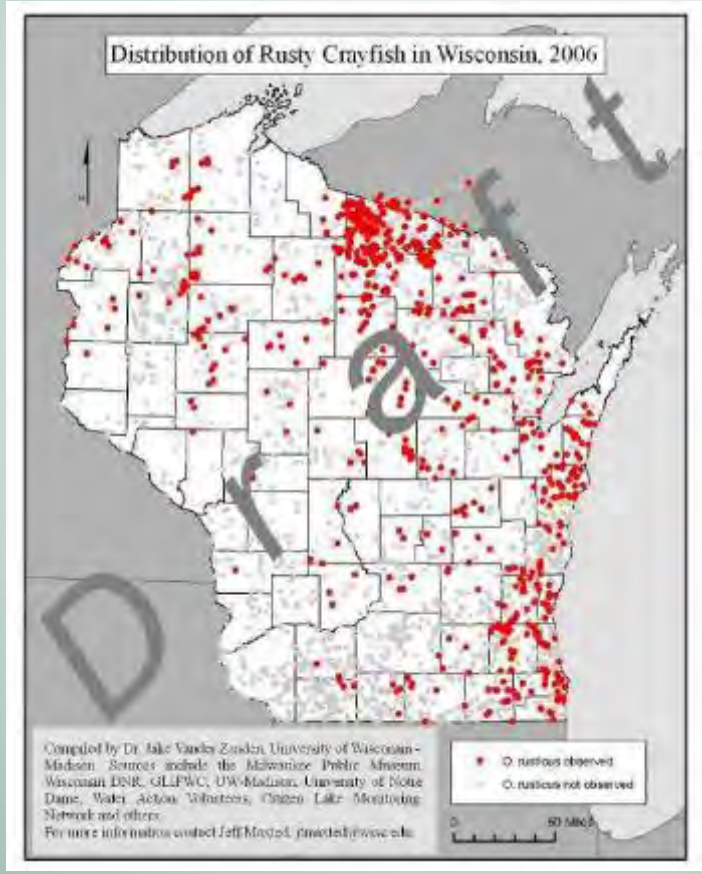

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Virile Crayfish

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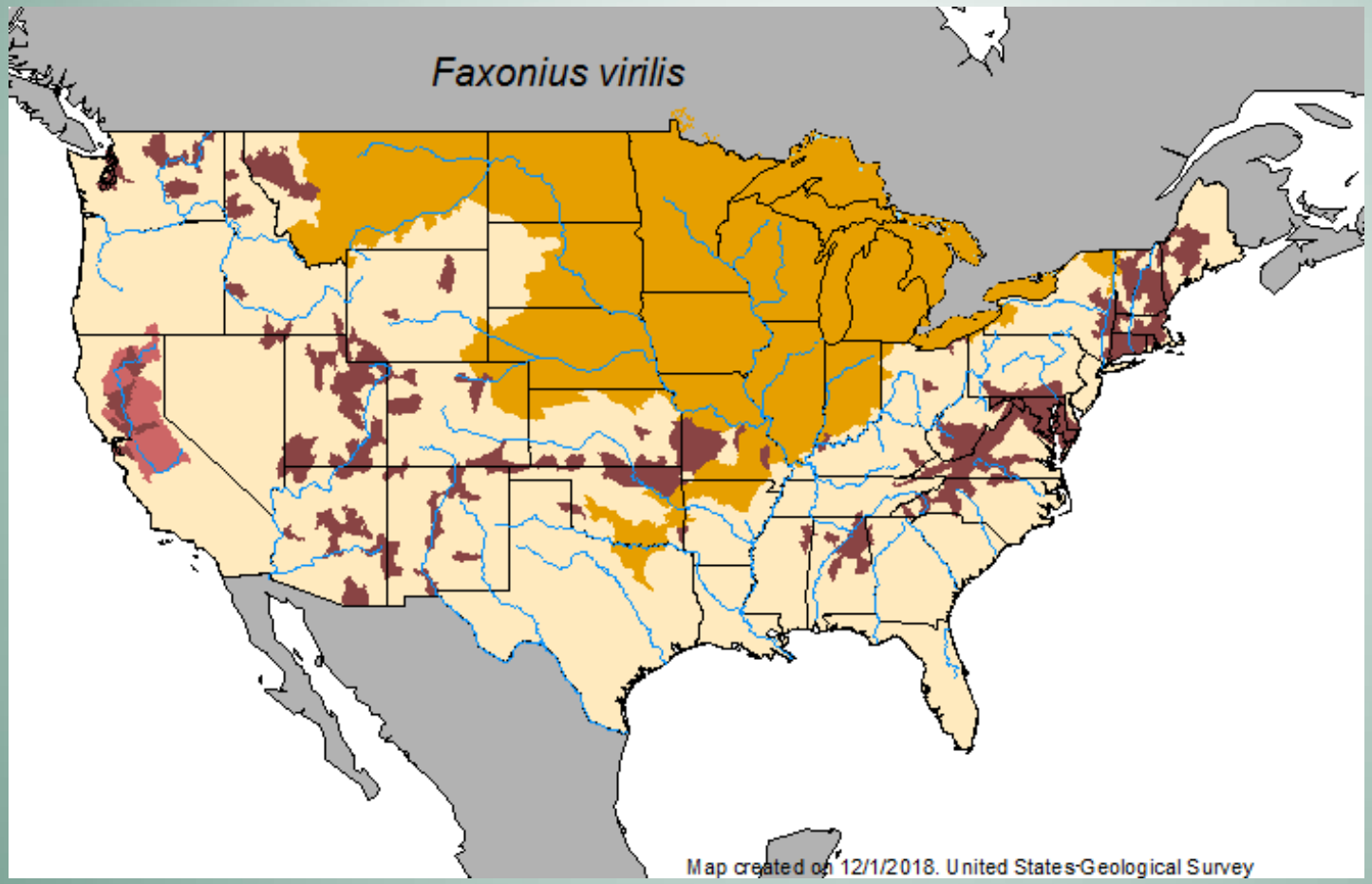

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Marbled Crayfish (Marmokrebs)

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Red Claw Crayfish (Cherax sp.)

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Home » Animals » Crustaceans » Crayfish

Print

Feeder Crayfish, Living, Pack of 12

Item # 142532

4.5 (2) Write a review Ask a question

This pack of 12 feeder crayfish may be used for growth and behavior studies. Effective scavengers for the aquarium (but not compatible with all fish). May also be used as food for some large amphibians and reptiles. Size ranges from 1/4 to 2".

PRICE $24.65

In stock and available to ship.

Qty 1

Add to Cart

Add to List...

Overview Resources Ratings & Reviews

This pack of 12 feeder crayfish may be used for growth and behavior studies. Effective scavengers for the aquarium (but not compatible with all fish). May also be used as food for some large amphibians and reptiles. Size ranges from 1/4 to 2".

Note: *These organisms should not be shipped over a weekend.* *Carolina recommends that you request your order to arrive on a Wednesday, Thursday, or Friday (or even a Saturday) to avoid weekend shipping.*

This item contains living or perishable material and ships via 2nd Day or Overnight delivery to arrive on a date you specify during Checkout. To ensure freshness during shipping, a Living Materials Fee may apply to orders containing these items.

Residents of NV, OR, and UT need a permit to obtain this material. Canadian customers must apply for a Canada Dept. of Agriculture permit.

Due to USDA or USDOT regulations this item may not be shipped to the following locations:

Alaska California
Virginia Washington

Product Families Featuring This Item:

Feeder Crayfish, Living

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Roll over image to zoom in

Aquatic Arts 1 Self-Cloning Marmorkreb Crayfish/Freshwater Lobster (Reproduces Without a Mate!) - 1+ Inch Juvenile

by Aquatic Arts

4.0 out of 5 stars 9 customer reviews | 3 answered questions

Price: $15.95 + $16.95 shipping

Get $70 off instantly: Pay $0.00 upon approval for the Amazon Prime Rewards Visa Card.

Note: Not eligible for Amazon Prime.

- Ships as a 1+ inch long juvenile (body length, minus the claws). Grows up to 4 to 5 inches with marbled color greatly intensifying as the crayfish grows larger. Some Marmorkrebs develop a blue coloration.
- Due to its fast reproduction and nutritious qualities as a prey item, the Marmorkreb is an excellent crayfish to cultivate as a live food item for many predatory fish that are stubborn eaters.
- This crayfish may TEMPORARILY change color and hide more than usual after molting, which may occur during shipping. If your crayfish is dull colored and you find a molt in the bag or in your aquarium, do not worry; this is normal and the bright color will return in 2 weeks or less.
- Features beautiful coloration and markings on the body that vary greatly from crayfish to crayfish! No two Marmorkrebs look quite the same!
- Please be advised that this crayfish will produce a great deal of clones, many of which will reach adulthood and also begin reproducing at the same rate.

New (1) from $15.95 + $16.95 shipping

Report incorrect product information

Free shipping
on all Prime Pantry orders over $35
prime pantry

Share

$15.95
+ $16.95 shipping

Get it as soon as March 4 - 11 if you choose Expedited Shipping at checkout.

Ships from and sold by Aquatic Arts - Live Fish, Inverts, and Aquarium Plants To Your Door.

Qty: 1

$15.95 + $16.95 shipping

Add to Cart

Buy Now

Deliver to Anna - Morganton 28655

Add to List

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5 AUSTRALIAN RED CLAW CRAYFISH 1.5-3" JUVENILES

« View Larger Photo

Like 0 Share

Alternative Views:

Our Price: $29.95

Availability: Pre-Order
Product Code: SARC2

Qty: 1

ADD TO CART

ADD TO WISH LIST

Description

Qty. 5 Australian Red Claw Crayfish 1.5-3"

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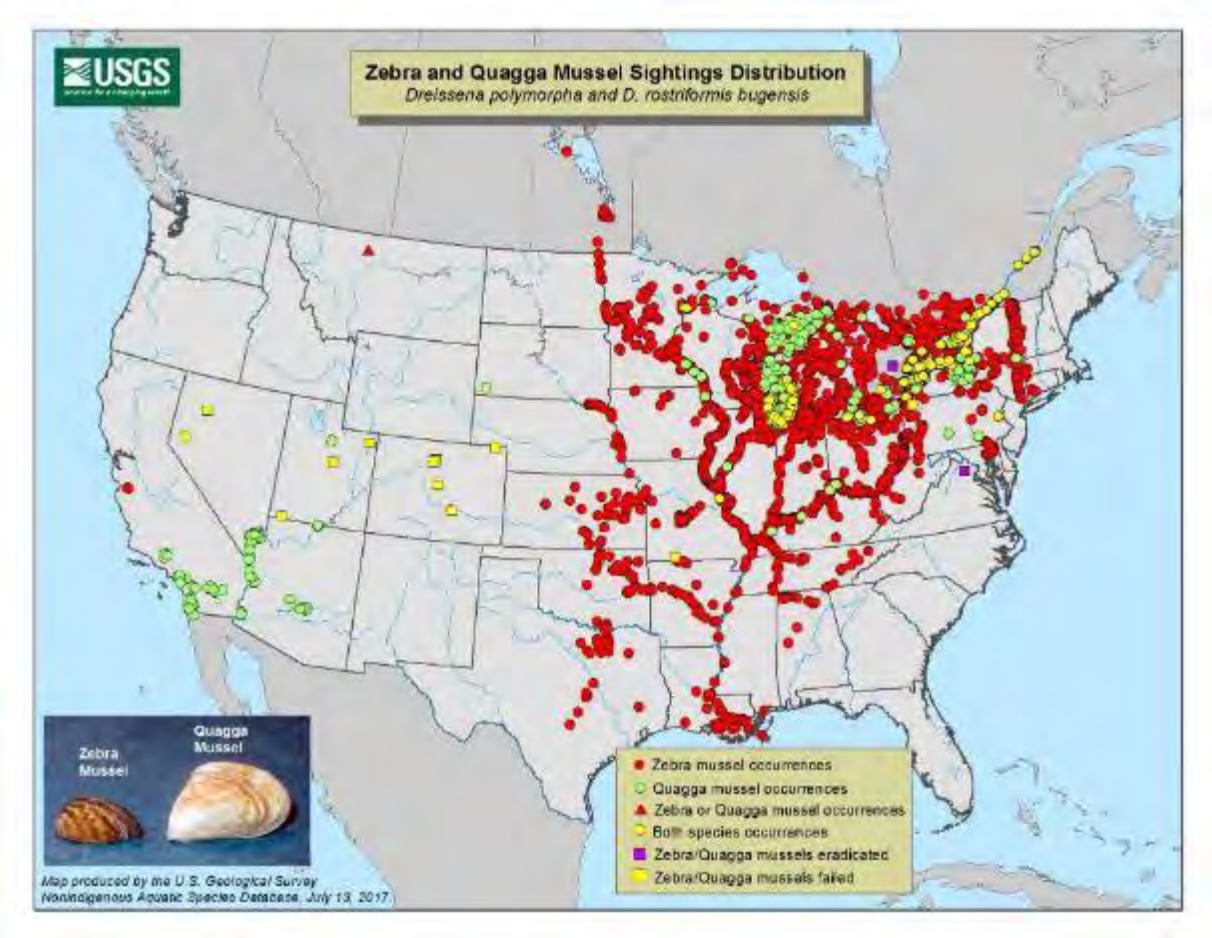

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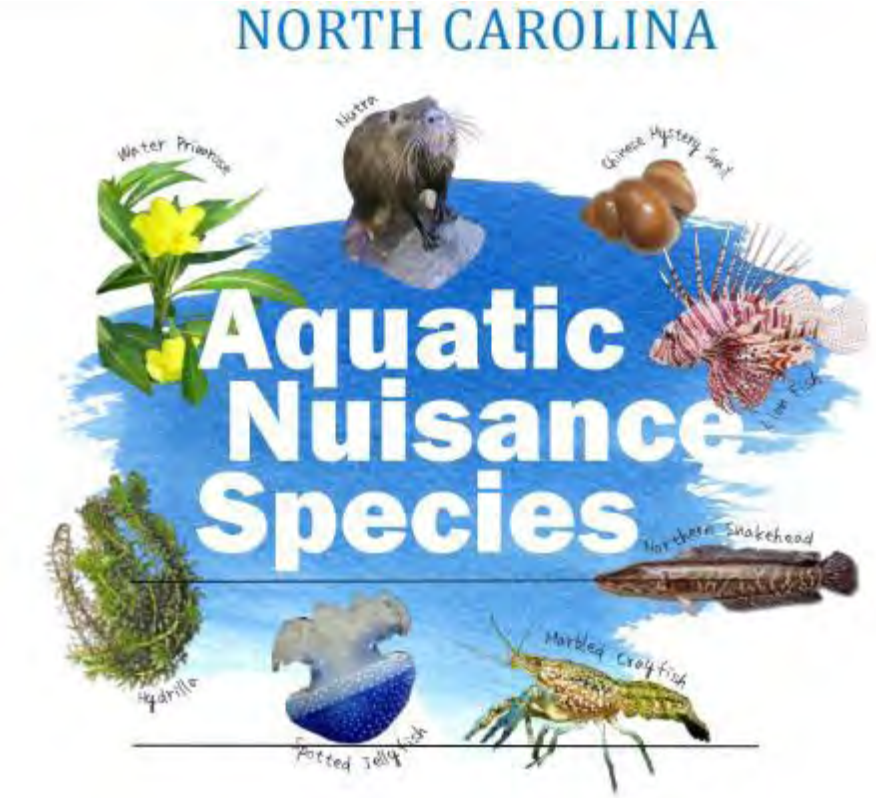
Aquatic Nuisance Mollusks



Luke Etchison and Dylan Owensby

NC Wildlife Resources Commission, Aquatic Wildlife Diversity Program, Waynesville, NC

Non-native mollusks

1. Direct competition with native species
   - Space
   - Food

Photo Credit: Oregon Division of Fish and Wildlife

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Non-native mollusks

1. Direct competition with native species
2. Disease/parasite transmission
   – Human and wildlife

Photo Credit: CDC

Non-native mollusks

1. Direct competition with native species
2. Disease/parasite transmission
3. Human problems
   - Biofouling in power plants, water treatment systems, and pipes

Photo credit: Gemma Grace

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Non-native mollusks

1. Direct competition with native species
2. Disease/parasite transmission
3. Human problems
4. Indirect effects on native species
   - Many methods for control also impact native species

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Non-native mollusks

- What is here?
  - 14 species (USGS)
  - 5 bivalves
  - 9 gastropods
  - More are likely undetected

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Higher Priority ANS Species

- Chinese Mysterysnails (*Cipangopaludina chinensis*)
- Japanese Mysterysnails (*Cipangopaludina japonica*)

Photo Credit: CDC

Photo Credit: Brena Jones, NCWRC

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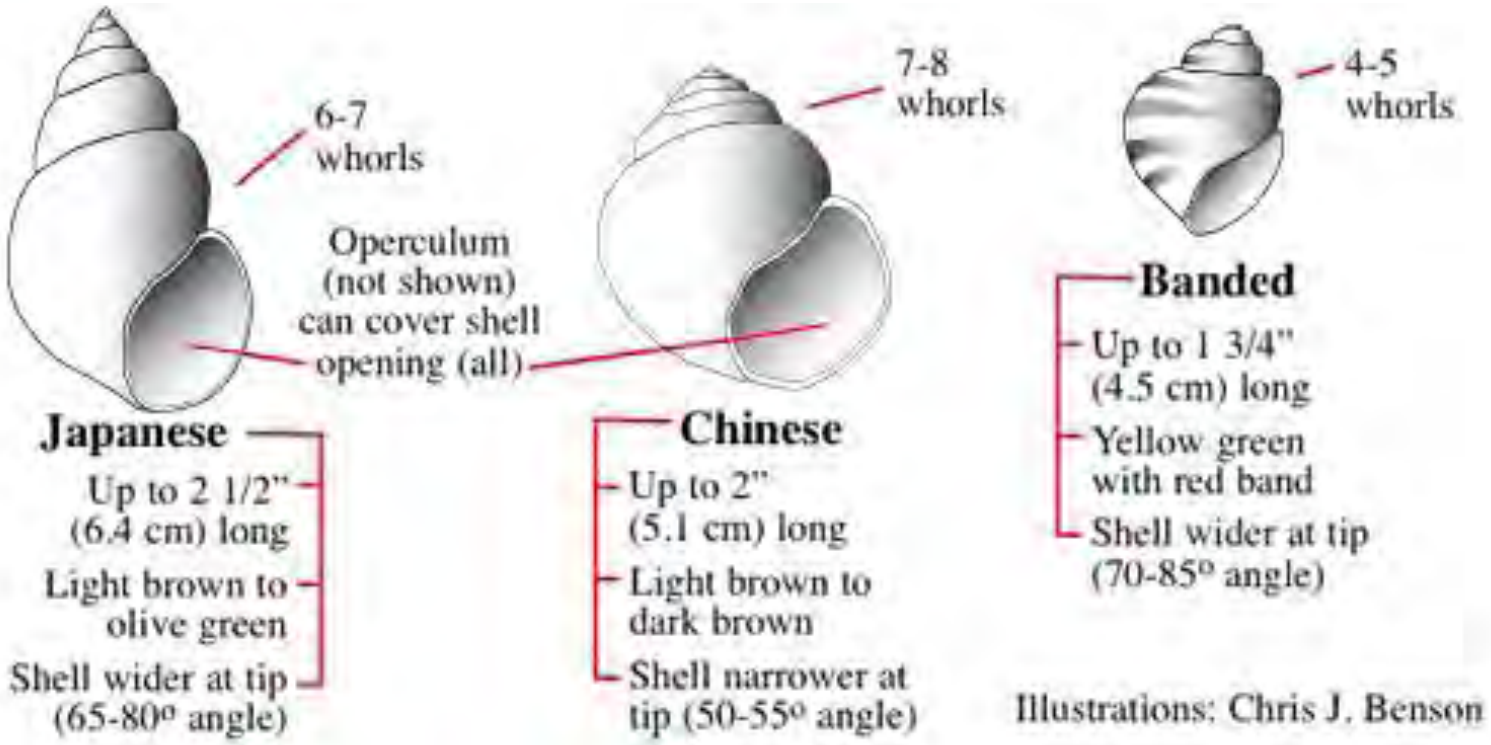
Mysterysnails



Credit: Sea Grant

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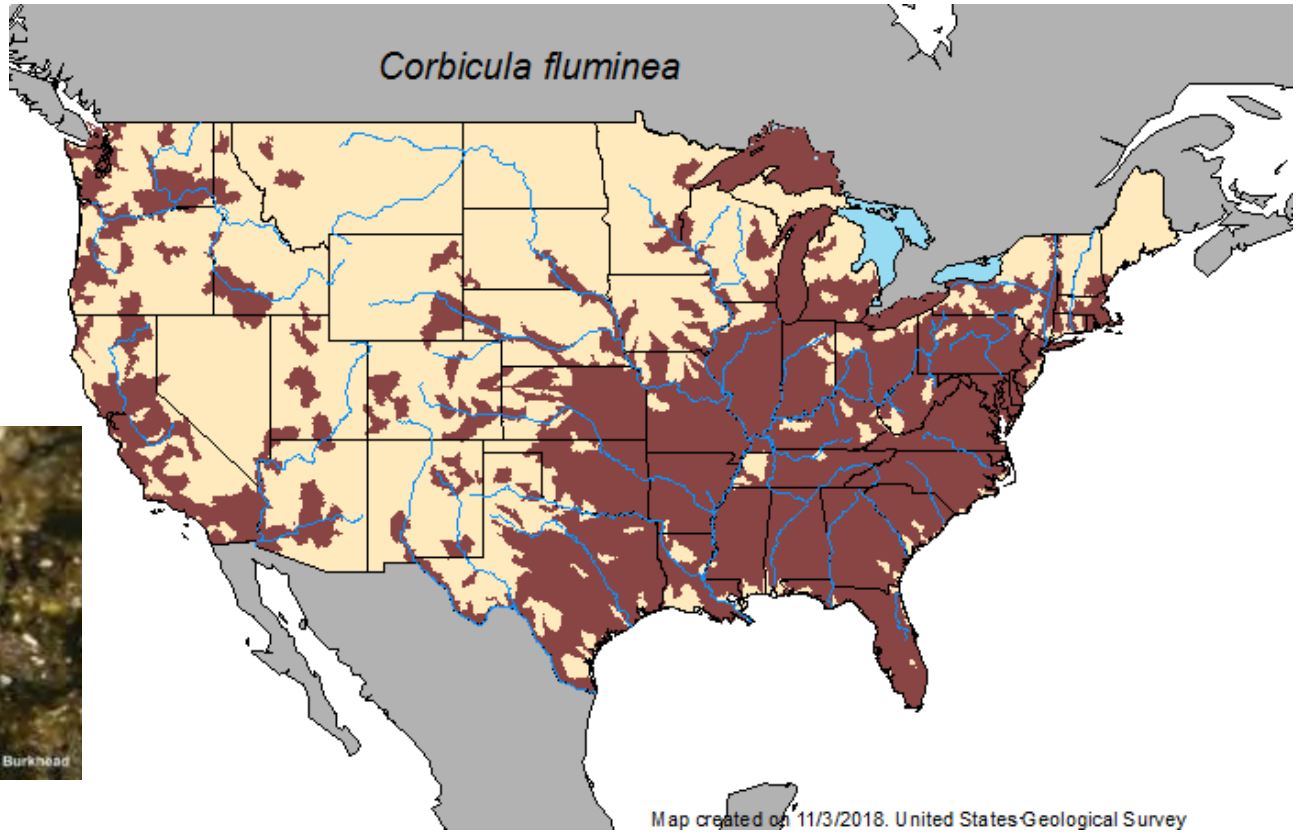
Asian Clam, *Corbicula fluminea*



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Accumulation of human waterborne parasites by zebra mussels (Dreissena polymorpha) and Asian freshwater clams (Corbicula fluminea).

Soon To Come?

Hawaii DLNR/Division of Aquatic Resources

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Dreissena Genus: Zebra and Quagga Mussels

- Native to Eurasia
- Small mussels
  - 40-50 mm
- Huge economic/ecological impacts across North America

Cody Warner

Dreissena Genus: Zebra and Quagga Mussels

- Biofouling Threat!
  - Aquatic species
  - Any submerged structure
- Ecosystem Changes
  - Altered food web
    - Less plankton = loss of planktivores
    - Aquatic vegetation increase
    - Large biomass
  - Bioaccumulate toxins

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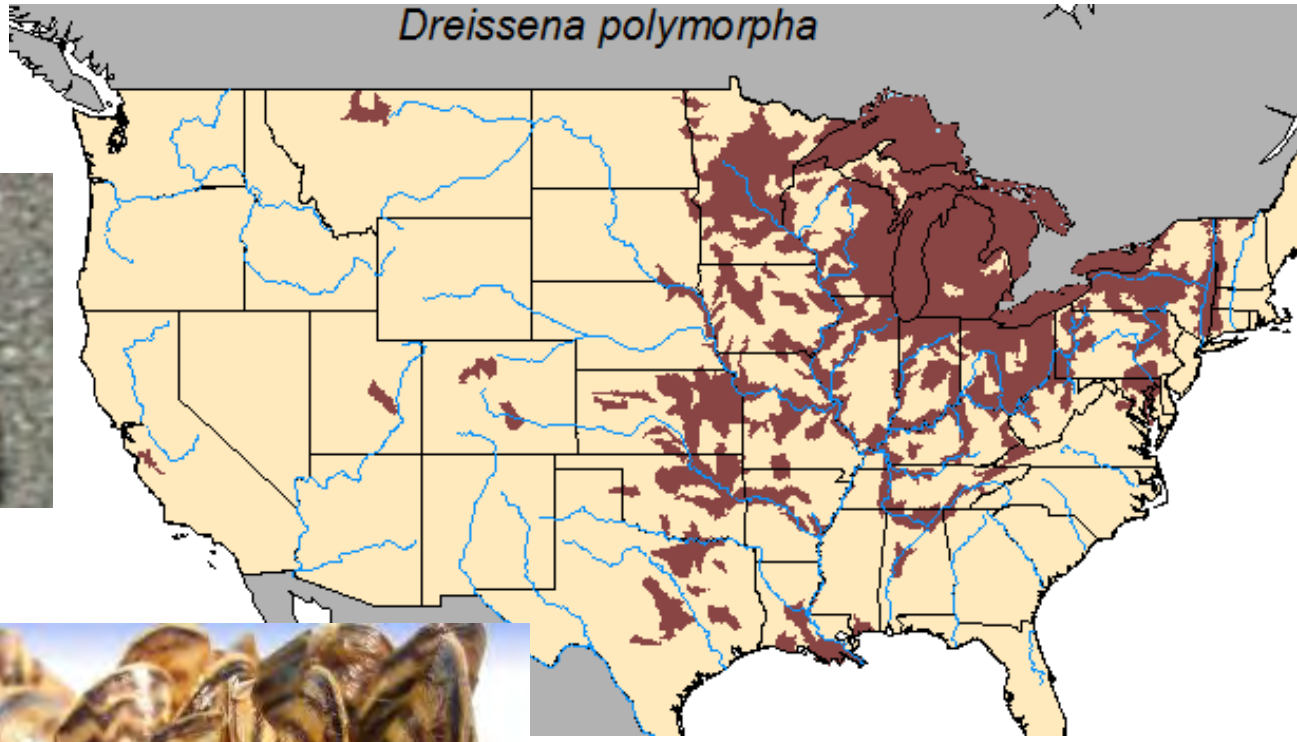
Zebra Mussels, *Dreissena polymorpha*



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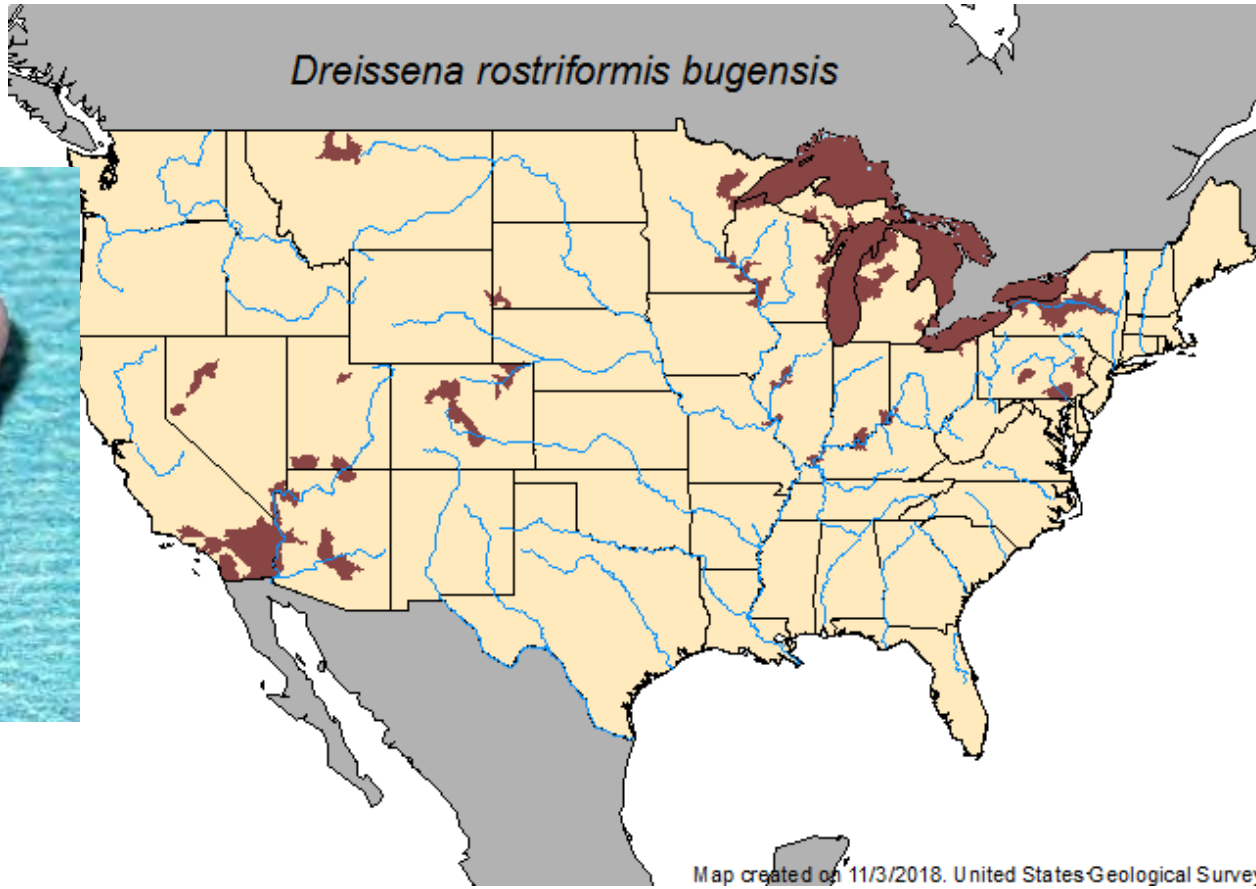
Quagga Mussels, *Dreissena bugensis*



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Zebra vs Quagga Mussels

Golden Mussel, Limnoperna fortunei

- Native to China, Southeastern Asia
- Not yet reported in U.S.
  - Problematic in South America
- 20-30 mm
- Similar biofouling/food web threat to Dreissena

Darrigran G.

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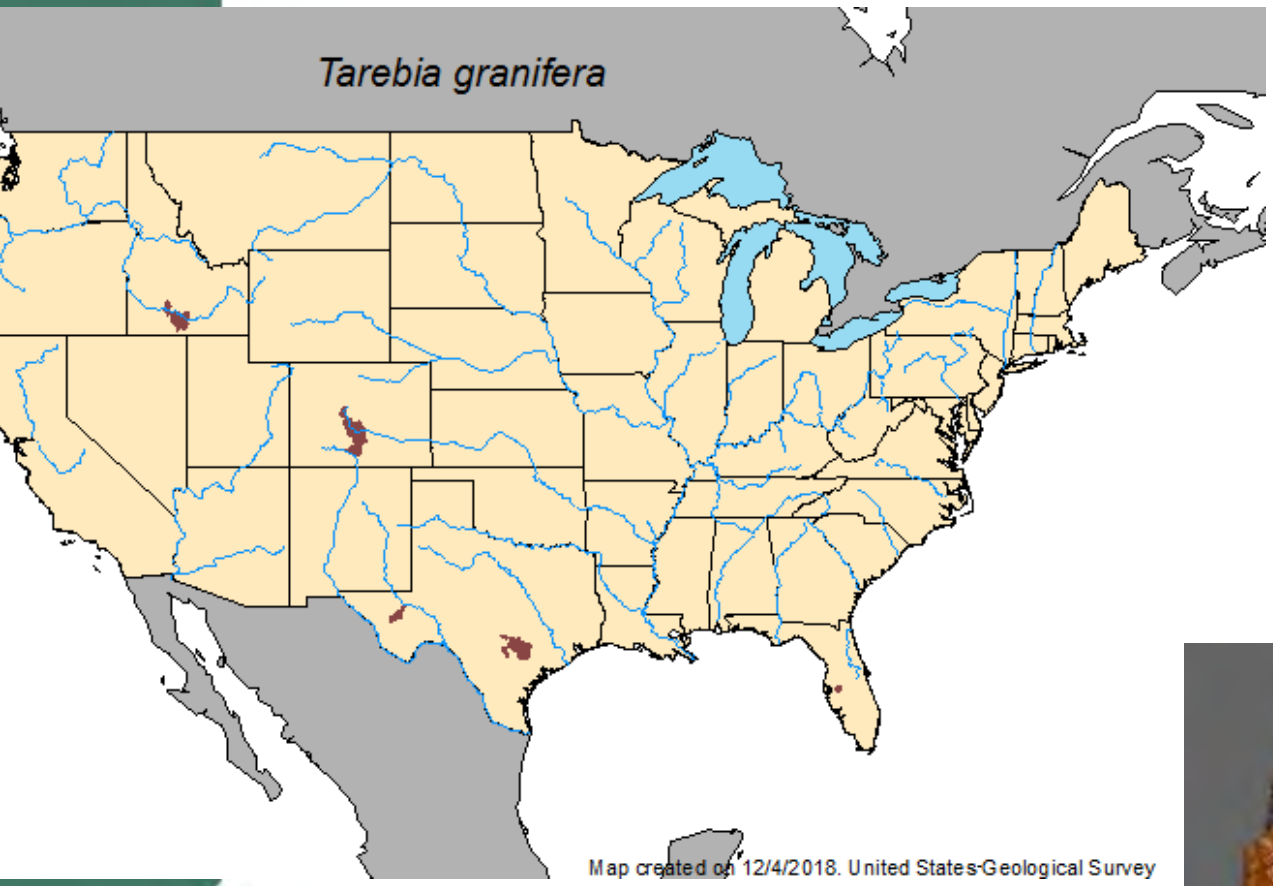
Quilted Melania, Tarebia granifera



- Native to Southern Asia
- 6-40 mm
- Human disease potential
  - Oriental lung fluke

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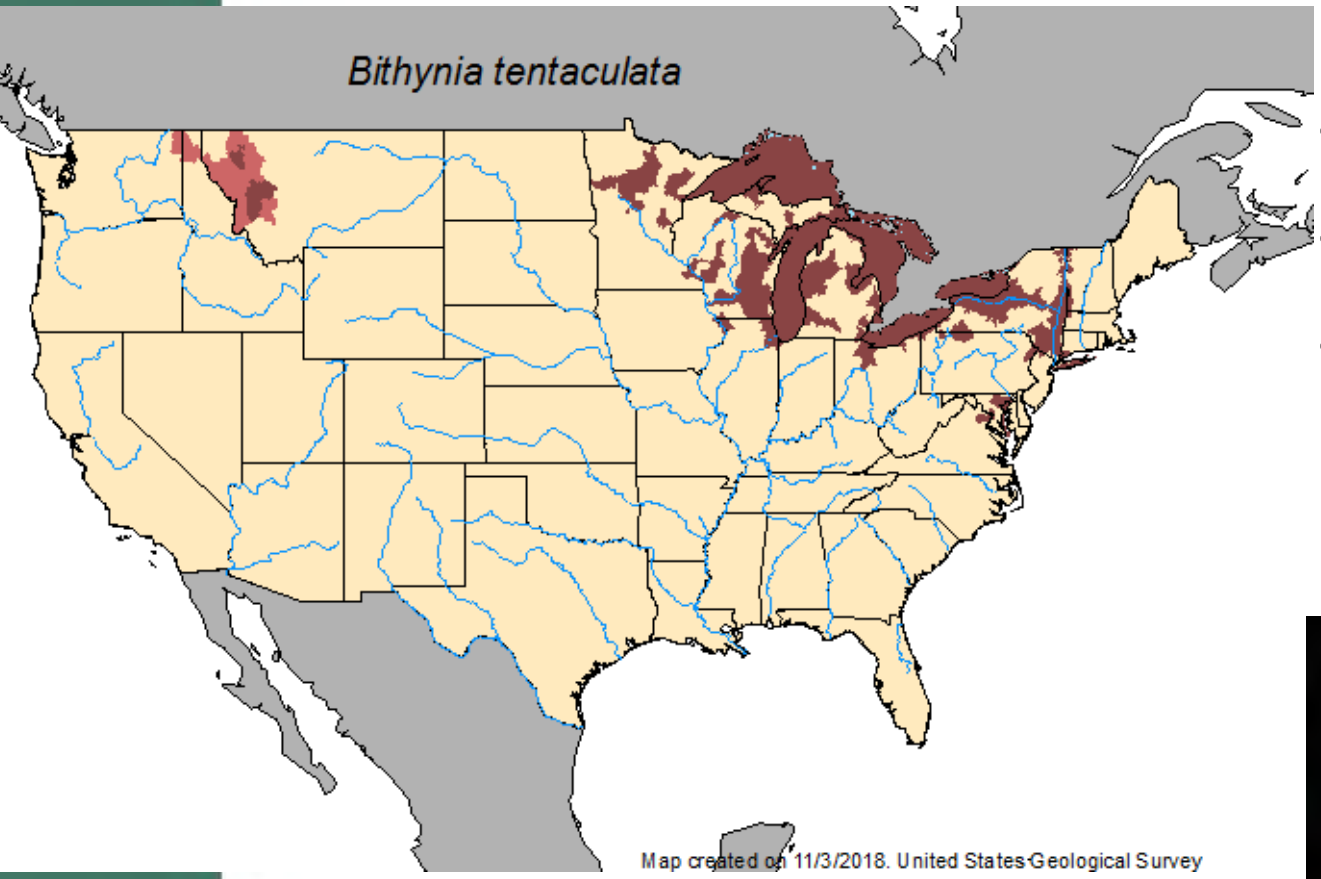
Faucet Snail, Bithynia tentaculate

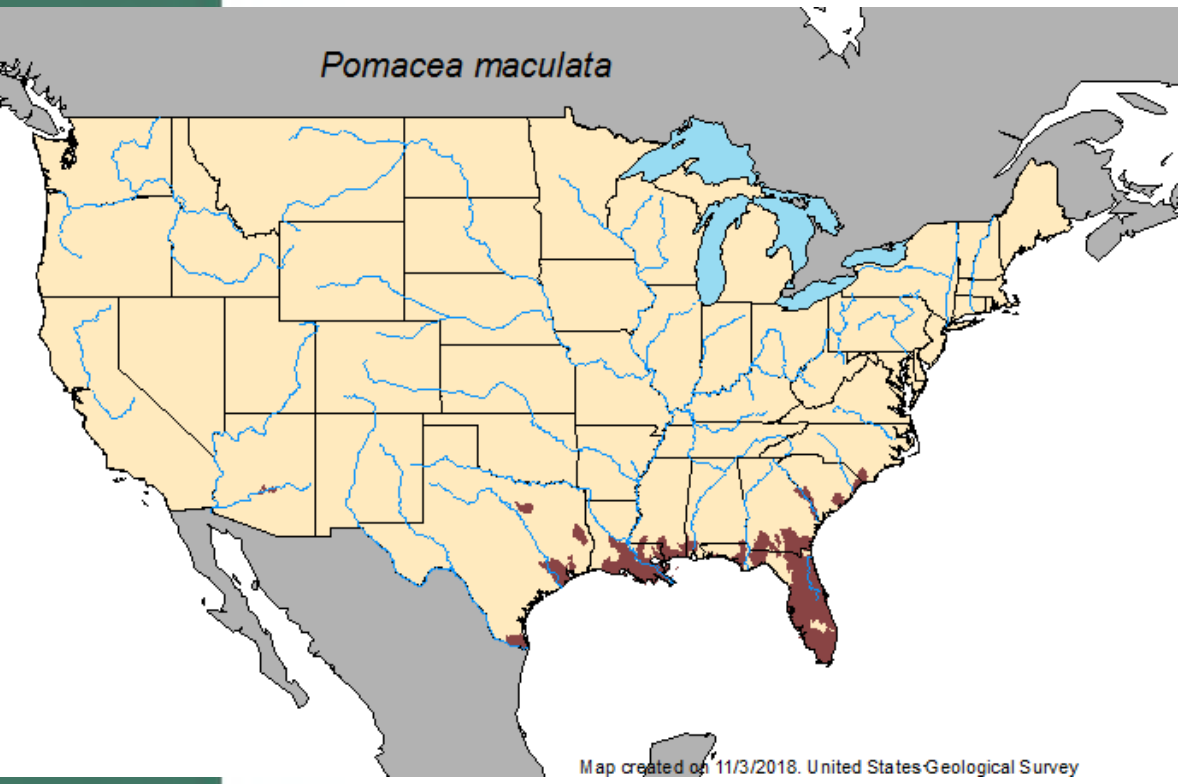


- Native to Europe
- 8-15 mm
- Hosts trematodes that can be lethal to waterfowl


Amy Benson

NORTH CAROLINA Wildlife RESOURCES COMMISSION

Giant Apple Snail, Pomacea maculate



- Native to South America
- Can grow to 155 mm

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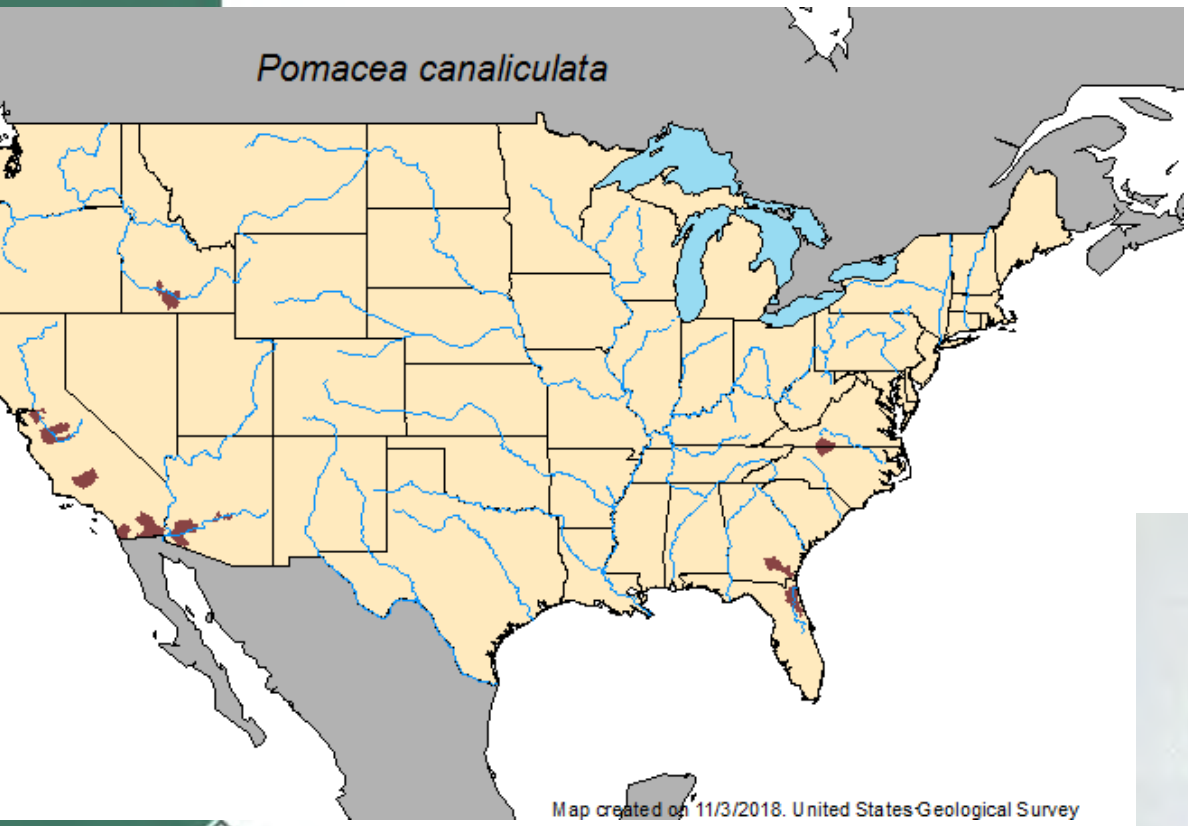
Channeled Applesnail, Pomacea canaliculata



- Native to South America
- Can grow to 63 mm


Amy Benson

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Introduction Sources

- Hitchhiking
  - Boats/motors/trailers
- Bait buckets
- Aquarium trade
- Aquaculture

National Park Service

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Prevention

- Use same methods as other ANS prevention
- Other states use boat-trailer inspection/decontamination checkpoints
  - Minnesota and other states use dogs to sniff for Zebra Mussel

PDF - opens in a separate window

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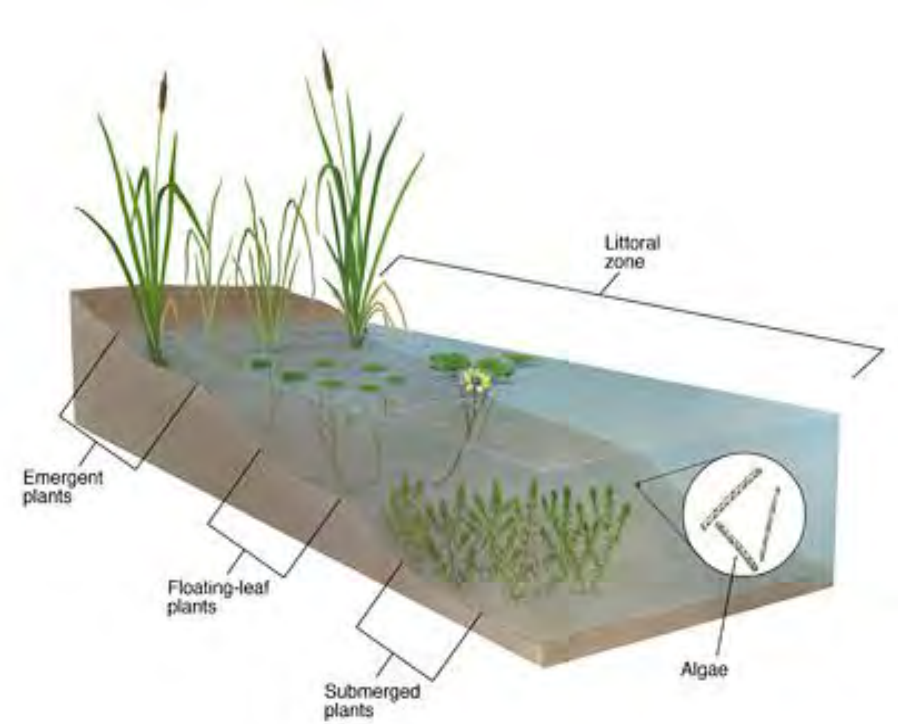
Invasive Aquatic Plant Management in North Carolina

Erika Haug and Jessica Baumann
Crop and Soil Science Department
North Carolina State University

NC STATE EXTENSION

Aquatic Vegetation

- Emergent (shoreline)
- Floating
  - Floating-leaved
  - Free-float
- Submersed (SAV)
  - Rooted
  - Non-rooted
- Algae
  - Planktonic
  - Filamentous



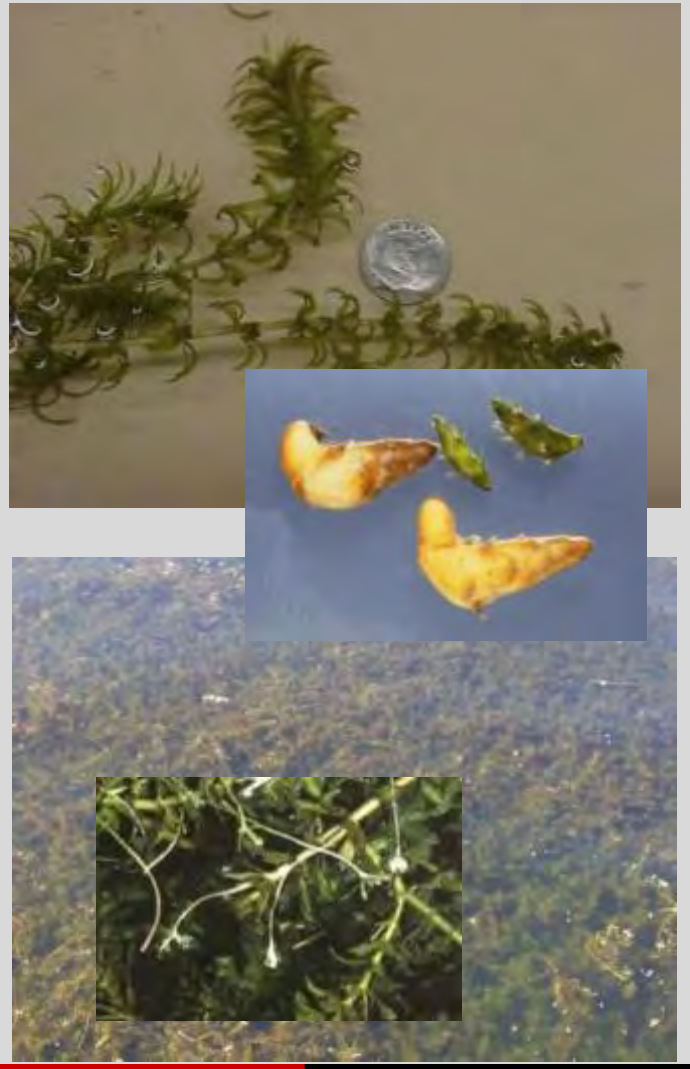
http://www.science-art.com/gallery/154/154_3152009174032.jpg

Benefits of Native Aquatic Plants

- Food, shelter, and breeding habitat for fish and wildlife
- Protection from erosion
- Oxygenation of water
- Aesthetics

Hydrilla

- Called the “perfect aquatic weed”
- Leaves in whorls of 5-10+
- Serrated leaf margins
- Reproduction: tubers, turions, fragments, flowers (?)
- Advantages:
  - Tubers can remain in sediment for over 7 years
  - Very shade tolerant
  - Low CO_2 compensation



Submersed

Brazilian Elodea

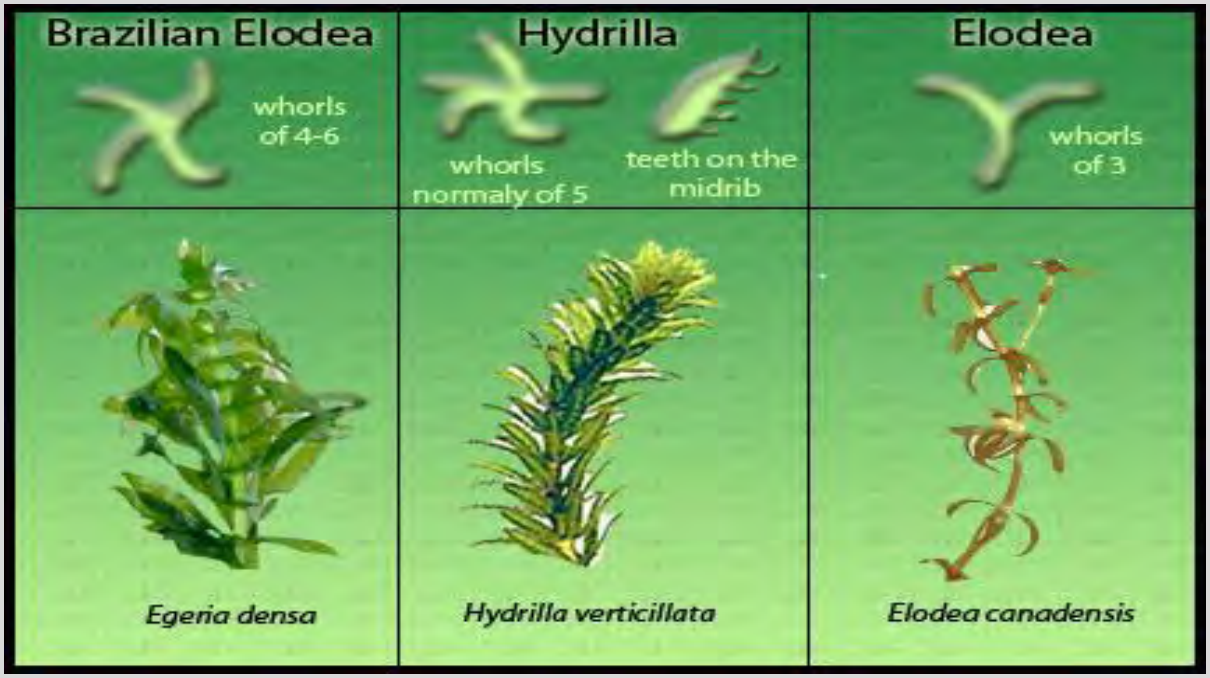
Egeria densa

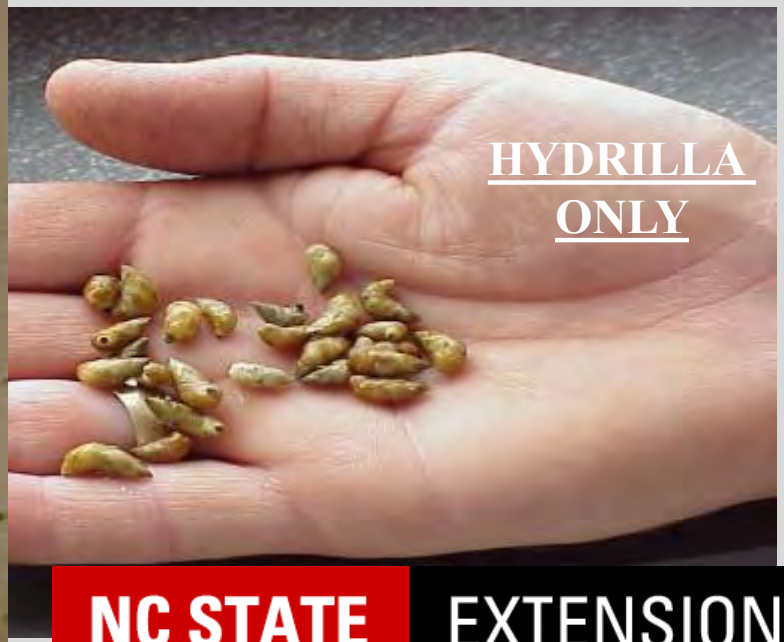
NC STATE EXTENSION

Submersed

Waterweed (Elodea)

Elodea canadensis





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Submersed

Eurasian watermilfoil
Myriophyllum spicatum

NC STATE EXTENSION

Yellow floating heart
Nymphoides peltata

NC STATE EXTENSION

Water Snowflake
Nymphoides indica

Crested Floating Heart
Nymphoides aquatica

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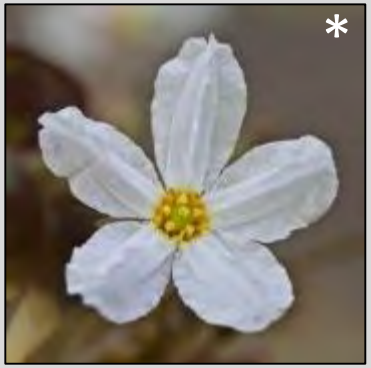
Hybrid Floating Heart

	Flower	Leaf Surface	Leaf Underside
Crested Floating Heart *(Non-Native)* *N. cristata*			
Hybrid *N. cristata* x *N. aquatica*			
Big Floating Heart *(Native)* *N. aquatica*	 *		

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Parrot feather

Myriophyllum aquaticum

Water Hyacinth in Stormwater Pond

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Alligatorweed in drainage ditch

S. H. Kay, NCSU, 1989

NC STATE EXTENSION

Cyanobacteria

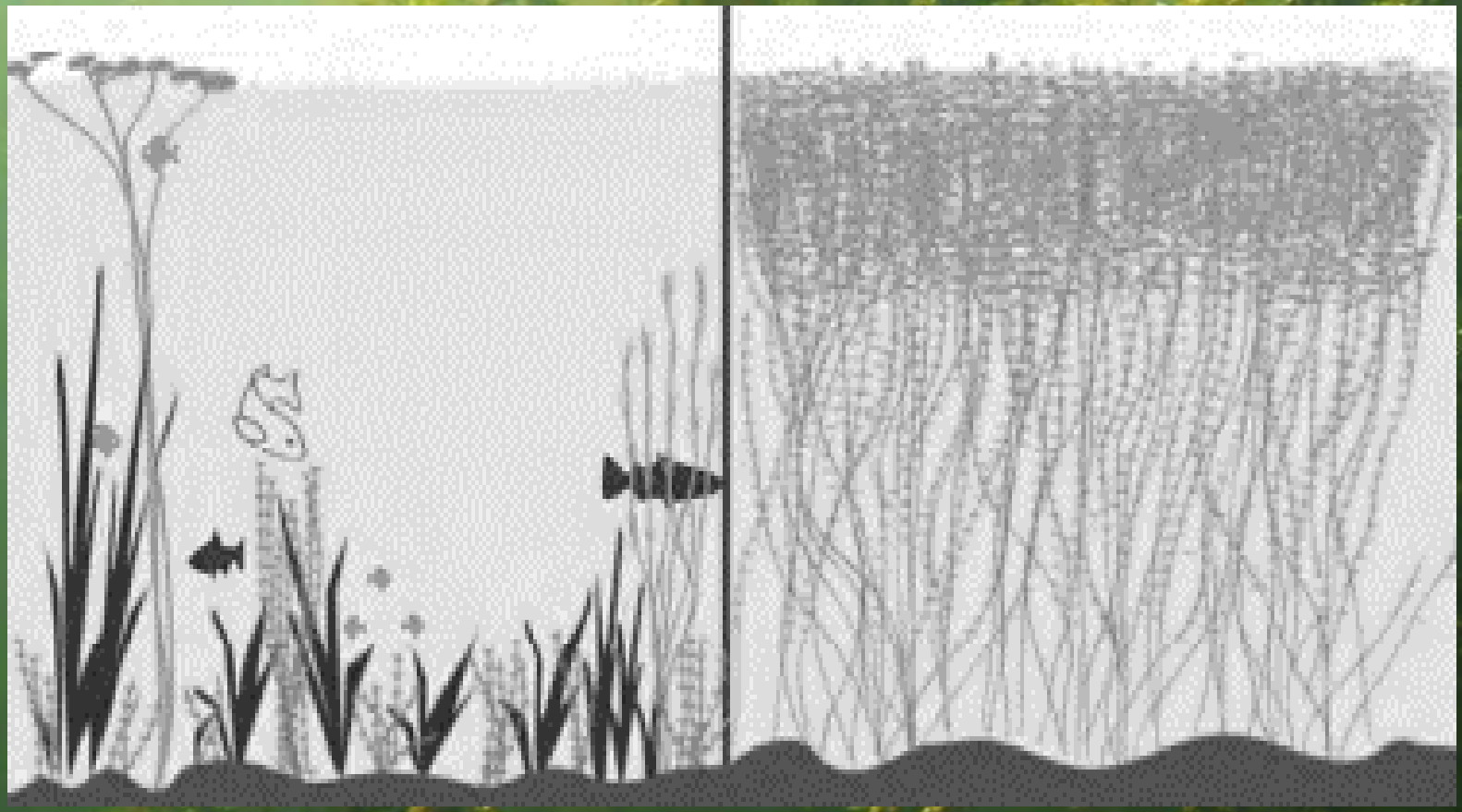
Why Do We Manage Aquatic Weeds in North Carolina?

- Aesthetics
- Recreation
- Ecosystem Health
- Aquaculture
- Transportation
- Water supplies
- Power generation
- Irrigation
- Drainage
- Flood control

Native plant diversity and fishery productivity:

Native Community

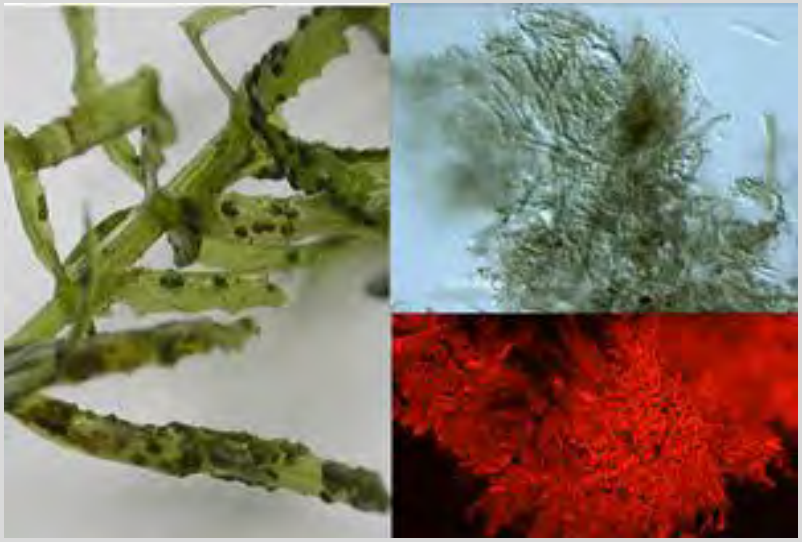
Invasive Monoculture



Ecosystem Health:

Mosquito-borne diseases

Avian Vacuolar Myelinopathy (AVM)



Control Options

- Prevention
- Cultural/Physical
- Mechanical
- Biological
- Chemical

Prevention: How Do Aquatic Plants Spread?

- Animals (wading birds, aquatic mammals)
- Water movement
- Transport by wind and rain (seeds, spores)
- Human activities

Figure 5. A duck with watermeal (arrow) clinging to its breast feathers.

Prevention: How Do Aquatic Plants Spread?

- Animals
- Water movement
- Transport by wind and rain
- Human activities (boating, fishing enhancement, aquarium dumping, water gardens, dredging, mechanical harvesting)

Cultural/Physical Mgt.

- Modify the environment to create less favorable conditions
- Some techniques cheap and easy with few environmental impacts
  - Fertilization
  - Liming
  - Pond dyes
  - P precipitation
  - Benthic barriers
  - Water level manipulation
  - Hand-removal

Pond Dyes

- Work by blocking sunlight
- Not effective on vegetation within 18” of water surface
- Must be applied early in the season
- Appropriate concentration must be maintained
- Water flow reduces effectiveness

Nutrient Management

- Phosphorous removal:
  - Buffered Aluminum
  - Phoslock - Lanthanum

Water Drawdown

- May be used to supplement other management tools or used alone
- Drawdown less effective on hydrilla than other aquatic species
- Best for control of annual species
- Tubers/turions and seeds can survive desiccation and have some cold tolerance
- Summer drawdown more effective on hydrilla than winter

Benthic Barriers

- Pond owners can install
- Small scale
- Broad spectrum immediate control
- Maintenance required
- Impacts on other organisms, fish spawning, macro-invertebrates

Hand Removal

- Most common management form
- Highly labor intensive/inefficient
- Plants may reproduce as fast as removed
- Generally for special situations:
  - Active water intakes
  - Active irrigation intakes
  - Small newly discovered infestations

Biological Management

- Triploid grass carp is main option
  - Will not reproduce
  - Relatively non-specific herbivore
  - Hydrilla is a preferred food
  - Eurasian watermilfoil is not
  - Permits may be required
- Some other biocontrol agents milfoil weevils, alligatorweed flea beetle, purple loosestrife beetle, hydrilla leaf mining fly

Mechanical Techniques

- Generally short-term control
- May actually spread problems
- Expensive

- Chains
- Cutter bars
- Hydro-rake
- Weed harvesters
- Cutter boats
- Dredges

NC STATE EXTENSION

Chemical Management

Questions to Ask Before Herbicide Use:

- What is the Major Use of the Water ?
  - Irrigation, retention, recreation, multipurpose
- Where Does the Treated Water Go ?
  - What is downstream and what is the flow rate, significant rain event
- Are Fish an Important Resource ?
  - Pay attention to water temperature, DO, plant mass, alkalinity
- What non-target plant species are present?
  - Herbicide selection, determine time of year to treat

Chemical Options

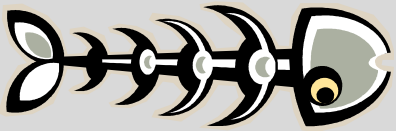
- 2,4-D products
- Bispyribac
- Carfentrazone
- Copper products
- Diquat
- Endothall
- Flumioxazin
- Flurpyauxifen-benzyl
- Fluridone
- Glyphosate
- Imazamox
- Imazapyr
- Penoxsulam
- Peroxide products
- Triclopyr

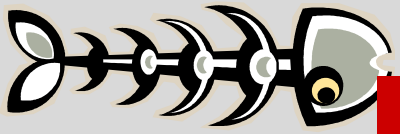
Water Use Restrictions

- Fishing: consumption of fish or use for fish meal
- Swimming: any activity which immerses the body
- Irrigation: including use for preparation of agricultural pesticide sprays
- Livestock watering: may include humidification of poultry houses
- Domestic drinking water supplies: a setback distance also may apply

Fish Kills

- **Most fish kills (> 99%) due to oxygen depletion**
- **Application of copper products at incorrect rate or to too large of an area**
- **Fish kills by oxygen depletion when:**
  - **Herbicide treatments are too late in the season**
  - **Too much weed growth treated/killed at once**





Aquatic Herbicide Application Techniques

- Direct pouring of undiluted or (preferably) diluted product into the water
- Surface application (spraying over surface)
- Foliar application (for emergent vegetation)
- Dilute injection beneath water's surface
- Direct metering into water column
- Granular spreader (centrifugal or blower)

NC STATE EXTENSION

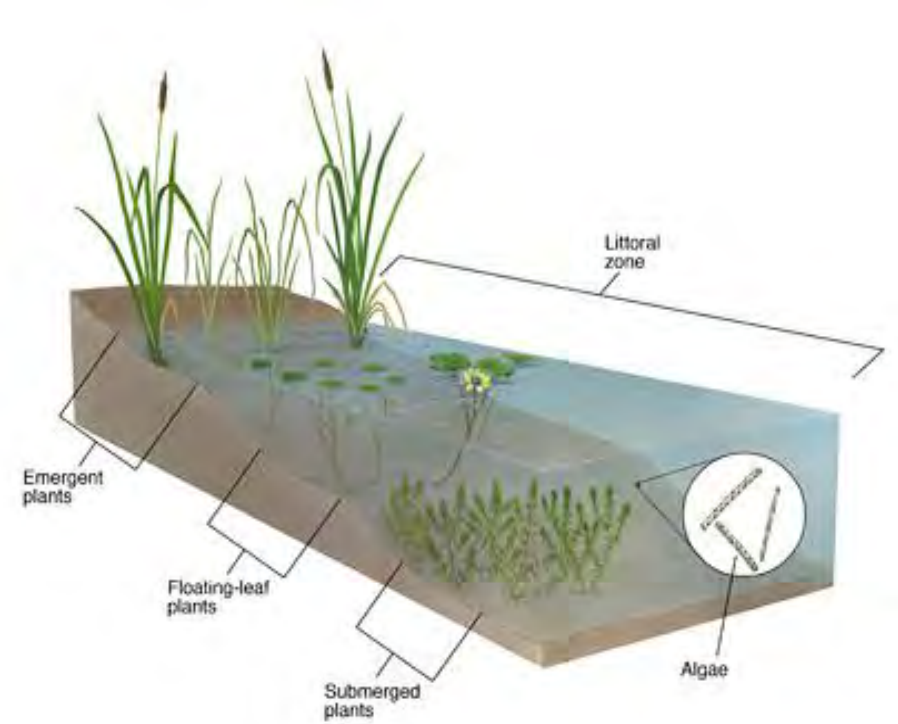

shindaiwa

Questions?

Erika Haug
Email: ejhaug@ncsu.edu

Aquatic Vegetation

- Algae
  - Planktonic
  - Filamentous
  - Macroalgae
- Vascular Plants
  - Submersed
  - Floating
    - Rooted
    - Non-rooted
  - Emergent



http://www.science-art.com/gallery/154/154_3152009174032.jpg


Algae
Lack true stems, leaves or roots
NC STATE EXTENSION

Planktonic Algae

Cyanobacteria

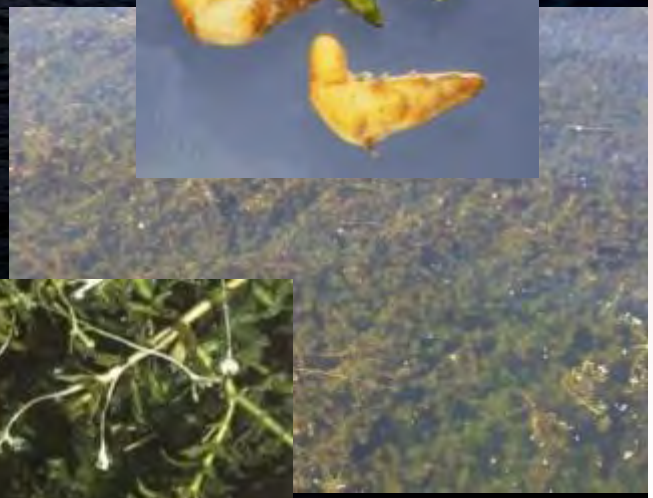
Algal Management Techniques

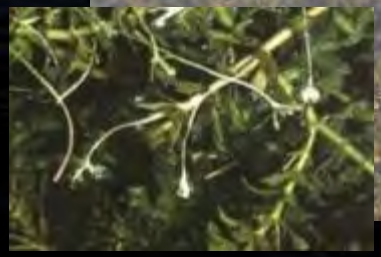
- Herbicides
  - Copper products (most algae)
  - Diquat bromide (difficult algae)
  - Hydrothall 191 (may kill fish)
  - Peroxide products
- Pond dyes
- Biological control??
  - High stocking rates (50-60/A) of small grass carp (4-8”), maybe


Submersed Plants
All or most of the plant
is below the surface of the water.
NC STATE EXTENSION

Hydrilla

- Called the “perfect aquatic weed”
- Leaves in whorls of 3-10+
- Serrated leaf margins
- Reproduction: tubers, turions, fragments, flowers (?)
- Advantages:
  - Tubers can remain in sediment for over 7 years
  - [illegible]





Submersed

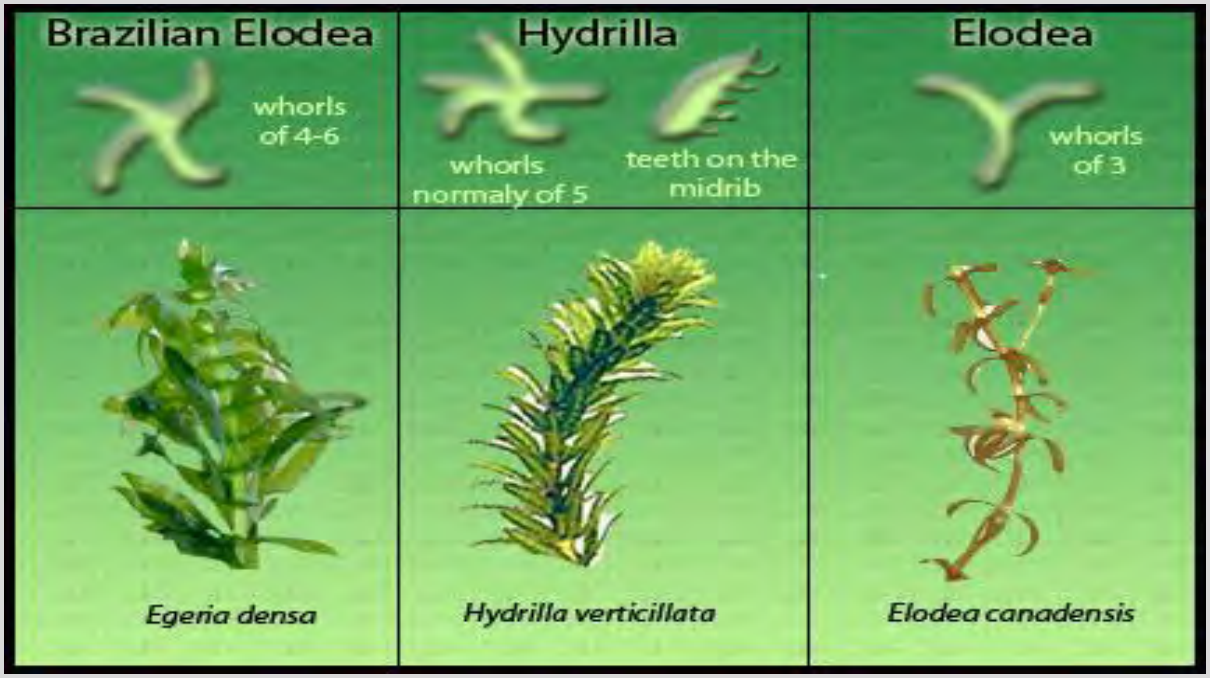
Brazilian Elodea

Egeria densa

Submersed

Waterweed (Elodea)

Elodea canadensis


Brazilian Elodea
whorls of 4-6
Hydrilla
whorls normaly of 5
teeth on the midrib
Elodea
whorls of 3
Egeria densa
Hydrilla verticillata
Elodea canadensis


Hydrilla
Egeria densa
(Brazilian Elodea)


HYDRILLA
ONLY

Eurasian watermilfoil
Myriophyllum spicatum

Submersed

Variable-leaf milfoil

Myriophyllum heterophyllum

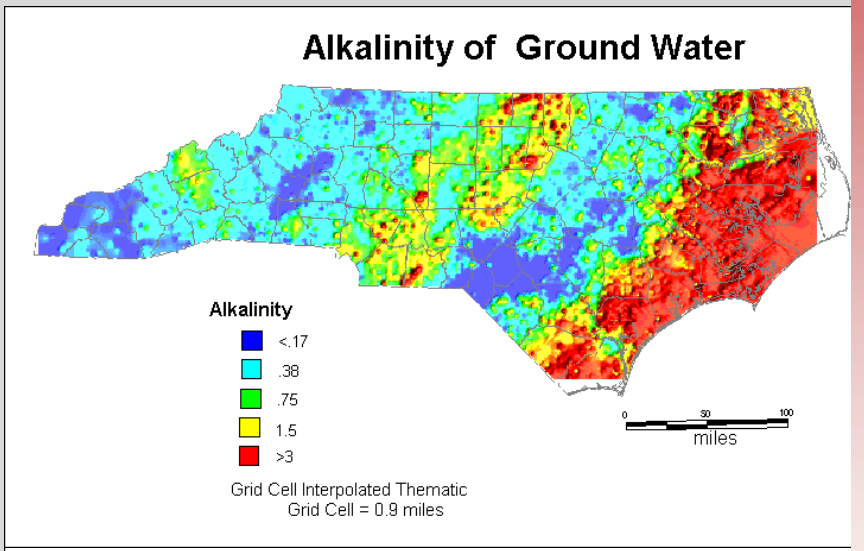
Brittle or Spiny Naiad
Najas minor

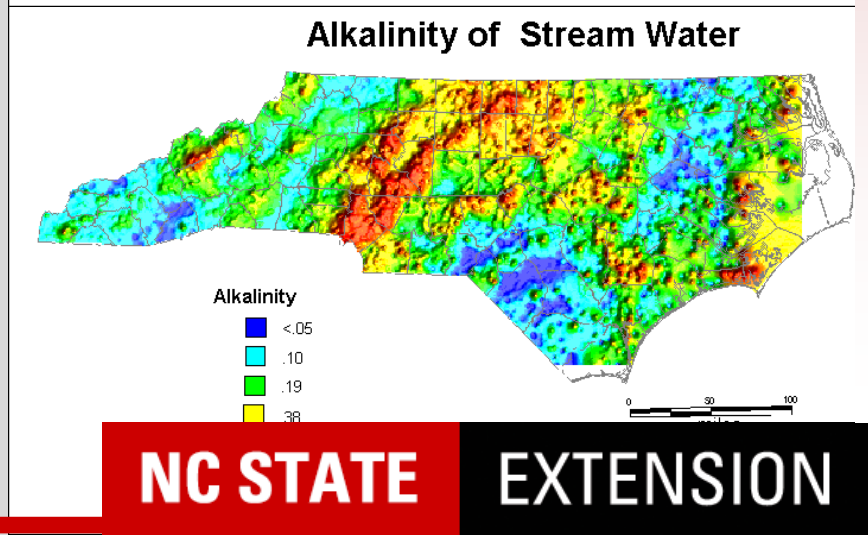
Submersed Weeds

- Bottom barrier
- Removal by hand or mechanical means
- Grass Carp
  - Effective on hydrilla, chara, and all vascular plants except watermilfoil (15-18 fish per vegetated acre)
- Herbicides
  - 2,4-D and triclopyr (watermilfoils)
  - Diquat (Reward, Tribune)
  - Endothall (Aquathol)
  - Fluridone (Sonar)
  - Flurpyaxifen-benzyl (Porcellacor)
  - Flumioxazin (Clipper)

Alkalinity

- The buffering capacity of water
- Needs to be > 20 ppm
- Copper is much more toxic to fish at low alkalinities
- Use lower rates





Floating Leaf Plants

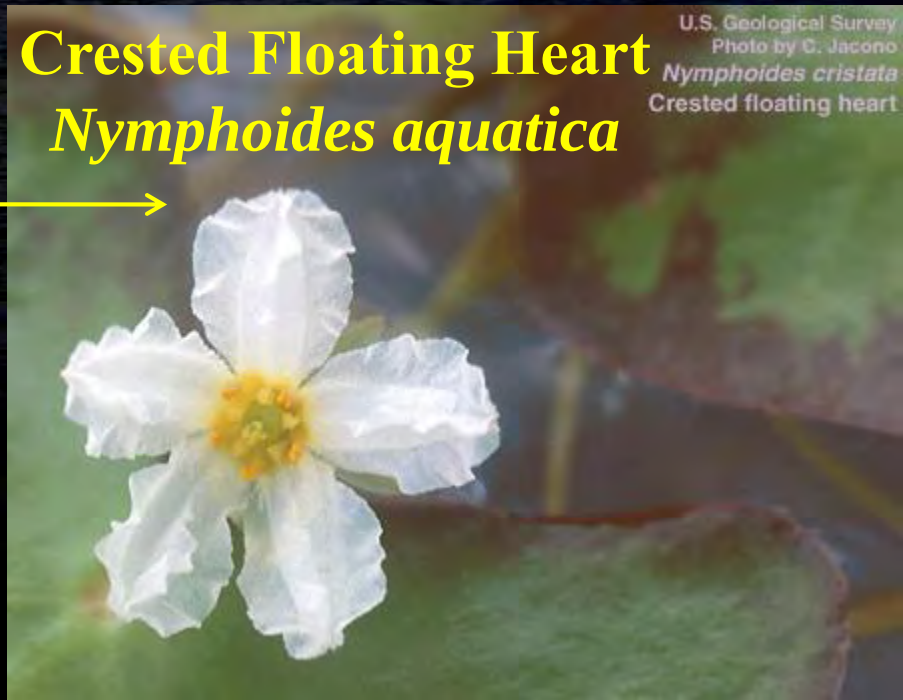
Plants rooted in bottom,
Most leaves float on the surface,
or may be slightly raised above the surface
in mature plants.

Banana Lily or Floating Heart *Nymphoides aquatica*

Yellow floating heart
Nymphoides peltata

Water Snowflake
Nymphoides indica

Crested Floating Heart
Nymphoides aquatica



Floating-leaf Weeds

- Herbicides
  - 2,4-D and triclopyr (broadleaves only)
  - Diquat
    - Contact \ surfactant required
  - Glyphosate – check label
    - Systemic \ surfactant may be required
  - Habitat (Imazapyr)
    - Systemic \ surfactant required


Free-Floating Plants
Float on surface of the water
and not rooted to substrate.
NC STATE EXTENSION

Free-floating Plants

- Herbicides
  - Diquat plus surfactant (duckweed)
  - Fluridone (duckweed and watermeal)
    - No surfactant; very slow on watermeal
  - Flumioxazin (duckweed and watermeal)
    - Two treatments or use combo

Emergent

Rooted in shallow water (in most cases)
or in damp soil.
Most of the plant is above the surface of the water.

Creeping Waterprimrose

Ludwigia hexapetala

Alligatorweed

Alternanthera philoxeroides

Emergent Weeds

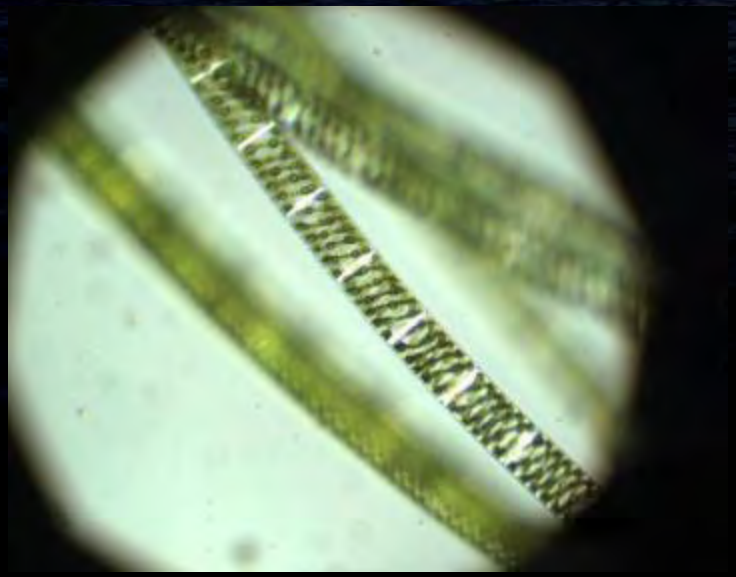
- Herbicides
  - 2,4-D and triclopyr (broadleaves only)
  - Diquat
    - Contact \ surfactant required
  - Glyphosate – check label
    - Systemic \ surfactant may be required
  - Habitat (Imazapyr)
    - Systemic \ surfactant required
- Biological control: Alligatorweed beetle

How Do We Make Weed Management Decisions?

- Use of the body of water
  - Irrigation, consumption, livestock, recreation etc.
- Plant identification
- Fish and wildlife populations
- Water quality
- Physical, environmental, and economic limitations

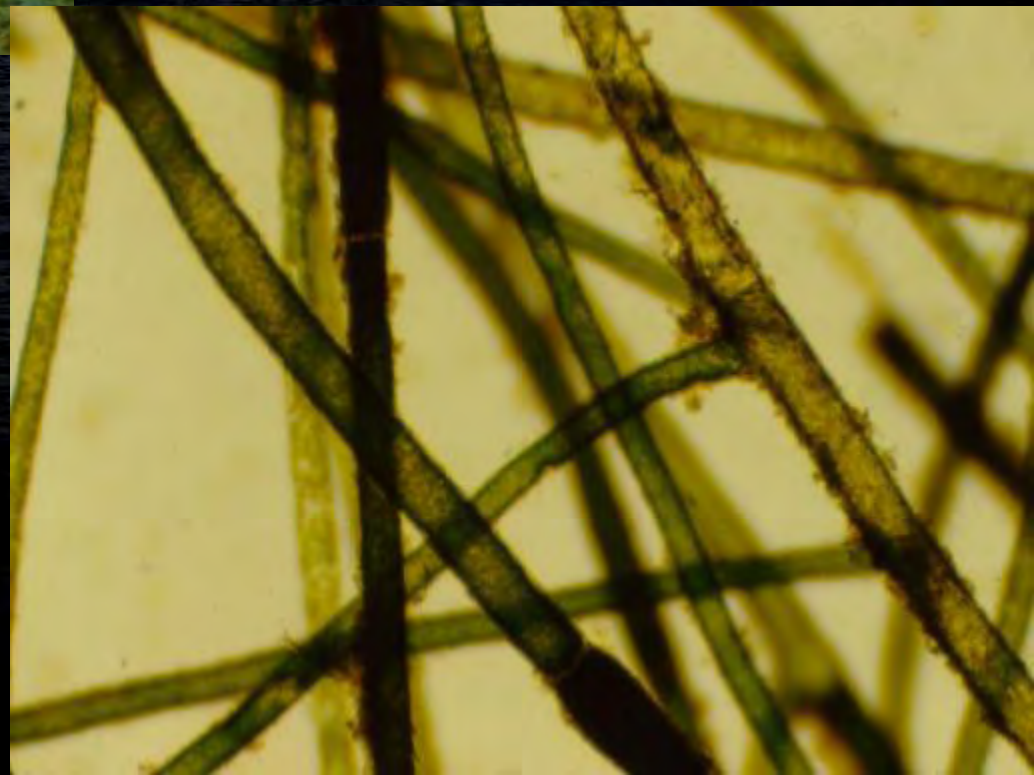
Filamentous green algae

Spirogyra



Filamentous green algae

Pithophora



Macroalgae

Muskgrass

Chara

Duckweeds

Watermeal

Wolffia columbiana

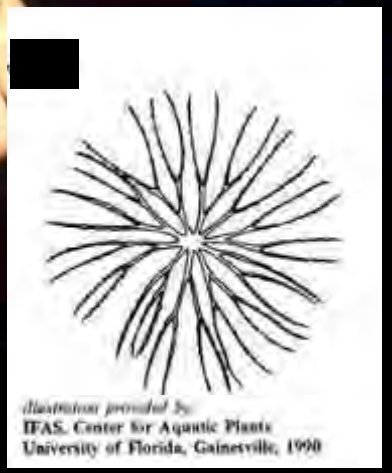
Pondweeds

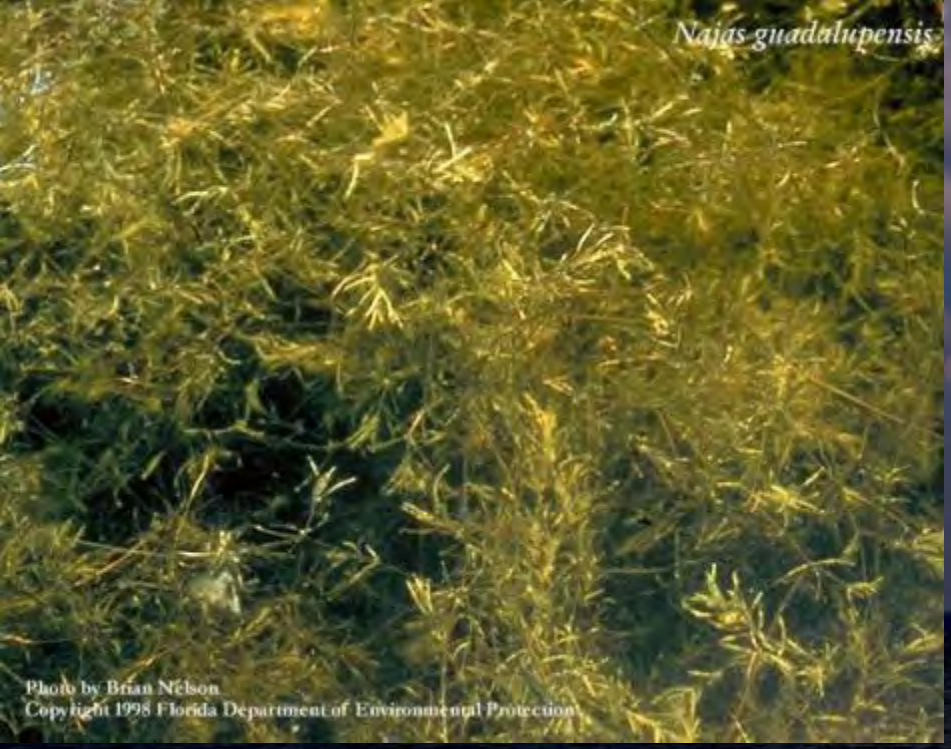
Potamogeton Species

There are about 80 species of pondweeds in the world.
Pondweeds are very important as wildlife food.

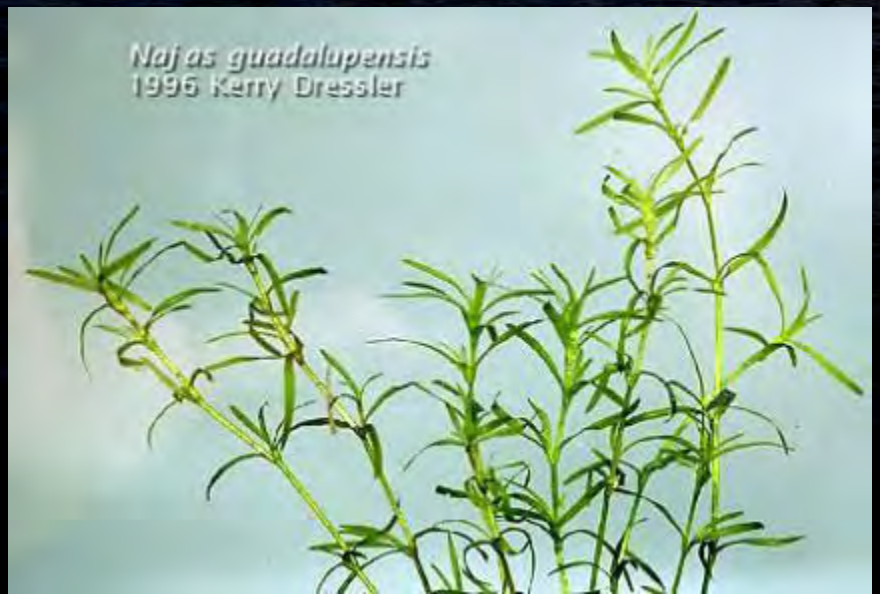
Bladderwort
Utricularia spp.

Coontail
Ceratophyllum demersum





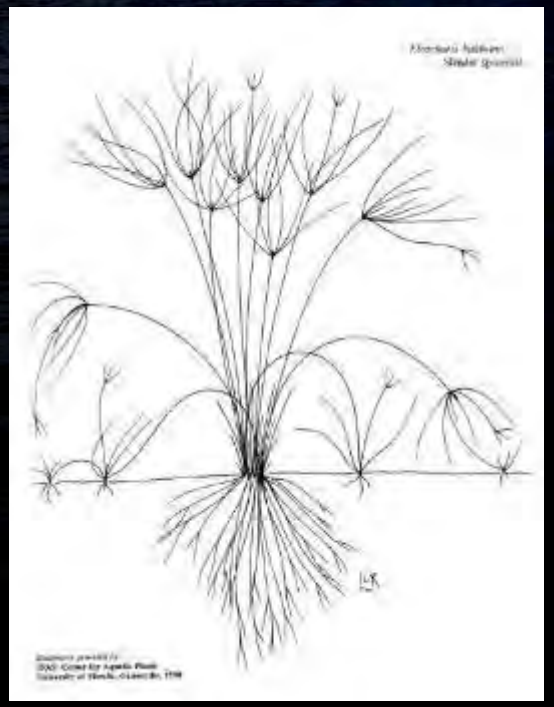
Southern Naiad
Najas guadalapensis



Proliferating Spikerush

Eleocharis baldwinii

Submersed to Emergent



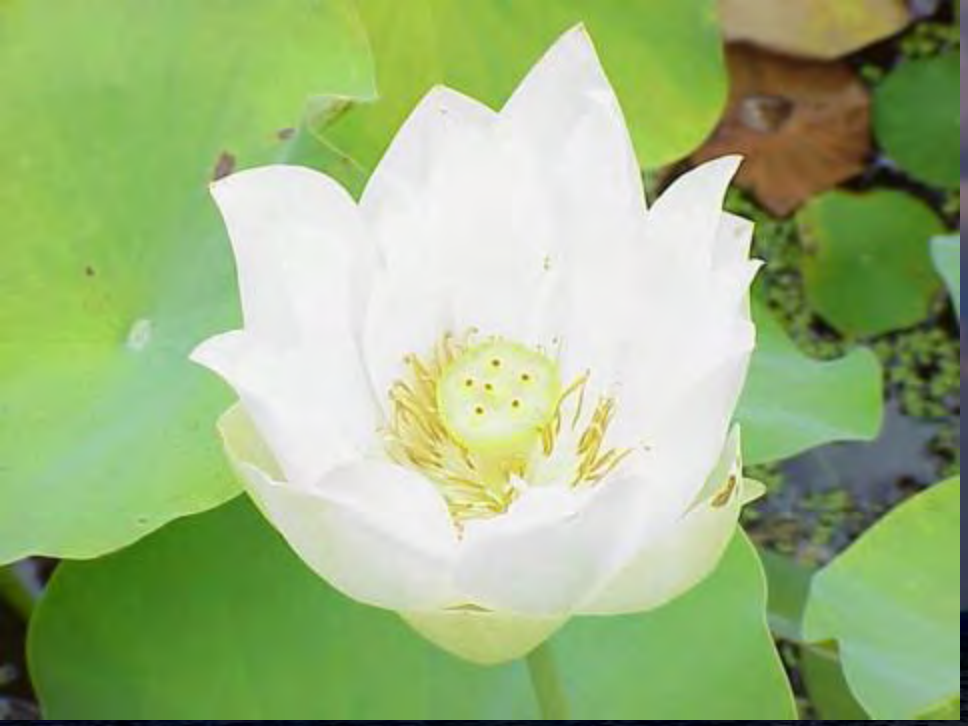
Fanwort (Cabomba)
Cabomba caroliniana

- Submersed
- Fan-like leaves in whorls of 2
- May be red or green in color
- Inflorescence emerges from water
- Spread by seed & fragmentation

Spatterdock
Cow lily

Nuphar lutea

Fragrant waterlily
Nymphaea odorata



American Lotus
Nelumbo lutea

Watershield
Brasenia schreberi

Watermeal Control

NC STATE UNIVERSITY
A&T STATE UNIVERSITY
COOPERATIVE EXTENSION
Helping People Put Knowledge to Work

Watermeal (Wolffia spp.)

- Dense colonies can completely cover water surface causing:
  - Decreased gas exchange between atmosphere and water = decreased levels of dissolved oxygen
  - Blocks sunlight critical for beneficial submersed plants
  - Aesthetics
  - Clogged irrigation intakes
- Easily transported
- Few control measures

Figure 5. A duck with watermeal (arrow) clinging to its breast feathers.

NC STATE EXTENSION


Watermeal Infested Pond at Treatment
08/28/2006 12:11


1 Month after Treatment
45 ppb fluridone


At Treatment
08/28/2006 12:11
1 MAT
12 Month after Treatment
45 ppb fluridone

Before and After

Pretreatment

2 WAT
400ppb flumioxazin

Before and After

Pretreatment

4 MAT
30ppb fluridone
fb 100 ppb flumioxazin

Before and After

Pretreatment

4 MAT of 200ppb Flumioxazin +
100 ppb Diquat

Copper Products

- Primarily an algaecide / fast acting
- Toxic to fish if not used properly
- Copper sulfate is worst environmentally
- Often used in tank mixes with either diquat dibromide or endothall
- Formulations included copper sulfate pentahydryate and several chelated (complexed copper) formulations

Peroxide Products

- AI: sodium carbonate peroxyhydrate
- PAK27 and GreenClean registered
- Fast acting / contact algaecide
- Non-toxic to fish (as labeled)
- Primarily for blue-green algae control
- May control other algae as well

Endothall Products

- Fast acting / contact algaecide
- Important differences in products
  - Ex. Hydrothol controls algae, Aquathol does not
- Only effective on submersed plants
  - Coontail, Eurasian watermilfoil*, hydrilla, parrots feather, pondweeds, brittle naiad, variable leaf milfoil

Diquat Dibromide (Reward)

- **Fast acting \ contact \ non-selective**
- **Excellent algaecide, particularly for difficult species of algae (*Spirogyra, Pithophora*,etc.)**
- **Used extensively for control of submersed weeds and duckweed (not good on watermeal)**
- **Often used in tank mixes with copper**
- **Should not be applied to muddy water or mixed in a tank with muddy water due to irreversible binding onto soil particles**

2,4-D Products

- Primarily a broadleaf herbicide used for many submersed dicot weeds and a few selected broadleaf monocots
- Both liquid and granular formulations
- Best available product for waterhyacinths
- Excellent for all of the watermilfoil group (parrotfeather, variable-leaf milfoil, etc.) and for fragrant waterlily

Triclopyr (Renovate)

- Primarily a broadleaf herbicide used for many submersed dicot weeds and a few selected broadleaf monocots
- Liquid - 3 lb/gal formulation
- Excellent for all of the watermilfoil group (parrotfeather, variable-leaf milfoil, etc.) and for waterlily, alligatorweed, spatterdock.
- May be used to control brush in and around water

Fluridone (Sonar/Avast)

- Slow acting herbicide for submersed weed control in slow moving waters
- Only product effective on watermeal
- Requires a long contact time
- No fish kills from oxygen depletion, as plants die slowly (several weeks to several months)
- Essentially non-toxic to fish, wildlife, humans
- No algaecidal properties

Carfentrazone (Stingray)

- **Registered in 2005**
- **Fast acting / contact herbicide**
- **Labeled for controlling water lettuce, water hyacinth, salvinia, duckweed, mosquito fern, water spinach, and *watermeals****
- ****Will not control watermeal***

Flumioxazin (Clipper)

- Registered in 2011
- Fast acting / contact herbicide
- Will control certain algae, watermeal, cabomba, milfoils, hydrilla, numerous floating plants, and others
- ***Activity in water is pH dependent***

Imazapyr (Habitat)

- Slow acting / systemic herbicide
- Only for floating and emergent plants; no activity on submersed plants
- Best product for alligatorweed and phragmites control
- Lengthy residual period

Glyphosate Products

- Broad-spectrum herbicide applied for control of most emergent weeds
- Certain species such as waterlily and watershield may be controlled effectively, provided that there is minimal wave action to wash the herbicide off the floating leaves
- Not applied into the water column
- Not effective on small, floating plants such as duckweed, watermeal, or mosquito fern

Imazamox (ClearCast)

- ALS inhibitor
- Used pre- or post-emergence in soybeans and 15 other crops
- EPA exempt from food tolerances
- Registered in 2008
- Very selective, minimal soil residual

Penoxsulam (Galleon)

- Acetolactate synthase (ALS) inhibitor
- Considered low-risk by EPA
- Used as a pre- or post-emergence rice herbicide
- Registered in 2007
- Expensive, but excellent on most floating species and good on many others

Procellacor

- A new herbicide chemistry
- Florpyrauxifen-benzyl
- Synthetic Auxin
- Registration expected spring 2018
- Different, stronger binding affinity for sensitive species than previous aquatic-registered auxin herbicides
- Subject to rapid photolysis in water
- Can also convert partially via hydrolysis to an acid form that also has herbicidal activity

2015 CFH Field Trial

- Private lake in Liberty, NC
- Infestation identified in 2014
- Treated approximately 0.5A

Treatment

- Treated on May 14th, 2015
- In-water treatment
- 50 ppb

Pretreatment

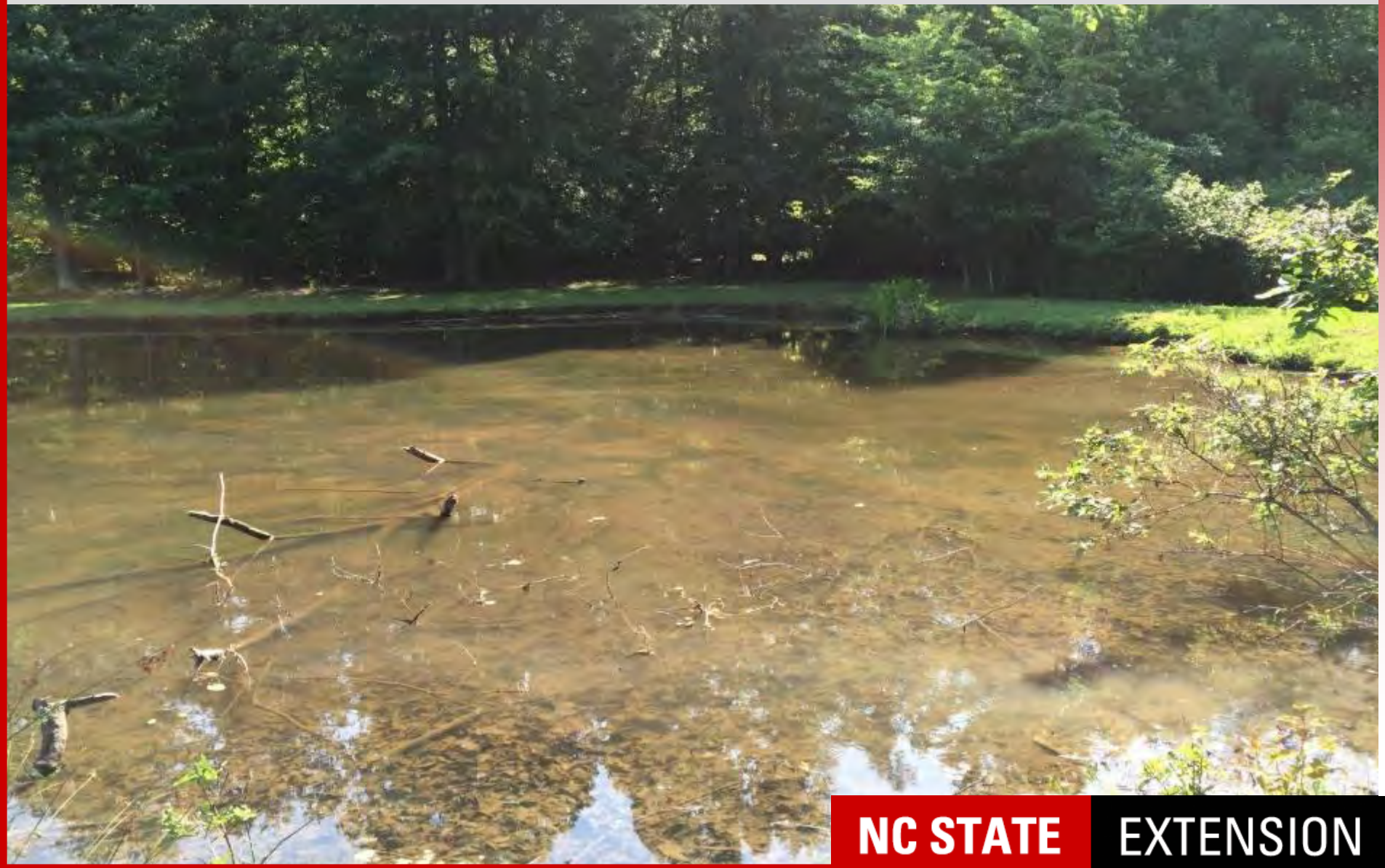
2 WAT

NC STATE EXTENSION

1 MAT

NC STATE EXTENSION

1.5 MAT



NC STATE EXTENSION

2 MAT

- Rooted daughter plants that likely floated from untreated side of pond

Irrigation

- Includes water use for preparation of agricultural pesticide sprays
- Restrictions on:
  - 2,4-D (21 & check label)
  - Carfentrazone (to 14)
  - Diquat (3 to 5)
  - Endothall (0 to 25)
  - Fluridone (to 30 days)
  - Imazapyr (120)
  - Triclopyr (120*)

    *0 for established grass
- Clearcast <50 ppb: no restrictions
- Galleon>1ppb: no irrigation
- Testing can be done to determine levels