Blue Green Algae Dominance within Florida Springs

Are Current Invasive Plant Management Paradigms Counter-Productive in a Time of Nutrient Enrichment?

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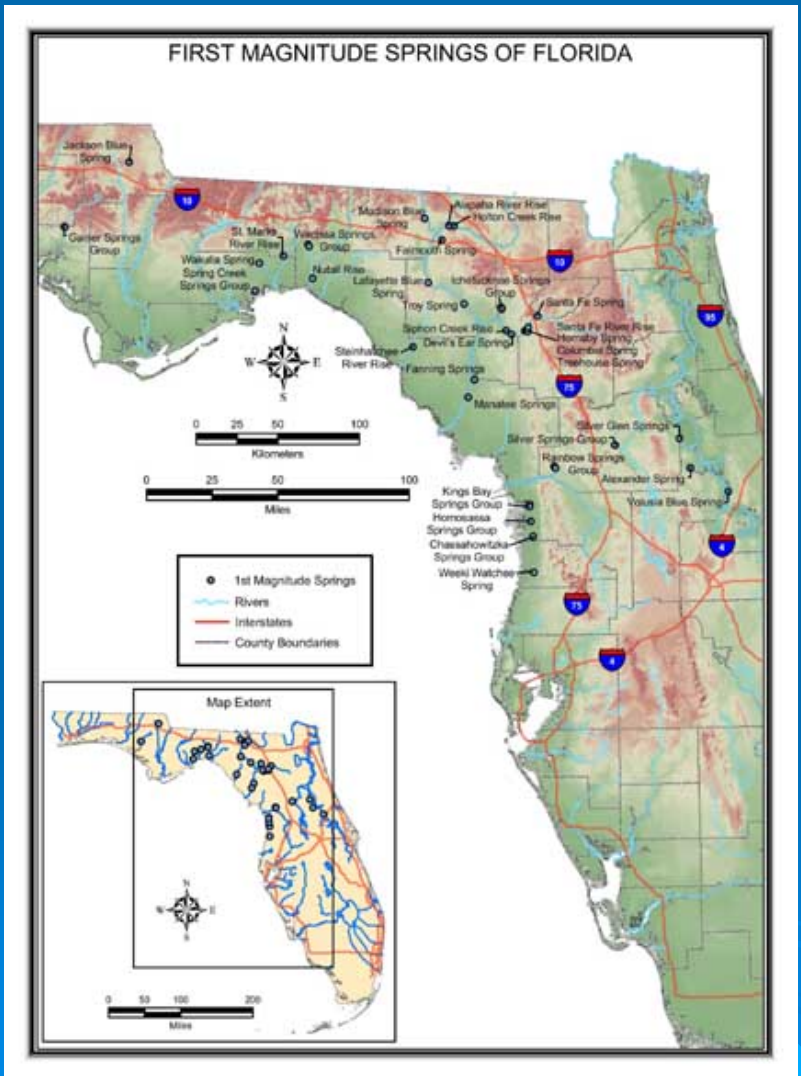
Florida's Springs: A Unique Resource



Map source: www.dep.state.fl.us

Florida's groundwater aquifers support the most productive and concentrated grouping of freshwater artesian springs found in the world

Over 700 springs known in the state, including 33 first magnitude springs with flows over 64 million gallons a day

Total discharge of approximately 8 billion gallons per day

Hydrogeology of Springs

Florida's major springs tend to occur within "karst" regions where underlying limestone is close to the ground surface

Most rainwater that does not evapotranspire is recharged to the groundwater in karst regions (i.e., little to no surface runoff)

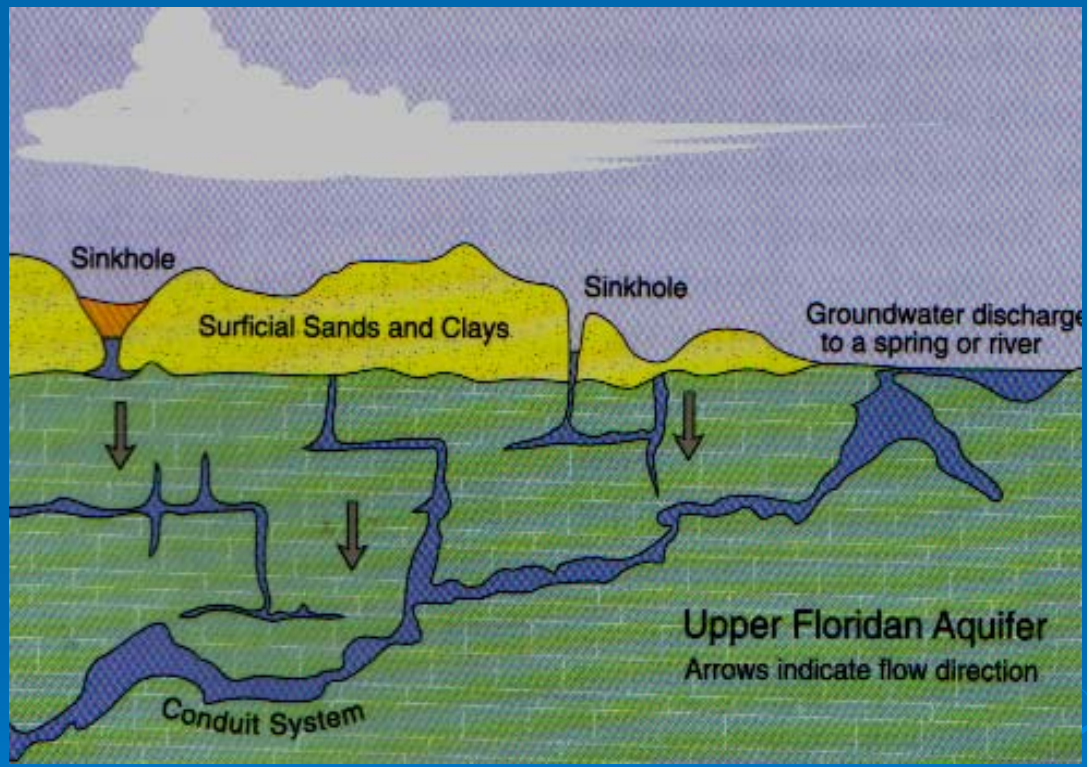
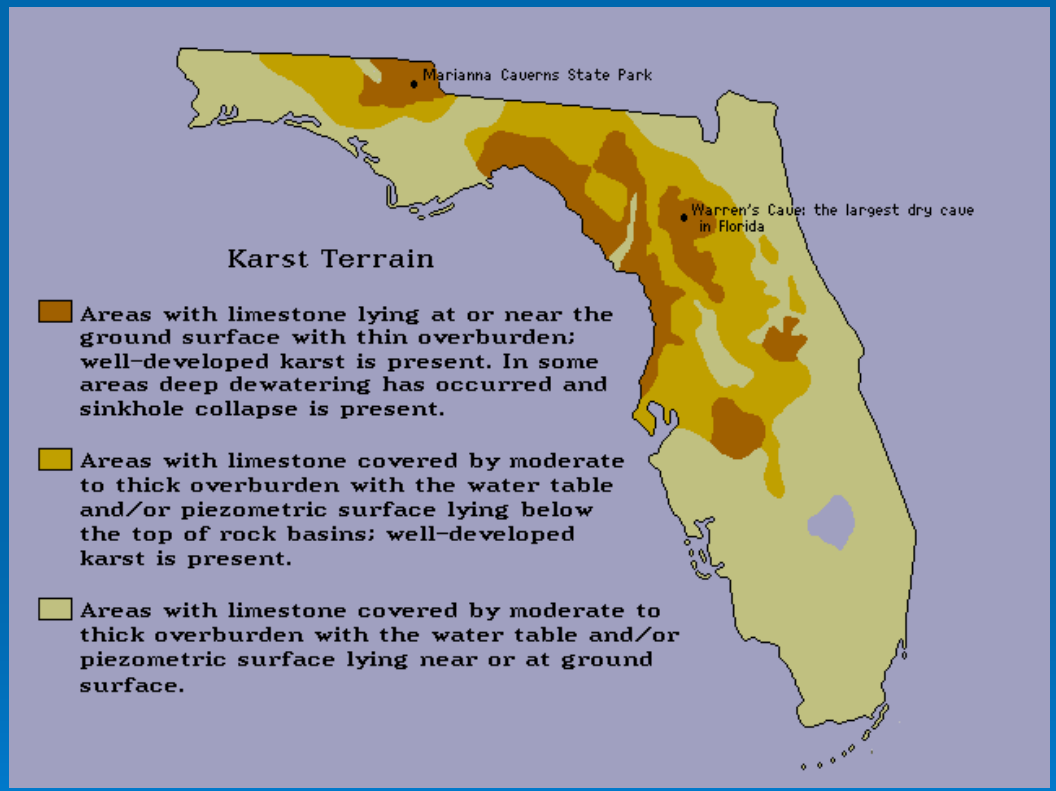
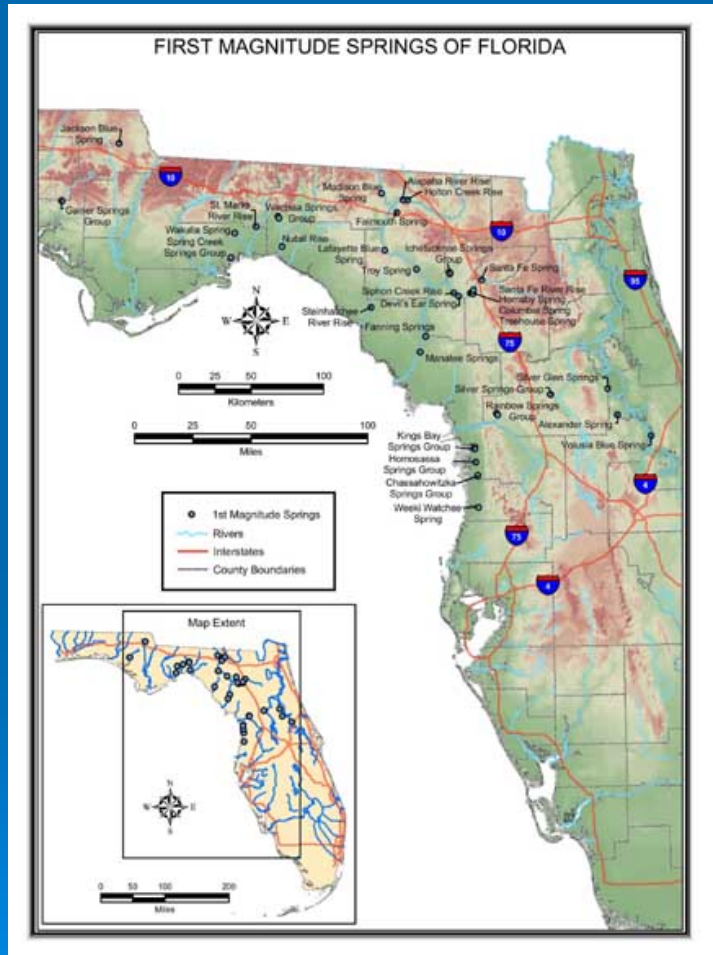


Diagram source: (Berndt et al. 1998)

Karst and Springs in Florida



Map source: www.luddist.com



Ecological “Jewels”

Eel grass meadow in the Ichetucknee River

Source: www.karstproductions.com

The pallid cave crayfish (*Procambarus pallidus*) is endemic to groundwater cave systems in the Suwannee River basin.

Source: United States Geological Survey (soundwaves.usgs.gov/ 2003/06/research2.html)

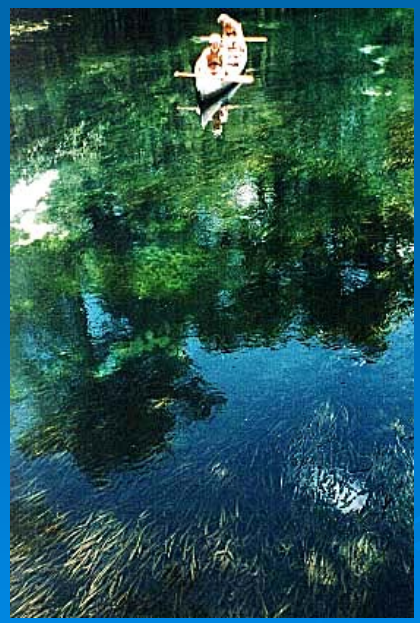
Florida limpkins (*Aramus guarauna*) commonly feed on apple snails that live within spring-fed streams.

Source: www.floridasprings.org

Each (spring) is a little ecologic jewel in which geology and biology have created a masterwork of natural art

-Archie Carr

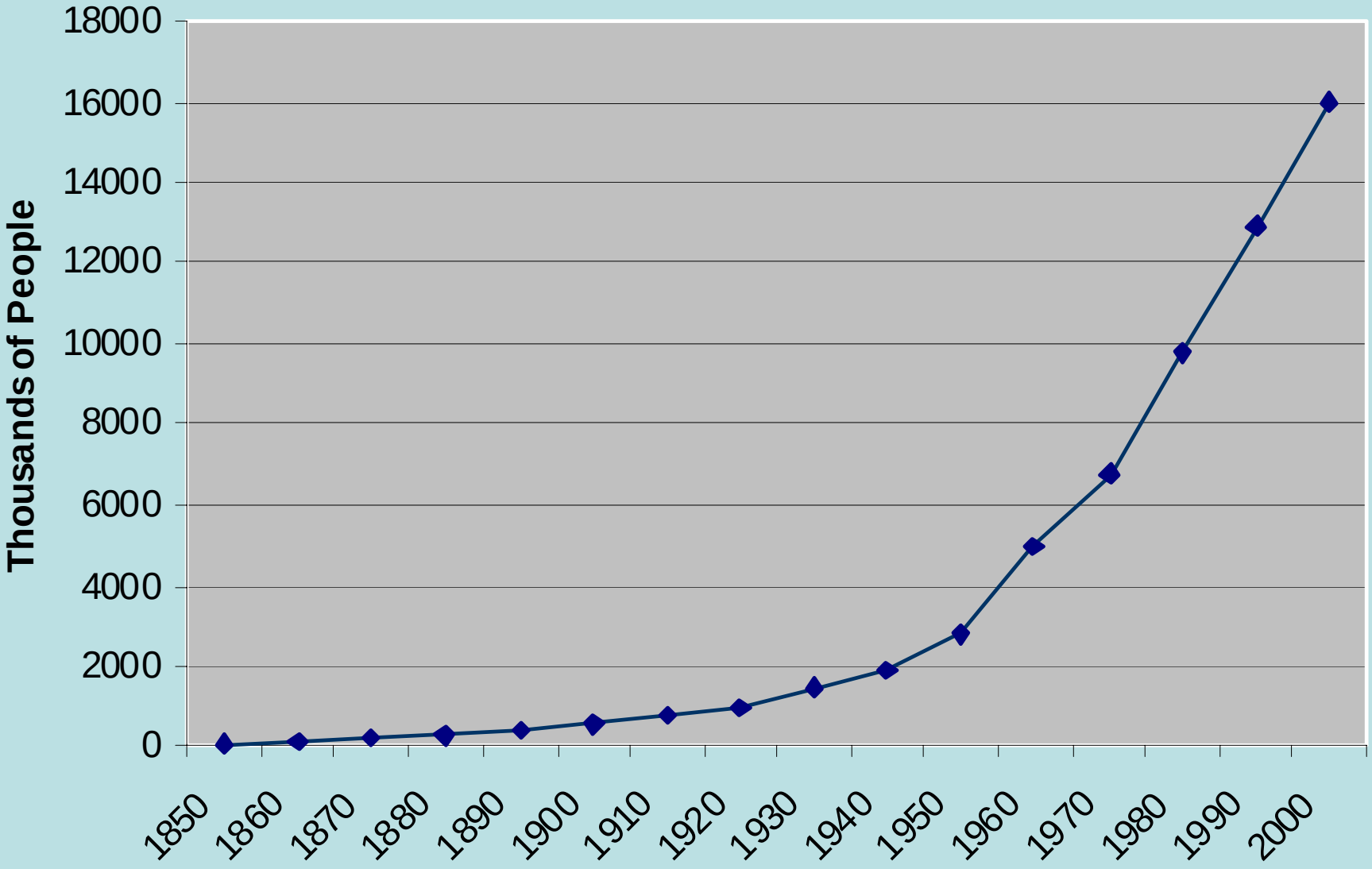
Recreational and Economic Value



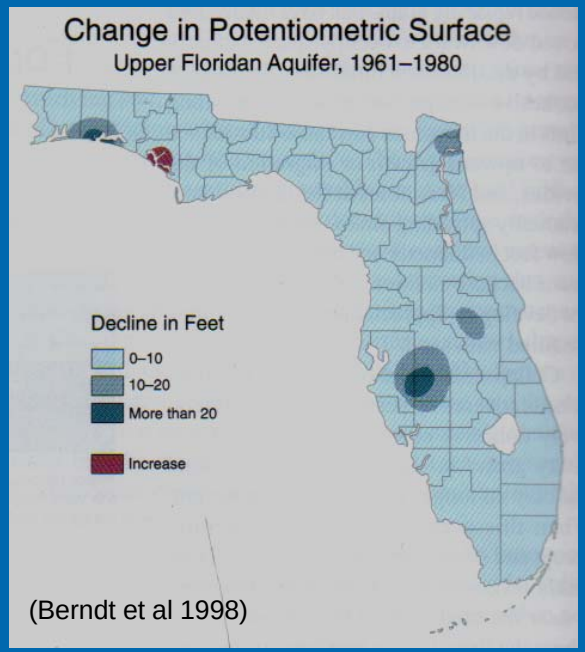
State parks with springs attracted over 2 million visitors in 2003 (www.dep.state.fl.us/springs)

A recent study indicates that the economic impact of visitation at 4 springs state parks (Wakulla, Ichetucknee, Homossassa, and Volusia Blue) exceeds $60 million (Bonn and Bell 2003)

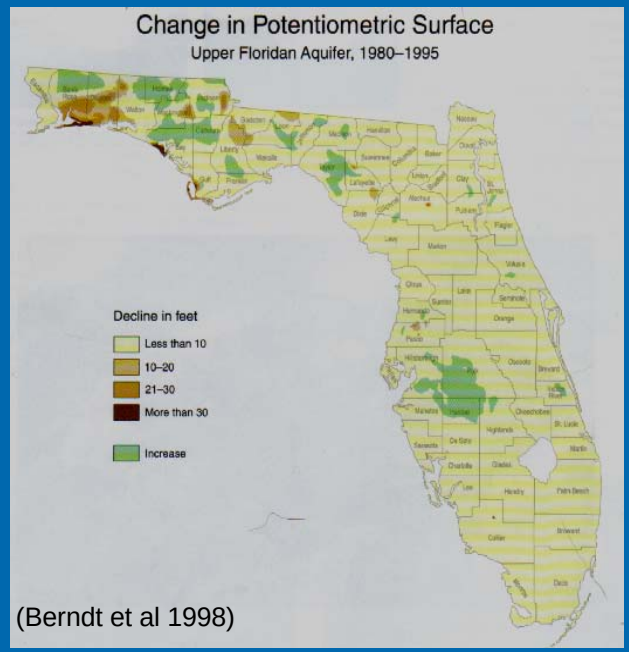
Florida Population: 1850-2000



Problem: Groundwater Quantity



(Berndt et al 1998)



(Berndt et al 1998)


Kissengen Spring in the 1920's


Kissengen Spring today

http://www.dep.state.fl.us/springs/images/kissengen.jpg

- Groundwater pumping by humans causes decreased potentiometric surface, resulting in less flow from springs.
- Many springs – particularly those near major population centers (e.g., Orlando, Tallahassee, Tampa Bay, and Jacksonville) – currently show declining flow trends.

Problem: Groundwater Quality

Stormwater in Lake City

Agricultural spray fields in Suwannee River basin

- Aquifers in karst regions are extremely vulnerable to contamination
- Lawns, agriculture, septic tanks, sewage treatment plants, and other human land uses can leach contaminants into the groundwater

Fertilizer intensive subdivision lawns

Source of images: www.floridasprings.org

Regulatory Response

Jim Stevenson, former Chairperson of Florida Springs Task Force, leading the Ichetucknee Springs Working Group on a field trip of the Ichetucknee springshed (February 2005)

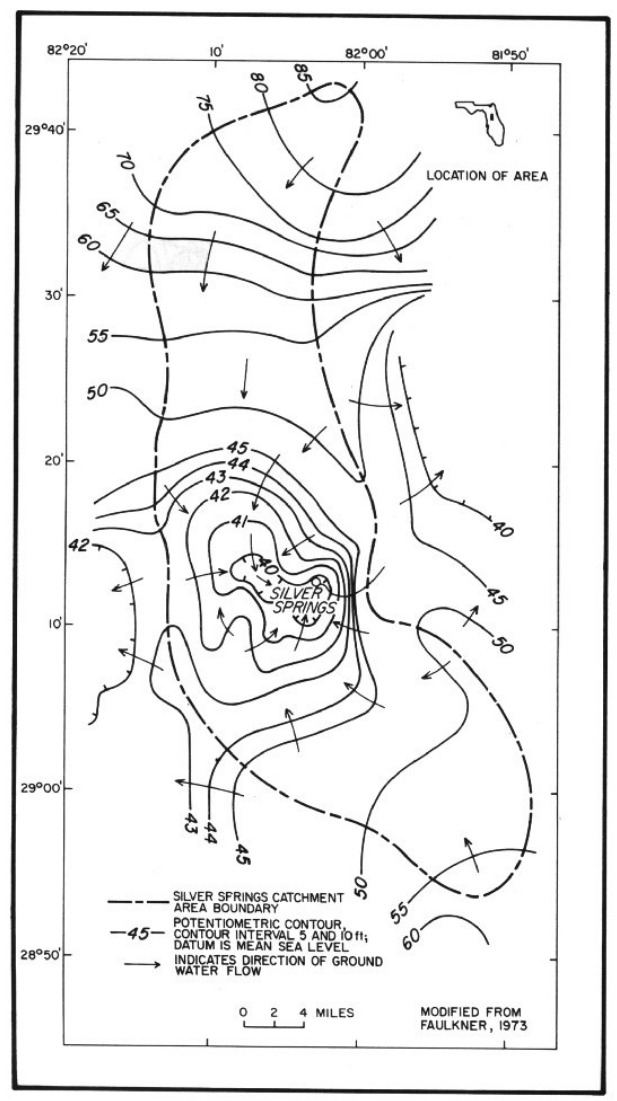
- Formation of Springshed Working Groups at Wakulla, Ichetucknee, Silver, Santa Fe, and other springs.
- Governor-appointed Florida Springs Task Force
- Local Land Use Planning Guidelines for Springshed Protection
- Water management districts beginning to set minimum flows and levels (MFL's) for first magnitude springs
- Voluntary implementation of agricultural best management practices (BMP's) through the Suwannee River Partnership program

Regulatory Problems

- Drinking water standards for groundwater are much less stringent than surface water "ecosystem standards."
  - Result: Wastewater spray fields (domestic and agricultural) preferentially located in karst areas for groundwater disposal
- Surface water standards apply to springs in theory, but tracing specific sources to degradation of water quality within a spring is very difficult
  - Also, non-point pollution (e.g., lawns) is very significant
- Springs protection legislation designed to strengthen groundwater quality standards in springsheds was introduced in both Houses of the Florida Legislature this year.
  - Tabled in committee due to strong opposition from business, agriculture, and DEP

More information at www.law.ufl.edu/conservation/springs_narrative.shtml

Contamination "Legacy"



- Water in large springs is, on average, 15 – 50 years "old."
  - Groundwater protection measures taken now may not show measurable benefits for a decade or more.
- Some large springs (e.g., King's Bay/Crystal River) have detectable "plumes" of contaminated groundwater within their springshed.

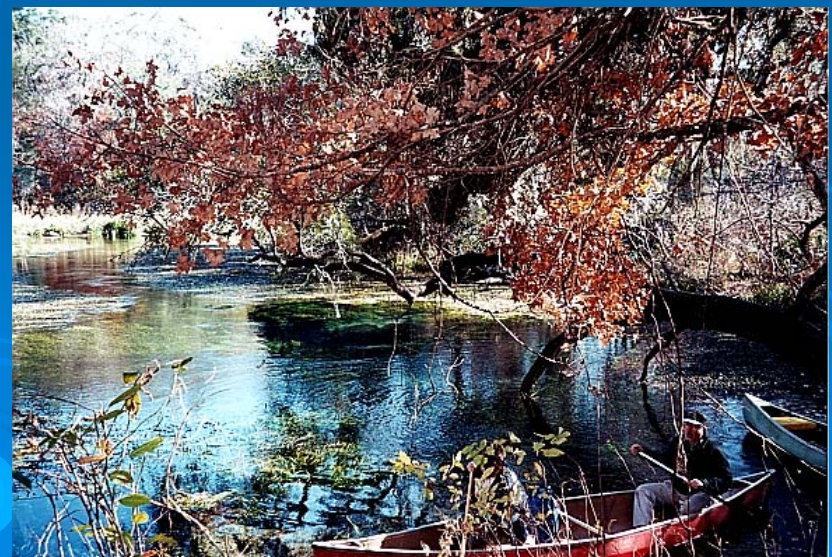
Ecosystem Shifts

Rapid growth of “nuisance” algae (particularly *Lyngbya sp.)* in recent years has had undesirable effects on the ecological, recreational, and aesthetic values of many springs systems

Gainesville Sun: “Itchy-tucknee” Algae Article

Observations

- While working as an intern at Ichetucknee Springs State Park in early 2001, I repeatedly observed that manual removal of water lettuce seemed to be quickly followed by algae smothering of submerged plants.
- In May 2004, I observed large amounts of lyngbya algae “trailing” from water lettuce, water hyacinth, and pennywort mats that had been recently treated with herbicides on the Wekiva River.



Alternate Stable State Hypothesis

- Recent limnological research in Florida and other areas suggests that many aquatic systems can be equally stable in either an algae or vascular plant dominated state.
  - Much energy is needed to “flip” systems from one “stable state” to the other.
- Restoration Implication:
  - Additional energy aside from water quality improvements will likely be needed to “restore” submerged plant communities within degraded springs ecosystems.

Aerial Photo of King’s Bay/Crystal River

http://www.swfwmd.state.fl.us/education/interactive/springscoast/1.shtml

Aquatic Plant Literature

Prototype water hyacinth and algal turf "scrubber" for nutrient removal in Everglades watershed.

www.hydromentia.com

- Water hyacinth and water lettuce are among nature's most efficient "luxury" consumers of nutrients, heavy metals, and other pollutants.
  - Both plants used extensively around the world for highly effective and energy efficient wastewater treatment.
- Water hyacinth and water lettuce have been shown to remove algae with their fibrous roots (Kim et al. 2001) and to contain allelopathic chemicals that directly suppress algae growth (Aliotta et al. 1991; Gross 2003; Jin et al. 2003).
  - Often used as "bio-filters" to remove algae and clarify water within garden ponds.
- Herbicidal treatment of water hyacinth and water lettuce may have contributed to the decline of both Lake Okeechobee (Grimshaw 2002) and Lake Apopka (Clugston 1963).

Invasive Plant Control as Management Pathology?

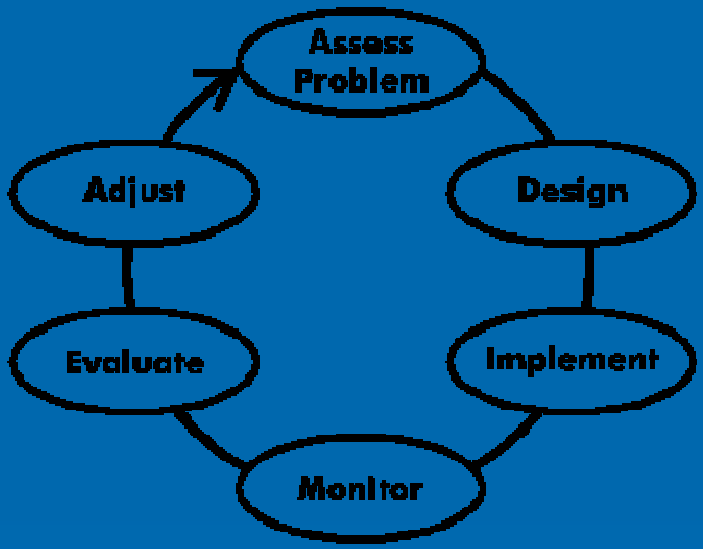
Hypothesis: Current methods of controlling water lettuce (*Pistia stratiotes*) and/or water hyacinth (*Eichornia crassipes*) within nutrient enriched springs catalyze rapid system shift towards blue green algae dominance.

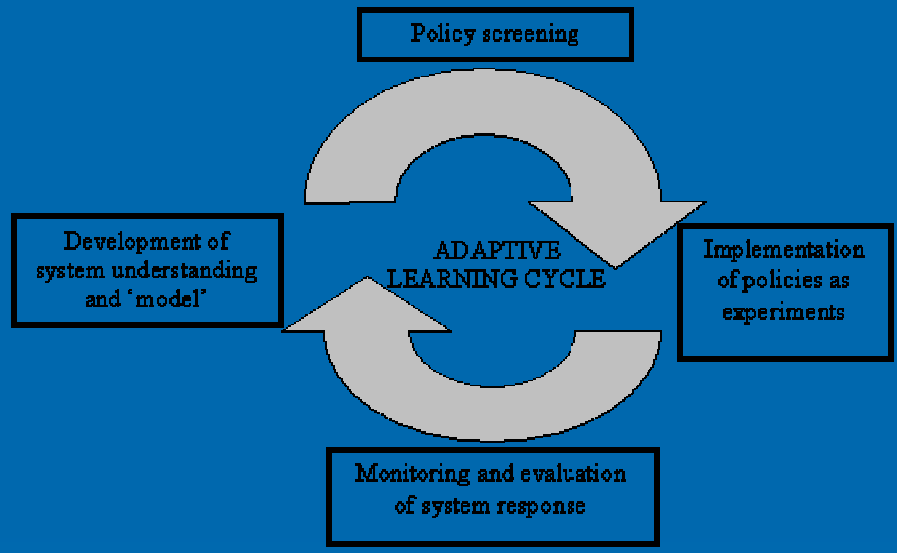
Definitions

Adaptive Management: “A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices.” http://www.greenfacts.org/glossary/abc/adaptive-management.htm

Paradigm: “A set of assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them, especially in an intellectual discipline.” http://www.thefreedictionary.com/paradigm

Adaptive Management





To what extent are the principles of adaptive management being utilized in the conservation efforts within springs ecosystems?

Are managers monitoring system response and adjusting actions to reflect new information about undesirable ecosystem shifts?

Management Pathologies

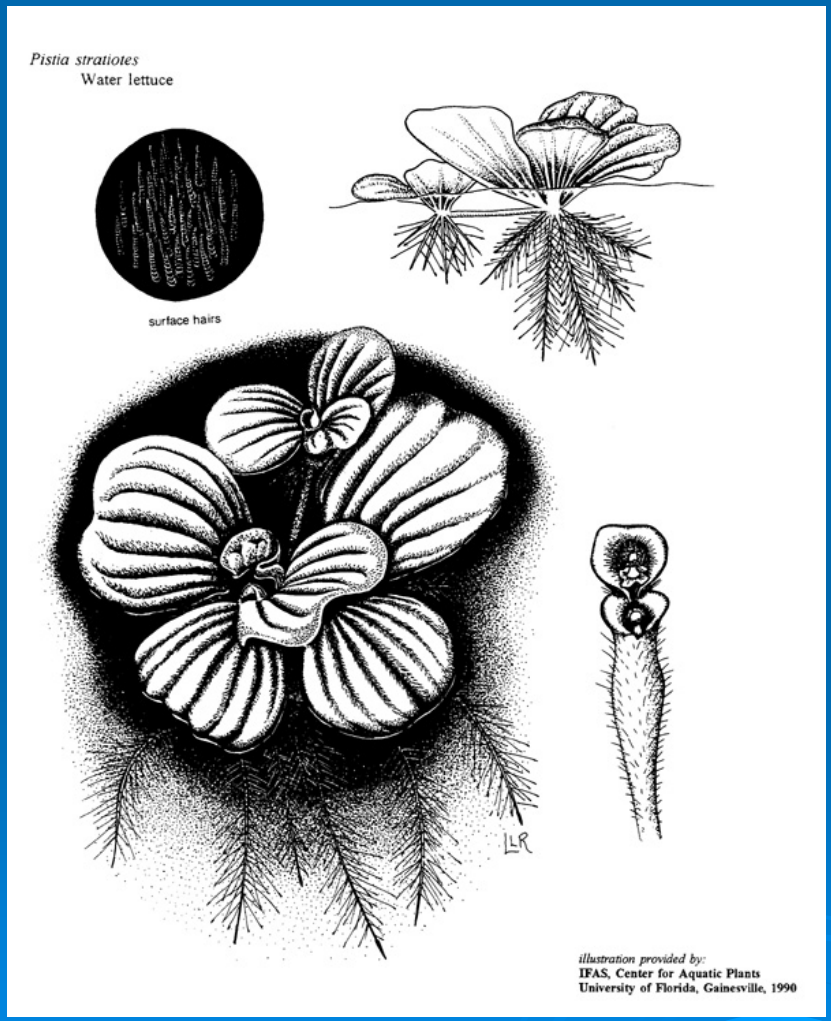
Initial success in managing a target variable at one scale may lead “inevitably to an ultimate pathology of less resilient and more vulnerable ecosystems” as well as “more rigid and unresponsive management agencies.”

(Gunderson et al. 1995)

Institutional Paradigms

- Water lettuce, water hyacinth, and hydrilla defined *a priori* as "harmful" by policy-makers, often with misleading presentation of information.
  - Extirpation of apple snails and limpkins in Wakulla Springs frequently attributed to hydrilla
    - What effects do herbicide treatments have on apple snail, green algae (food for apple snails), and native macrophyte populations?
  - Water hyacinth said to reduce water quality in springs http://www.floridasprings.org/protection/threats/invasive/
    - What water quality parameters and under what conditions?
    - What are the water quality and ecosystem effects of herbicide treatments?
  - Water lettuce said to "choke life" from Ichetucknee Springs
    - Why have major reductions in submerged macrophytes and increases of filamentous blue-green algae occurred at Ichetucknee since water lettuce eradication programs were instituted?

Case Study: Ichetucknee Springs



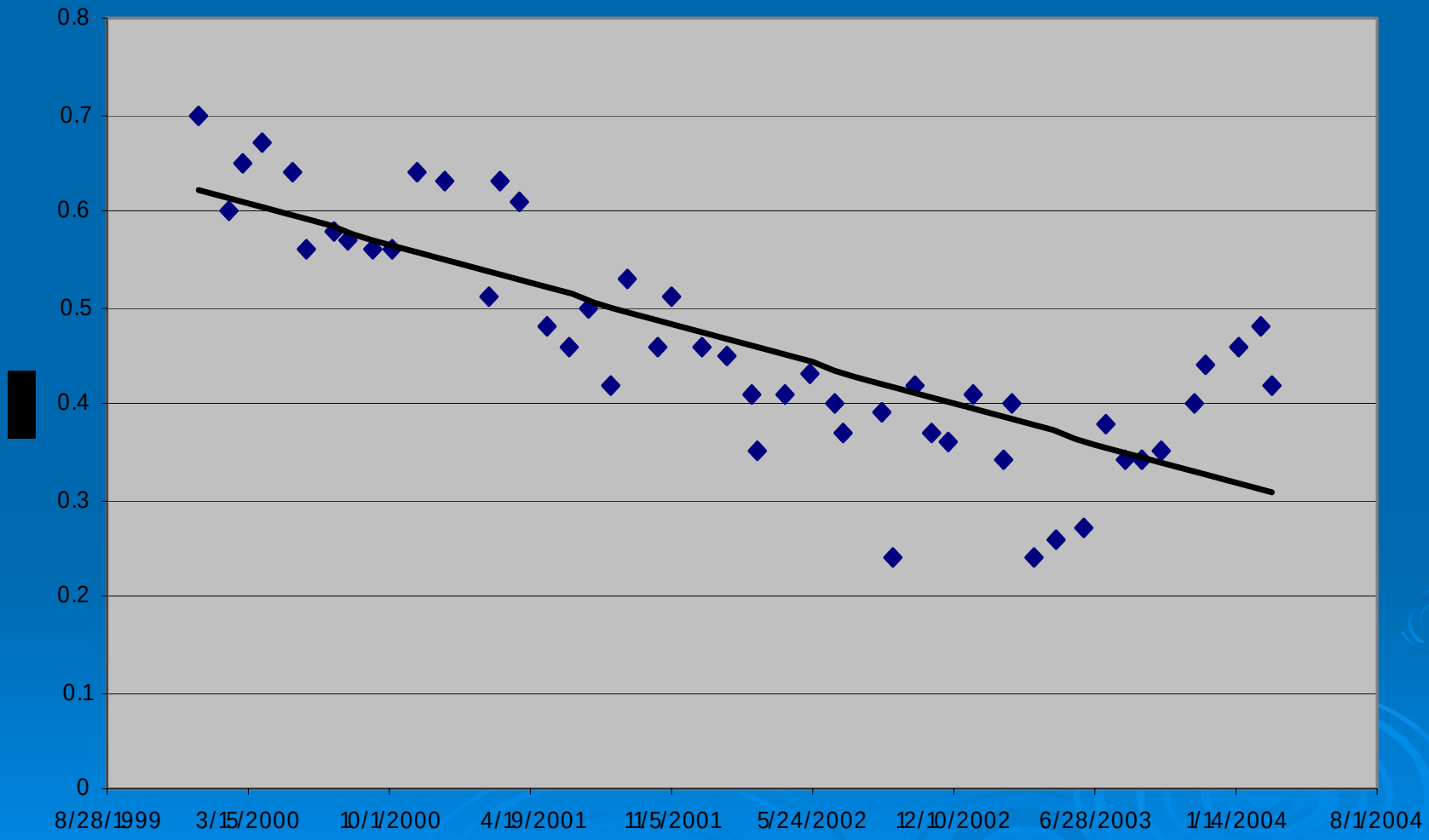
Increased algae and associated ecosystem changes generically attributed by managers to “rising nitrates.”

Park managers have so far shown little interest in performing experiments and/or monitoring management practices to better determine if water lettuce eradication activities have exacerbated algae proliferation observed in recent years.

Ichetucknee Springs Water Quality Working Group has twice denied requests to present information about potential linkages between algae proliferation and water lettuce eradication practices.

Nitrate Levels within Ichetucknee River since Institution of Water Lettuce Eradication Program

(Data from EPA Storet)



Case Study: King's Bay/Crystal River

Nutrients not likely to be limiting factor for blue-green algae communities in King's Bay (Munson 1999)

Inverse relationship between macrophyte coverage and filamentous blue-green algae coverage at King's Bay (Munson 1999)

Very long history of herbicides such as2,4D, sulfuric acid, diquat, and copper sulfate being used for treatment of hyacinth, milfoil, elodea, water lettuce and hydrilla within King's Bay.

King's Bay has high amounts of copper residue in sediments from copper sulfate applications (Leslie 1992).

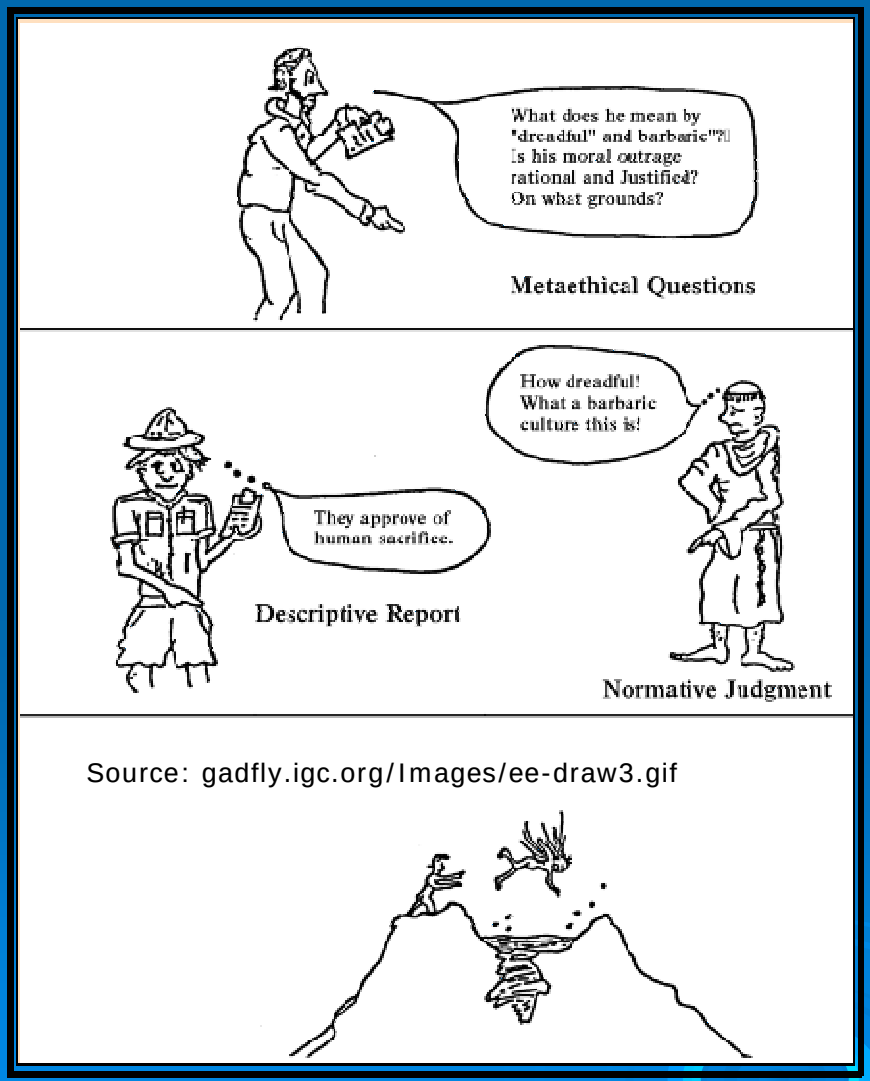
Lyngbya has been found to be highly resistant to herbicides commonly used in aquatic systems (Hawxby et al. 1977) and may be an indicator of heavy metal contamination (including copper) (Nakanishi *et al*. 2004)

Lyngbya mat in King's Bay: February 2005

King's Bay/Crystal River

- Stakeholders at King's Bay/Crystal River are pursuing a restoration strategy that includes utilizing water hyacinth for the following purposes:
  - Algae suppression
  - Contaminant sequestration
  - Manatee fodder
- Fierce resistance to this idea from some aquatic plant scientists and managers has emerged.
  - Called "environmentally unacceptable" by one aquatic plant scientist with many years of experience at King's Bay

Environmental Ethics 101



Source: gadfly.igc.org/Images/ee-draw3.gif

Concepts such as ecological "harm," "decline," "protection," "acceptable," and "restoration" are imbued with value-laden judgments and moral choices

Science is an invaluable source of information, but does not by itself provide justification for ecosystem management decisions

- To paraphrase David Hume, there is no direct logical connection from a descriptive "is" to a prescriptive "ought" statement

A Moral Dilemma?

If the hypothesis about the relationship between management of invasive exotic species and algae proliferation in springs was to hold, which is worse - the invasive macrophytes or system shift to algae-dominance?

What role (if any) should categories such as “native” and “exotic” play in these discussions?

Exotic

Native

Policy Recommendations

- If I was King
  - Moratorium on herbicide treatments within springs ecosystems pending *independent* and *thorough* research on ecological effects.
- Common sense
  - Transport plant material from manual harvesting to off-site locations.
- Adaptive Management
  - Research to determine if there may be “optimal harvest” levels for maximizing contaminant sequestration and algae-suppression potential of macrophytes (including listed invasive species) within nutrient-enriched spring systems.
    - Even in best case (and unlikely) conservation scenarios, water quality in nutrient-enriched springs will not improve for many years due to groundwater contamination legacy.
- Monitor, monitor, monitor…

Questions?

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