

# ***Aquatic plant biomass in the age of eutrophication:***

## ***Opportunities, challenges, and other such tales from the SE United States***



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August 28, 2013  
ReBALAN:CE Workshop  
University of Stirling, Scotland

# Who am I?

- “Interdisciplinary Ecologist”

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  - ??????????????
  - Systems analyses and life cycle assessments  
(Evans and Cohen 2009; Evans and Wilkie 2010;  
Evans and Geller 2012)

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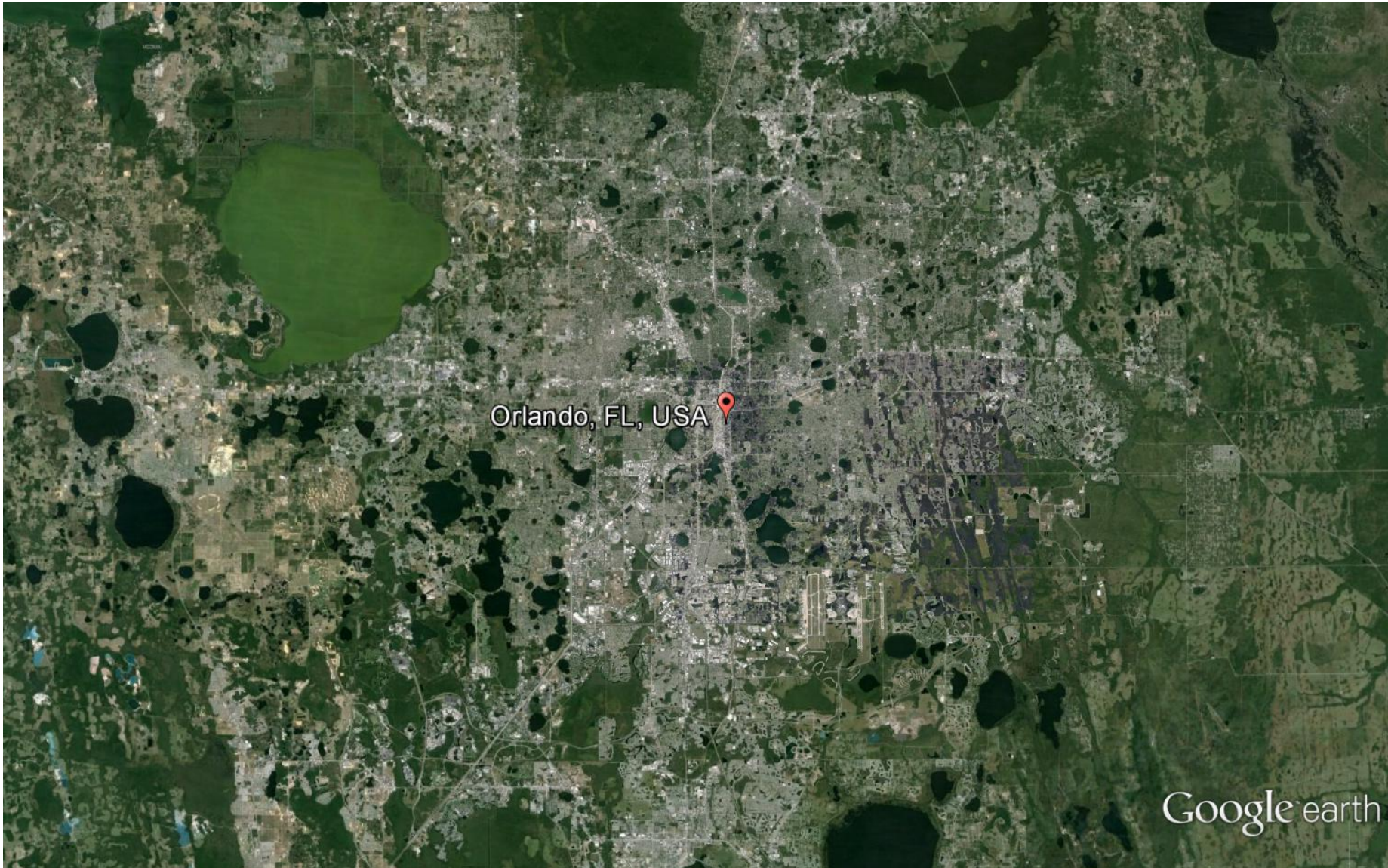
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# Where am I from?





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*Lake Apopka*

*(Hypereutrophic)*

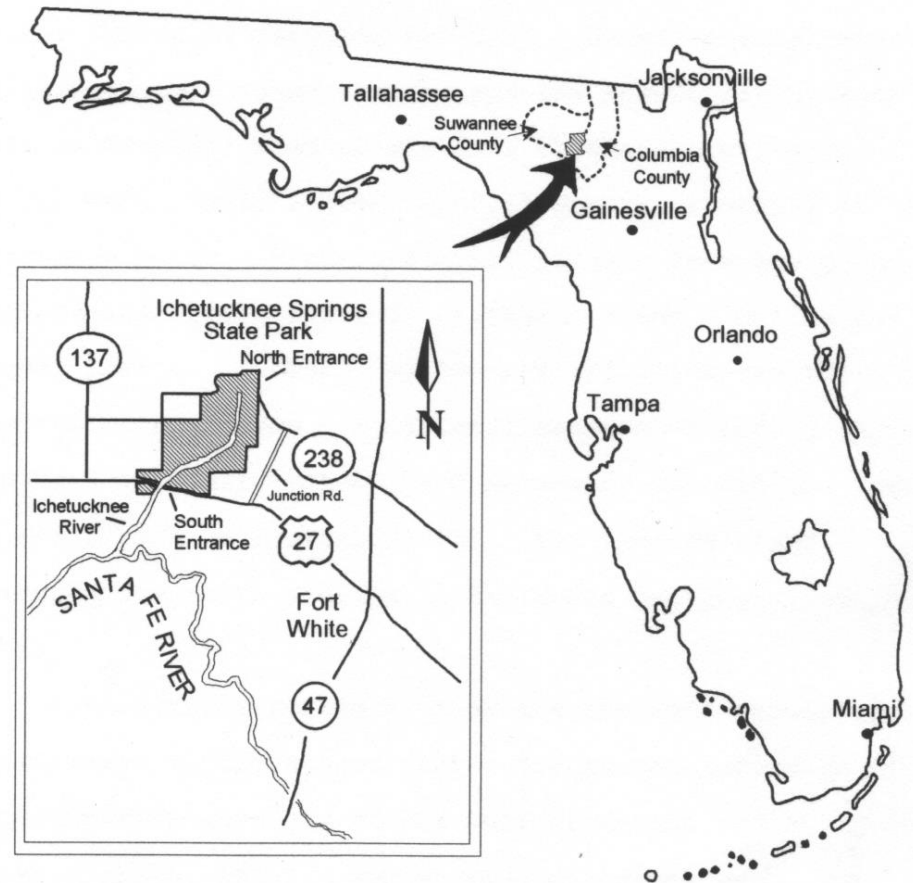




And some things I've observed...

# Ichetucknee Springs, Florida

- Groundwater fed stream in northern Florida, discharge of 822 million l/day





ICHETUCKNEE HEAD SPRING

CEDAR HEAD SPRING

BLUE HOLE SPRING

MISSION SPRING

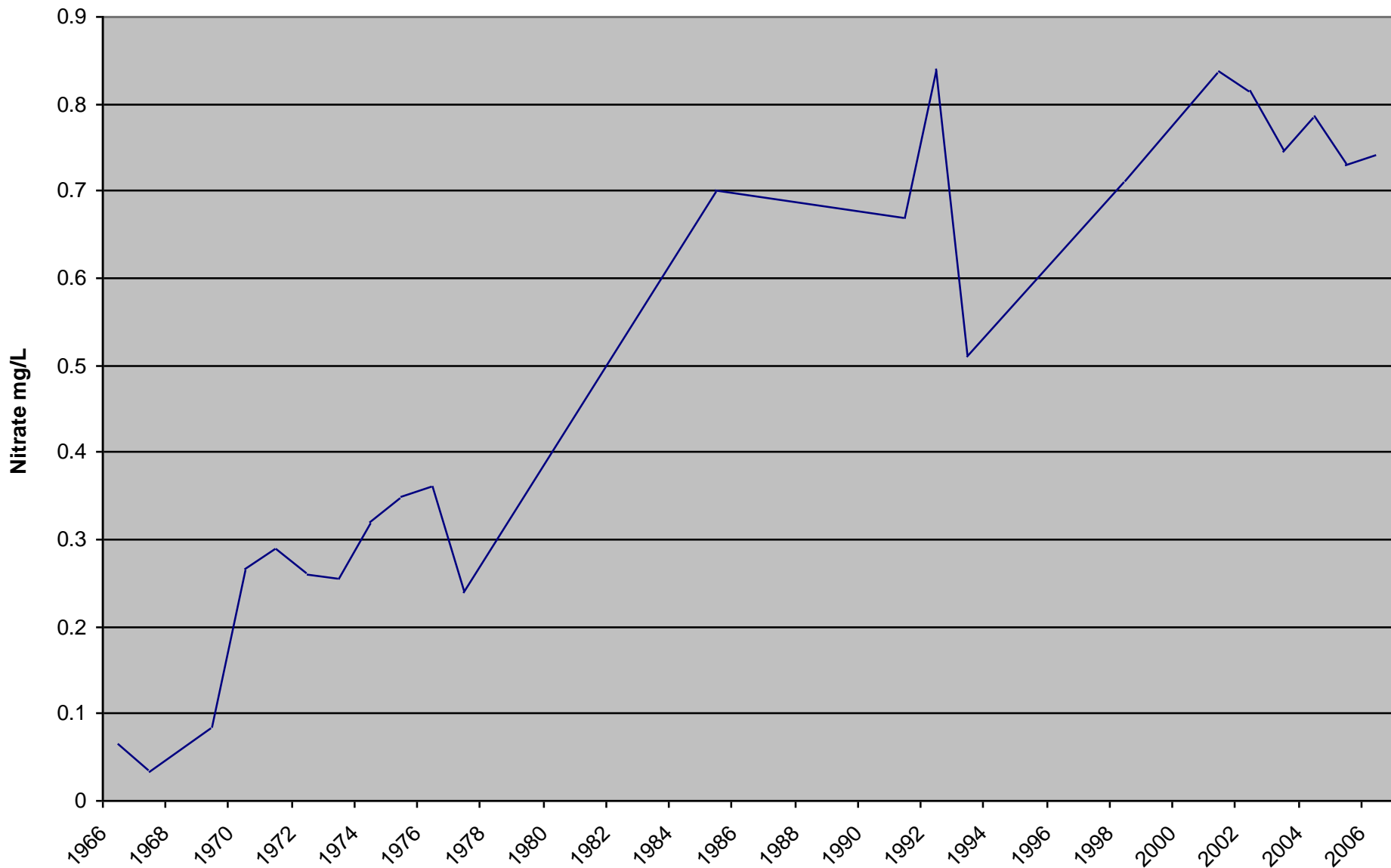
DEVL'S E YE SPRING

GRASSY HOLE SPRING

MILL POND SPRING

COFFEE SPRINGS

### Nitrate in Ichetucknee River

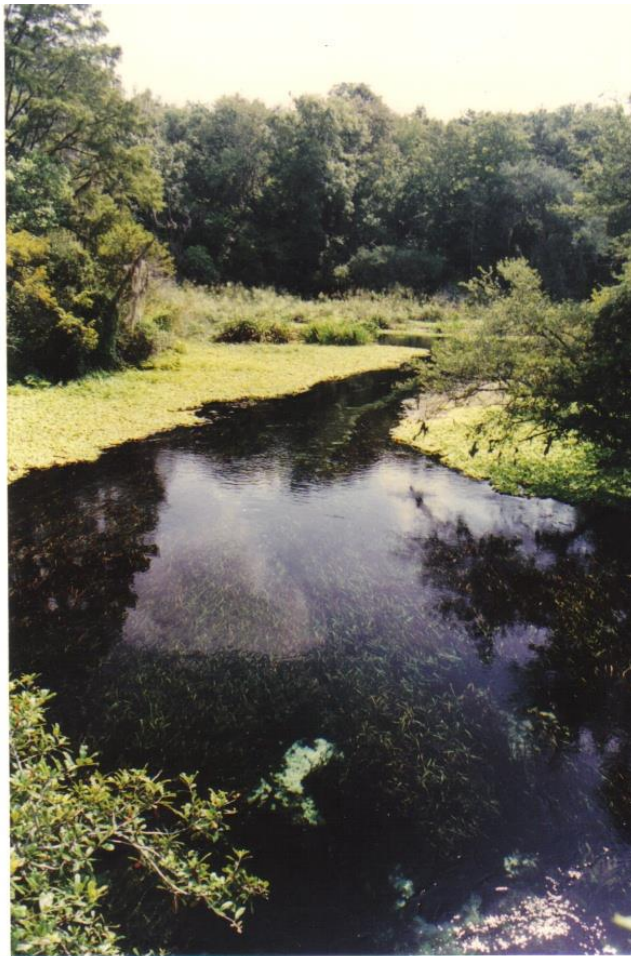




# Ichetucknee Devil's Eye Time Series



1987



1989



1993

Photos by Johnny Dame



# Devil's Eye



2000

Photo by J. Follman

(Follman and Buchanan 2007)

## Battle continues to rid river of life-sucking waterlettuce

By Alanna Sobel  
For The Herald

High Springs Herald, December 2004

FORT WHITE -- Two canoes, two non-motorized boats, 20 volunteers and four hours later, approximately 1 ton of pollution lay on the riverbank.

But there was something different about this pollution. It was green.

Waterlettuce is its name.

Waterlettuce is a problem along the Ichetucknee River, and park staff and volunteers dedicate numerous hours in the form of waterlettuce cleanups in an effort to remove it from the waterway.

"The biggest problem that waterlettuce presents to the Ichetucknee River is the adverse effect it has on plants and animals," said Cathy Nagler, a biological scientist for Ichetucknee Springs State Park. "It decays and then absorbs the oxygen from the water. It also can grow in big mats that cover large areas of the river and make it almost impossible to canoe, boat and maneuver through."

Its rapid growth and ability to completely cover vast stretches of water surface are two main reasons that this invasive aquatic plant is considered highly disruptive to the environment and park staff find it so necessary to remove.

The non-native plant, which resembles a floating, open head of lettuce, can replace native plants and deprive native animals of their natural habitats.

It also has the tendency to cover water bodies and prevent oxygenation, which suffocates fish and other animals. Not only does waterlettuce have a negative effect on the plant and animal life within a region but also can disrupt flood control and irrigation systems because of its ability to greatly slow or even stop water flow.





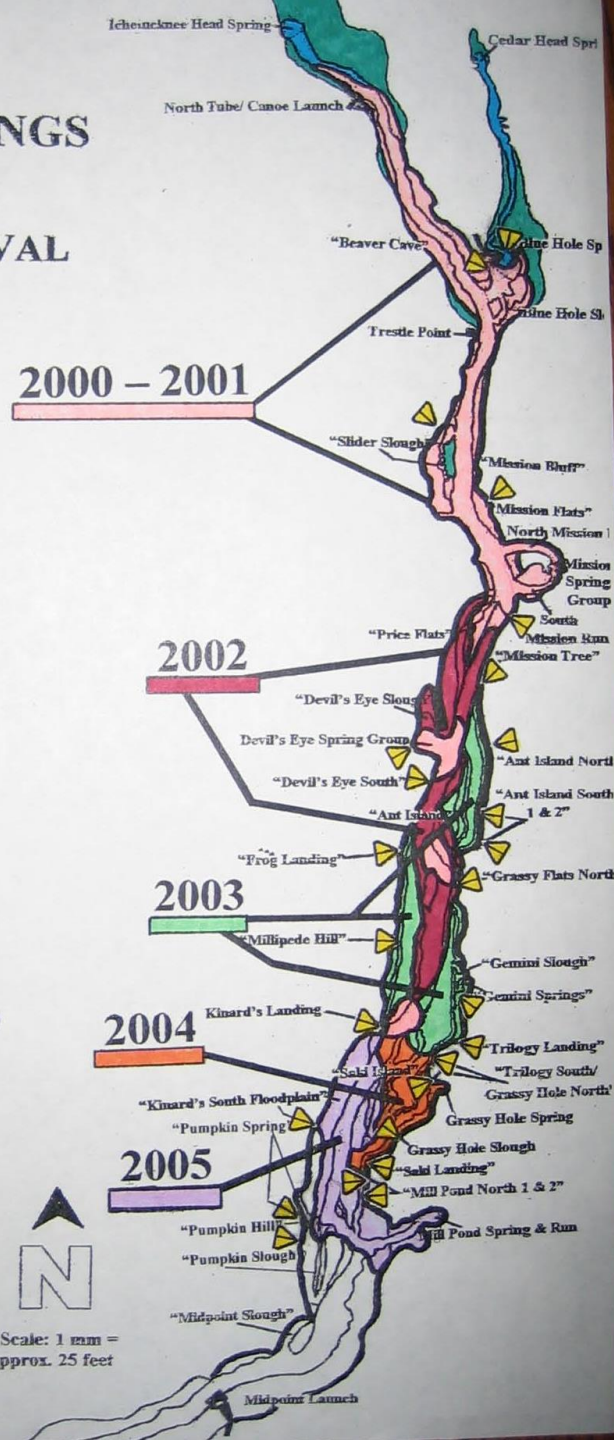
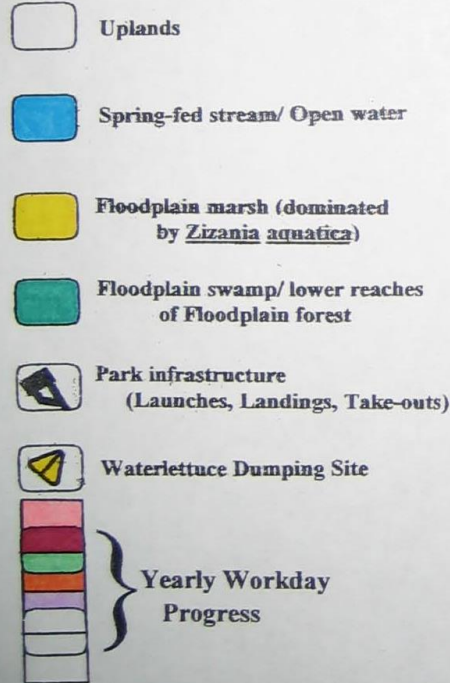
# ICHETUCKNEE SPRINGS STATE PARK

## WATERLETTUCE REMOVAL PROGRAM

### ANNUAL PROGRESS

### Composite Map

Key:



Courtesy of Joe Hand, Florida Department of Environmental Protection

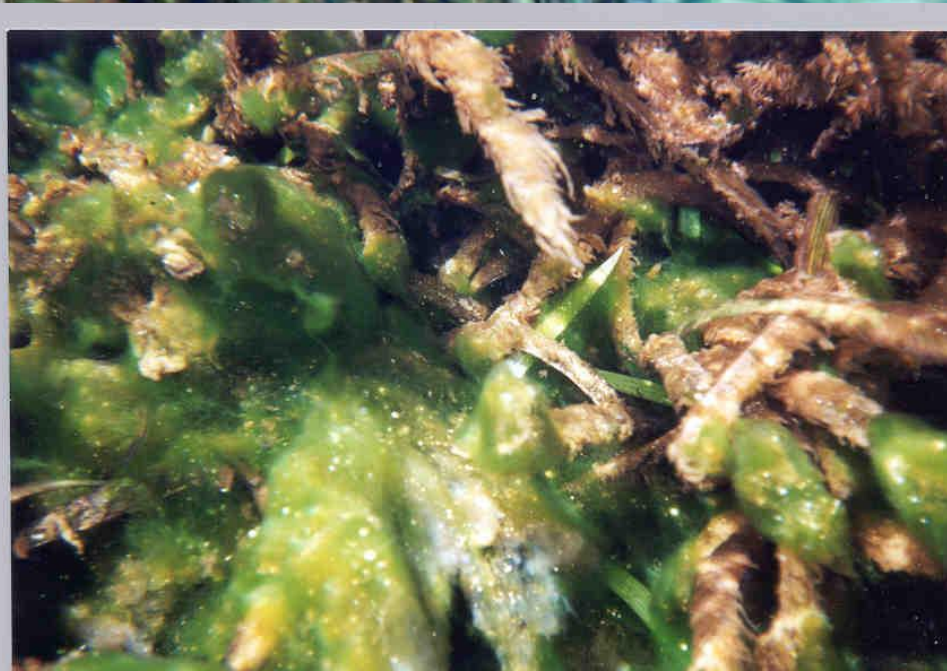
# Water Lettuce (*Pistia stratiotes*)

- Legally classified in Florida as a Class 1 Invasive Exotic species
- Statutory mandate to manage at “lowest feasible level”
  - Typically through herbicides, primarily diquat



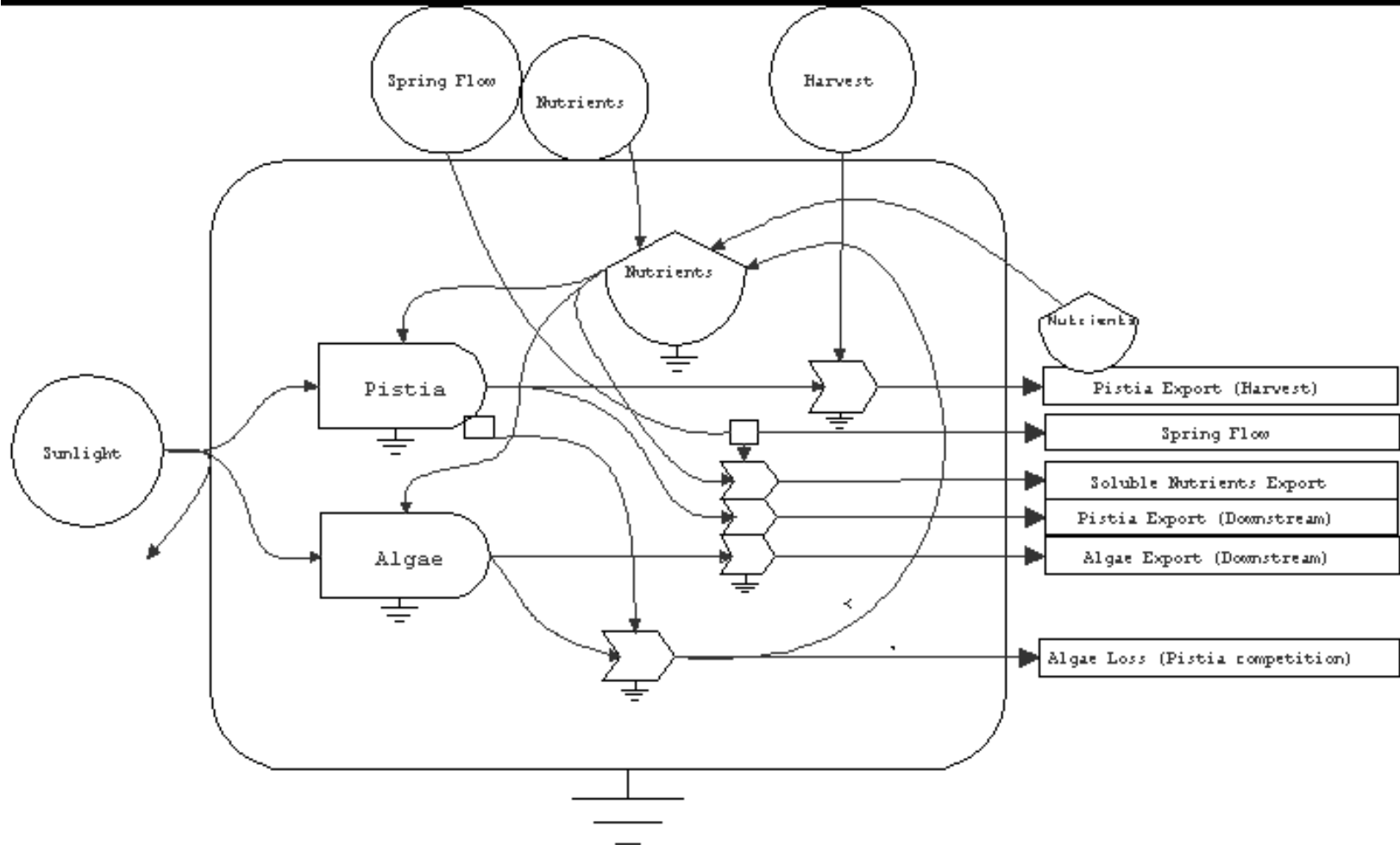


Devils Eye  
May 2001  
Joe Hand, Florida DEP





# Systems model



## **A River in Danger -- Algae killing Ichetucknee Springs**

**By Christa Jenkins-Desrets  
Herald Writer**

FORT WHITE - The cool, clear water of the Ichetucknee River gently flows around tubers enjoying one of their final floats this season.

To those who visit the river as a retreat into nature's beauty, the water is pristine, one of the few bodies left untouched by the complications of civilization.

But to many experts, changes to the river are coming at an alarming rate.

Slow though the changes may be to the visitors' eyes, experts say, the changes in plant and animal life have intensified over the past several years.

That intensification may even affect visitors to the springs. Some people have had severe allergies from something in the river, causing reactions as minor as itchiness to as serious as cardiac arrest.

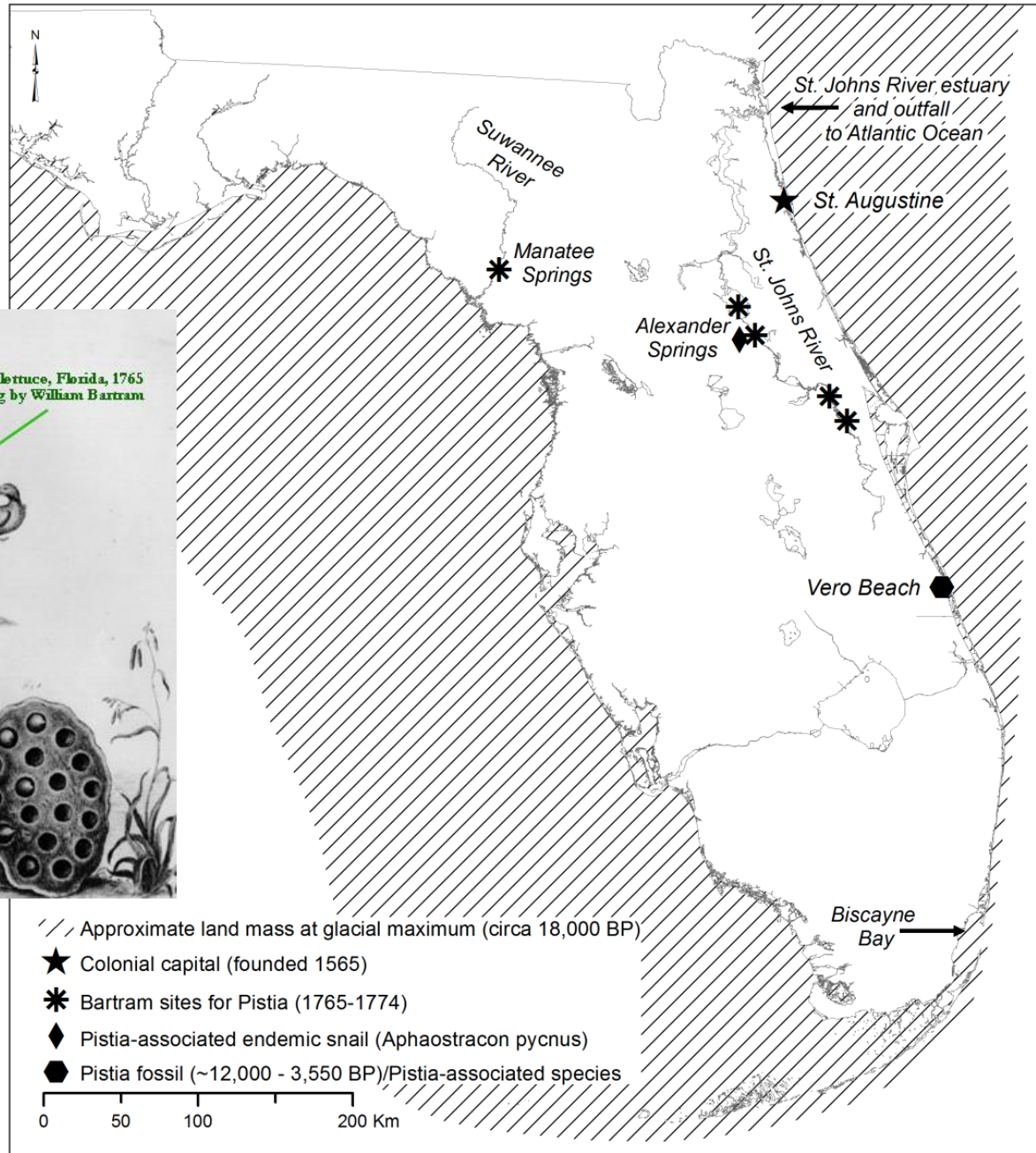
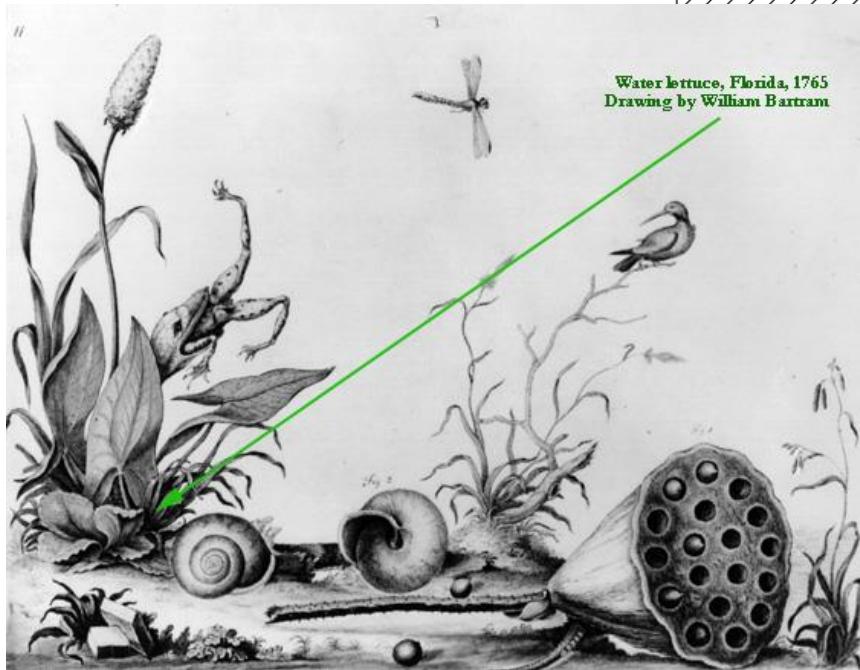
Many experts believe that the culprit may be the new algae that has formed as a result of the changes.

Experts attribute the changes to development - particularly spray fields, septic tanks and stormwater that carry nitrates - in and around the Ichetucknee Springs Basin.



*Photo By Emily Jourdan*

**An egret flies over the Ichetucknee River, a river that experts say is slowly dying because of algae that is coating the surface of the water and the underwater plant life, killing it.**



Highly productive **native** species (>100 dry/Mg/yr in non-limited conditions), but not exotic!

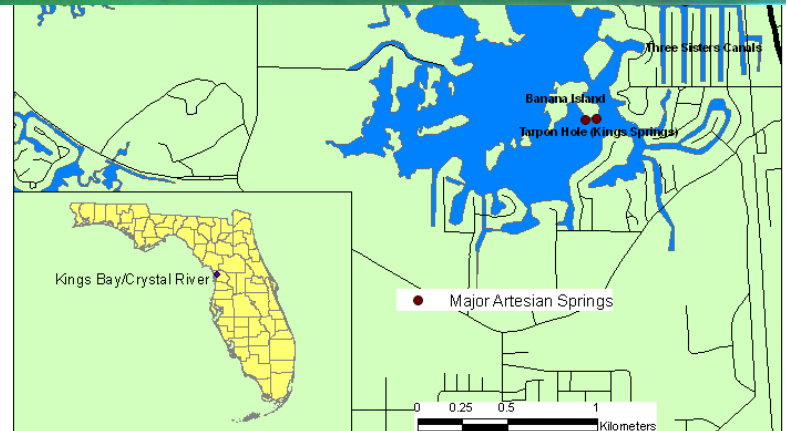
# Challenge...

*An extreme example of managers aggressively treating one symptom of eutrophication (to the point of reclassifying a species as invasive exotic), only to find another (worse) manifestation rapidly emerge from the vacuum*



# Kings Bay/Crystal River

- Approximately 30 springs with assumed discharge over 500 mgd (Rosenau et al. 1977)
- Tidally influenced
- Important winter refuge for Florida manatee population







*Kings Bay*  
1944



*Kings Bay*  
1960



*Kings Bay*  
**1974**

Aerial photos courtesy of David Tomasko, SWFWMD  
and Mark Edwards, Citrus County Aquatic Services





***Kings Bay***

**1998**



# Current Ecosystem State

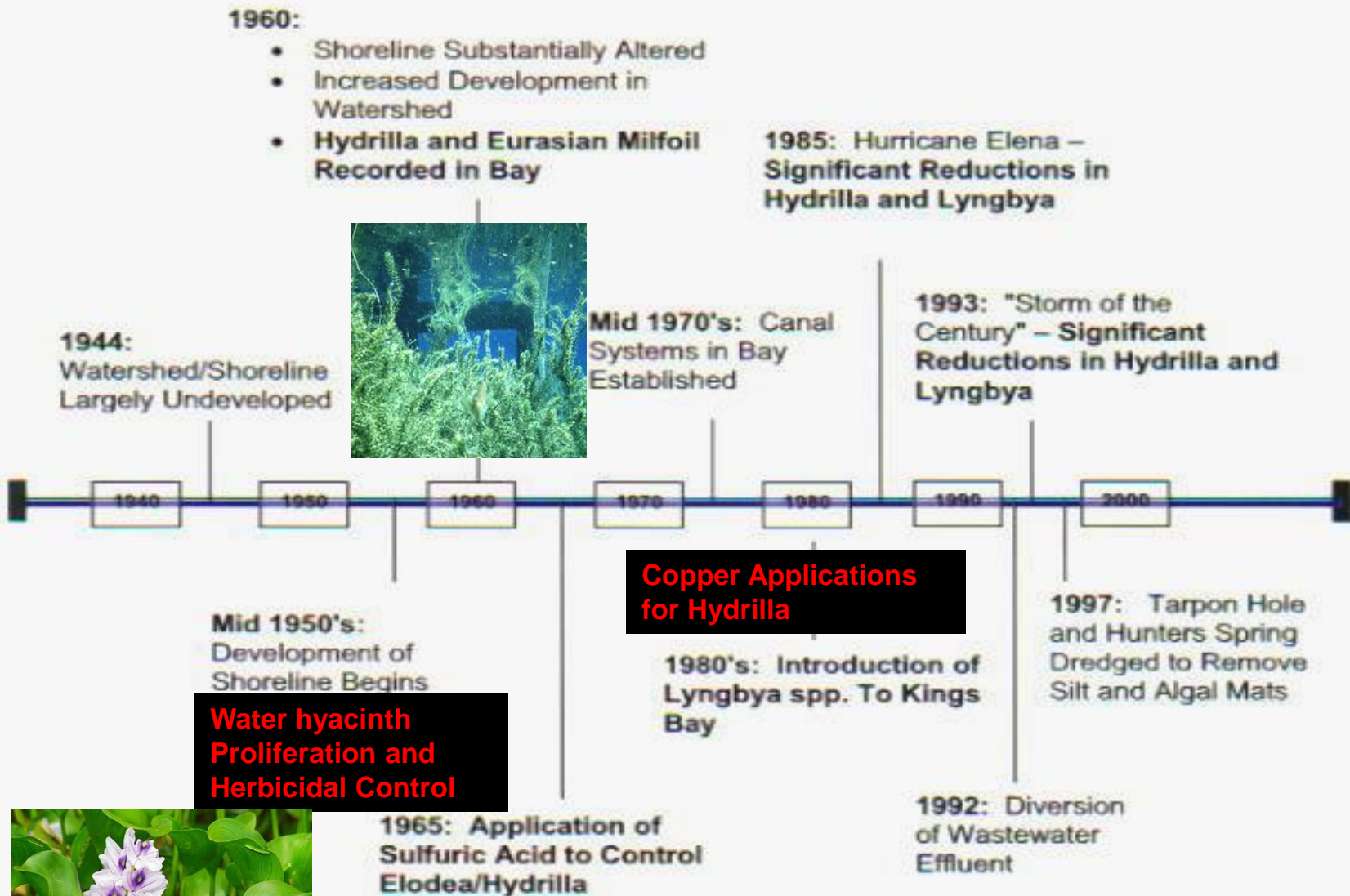
Much of Kings Bay is currently dominated by *Lyngbya wollei*, a filamentous blue green algae with toxic properties.





Figure 15. Timeline of significant events and activities in Kings Bay, Florida.

(From Southwest Florida Water Management District 2004)



# **Adaptive Management of Nonnative Species: Moving Beyond the “Either-Or” Through Experimental Pluralism**

**Jason M. Evans · Ann C. Wilkie · Jeffrey Burkhardt**

Accepted: 31 July 2008 / Published online: 19 August 2008  
© Springer Science+Business Media B.V. 2008

# Aquatic Weeds — Eradicate or Cultivate?

ROBERT P. BATES AND JAMES F. HENTGES, JR.<sup>1</sup>

Bates, R.P. and  
J.F. Hentges.  
1976. *Economic  
Botany*

The adverse effect of aquatic vegetation on the environment is an increasingly serious world-wide problem challenging the international community. The development of control methods will require innovative thinking and creative research.

In the 92 years since the introduction into the United States of the water hyacinth (*Eichornia crassipes*), the image of this plant has changed from a floral curiosity to an environmental menace (Raynes, 1972). The situation is even more severe in tropical areas, where the water hyacinth's free floating nature and prolific growth pattern distributes the plant with dismaying efficiency. Damaging effects include: clogging of drainage ditches, irrigation canals and sewage pipes, interference with hydroelectric power, increased loss of water by plant transpiration, incubation of insects and disease vectors, depletion of oxygen in water, restriction of desirable aquatic plant population, and reduced agricultural and recreational value of waterways (Ferguson, 1968; Office Sci. Technol., 1971). The water hyacinth has exhibited the most spectacular example of ex-

its 10th year of publication and devoted exclusively to aquatic weed papers.

In Florida in 1970, more than one million dollars were spent on partially effective efforts to keep its 4000 square miles of infested waters free of aquatic weeds (Huser, 1968; Environ. Info. Center, 1972). In the developing countries of the world, the loss of potential gross national product is proportionately larger than in the United States. It has been estimated that direct economic losses to these areas exceed 100 million dollars annually (Office Sci. Technol., 1971).

Control measures to combat aquatic weed infestations may be placed into three classifications: chemical, biological and mechanical (Hudson, 1973; Gupta, 1973).

## CHEMICAL CONTROL

Chemical control involves the use of herbicides which are highly effective for plant eradication but frequently indiscriminate in their devastation of associated flora and fauna. Chemicals have a unique potential



**Premise:** *Overgrowth of aquatic “weeds,” whether exotic or otherwise, are a manifestation/symptom of eutrophication*

**Argument:** *In a time of cultural eutrophication, we should be looking to utilize ecosystem functions of all **extant** aquatic plants – including those that are clearly exotic*

# Aquatic plants: an opportunity feedstock in the age of bioenergy

*Biofuels* (2010) 1(2), 311–321



**Ann C Wilkie<sup>†</sup> & Jason M Evans**

There is a growing impetus to identify and develop bioenergy feedstocks that can be harnessed in ways that do not require major land-use intensification or use of food crops. Although invasive aquatic plants have long been regarded as an intriguing potential feedstock because of their high growth rate in natural water bodies, most contemporary management is based on plant control rather than utilization. This review presents a comparative life cycle overview of modern aquatic plant control and alternative bioenergy utilization programs, highlighting costs and benefits associated with both approaches. Given recent advances in harvester and bioenergy conversion technologies, it may be cost effective to incorporate utilization techniques in many water bodies, particularly if ancillary benefits associated with nutrient removal and greenhouse-gas reductions are given monetary credit. Pilot projects and site-specific evaluations are, however, needed to determine the ultimate scale in which bioenergy production from aquatic plants will be feasible.

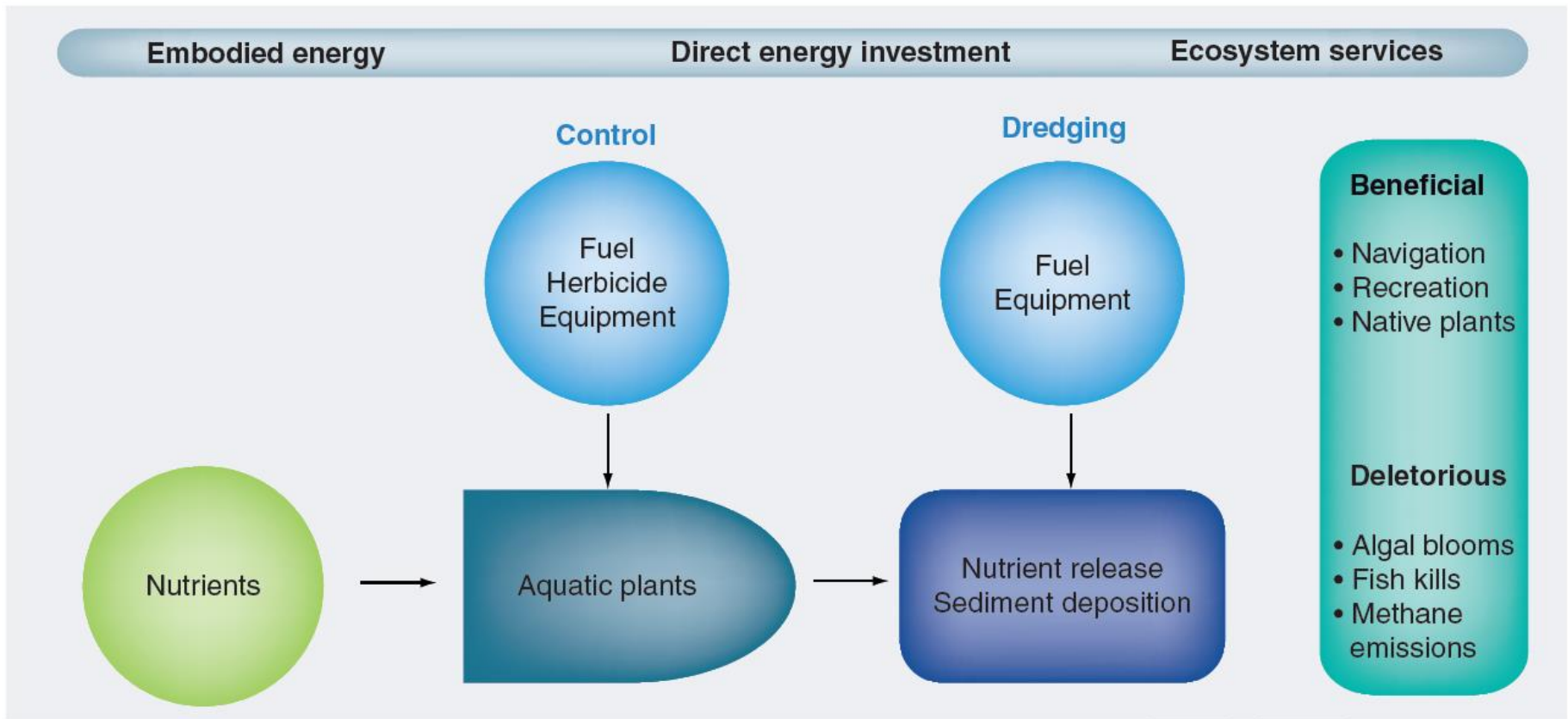
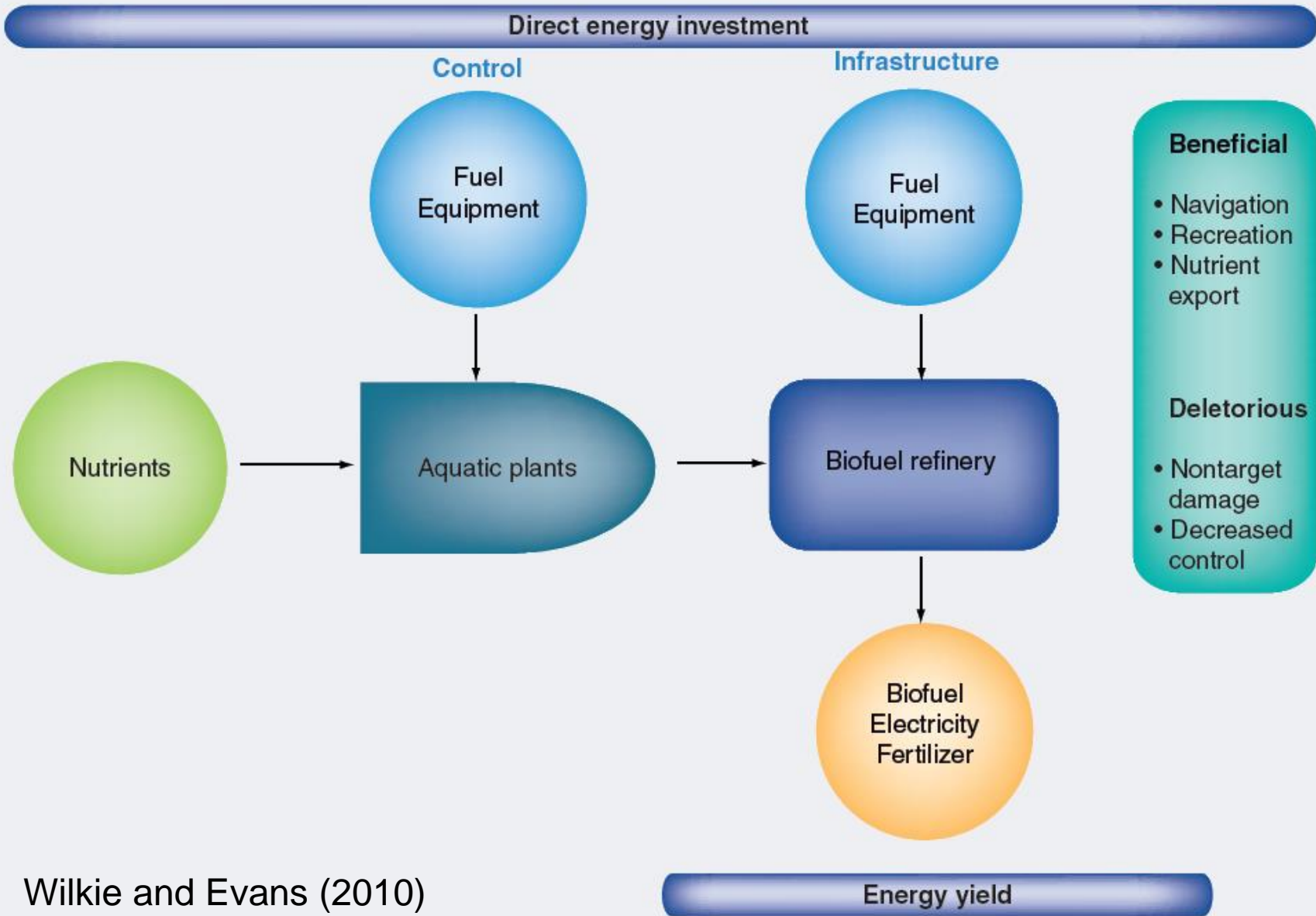


Figure 1. Life cycle for chemical and mechanical control of aquatic plants without biomass harvest.

Wilkie and Evans (2010)





Wilkie and Evans (2010)

Figure 2. Life cycle of bioenergy production and fertilizer production from aquatic plant harvest program.

# In Crystal River...



*Water hyacinth provides several functions*

Luxury nutrient uptake

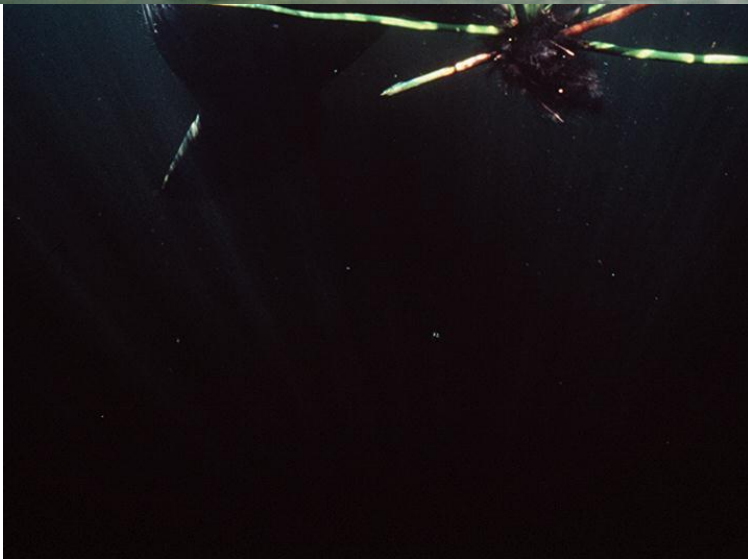
Shading of algae

Improved water clarity

Manatee fodder Ease of harvest

**Conclusion/Recommendation:**

*Relax control, or even experimentally promote, of water hyacinth in this system*



# Thailand example

- Managed phytoremediation (Mahujchariyawong and Ikeda 2001)
- Hyacinth furniture for export market
- Periodic hyacinth fiber shortages – even with  $>140$  dry Mg/ha/yr production





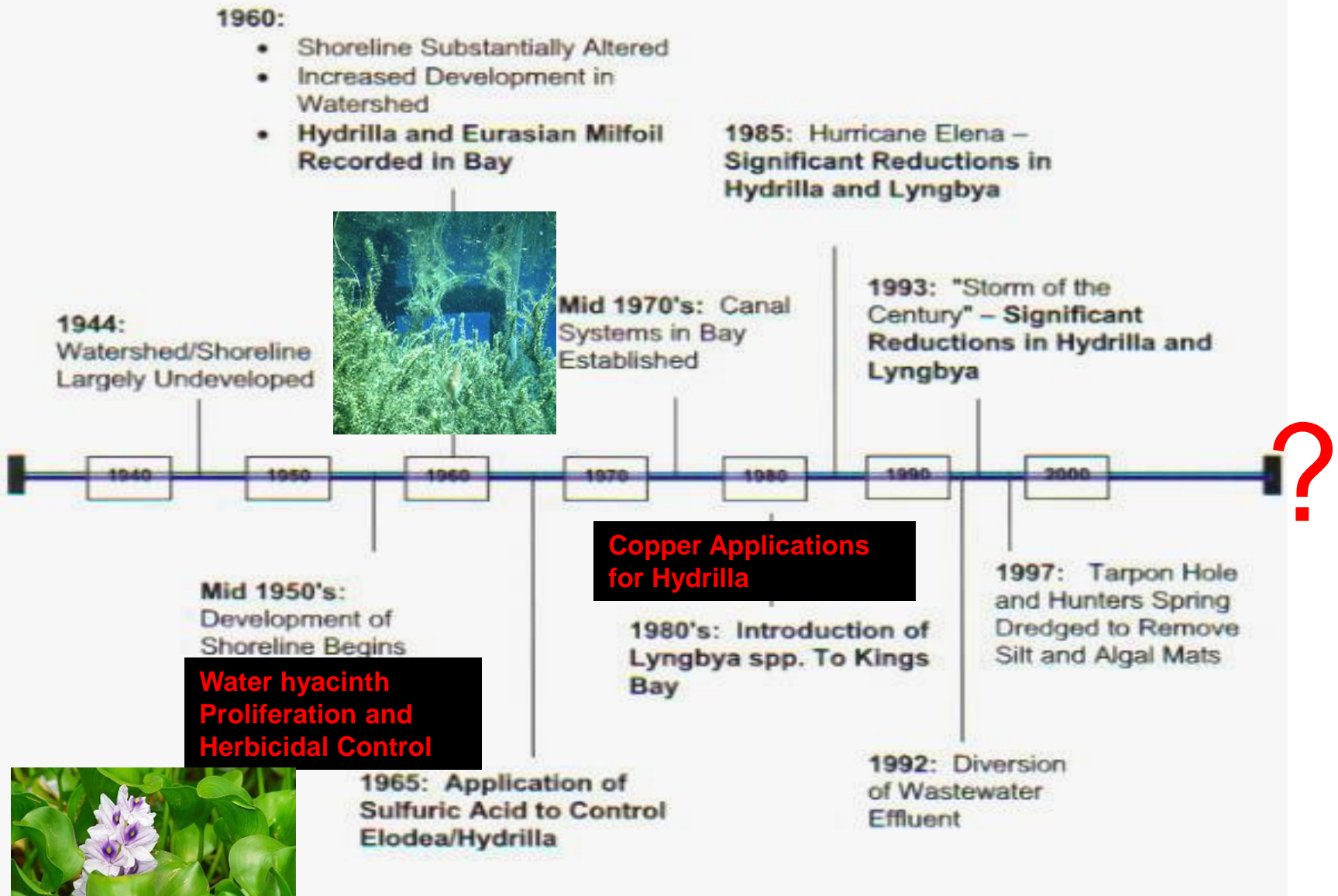
## Response from Florida managers (circa 2005-2007)

- “Counter-intuitive”
- “Contrary to science-based knowledge”
- “Environmentally unacceptable”
- “Shocking”
- “A sign of desperation”
- “Something that no one with any understanding of water hyacinth attributes would ever support”

Research into chemical controls of *L. wollei* (circa 2007-2009)

Figure 15. Timeline of significant events and activities in Kings Bay, Florida.

(From Southwest Florida Water Management District 2004)



# Circa 2012 - 2013

[http://www.youtube.com/watch?v=sqr\\_vPhIru8](http://www.youtube.com/watch?v=sqr_vPhIru8)





# Biggest problem so far...



# Toxins on Indian River Lagoon seaweed might be killing manatees, but mystery remains

Craig Pittman, Times Staff Writer ▾

Wednesday, July 17, 2013 12:10pm



834



65



899



## Ailing Waters

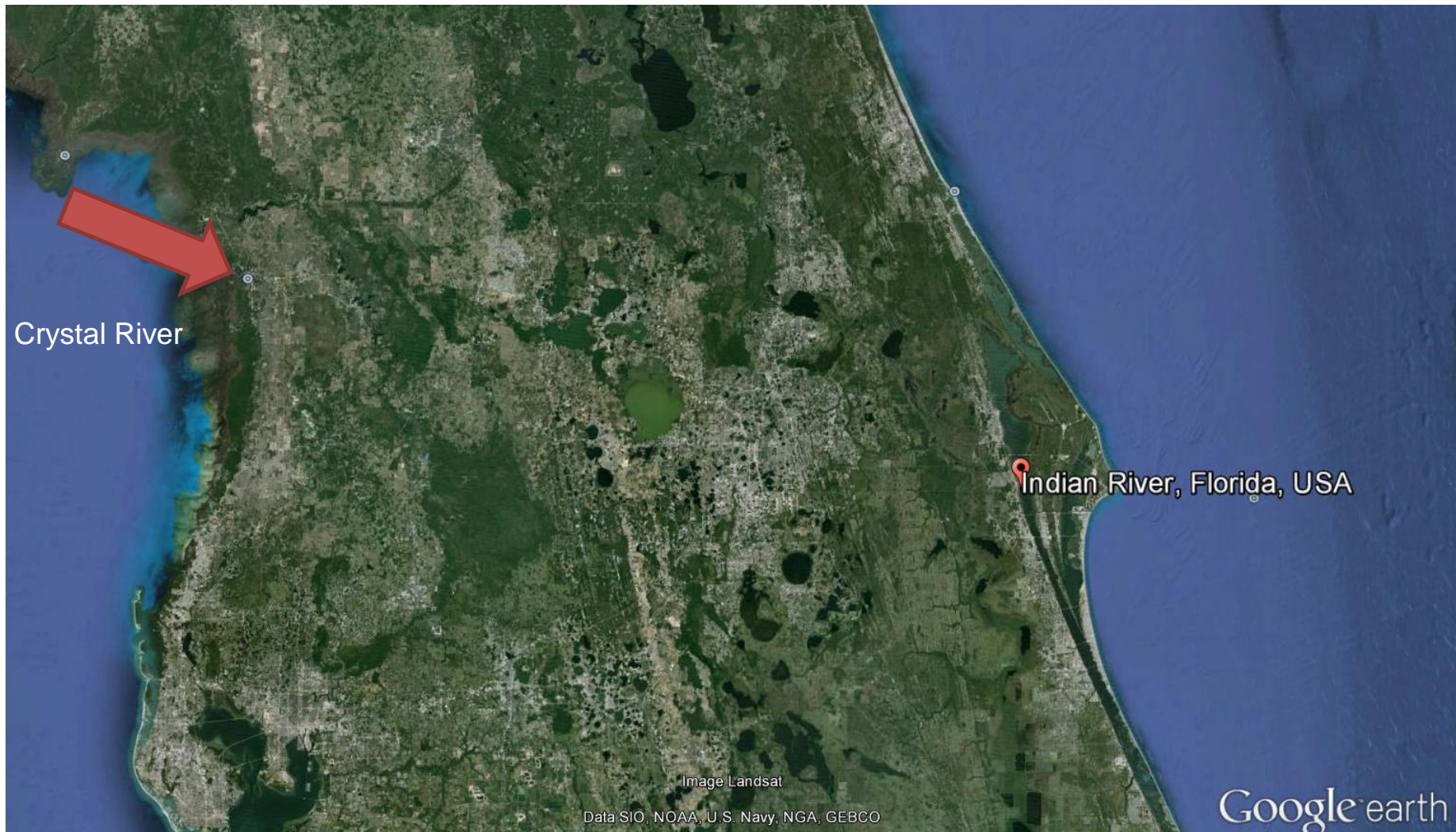
Tampa Bay Times

One of Florida's most important estuaries, the Indian River Lagoon, is sick, and no one can figure out what's wrong exactly. Vast stretches of its seagrass beds died off over the past two years, killed by a massive algae bloom. Then hundreds of manatee...



A government research chemist has isolated what he calls "a suite of toxins" on seaweed eaten by the 112 manatees that have died in Florida's Indian River Lagoon.





Crystal River

Indian River, Florida, USA

Image Landsat

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth



# Back to where I am from...



*Lake Apopka*

*(Hypereutrophic)*



# *Orlando Sentinel*

November 30, 1990

By Kevin Spear

## **Lake Apopka Cleanup Gets Star Treatment**

*The official start of Lake Apopka's cleanup began Thursday with water managers handing out commemorative T-shirts, hats and gizzard shad hors d'oeuvres to VIPs.*

# International opportunity?

## State considers controversial cure for polluted Lake Apopka: Let hydrilla spread

January 22, 2012 | By Kevin Spear, Orlando Sentinel

The sickly Lake Apopka has been healing at a snail's pace despite undergoing some of the more costly environmental rehabilitations in Florida history.

So a state agency is thinking about speeding up the process by encouraging an aggressive, aquatic weed — hydrilla — to take root in the lake.

It's a hotly contested idea that appears to be leaving little room for compromise. Those who want the lake restored to a natural condition say the foreign plant would devastate native varieties if allowed to spread and would destroy any real chances of reviving the polluted lake. Fans of hunting and fishing counter that the fast-growing plant, imported from Asia but now considered a costly nuisance throughout much of the U.S., would work wonders in the lake as habitat for ducks and largemouth bass.

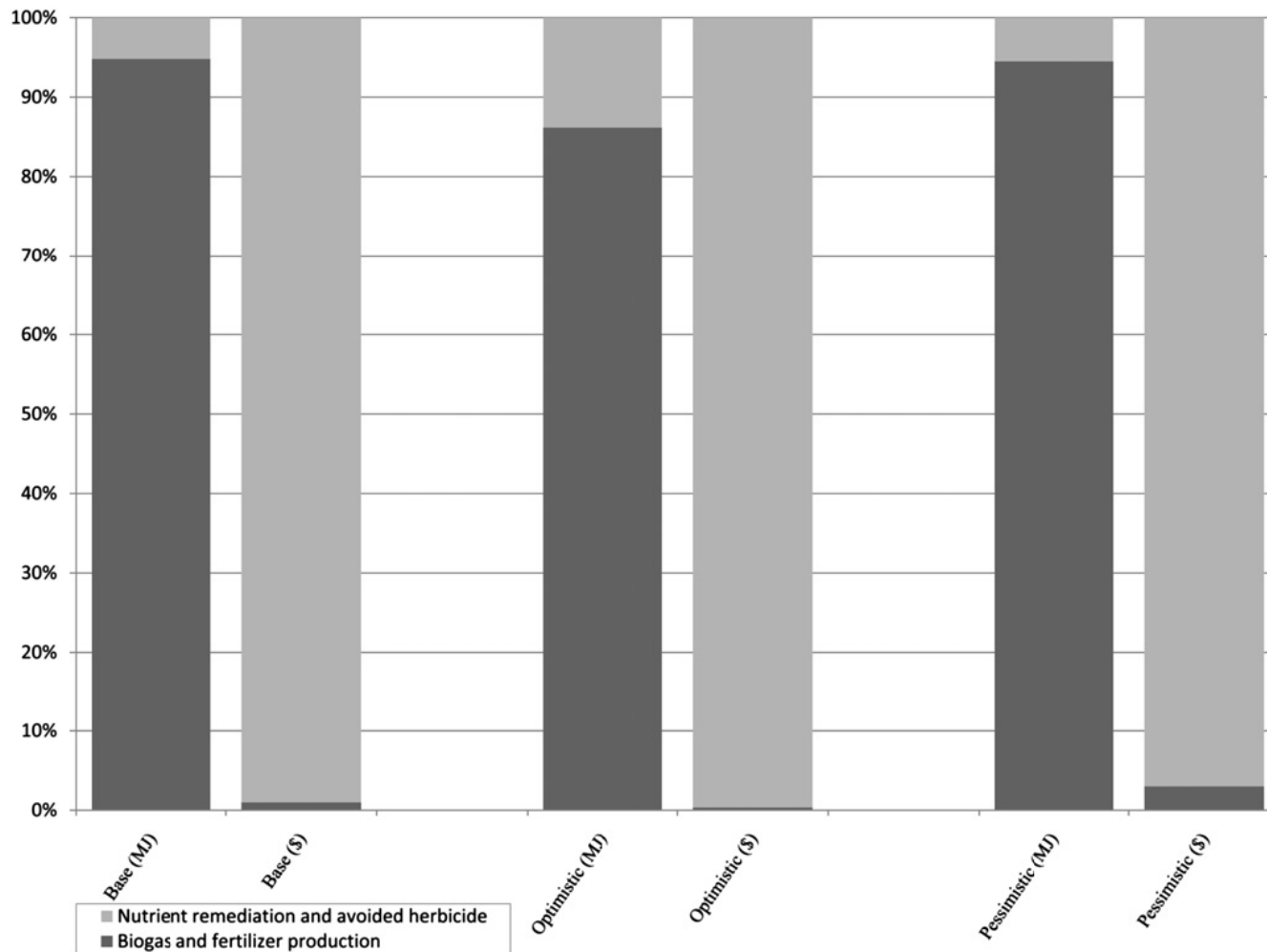


Native lily pads and eelgrass are bright spots in Lake Apopka, ... (Red Huber, Orlando Sentinel...)

[http://www.youtube.com/watch?v=\\_QEHNxNH9xM](http://www.youtube.com/watch?v=_QEHNxNH9xM)



# One More Challenge



Comment and  
to access ad  
features.

Fig. 1. Comparison of the relative energy (MJ) and monetary (\$) contributions from material exports (i.e., biogas and fertilizer production) and in-lake benefits (i.e., nutrient remediation and avoided herbicide) associated with hydrilla harvesting scenarios.

# Final thoughts...

*Catchment management is of course ultimate cause/solution, but in situ rehabilitation and recovery strategies is synergistic – not antagonistic – to such efforts*

*From an economic perspective, recovery of fugitive nutrients in aquatic biomass should be rewarded with tertiary treatment values*

*Fertilizer and energy returns have high sustainability yield, but not yet competitive economically with fossil-fuel driven processes*

*But we have an ethical obligation to develop and perfect these processes now while fossil energy resources are available*