

Contemplating the fate of freshwater-dependent Florida Keys ecosystems: what to do about species threatened with extinction due to Sea Level Rise?



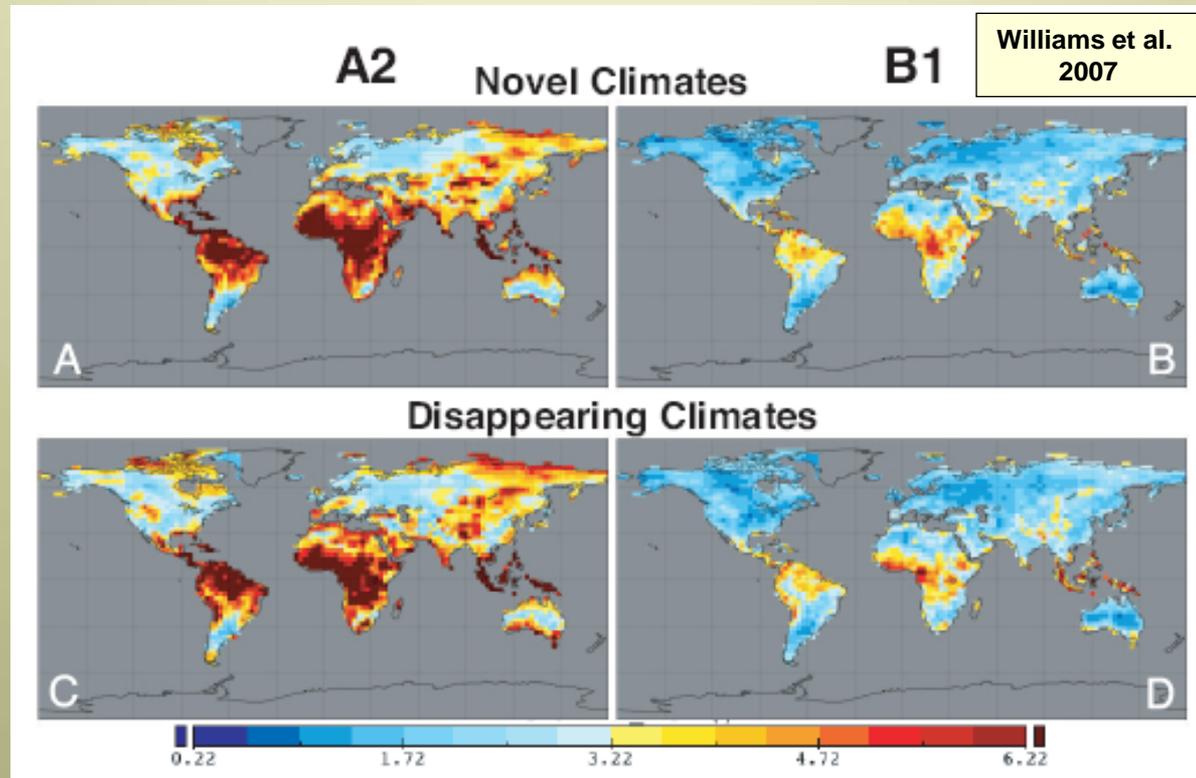
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The Keys represent a special case in what will become a common global theme:

A conflict between a “no-analog” environmental future

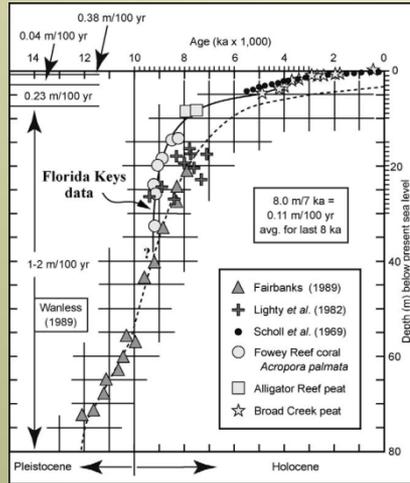


and a legal, political, and philosophical worldview based on “stationarity” (Milly et al. 2008; Craig 2010), the assumption that “natural systems fluctuate within an unchanging envelope of variability”

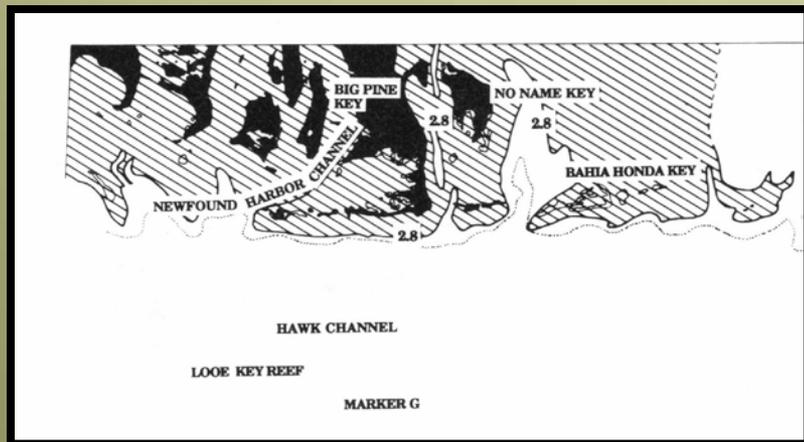
SLR & Lower Keys land surface in last 8000 years

(from Lidz & Shinn 1991, Lidz 2006)

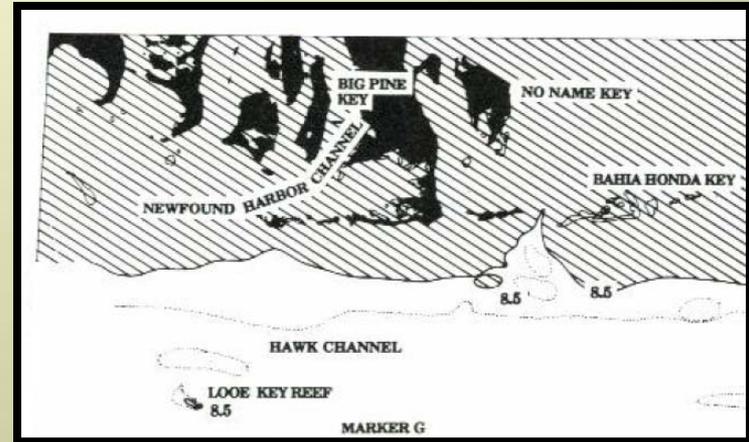
Sea level increase of ~20 m in last 8K yrs



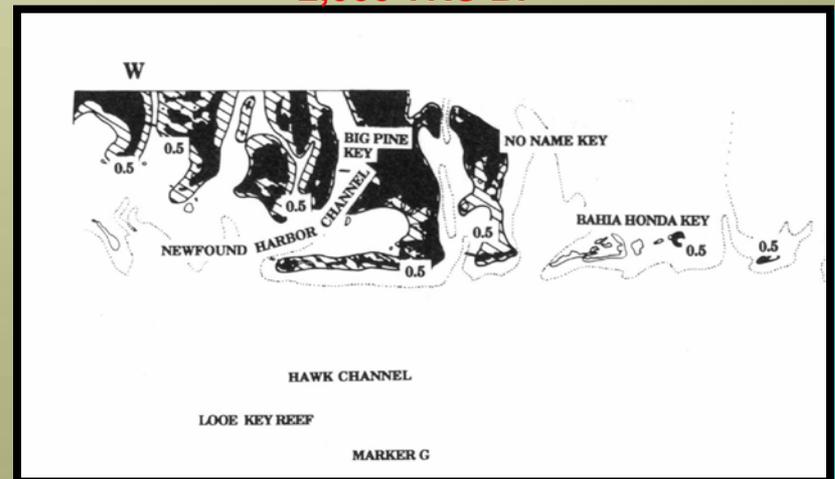
4,000 YRS BP



8,000 YRS BP



2,000 YRS BP



Keys terrestrial biota

1. Plants – primarily West Indian origin, species that managed to disperse at some point by long distance means.
2. Animals – primarily temperate in origin from SE US via the Florida peninsula, but living in a warmer environment than most of their close relatives, often smaller with relatively long appendages.
3. Recent isolation by water over last ~5K years has allowed evolution of numerous endemic taxa to the species, subspecies or varietal level

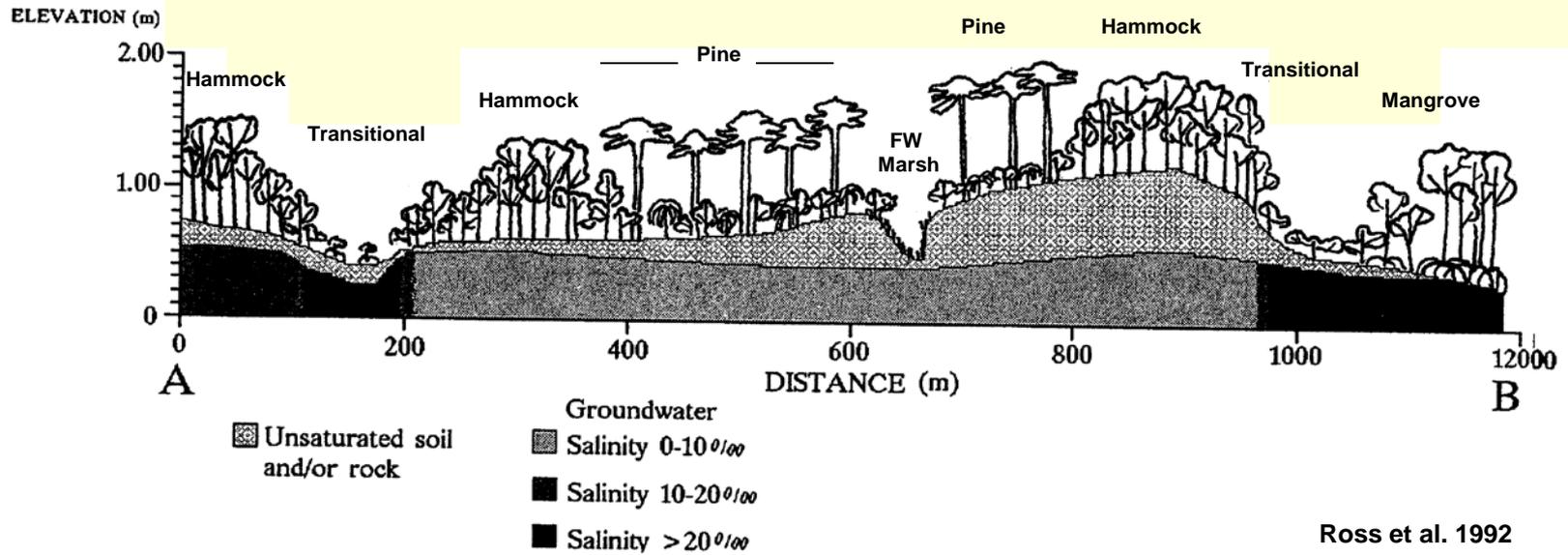


Big pine partridge pea (*Chamaecrista lineata* var *keyensis*) – Candidate for federal listing status since 1999

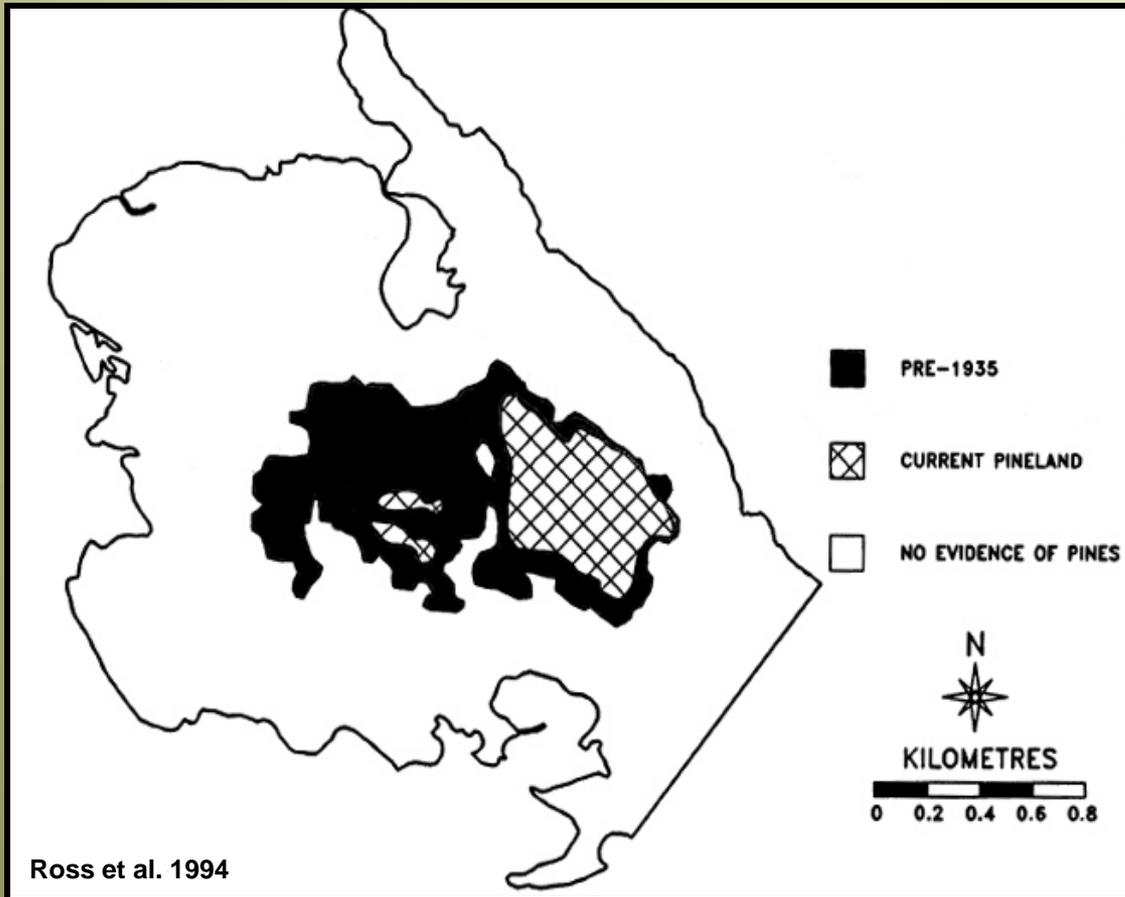


**Key deer (*Odocoileus virginianus clavium*)-
Federally Endangered, 1967**

Physiography of lower Keys vegetation mosaic

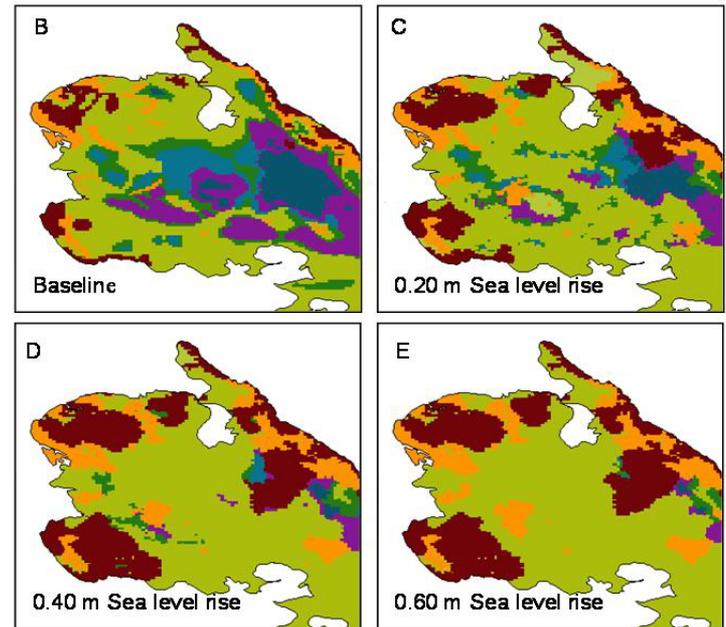
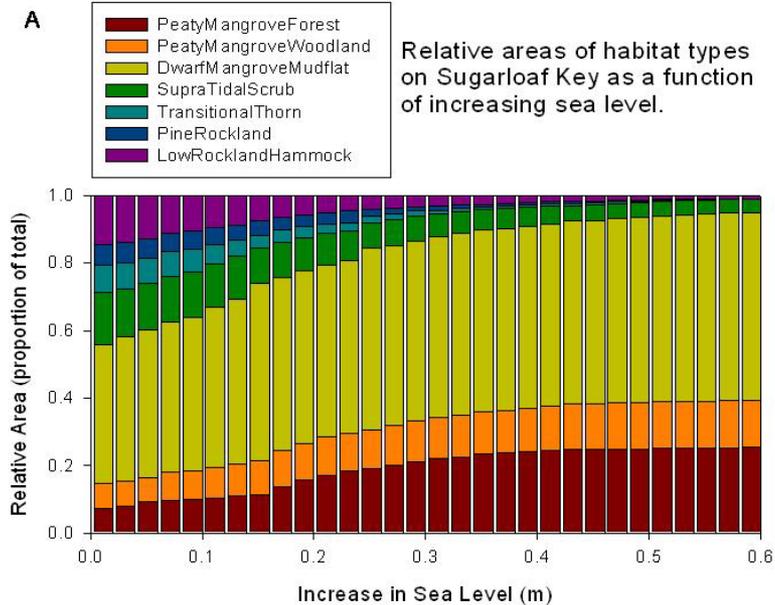


Recession of Sugarloaf pine forest (toward the interior of the island, toward higher elevations)



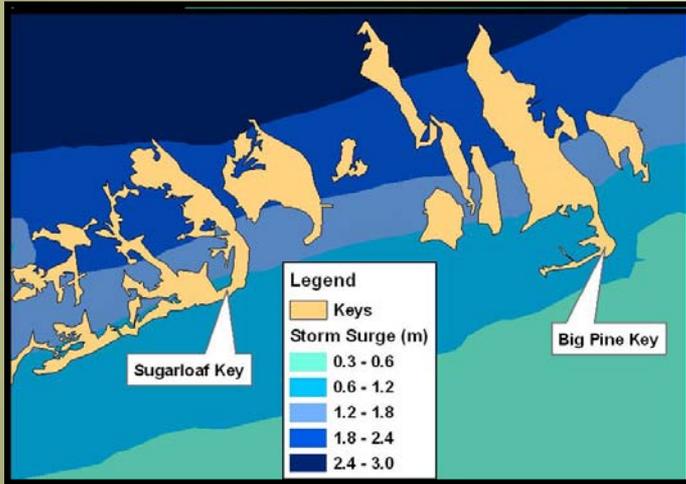
Evidence of environmental change on Sugarloaf Key– pine snags in buttonwood woodland

Projected habitat change with sea level rise on Sugarloaf Key



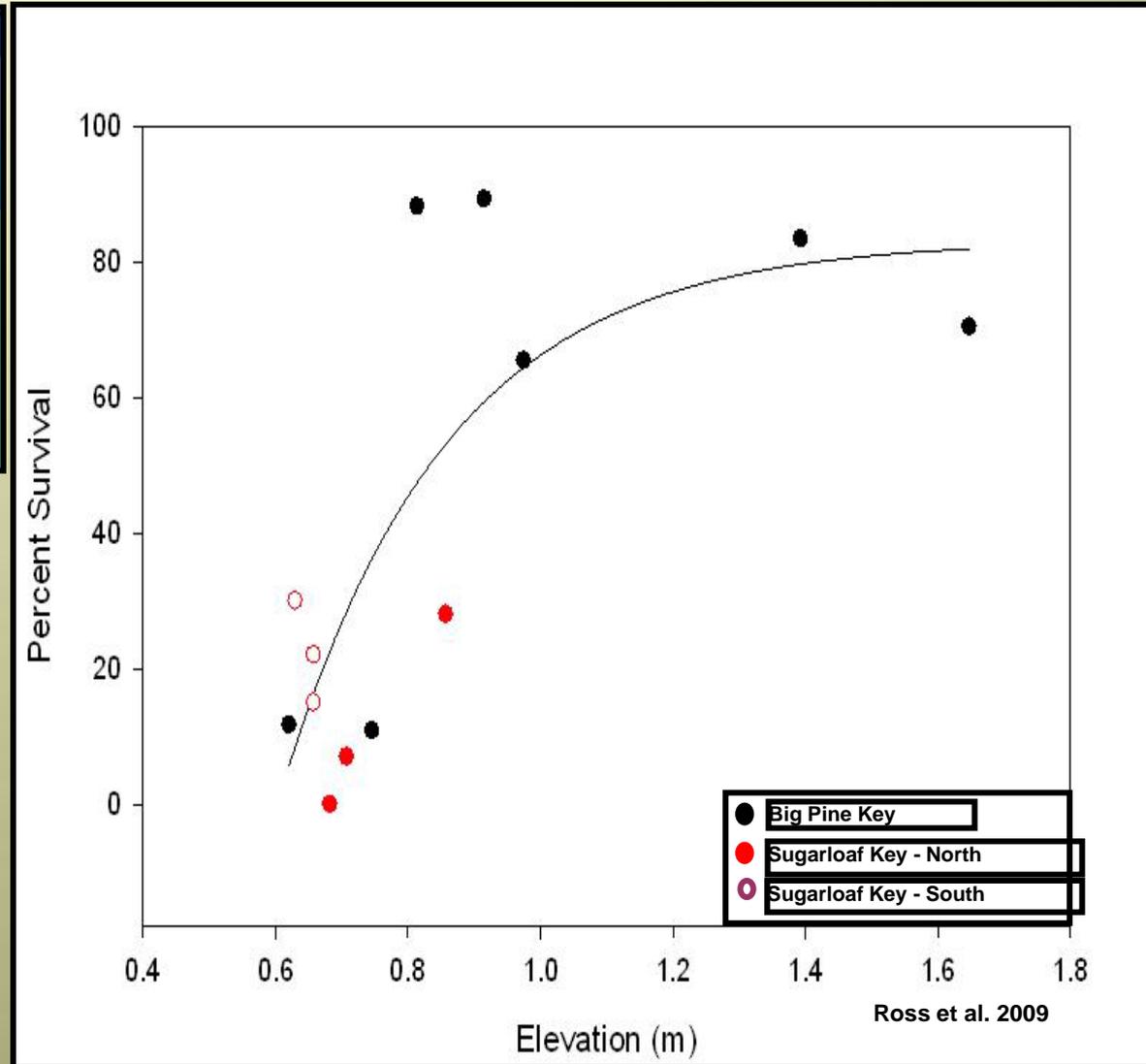
Ross et al. 2009

Hurricane Wilma, October 24th, 2005

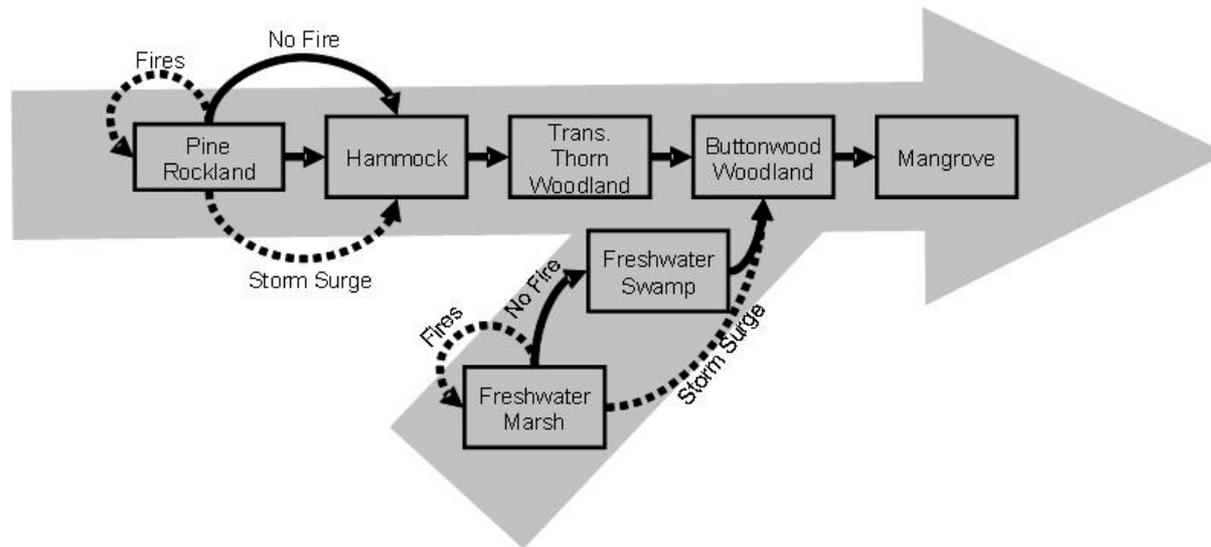


Storm Surge in the lower Keys

Wilma-related mortality:
Sugarloaf Key, 70-100%;
Big Pine Key, 10-90%;
concentrated at elevations
< 1m



Sea level rise (a ramp disturbance) alters longstanding regimes of fire and storm surge (pulse disturbances), with consequences for landscape pattern



Ross et al. 2009

Should sea level rise another foot (probably less), this confluence of disturbances will signal the end of freshwater-dependent communities and species in the Keys.

Alternative responses for conserving threatened endemic species (in order of increasing cost)

1.No action

2.Ex situ actions (e.g., zoos and botanical gardens)

3.Build resilience, improve ecosystem health in place (prescribed fire, ecological management of water, etc)

4.Reintroduce within historical range

5.Introduce outside range (e.g., “assisted colonization”)

Best option depends on:

- (1) characteristics of threat,**
- (2) characteristics of species,**
- (3) characteristics of potential recipient sites, and**
- (4) legal and policy considerations**

A simplified list of pros and cons of “assisted colonization”

YES!!

1. **Law** - illegal to not take all possible action for endangered species.
2. **Science** – Other alternatives lead eventually to extinction of species in nature.
3. **Policy** – Where not prohibited, some private citizens are likely to move species out of historical range.



NO!!

1. **Law** – presumption in law and agency mandate toward historical distribution patterns.
2. **Science** - experience with invasive species testifies to potential harm at recipient sites
3. **Science** - fitness of related taxa in recipient community may be reduced
4. **Policy** - redirection of limited conservation funds

Characteristic of species – key deer & BP partridge pea

	Key Deer	Big Pine partridge pea
Conservation Status	federally endangered	candidate
Potential population growth rate	low	moderate
Genetic diversity	unknown	unknown
Dispersal ability	moderate	low
Ecological impact	moderate to high	low
Habitat preference	pine rockland & others	pine rockland
Salt tolerance	low to moderate	low

Characteristic of recipient sites – key deer

	Everglades National Park	Bahamas
Related taxa	sub-species	no
Likelihood of genetic mixing	high	none
Habitat match	good	good
Flooding horizon	decades	centuries
Potential ecological impact	low to moderate	high
Political difficulty	high	high



Characteristic of recipient sites – BP partridge pea

ties	Everglades National Park	Bahamas
Related taxa	species	variety
Likelihood of genetic mixing	low to moderate	high
Habitat match	good	good
Flooding horizon	decades	centuries
Potential ecological impact	low	low
Political difficulty	moderate	moderate-high





A consensus on “assisted colonization” will be difficult to reach, but scientists should take the lead in initiating the conversation.

Given the heavy human hand evident everywhere on the planet, and the no-analog environmental future we face, it may be time for conservation scientists to recognize our biases towards a nature that no longer exists, and consider more proactive approaches to management of biodiversity.