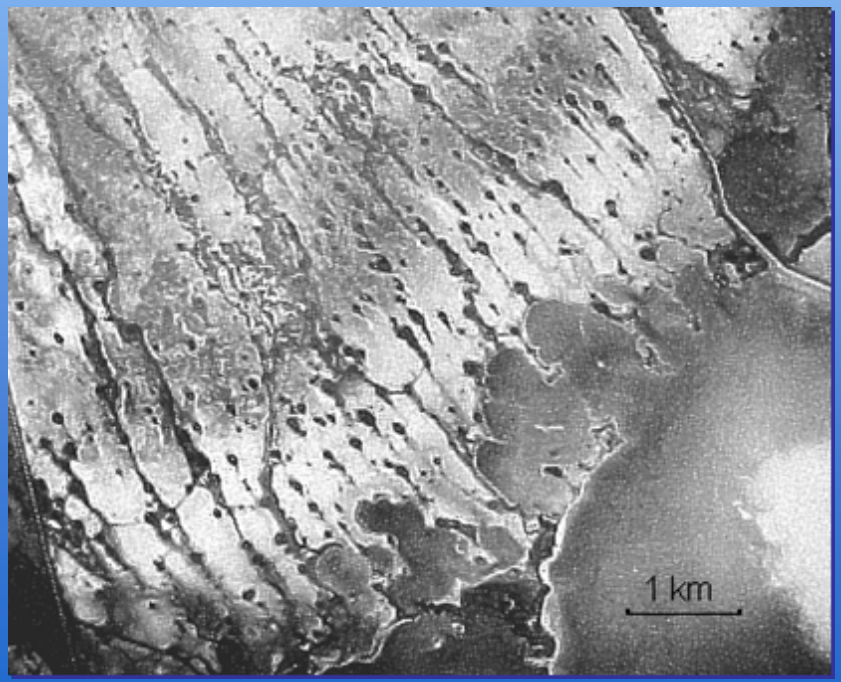
Sea level rise and pine forest loss in the Florida Keys

MS Ross[1], K Zhang[1], JP Sah[1], JJ O'Brien[2] & RG Ford[3]

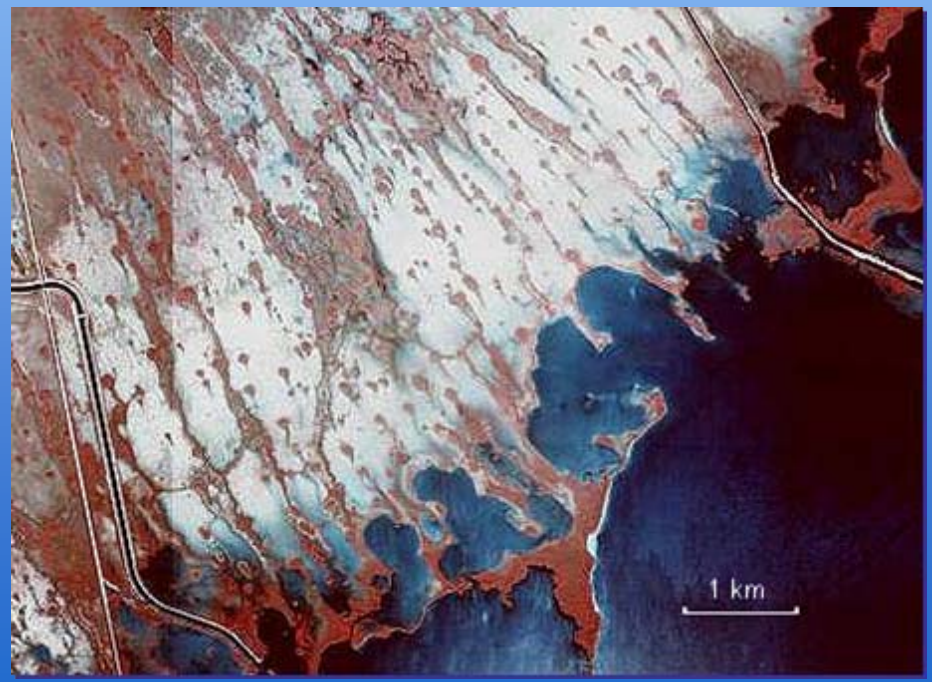
[1]Florida International University, [2]US Forest Service, [3]UC-Santa Cruz

Sea level rise and water management in the C-111 Basin (Southeast Saline Everglades)

The “white zone”,
north of Barnes Sound, 1940

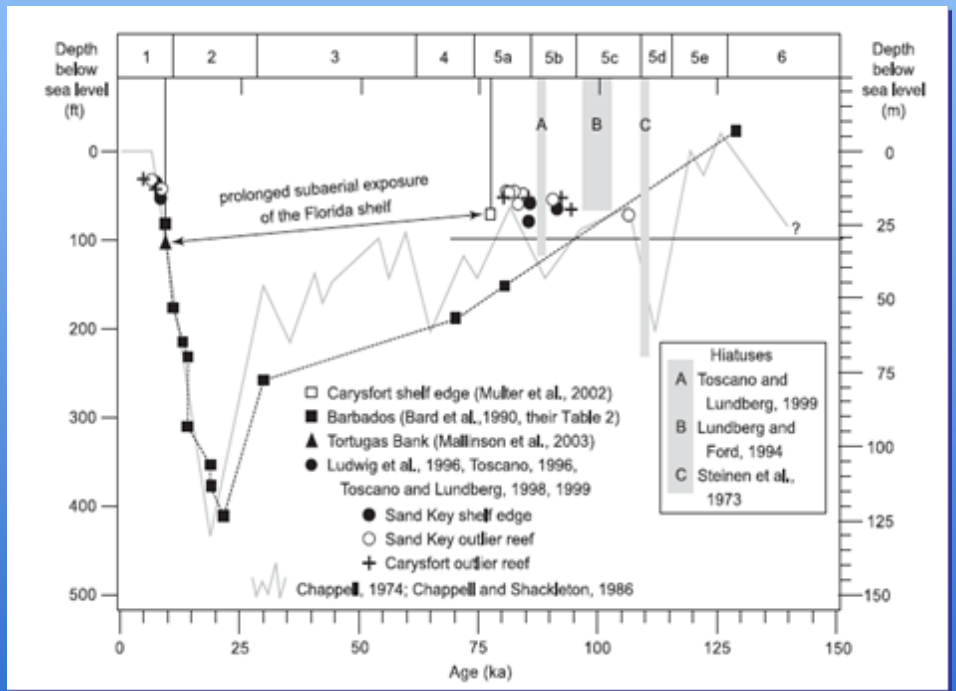


Same area, 1991

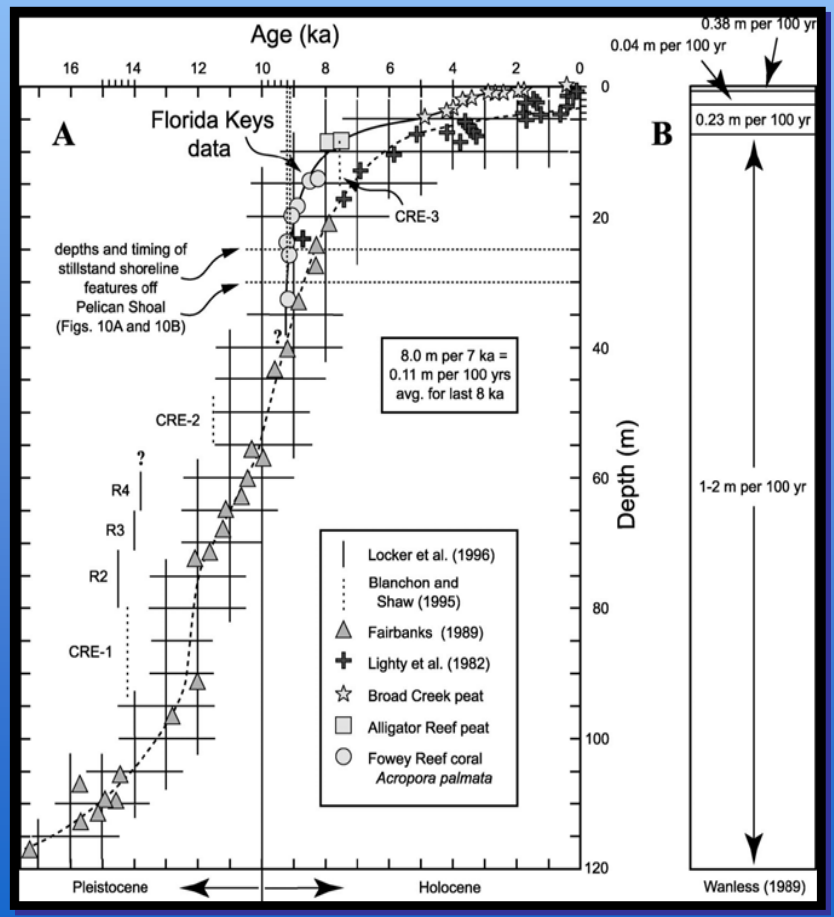


Sea level change over the long haul – the Late Quaternary period

135 K yrs ago to present



20 K yrs ago to present



The lower Keys 8 - 9K years ago?

Evidence from the sea

Organic debris deposit, New Ground Reef, 35 miles w of Key West: ^{13}C ~8500 yrs BP

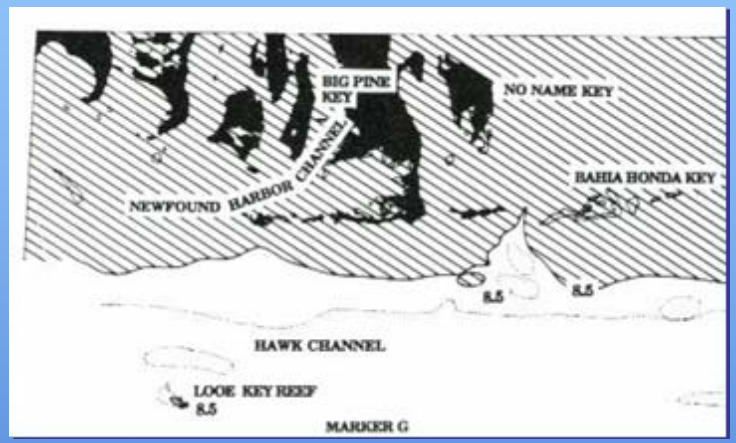
Extensive uplands: pine forest (background) & hammock (foreground) mix (e.g., Abaco today)

Debris components:
burned pine wood
pine cone

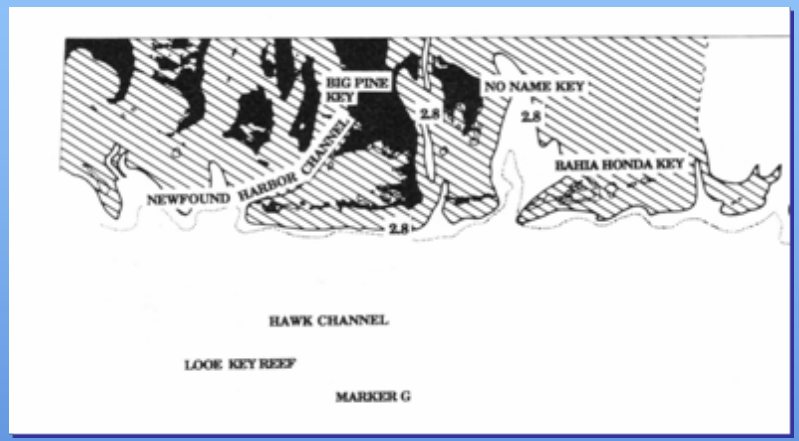
Debris photos courtesy Corey Malcom, Mel Fisher Maritime Heritage Exhibit

Lower Keys land surface, 8000 years BP to the present (**from Lidz & Shinn 1991**)

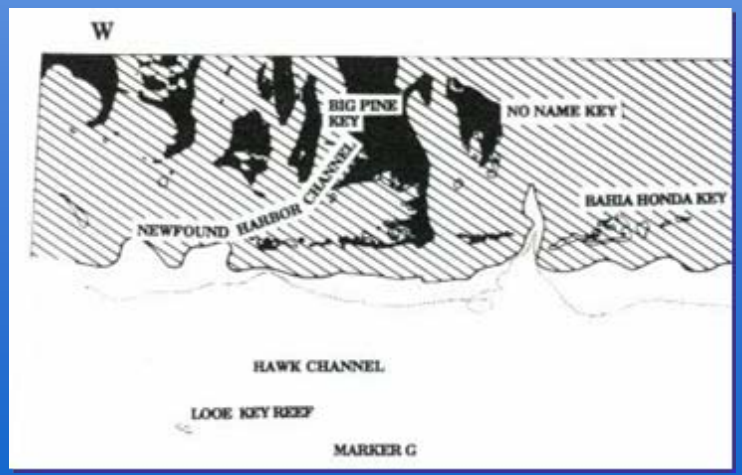
8,000 YRS BP



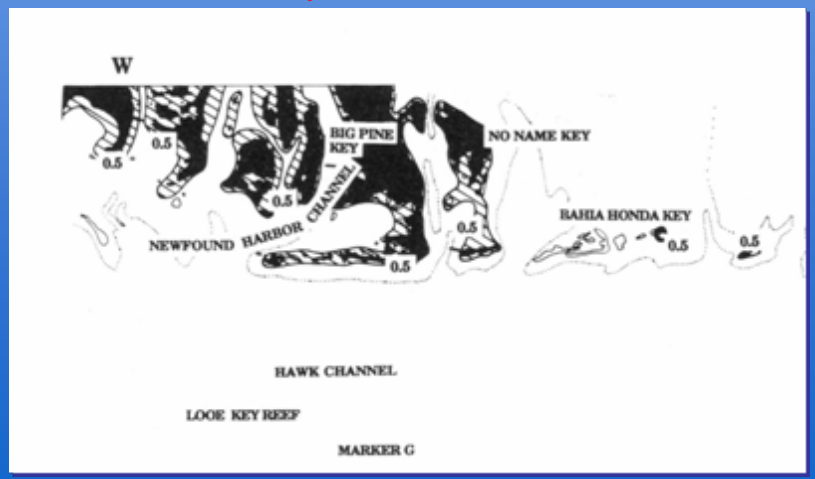
4,000 YRS BP



6,000 YRS BP



2,000 YRS BP

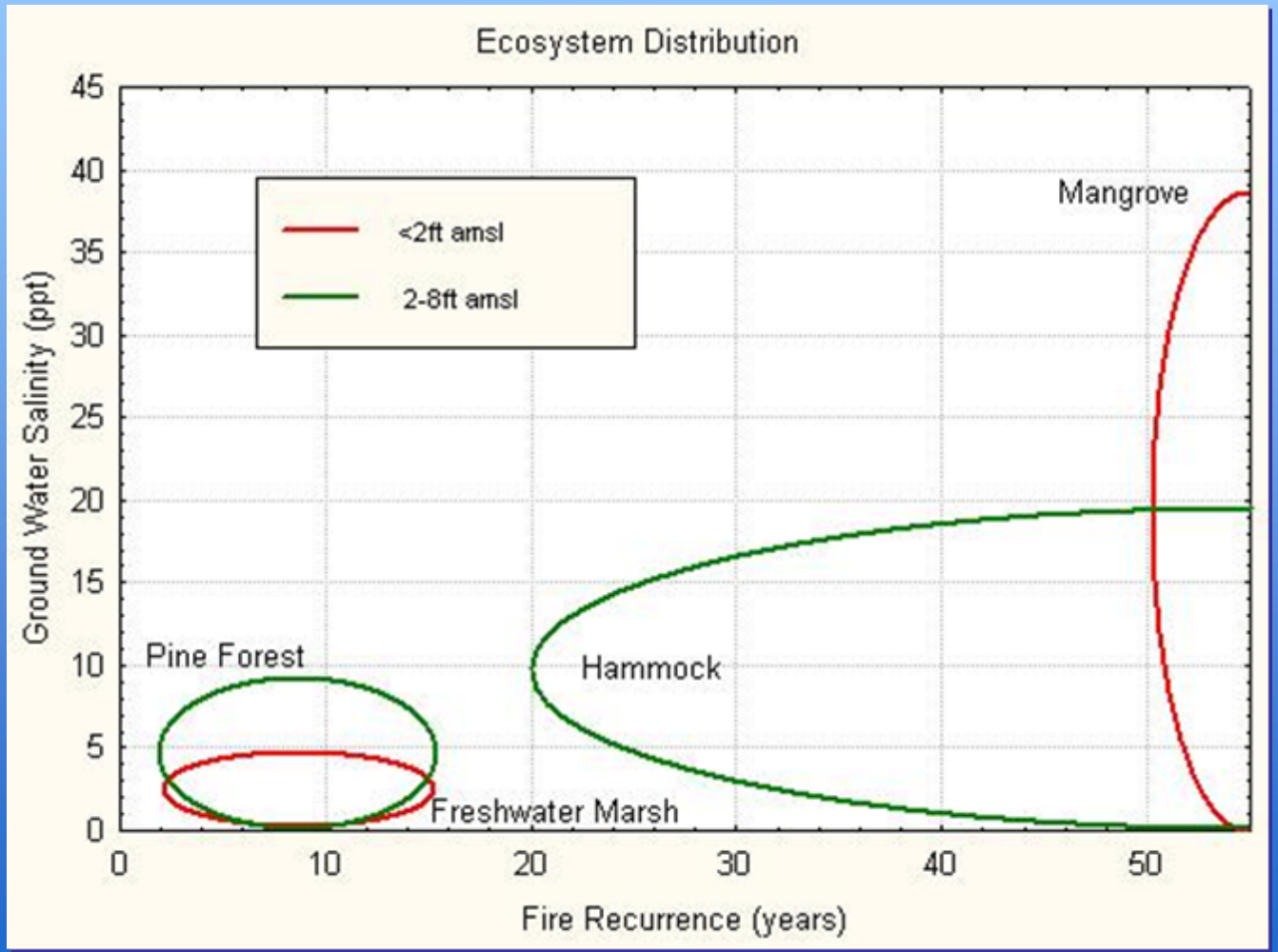


Pine forest extent, island size, and salinity.

Island	Upland area (ha)	Salinity (g/kg)	% upland in pine forest
Key Largo	2840	14	0
Big Pine	920	1	76
No Name	213	1	26
Cudjoe	211	2	34
Upper Sugarloaf	190	1	20
Big Torch	145	1	0
Middle Torch	127	2	0
Little Pine	105	1	50
Ramrod	87	1	1
Lignumvitae	76	6	0
Little Knockemdown	66	1	0
Summerland	37	2	0
Knockemdown	21	5	1
Big Munson	10	4	0

Salinity data: least saline of 1-5 solution holes, during drought conditions on May 18-20, 1992. Unpublished data from Kruer (pers. comm.) and Ross

Approximate distribution of Keys terrestrial communities along three major ecological gradients

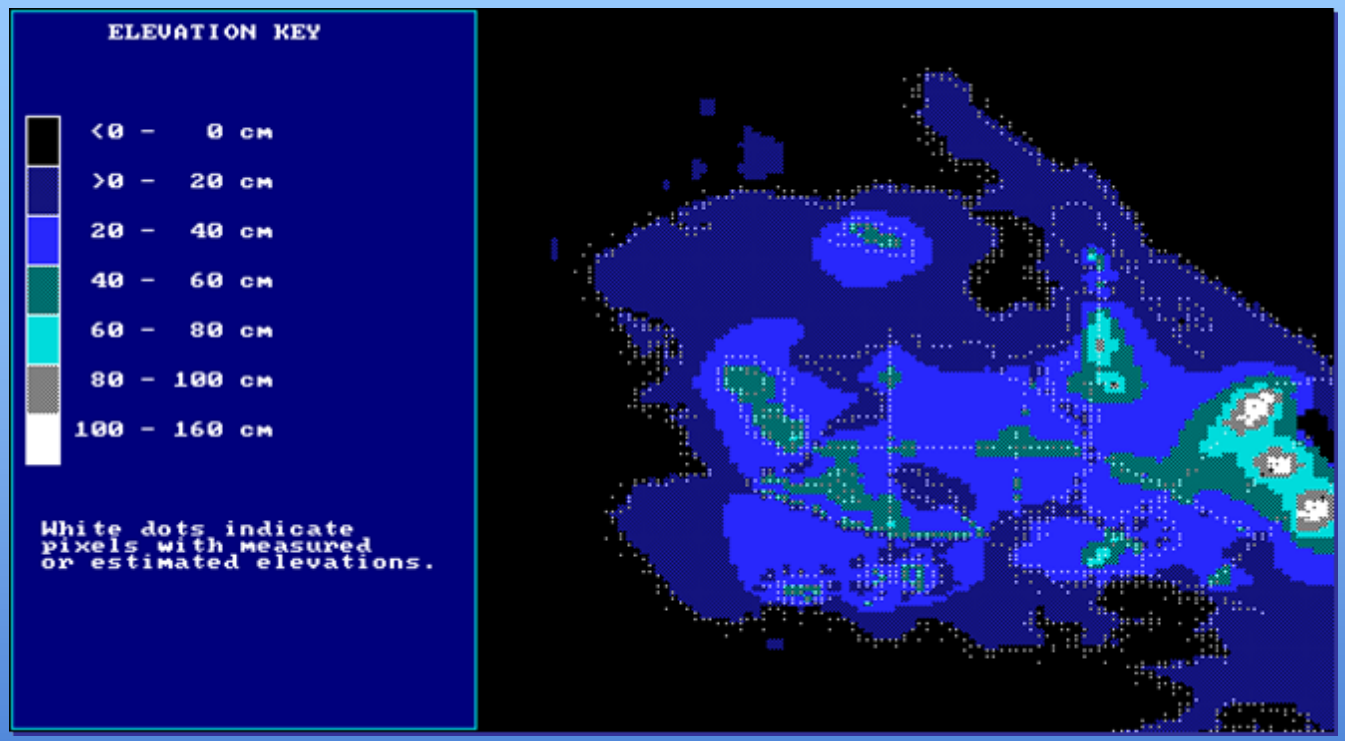


Evidence of environmental change – pine snags in buttonwood woodland

North Key Largo

Upper Sugarloaf Key

National Audubon Society study, Sugarloaf Key – 1989-1992



1. Surveyed topography along woods road network
2. Developed current (1991) vegetation map
3. Interpreted vegetation from historical aerials (1935, 1959, 1971)
4. Searched for pine snags in each 50 x 50 m cell to edge of island

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

Recession of pine forest

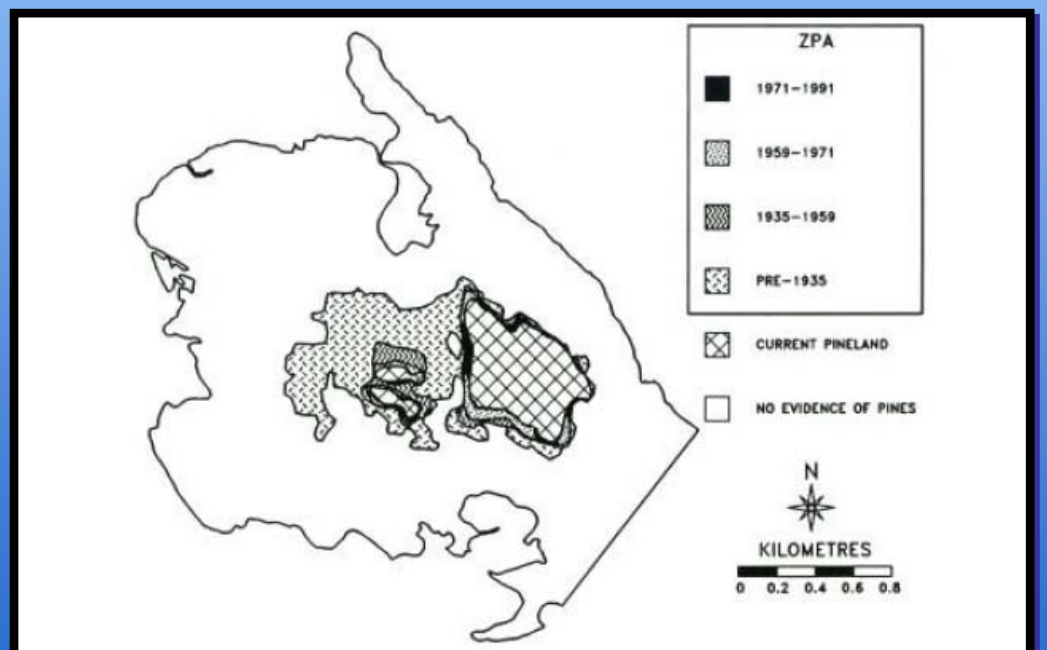


FIG. 3. Zones of pineland attrition (ZPAs) on upper Sugarloaf Key, with area of extant pine forest in 1991.

Current elevation in recessional zones

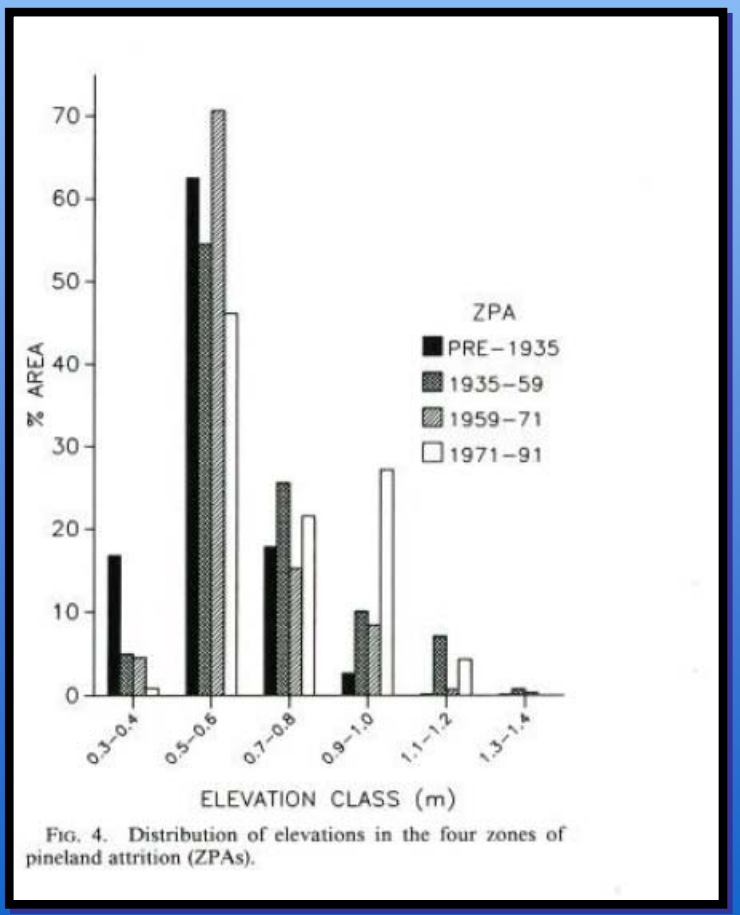


FIG. 4. Distribution of elevations in the four zones of pineland attrition (ZPAs).

SeaChange: A sea-level driven model of vegetation change for the Florida Keys

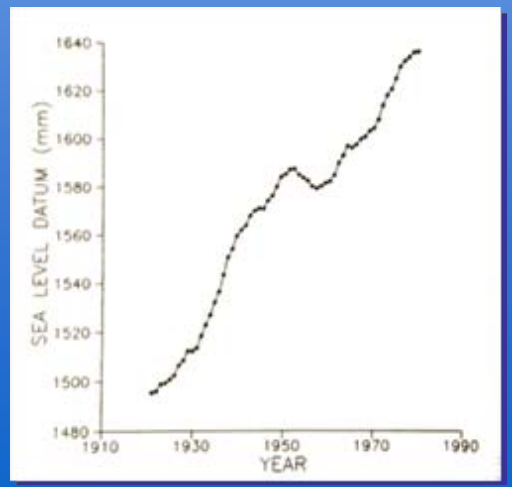
Model rules:

1. Start with 1991 vegetation pattern and elevation above sea level; raise sea level 2 cm in 5-year increments
2. Relative area of community types within 10 cm elevation bands remains constant
3. Proportional habitat "adjacency" remains constant
4. Fractal index of landscape remains constant
5. Except as above, community types expand by adding cells at their edges

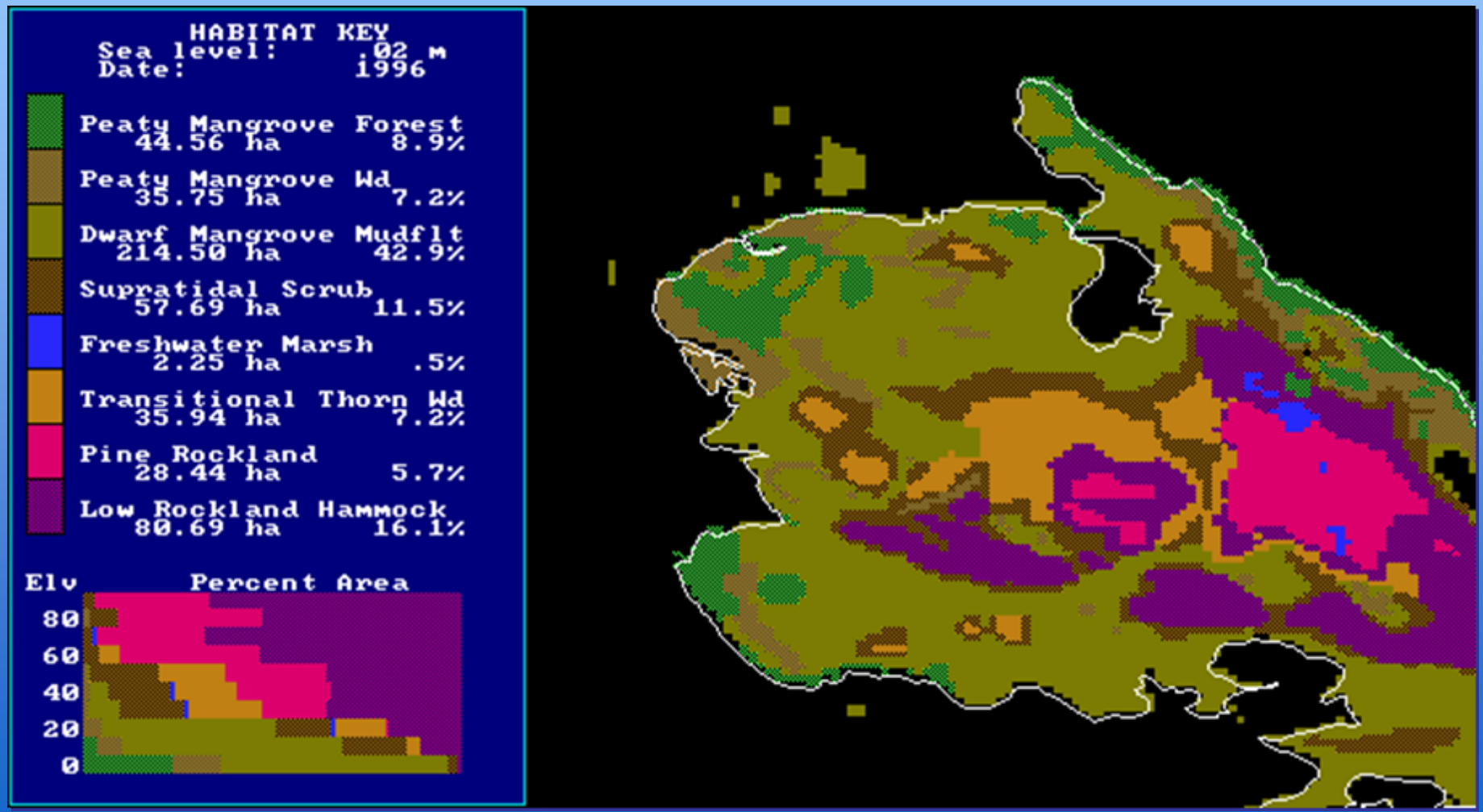
Verification:

1. 1935 – 1991 model run, using sea level data from Key West, compared to vegetation change (3 broad types) from photo interpretation
2. Model predicted well for uplands & mangroves, not so well for transitional habitats

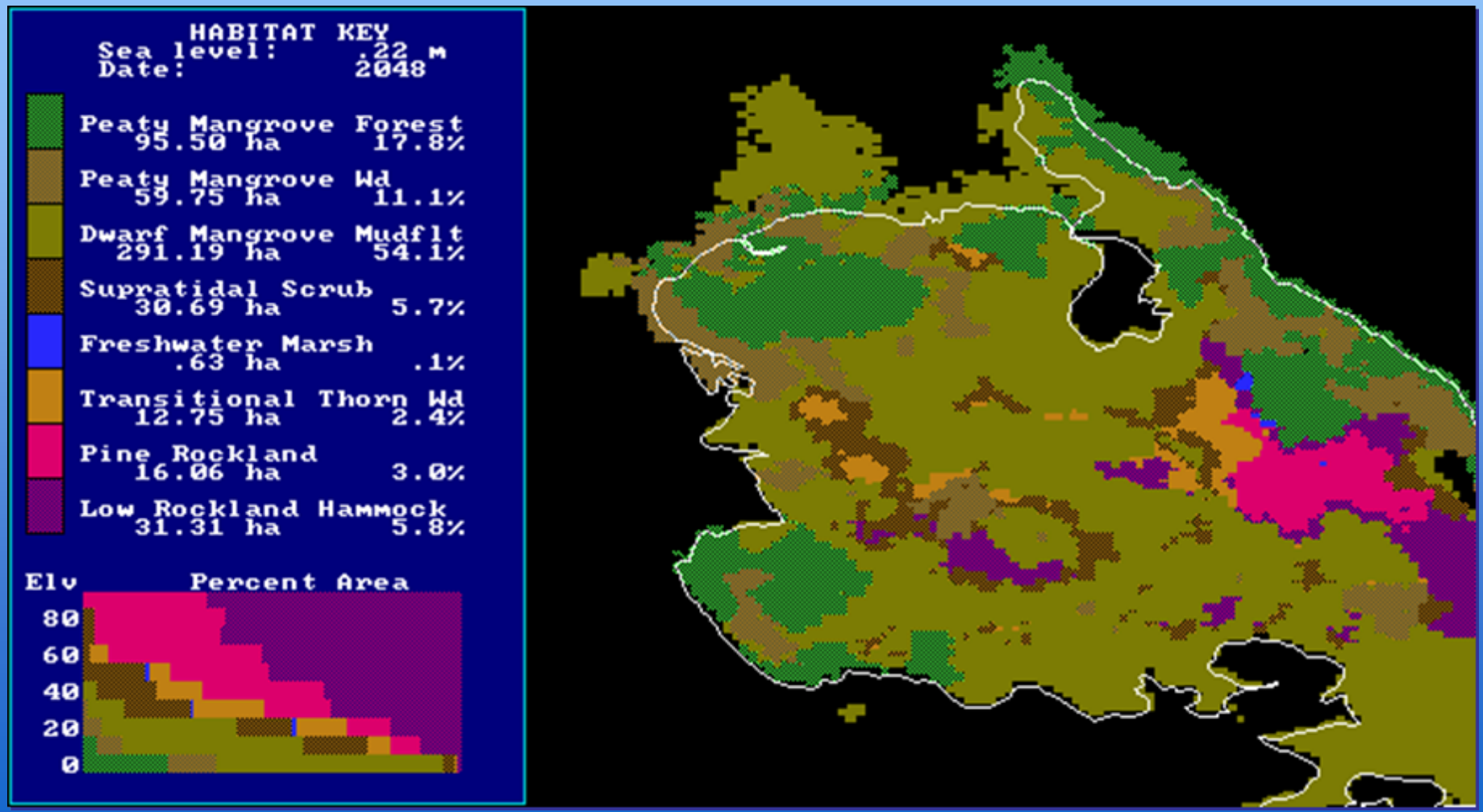
Sea level at Key West



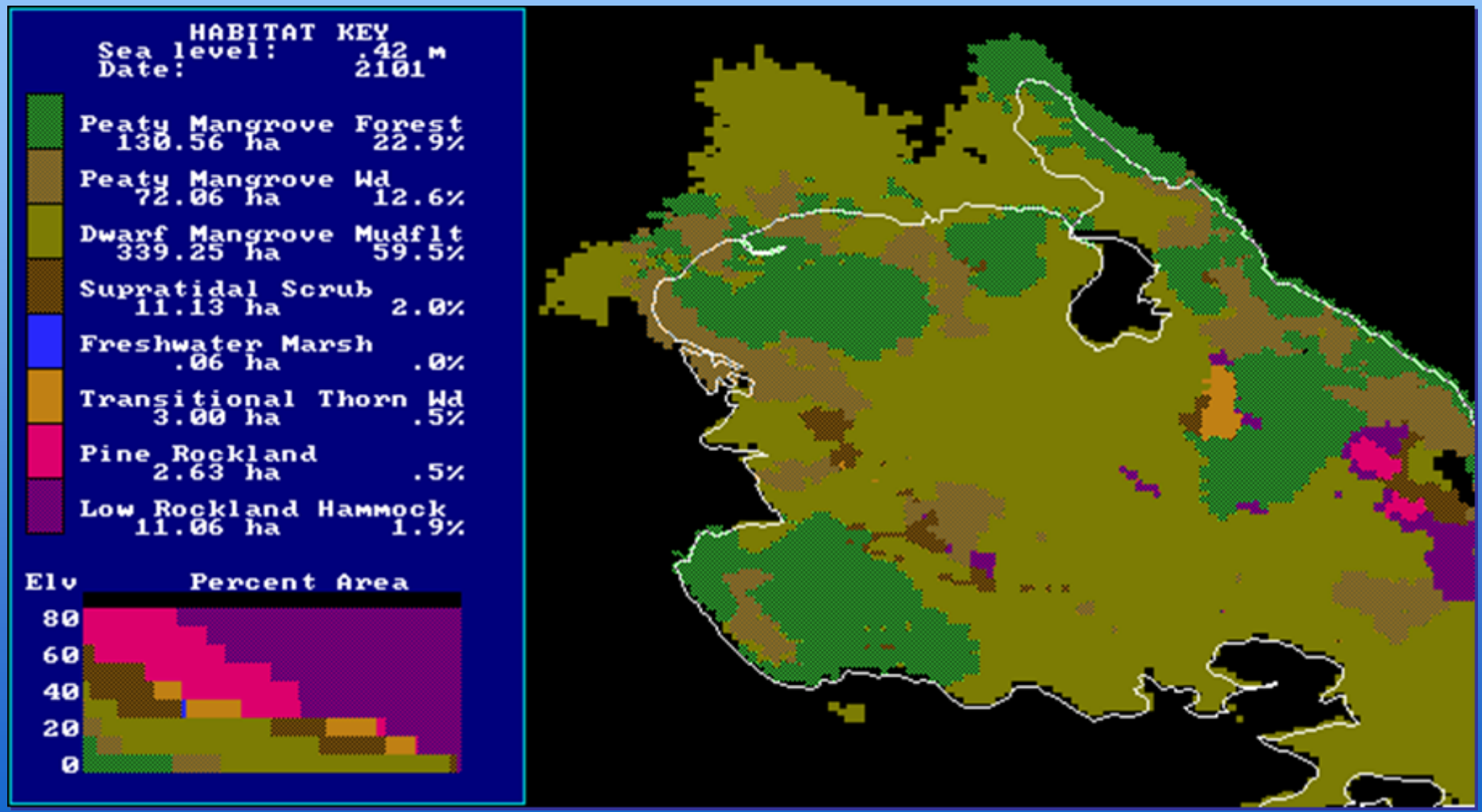
SeaChange model landscape, Sugarloaf Key,1996



SeaChange model landscape, Sugarloaf Key, 2048

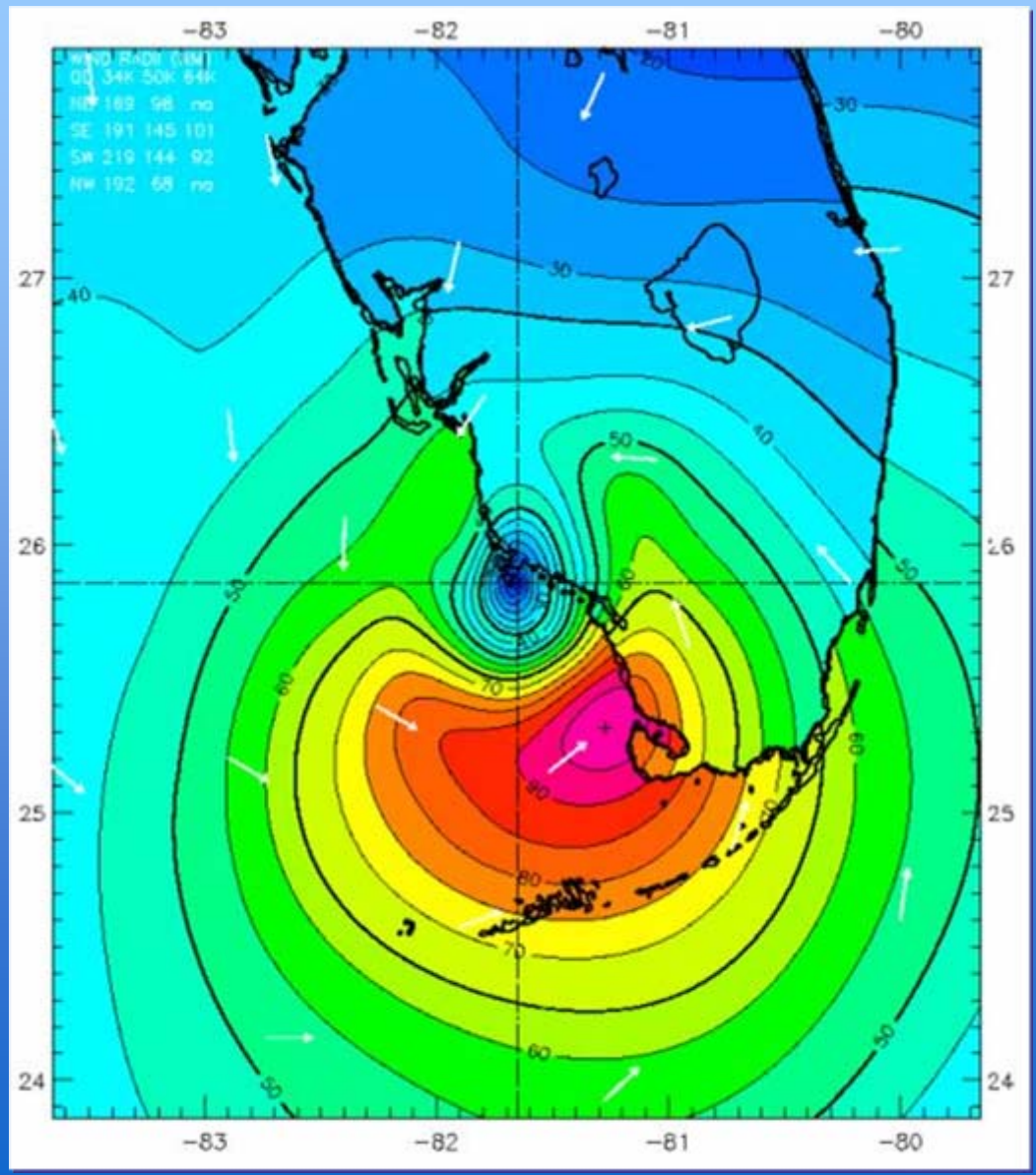


SeaChange model landscape, Sugarloaf Key, 2101

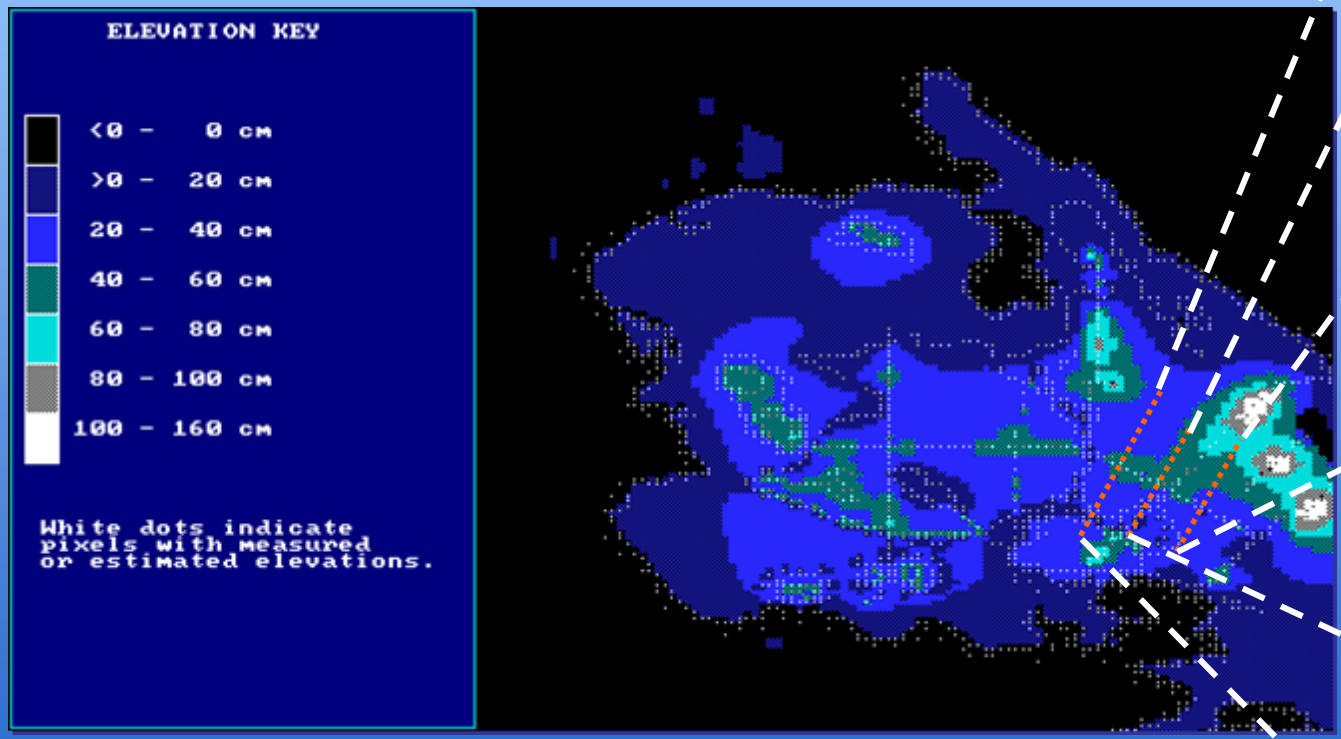


Hurricane Wilma Windfield

October 24th, 2005



Post-Wilma pine survival and density



Survival: 0%
Post-Wilma Density: 0/ha

Survival: 7%
Post-Wilma Density: 38/ha

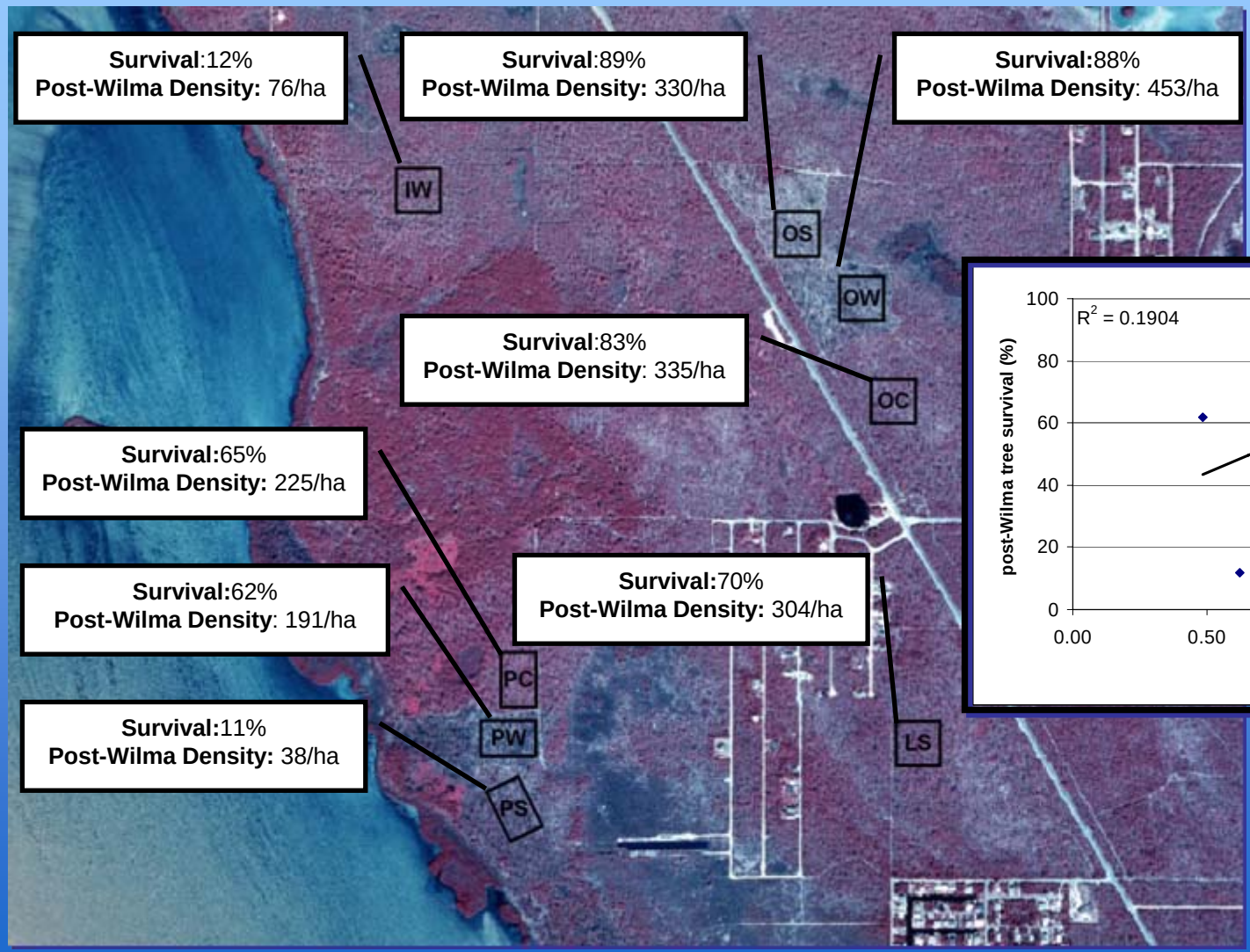
Survival: 28%
Post-Wilma Density: 71/ha

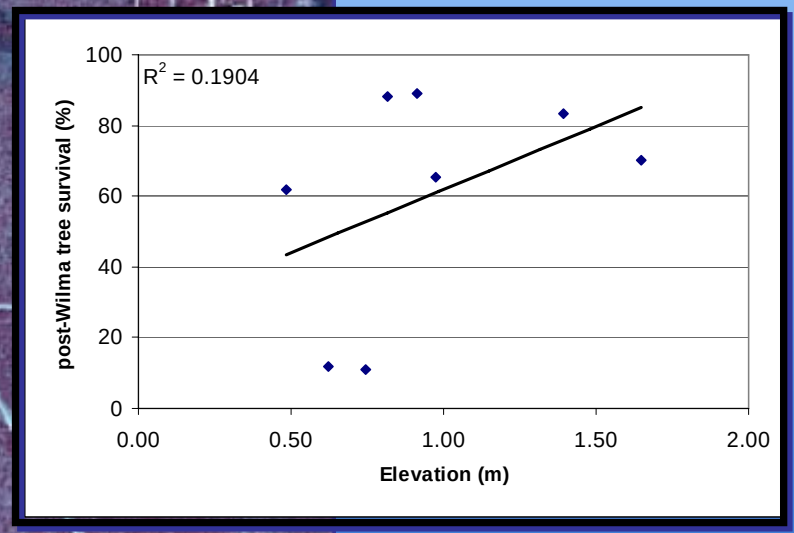
Survival: 15%
Post-Wilma Density: 20/ha

Survival: 30%
Post-Wilma Density: 102/ha

Survival: 22%
Post-Wilma Density: 81/ha

Post-Wilma pine survival and density





Storm surge effect

1. Interaction with ground water level, precipitation after event

2. Species resistance, recolonization potential affect post-event community dynamics

3. Fire may provide a tool to manage community recovery, but sensitivity of residual pines may be an issue

Managing terrestrial ecosystems on low islands in a rising sea

1. Keys ecosystems are at the cutting edge of this global problem.
2. Storm surge exacerbates the projections made a decade ago.
3. Planning is required, ignoring the issue is not an option.
4. Planning should be based on better projections of sea level rise, fresh water resources, storm surge, and their ecological consequences.
5. Fire is one habitat management tool that is within our control locally.
6. Need to balance reality, uncertainty, & responsibility