The Coastal Barrier Island Network (CBIN): Management Strategies for a Global Change Future

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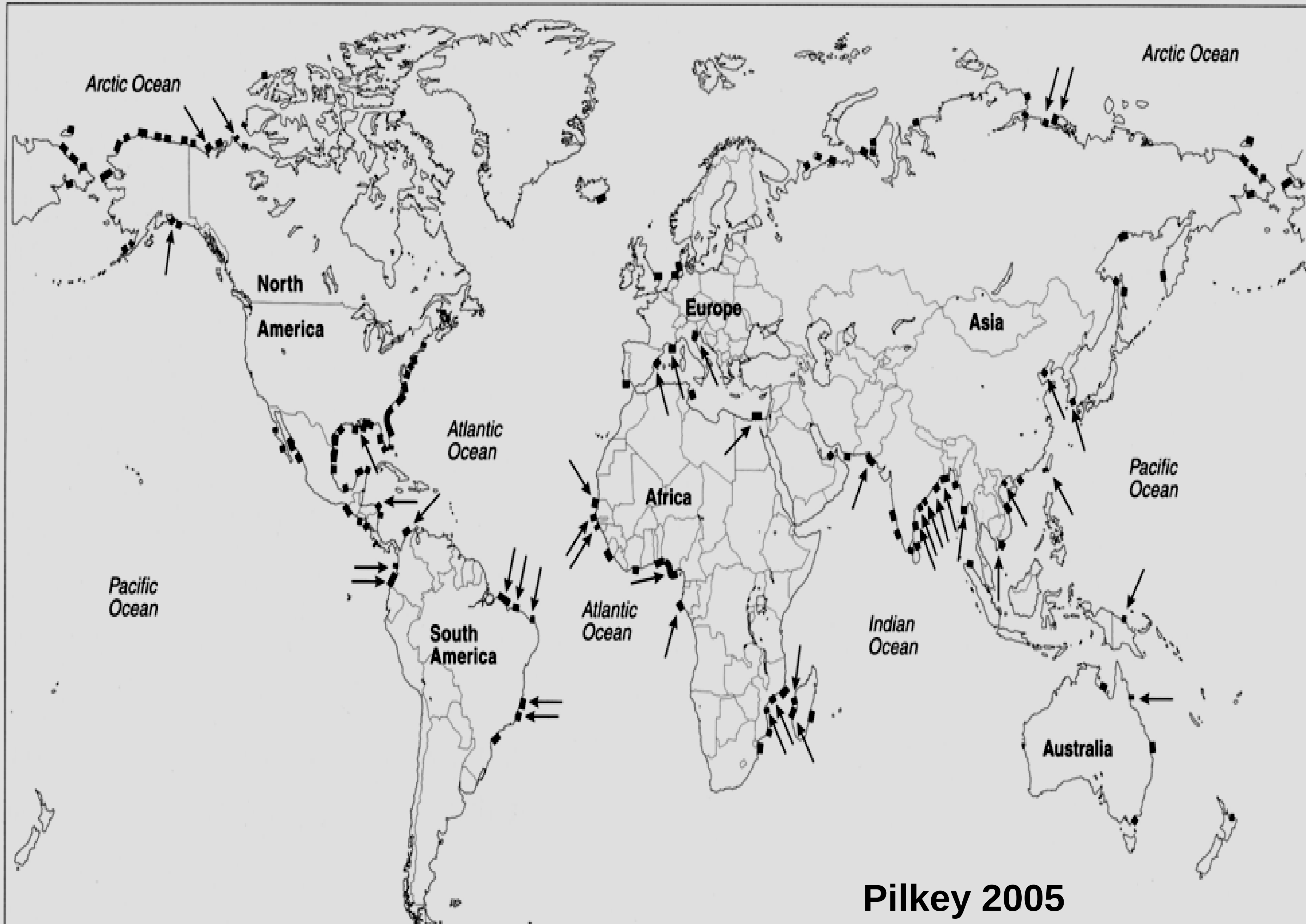
Global Distribution of Barrier Islands



Pilkey 2005

Barrier Island Ecology

-Barrier islands protect coastlines from extreme episodic storm events (EESE, e.g. tsunami, hurricanes, noreasters) on a world scale

-Highly vulnerable to global change (land-sea ecotone) .

-Dynamic substrate: vulnerability and stability linked to the presence of native vegetation.

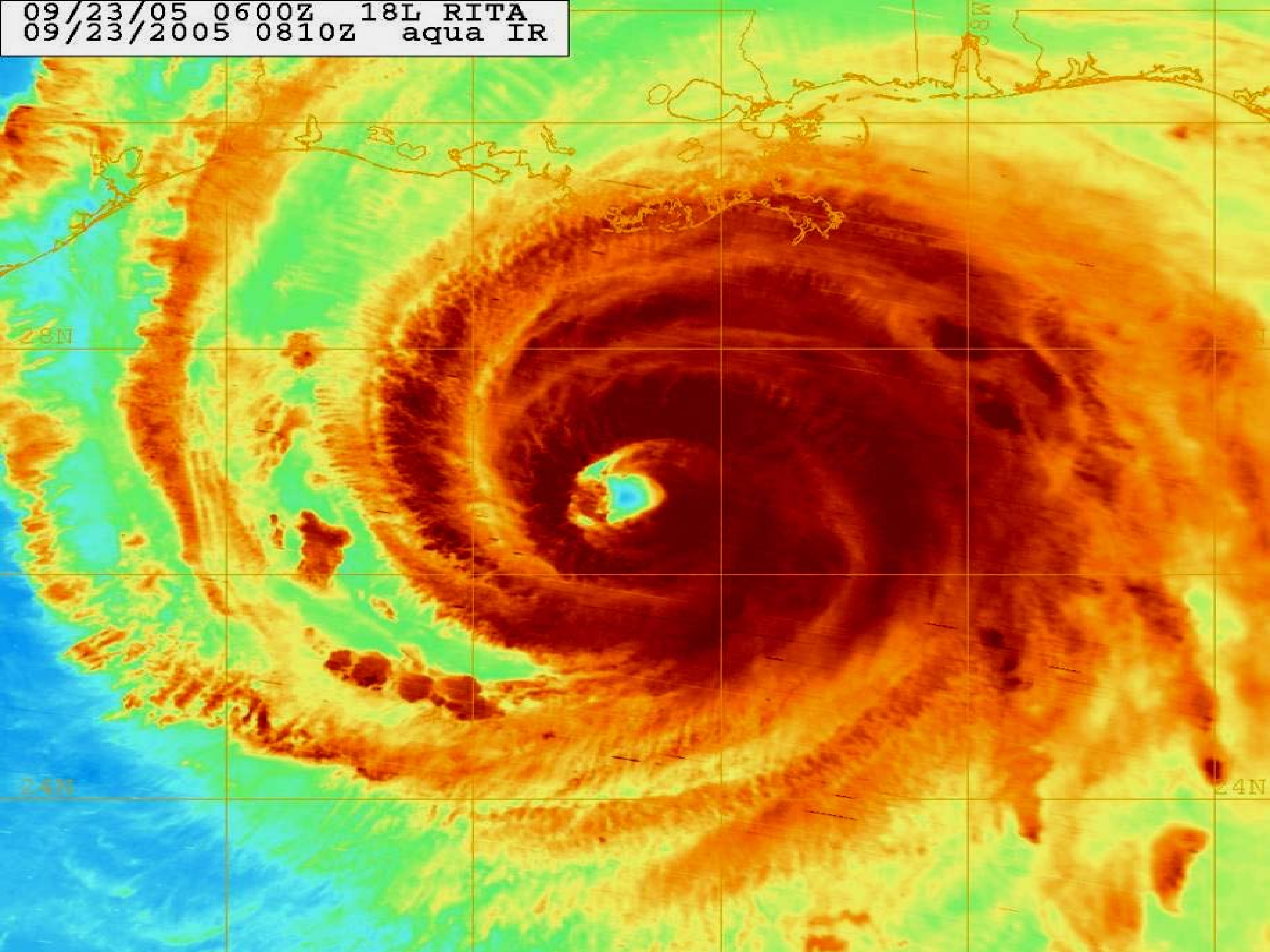
Understanding Barrier Island Ecosystems

Little is known about the influence of *Extreme Episodic Storm Events* (EESE) on species fitness (survival) and distribution patterns.

GLOBAL WARMING =

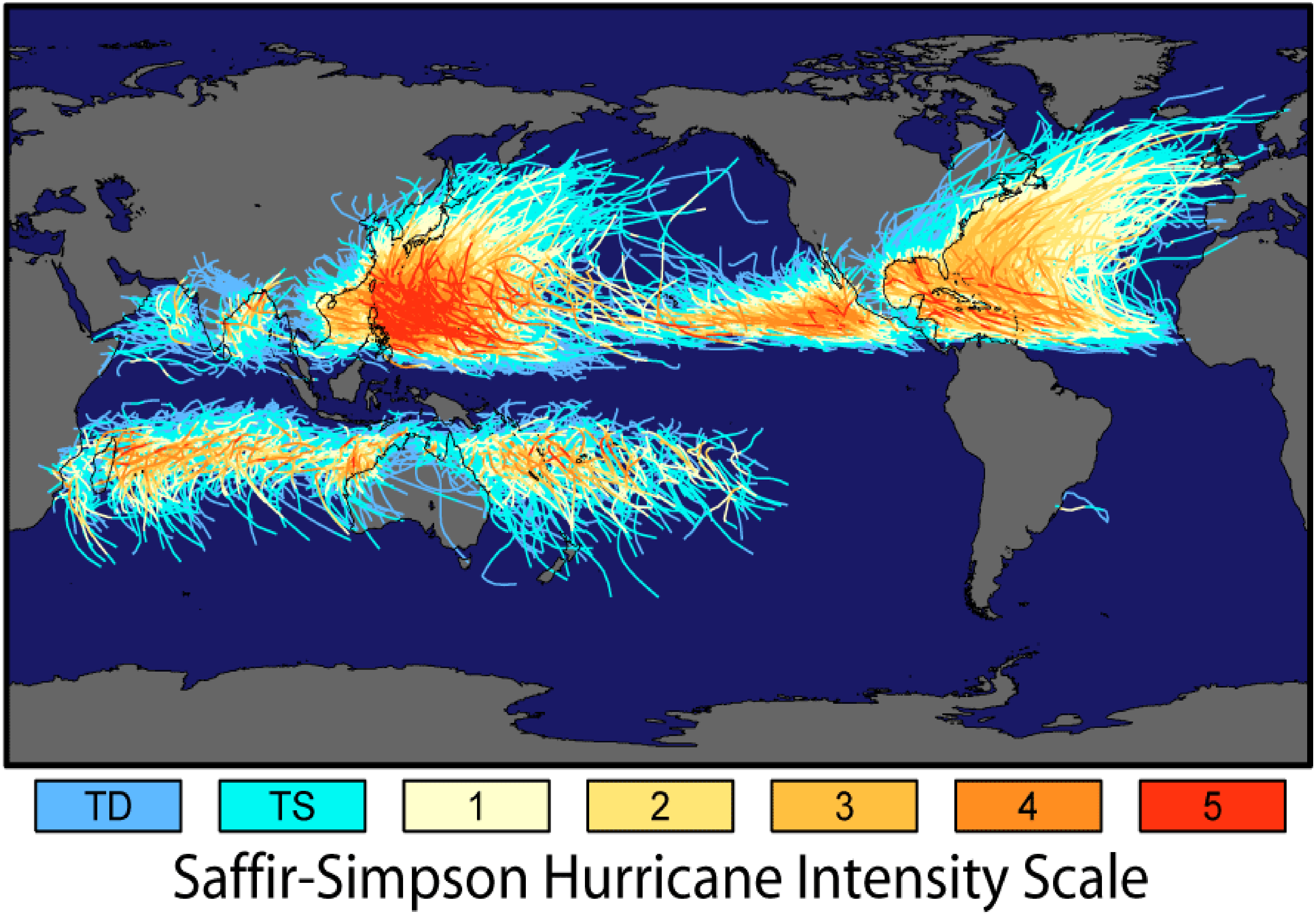
***Sea Level Rise* +**

More Frequent/Intense EESE

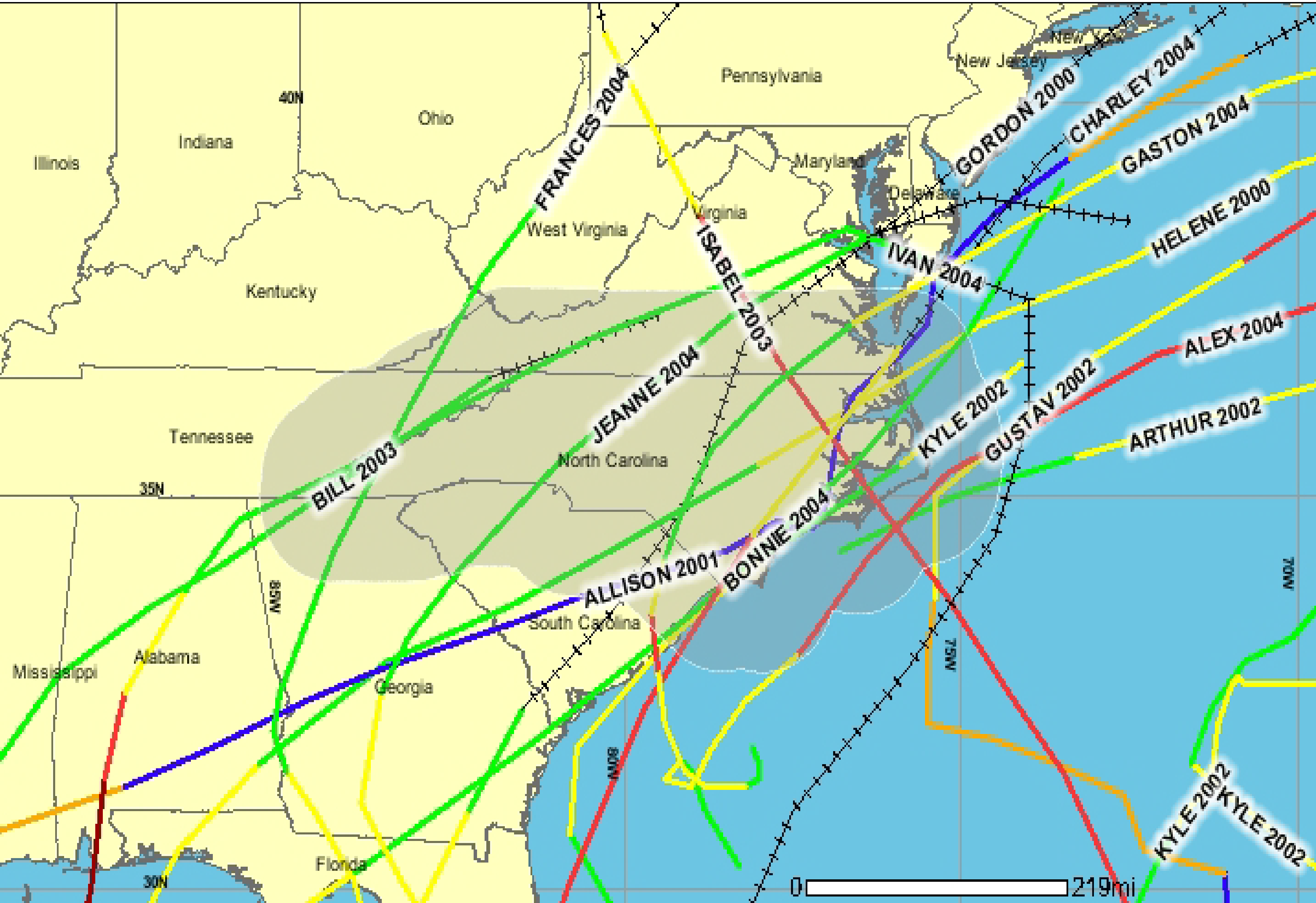

09/23/05 0600Z 18L RITA
09/23/2005 0810z aqua IR
28N
24N
24N


??
Extreme Episodic Storm Events (EESE)

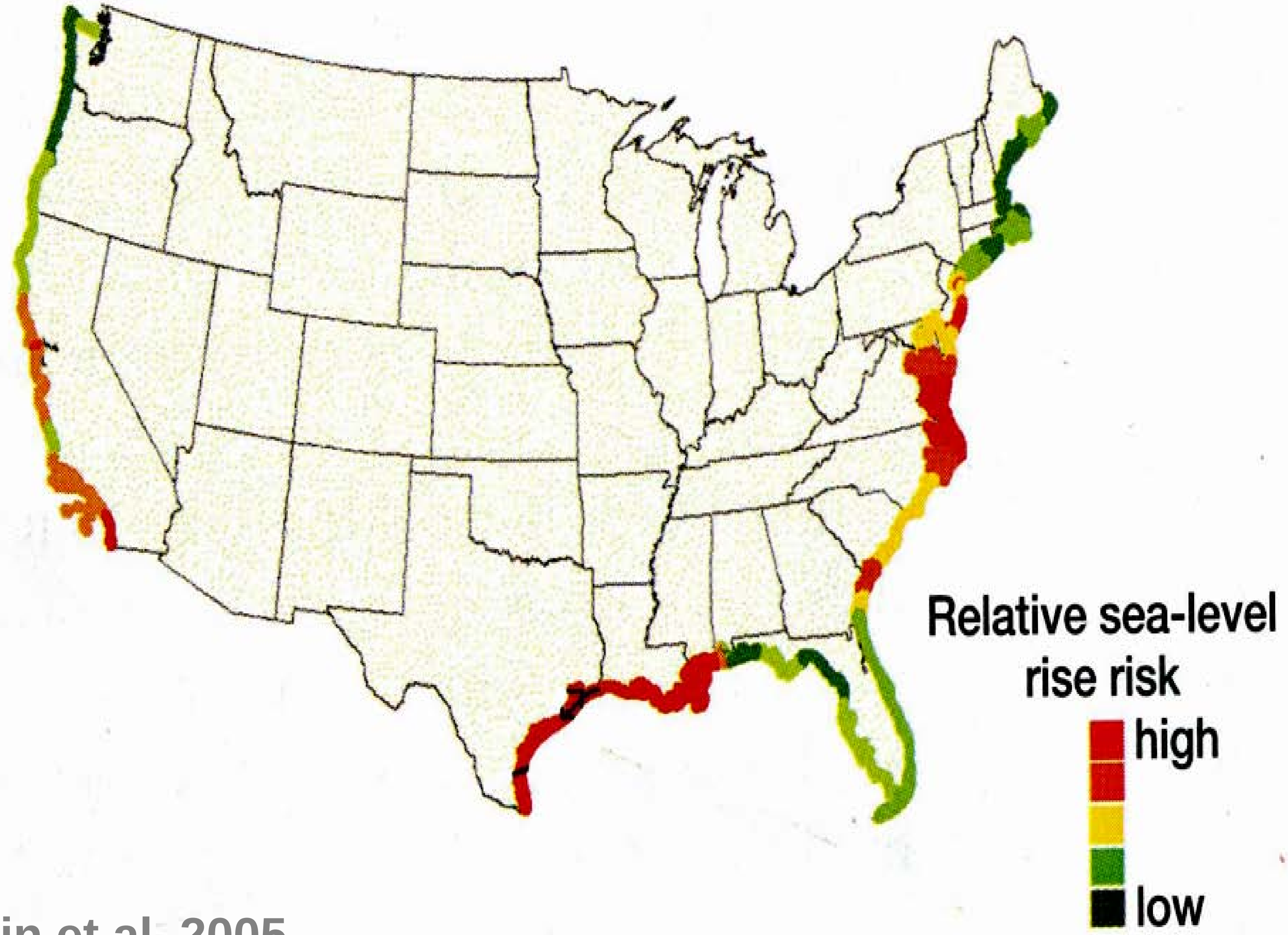
Tracks and Intensity of All Tropical Storms



Hurricane Tracks, SE USA, 2000 - 2004 (NOAA 2005)



Barrier Islands of US



Feagin et al. 2005

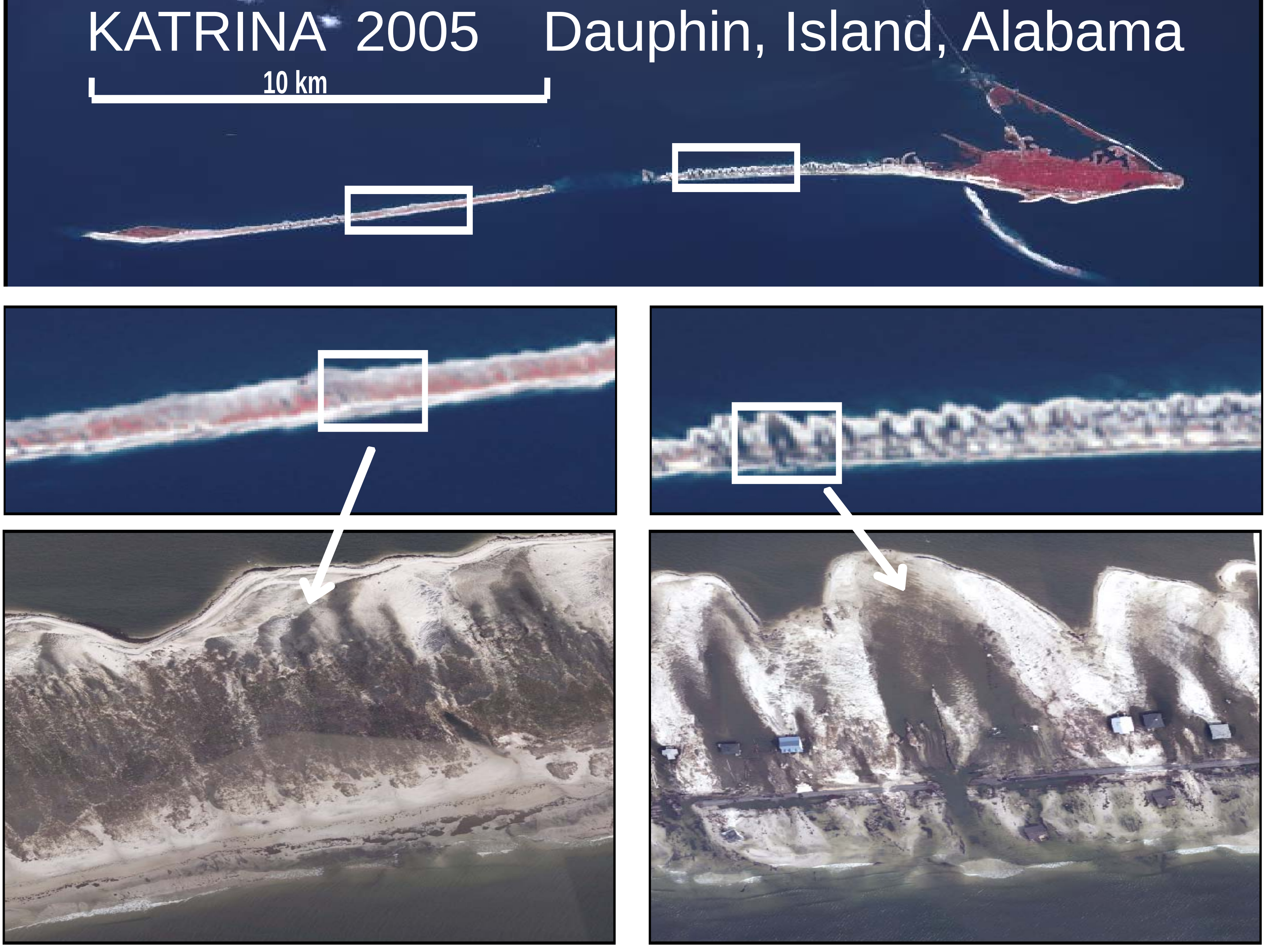
Sustaining Barrier islands the expensive way!

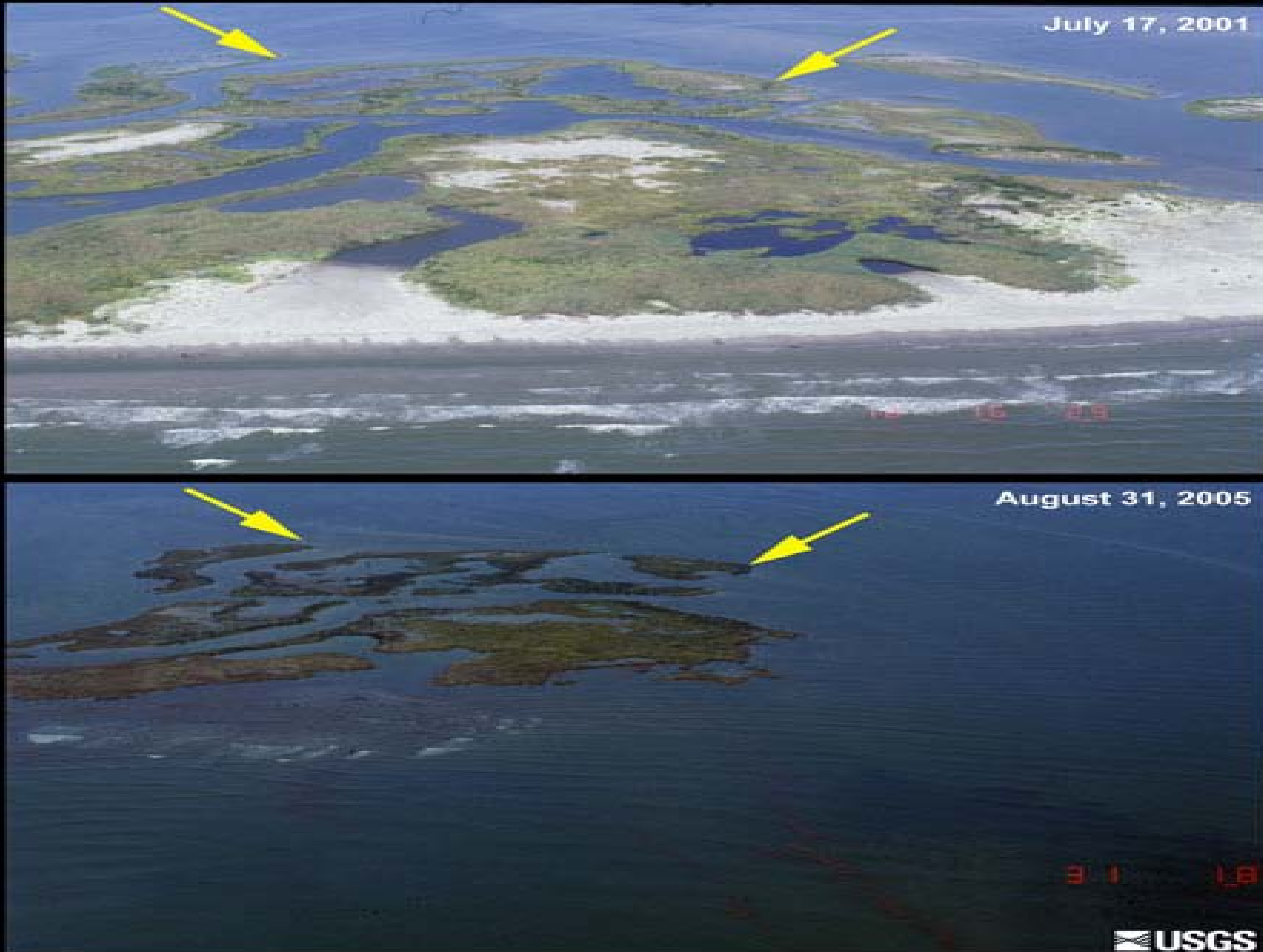
Sand acquisition

Sand Retention

Geotubes– Gulf Coast, USA

Hurricane Ike– Galveston, TX, 2008


KATRINA 2005 Dauphin, Island, Alabama
10 km


July 17, 2001
August 31, 2005
USGS

Hurricane Isabel, Sept 2003


VEGETATION REMOVED


CONSERVE, RESTORE, & CULTIVATE

Importance of Barrier Island Vegetation?

(1) **Stabilization, Vulnerability, Recovery**–

-protection from storm surge locally and for adjacent coastal communities

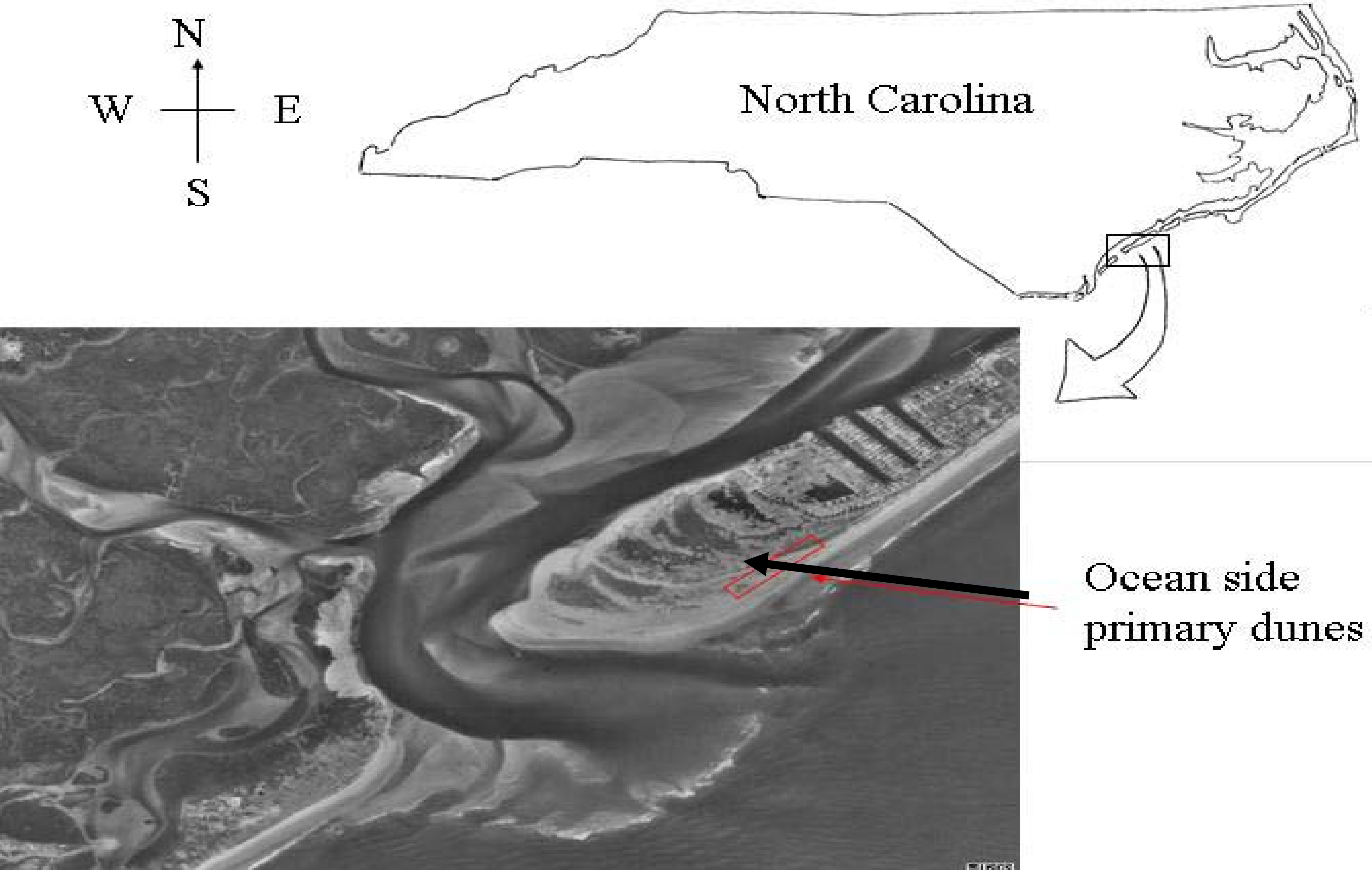
-**economics** and esthetics

(2) **Biodiversity and Extinction**

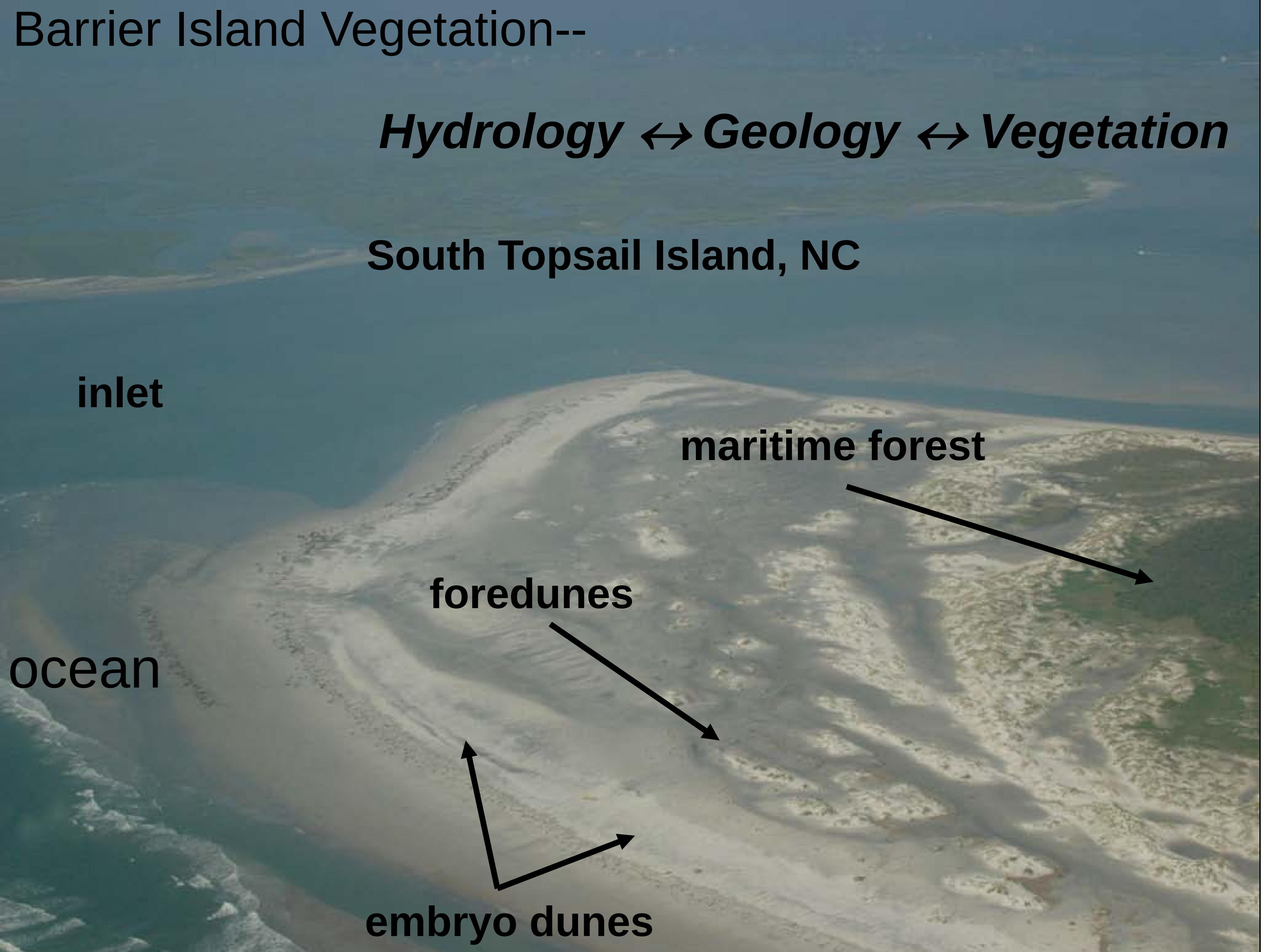
-loss of important genomes

Can barrier island vegetation be used to lesson storm damage and erosion—thus, help reduce economic impacts due to a dynamic substrate?

Study Site: south end, Topsail Island, NC



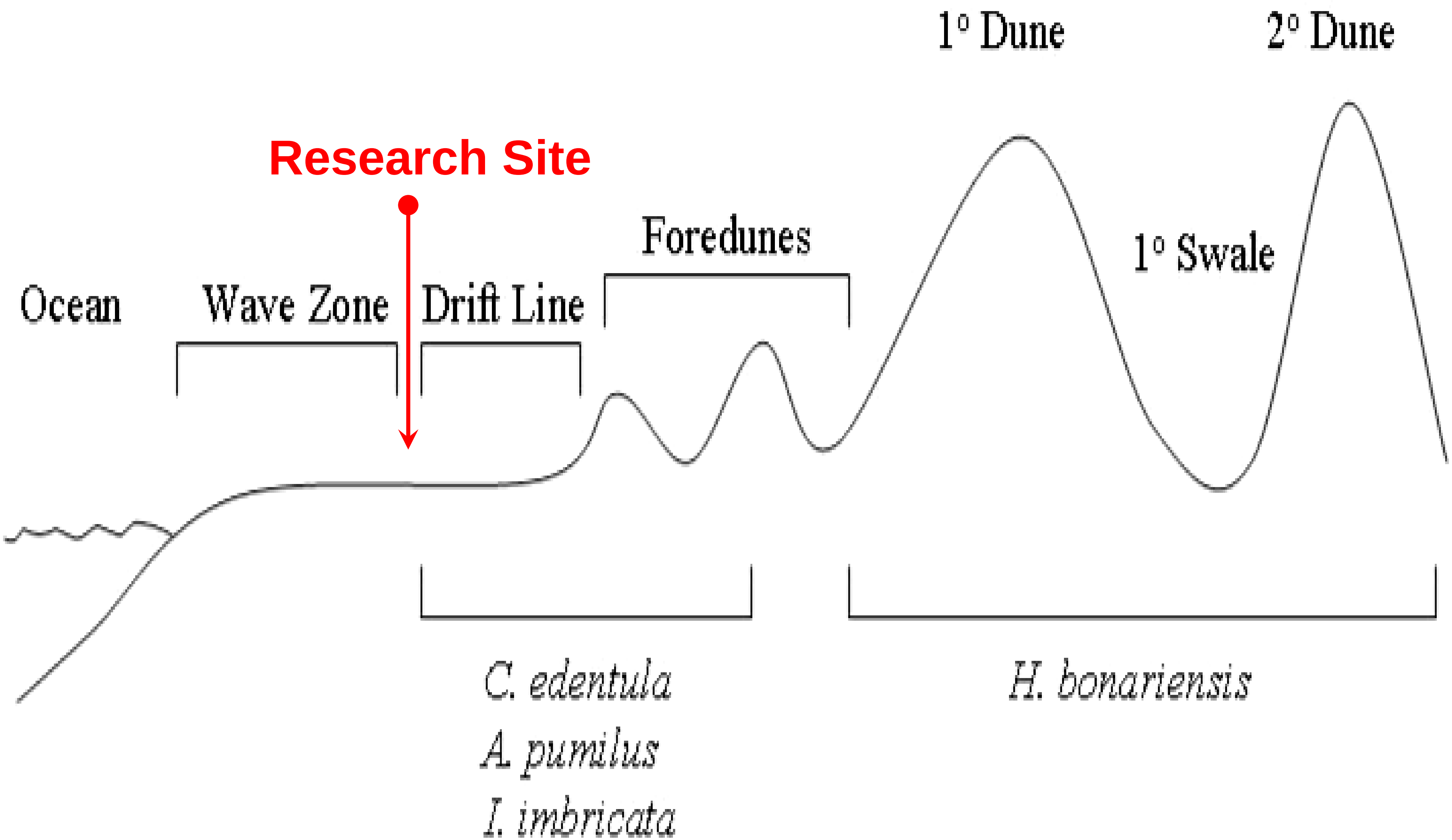
Barrier Island Vegetation--



THE LAND-SEA ECOTONE

One of the most dynamic and severe abiotic gradients among plant communities (hydrology + geology + biology).

Dune Zonation



Development !!

Save the Dunes!!

Maritime Forest

Research Objectives– which species are most effective at stabilizing substrate and providing wind protection?

First consideration– future SURVIVAL !!

-Calculation of annual photosynthetic carbon gain (ACG)

-Seasonal photosynthesis (ACG), growth, and regeneration patterns with and w/o storm events (EESE model)

-Relate ACG to mortality/regeneration according to storm frequency and intensity predictions (GCM models)

-Adult/seedling survival before/after storms- ***Ecological Vulnerability***, ***Resistance***, and ***Resilience***

Most Vulnerable to EESE !!

Colonizing Species of Embryo and Foredunes–Most Vulnerable!

Amaranthus pumilus (Seabeach Amaranth, federally endangered);

Iva imbricata (Seacoast Beach Elder); *Caklie edentula* (Sea Rocket)

Hydrocotyl bonariensis (Dollar Weed); *Uniola paniculata* (Sea Oats)

Amaranthus pumilus- annual herb

- Colonizes lowest tidal position of sanddunes (high water mark, wrack line)
- Federally endangered (USFWS 1993) and globally (G2) imperiled species (Marcone 2000)


A. pumilus


Overwash
Impacts


Sand burial


Mechanical
damage

PHYSIOLOGICAL IMPACTS

Which species are most resistant/resilient to EESE??

Field Measurements (Pre-storm and Post-storm)

Compare native species, e.g. dune vs maritime forest

--Annual Photosynthetic Carbon Gain

leaf level

whole-plant level

--Growth Response and Biomass

above and below groun

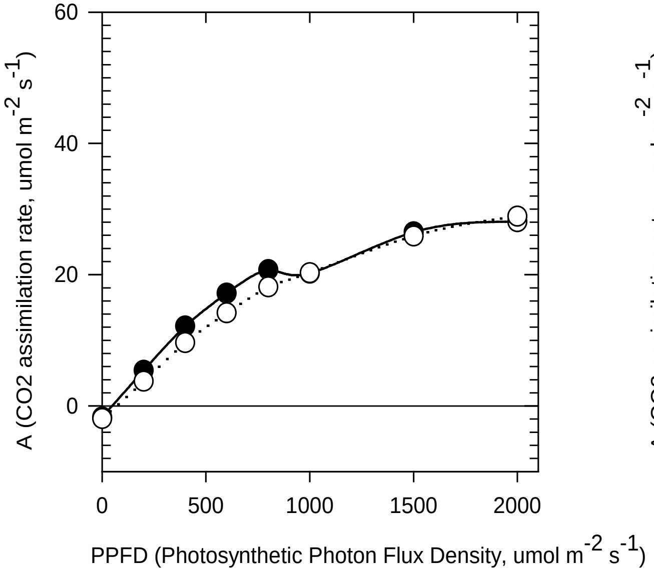
--Reproductive Effort

flowers, seeds, vegetative

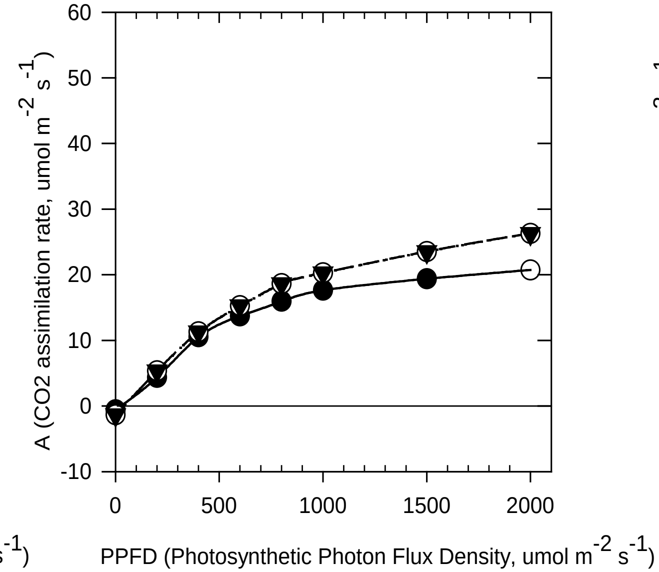
--Reproductive success (species survival)

viable seedlings (new germinants)

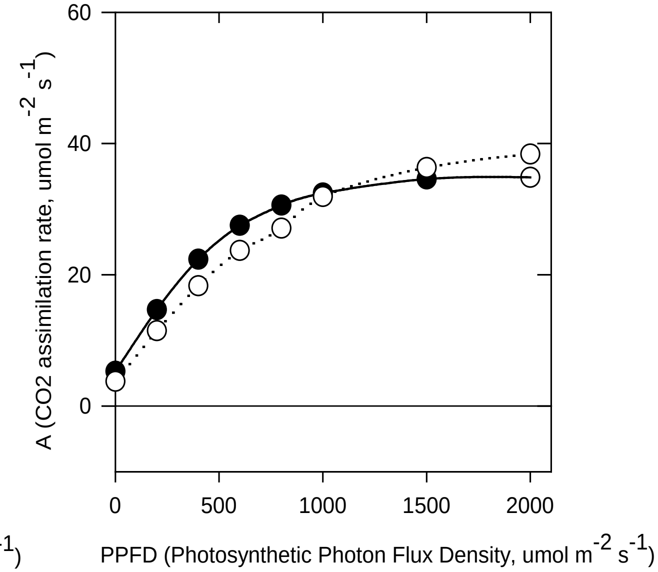
3 June 2004
Photosynthetic Measurements



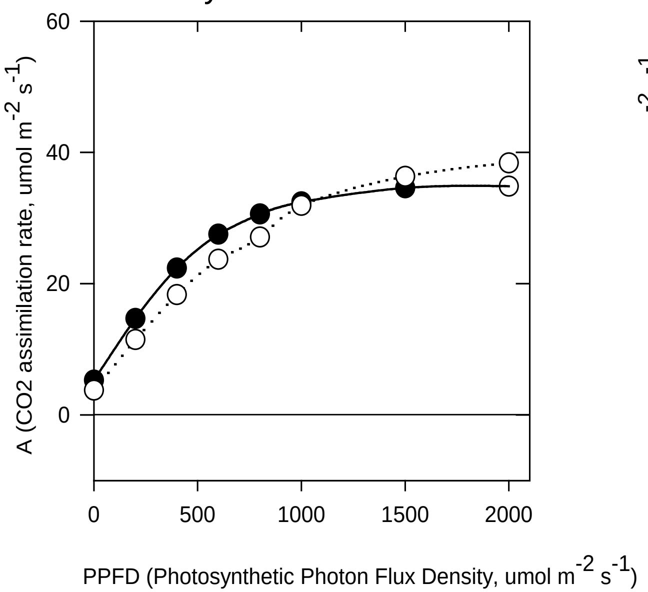
20 June 2004
Photosynthetic Measurments



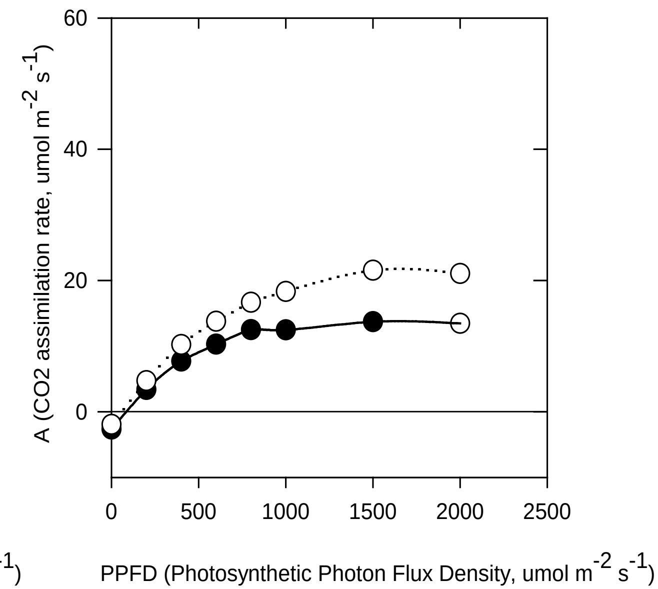
9 July 2004
Photosynthetic Measurments



17 July 2005
Photosynthetic Measurments



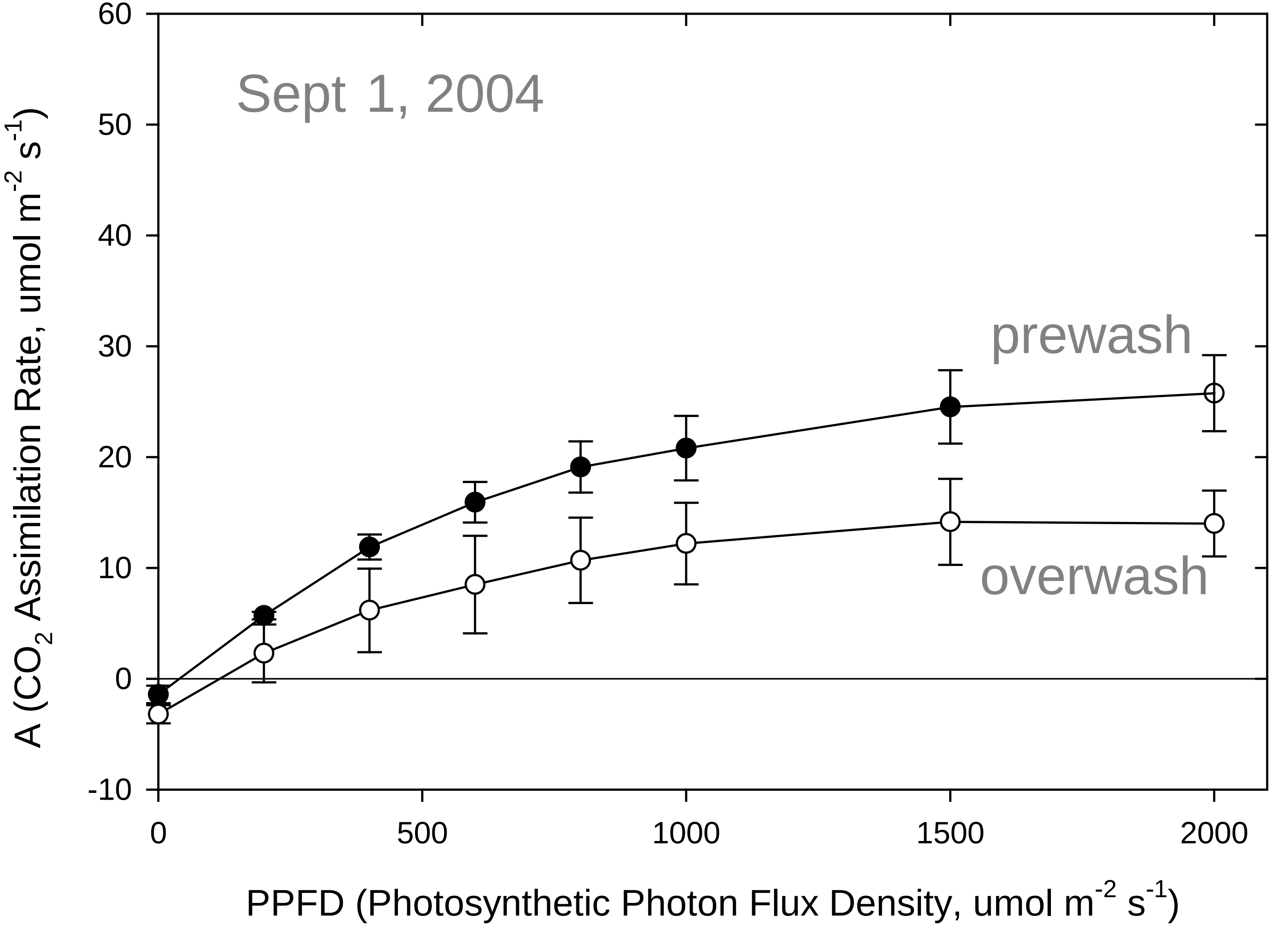
4 September 2004
Photosynthetic Measurments



Photosynthetic Response to Light (PRL)

Open- afternoon
Closed- morning

Noon Overwash Data

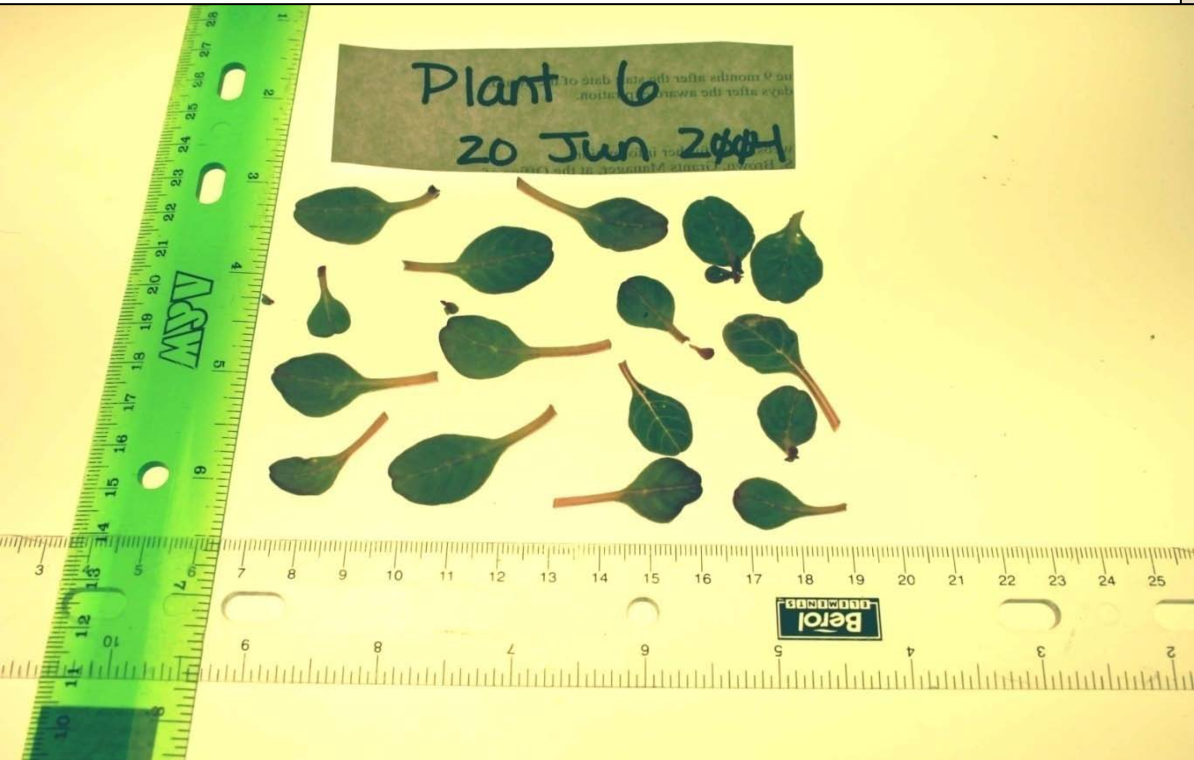


Estimated Storm Overwash Impacts on Annual Carbon Gain (ACG) and Subsequent Reproduction

STORM TYPE	% DECLINE	
	ACG	# Germinants
Minor Tidal Surge (MTS)	2-5	0-5
Major	10	20-30
2 Majors	50-70	70-90
3 Majors	70-90**	90-100
Major + 4 MTS	50-70	40-60

** no viable seed production

IMPACTS ON GROWTH AND REPRODUCTION


Plant 6
20 Jun 2004

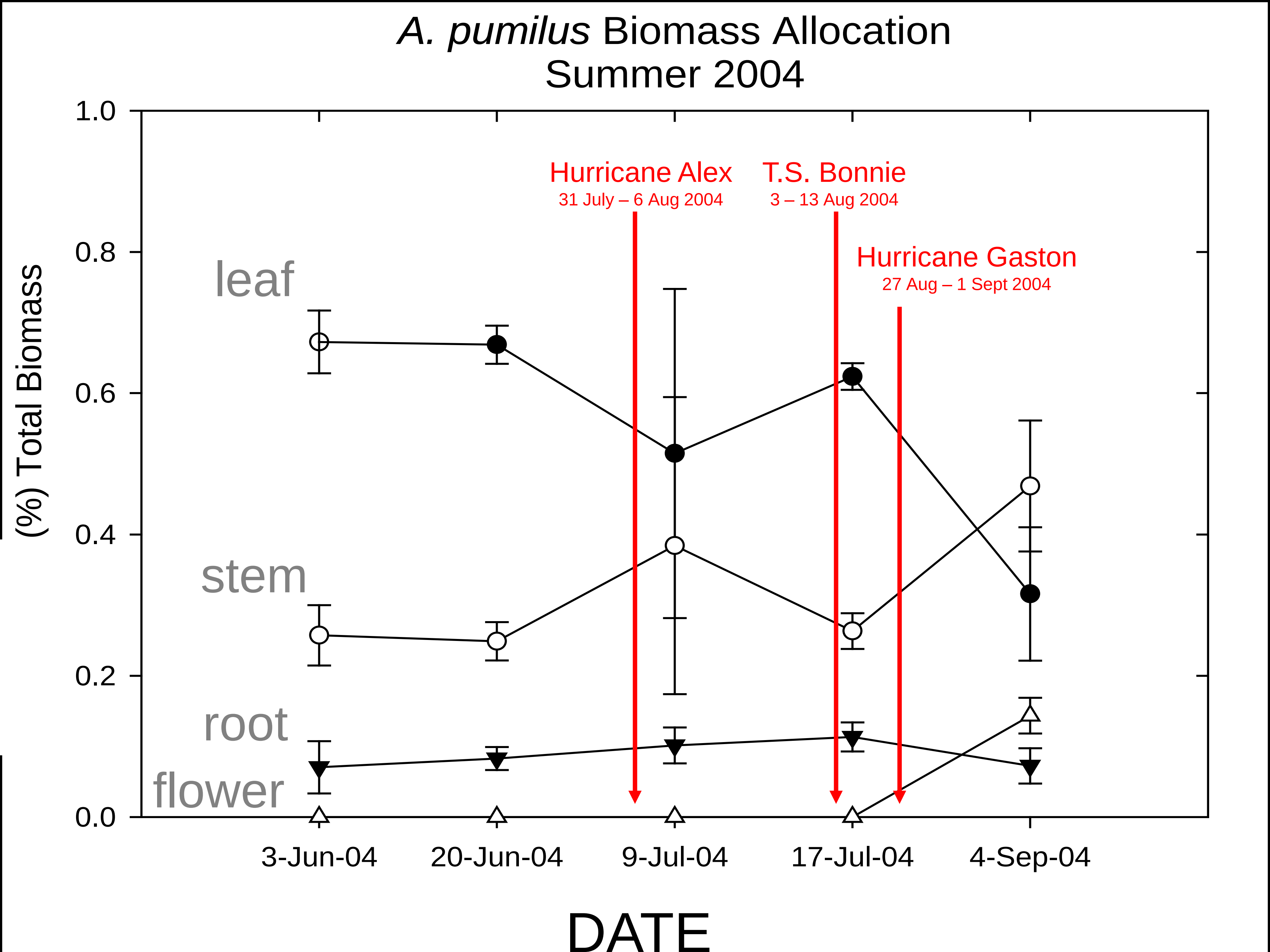

Plant 6
20 Jun 2004

Biomass Allocation

Leaves

Stems

Roots


A. pumilus Biomass Allocation
Summer 2004
(%) Total Biomass
1.0
0.8
0.6
0.4
0.2
0.0
leaf
stem
root
flower
Hurricane Alex
31 July – 6 Aug 2004
T.S. Bonnie
3 – 13 Aug 2004
Hurricane Gaston
27 Aug – 1 Sept 2004
3-Jun-04
20-Jun-04
9-Jul-04
17-Jul-04
4-Sep-04
DATE

Physiological Conclusions

- **Annual Photosynthetic carbon gain (ACG), growth, and reproduction substantially impacted by EESE .**
- **More than 2 major storm events per summer can reduce annual reproductive success to <u>zero</u>, indicating <u>potential</u> extinction .**
- **<u>Consecutive</u> years of lower ACG and the <u>timing</u> of EESE will lead to accelerated extinction??**
- **Maritime species much less impacted compared to dune species**

MANAGEMENT CONCLUSIONS of CBIN

Journal of Coastal Research– next volume

FIRST, we must stop biasing decisions towards the use of engineered structures on coasts, at the expense of utilizing native vegetation to achieve the same purposes

SECOND, we should begin to investigate more deeply the hypothesis that vegetated barrier island ecosystems can modify and control the sedimentary dynamics in response to gradual phenomena like sea level rise (as long as the rate is not too fast), but cannot completely resist discrete disturbances such as EESE

THIRD, **from an economic perspective, vegetation management should not focus on stabilization during EESE**. We know that coastal ecosystems contribute 77% of global ecosystem services, a value of ~33 trillion $USD per year (MARTÍNEZ *et al.,* 2007), and barrier islands are an integral part of approximately 12% of these coastal ecosystems (PILKEY AND FRASER, 2003). Moreover, beaches and dunes support a USA tourism industry valued at $USD 322 billion per year, more than 25 times the contribution of the National Park Service system to the USA economy (HOUSTON, 2008).

FOURTH, we need to develop laws analogous to Section 404 of the Clean Water Act (which protects wetlands from being developed or backfilled) to protect undeveloped beaches, sand dunes, maritime forests, and other critical barrier island habitats.

FIFTH, **we need to bring about a change in legal mindset about how to manage developed barrier islands**. For example, the State of Texas in the USA, defines the public-private property line as the ecological reality of the native vegetation line (Open Beaches Act, Texas Natural Resources Code   61.011, see FEAGIN, 2005), enhancing the ecological resistance and resilience (recovery rate) of a developed shoreline to EESE.

SIXTH, **federal governments could purchase as many undeveloped islands and contiguous marginal properties as necessary to enable ecosystem sustainability**. In the USA, beyond the original Coastal Barrier Resources Act of 1982 that prevented federal assistance for activities supporting commercial development of barrier islands and which designated certain parklands and national seashores to be preserved, no federal framework exists today for sustaining these ecosystems. In the USA, there are still many barrier island ecosystems that are undeveloped.

SEVENTH, **we need to begin thinking about our cultural view of these ecosystems.** The challenge may require re-envisioning our thinking about these landscapes, rather than re-envisioning the landscapes. Why did we start calling these features ‘barrier islands’? Should we not call them ‘migrating islands’?

“Take-home” Message

Barrier islands are naturally unstable and will, potentially, become more so, in response to factors such as sea level rise and extreme episodic storm events (EESE). We should aim for a strategy of stabilizing the natural sedimentary processes with plant species that occur naturally across barrier island landscapes, rather than trying to only use expensive artificial structures and accretion methods.

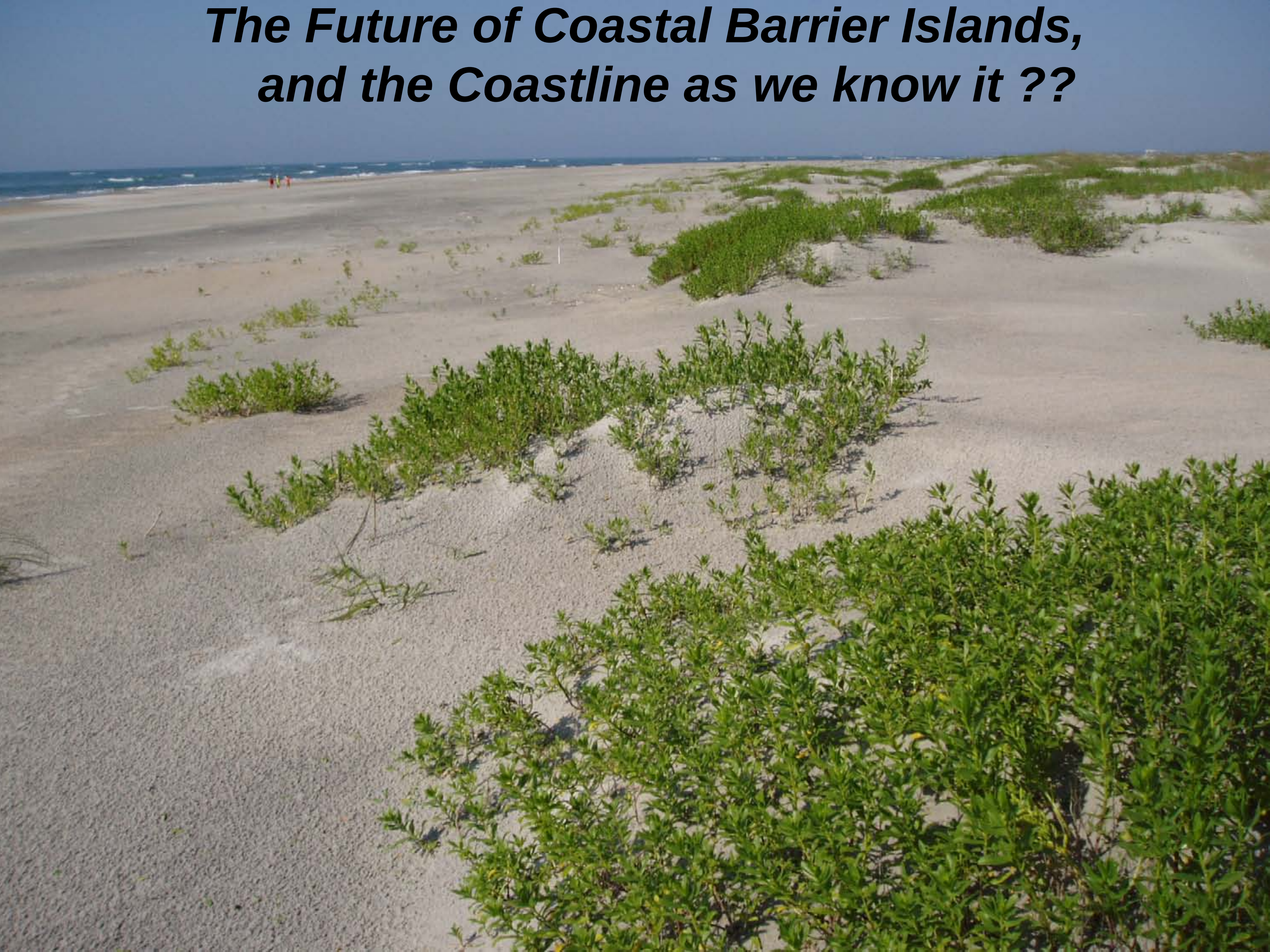
Overall, we must adapt more effectively with BI dynamism so that <u>ecosystem sustainability</u> might also be possible.

Urbanized Ecosystems

Defn: ***maintaining commercial/private development while sustaining ecosystem properties and critical services.***

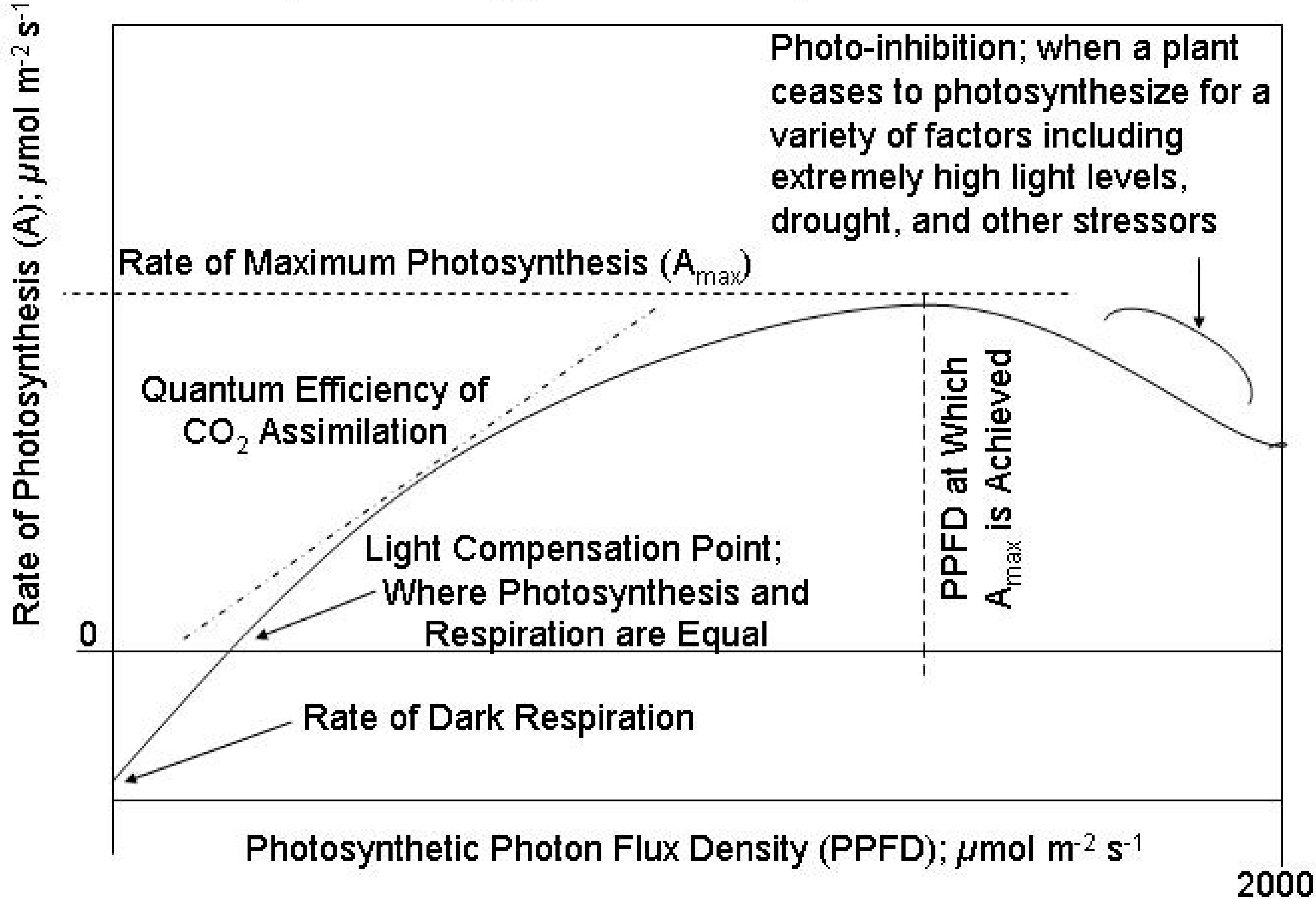
<u>Possible solutions</u> to sea level rise and Increased storm impact:

- **--Increased structural resistance and resilience**
- **--Mobile structures that can move <u>with</u> the substrate (decadal cycles)**
- **--Use of native vegetation for enhancing structural R and R and reducing erosion (e.g. maritime forest closer to beach, set-back requirements).**
- **--Conservation of enough undeveloped BI landscapes to insure ecosystem sustainability.**

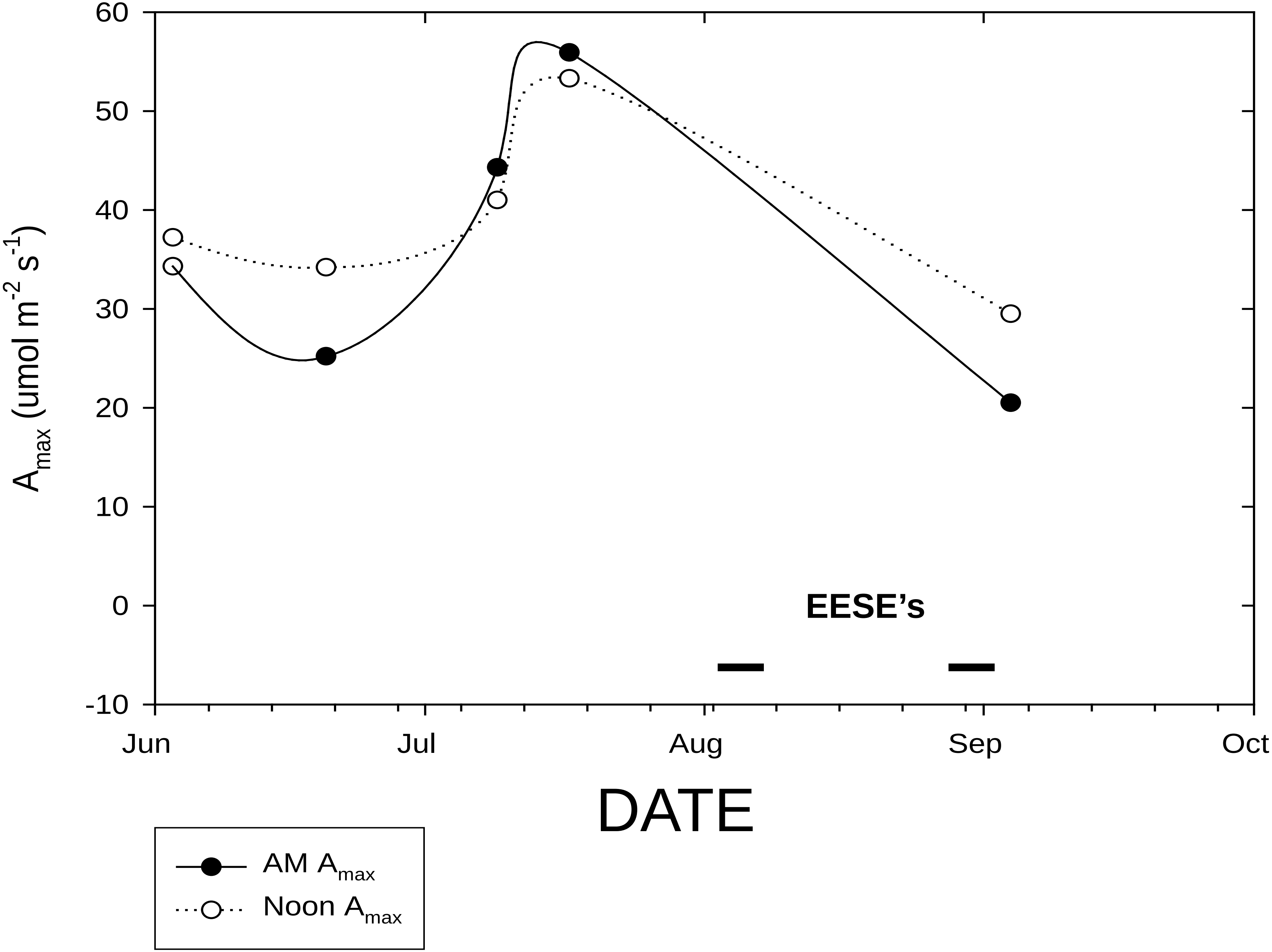

The Future of Coastal Barrier Islands,
and the Coastline as we know it ??

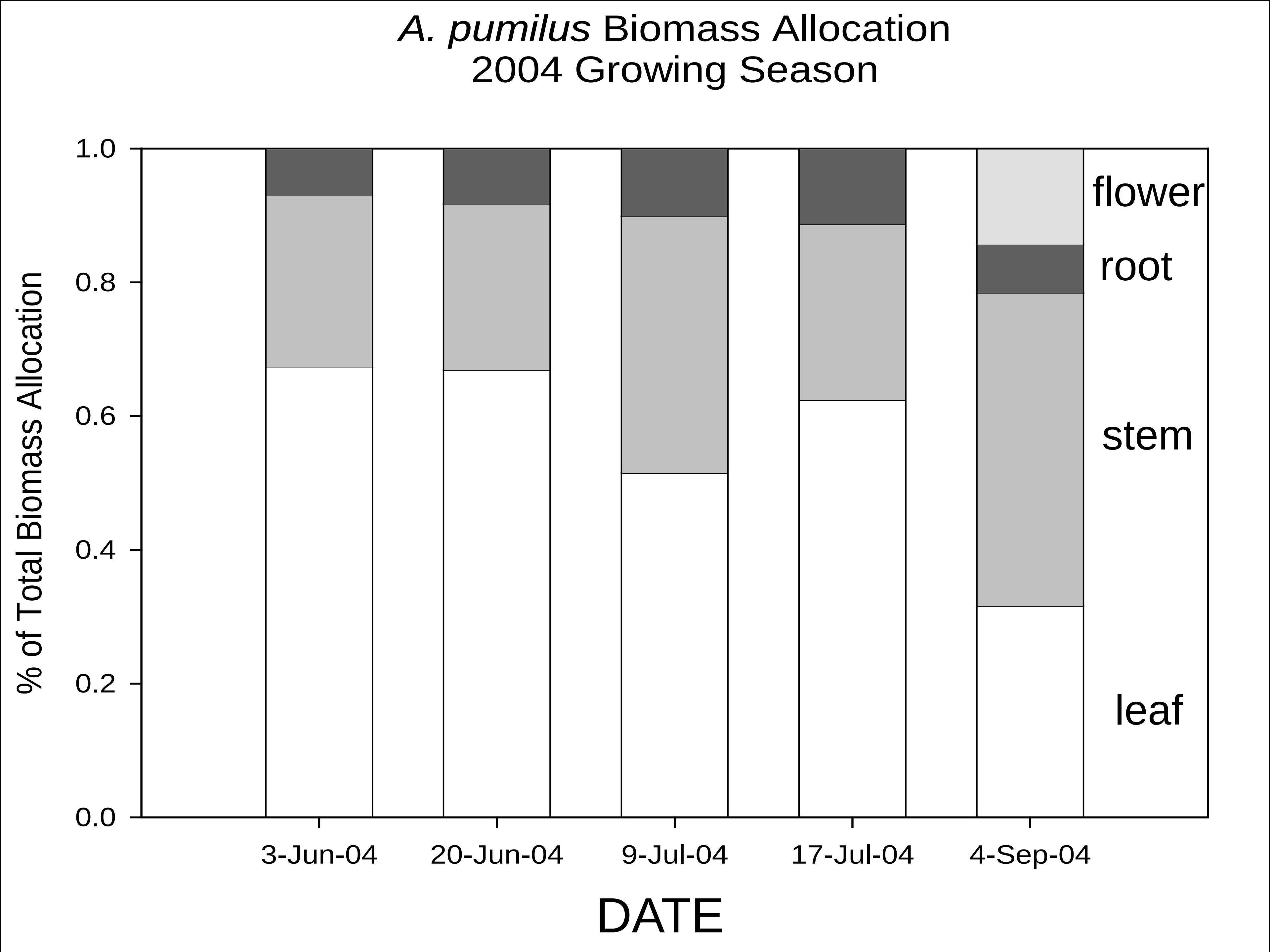

THANK YOU

Sample Light Response Curve

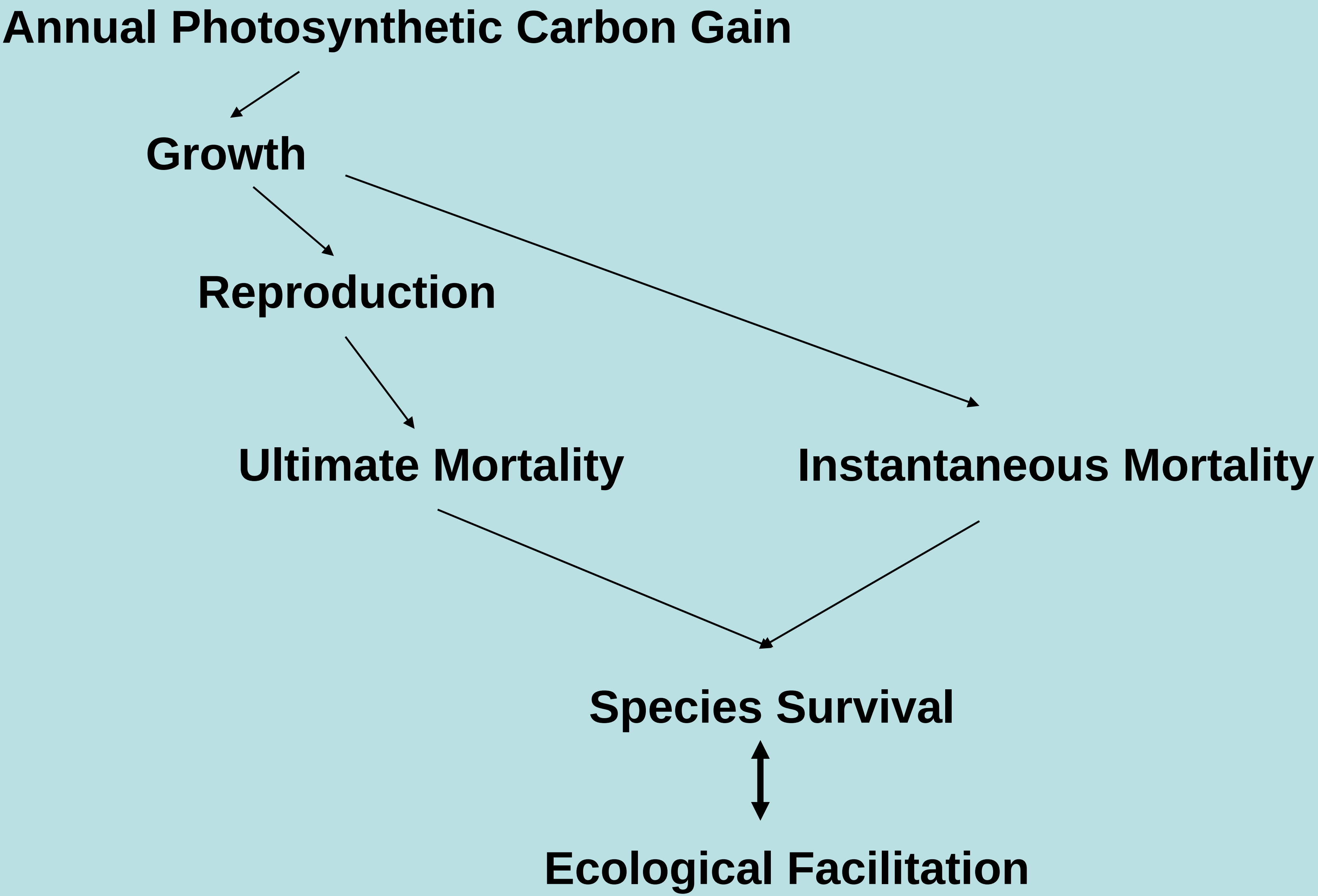


Maximum Photosynthesis, A_{max}




A. pumilus Biomass Allocation
2004 Growing Season
% of Total Biomass Allocation
1.0
0.8
0.6
0.4
0.2
0.0
flower
root
stem
leaf
3-Jun-04
20-Jun-04
9-Jul-04
17-Jul-04
4-Sep-04
DATE

Ecophysiology of Organism Survival Under EESE



SUMMARY-- Changes in PLR Characteristics

	AM	PM	Seasonal	Pre/Post EESE
A^{max}	No	No	Yes (Sept)	Yes (-)
QUE	No	No	No	Yes (-)
SLL	No	No	No	Yes (-)
LCP	No	No	No	Yes (-)
LLAS	No	No	No	No
R	No	No	Yes	Yes (+)
PI	No	No	Yes (Sept)	Yes (+)


July 17, 2001
18 16 28
August 31, 2005
31 18
USGS