The Association of State Wetland Managers Presents:

Improving Wetland Restoration Success 2014 — 2015 Webinar Series

Temperate and Tropical/Subtropical Seagrass Restoration: Challenges for the 21st Century

Presenters: Roy R. "Robin" Lewis, III, Lewis Environmental Services, Inc. & Coastal Resource Group, Inc. and Mark Fonseca, CSA Ocean Sciences, Inc.

Moderators: Jeanne Christie & Marla Stelk

Funded by EPA Wetland Program Development Grant 83541601

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AGENDA

- **Welcome and Introductions** (5 minutes)
- **Restoration Webinar Schedule & Future Recordings** (5 minutes)
- **Temperate & Tropical/Subtropical Seagrass Restoration** (60 minutes)
- **Question & Answer** (15)
- **Wrap up** (5 minutes)

WEBINAR MODERATORS

Jeanne Christie,

Executive Director

Marla Stelk,

Policy Analyst

WETLAND RESTORATION PROJECTS

- Convened interdisciplinary workgroup of 25 experts
- Developing monthly webinar series to run through September 2015
- Developing a white paper based on webinars and participant feedback
- To be continued through 2016 in an effort to pursue strategies that:
  - Maximize outcomes for watershed management
    - Ecosystem benefits
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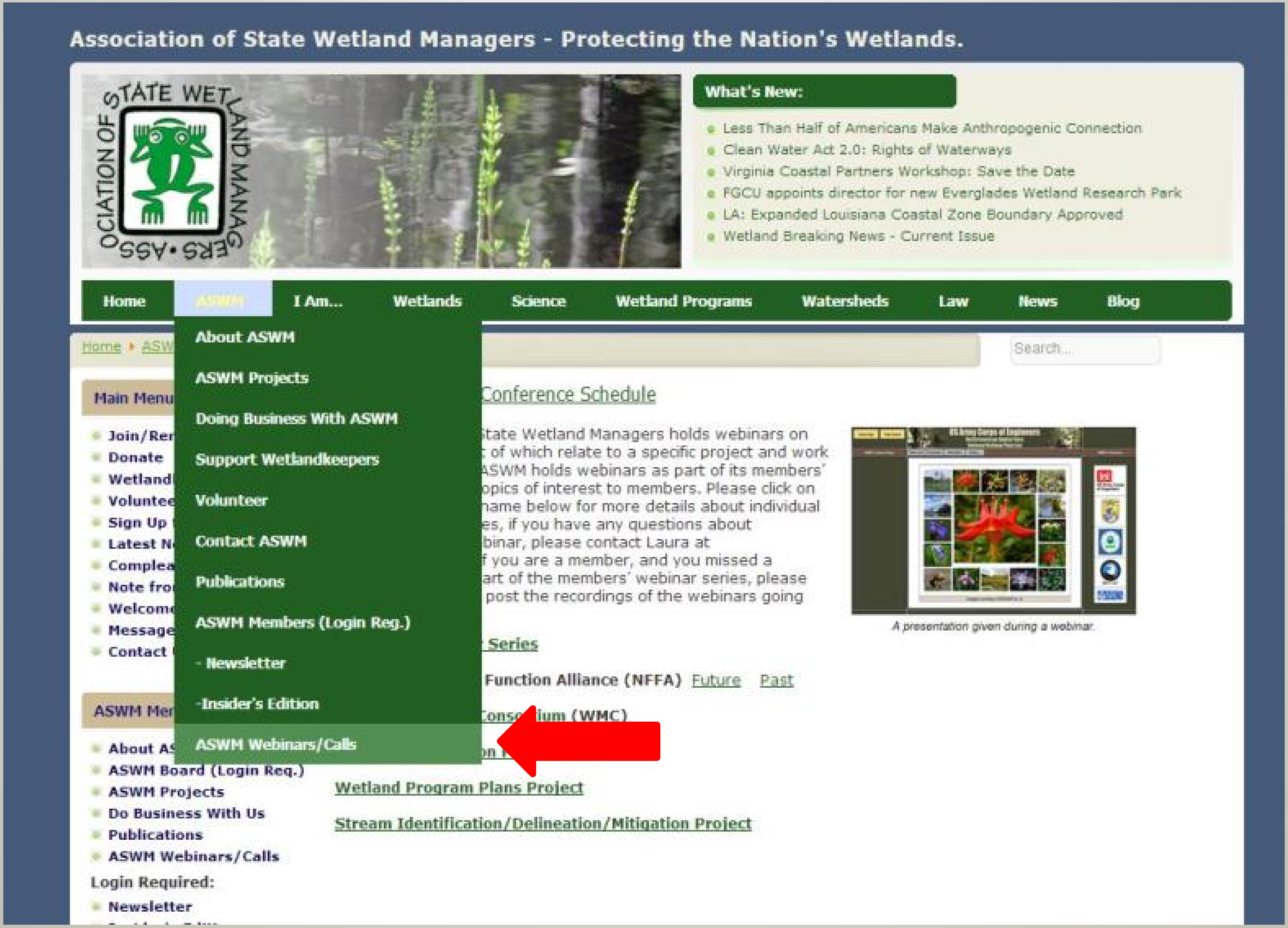
  - Improve permit applications and review
  - Develop a national strategy for improving wetland restoration success

WEBINAR SCHEDULE & RECORDINGS



WEBINAR SCHEDULE & RECORDINGS

FUTURE SCHEDULE - 2015

- **Tuesday, February 17, 3:00pm eastern:**
  - **Playa & Rainwater Basin Restoration**

    Presented by:

    Richard Weber, NRCS Wetland Team and,

    Ted LaGrange, Nebraska Game & Parks Commission
- **Tuesday, March 17, 3:00pm eastern:**
  - **Pacific Coast Wetland Restoration**

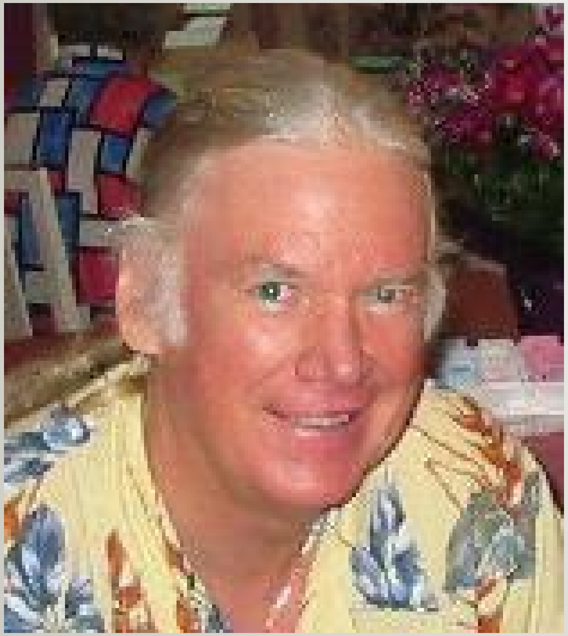
    Presented by:

    Charles "Si" Simenstad, University of Washington and

    John Callaway, University of San Francisco

FOR FULL SCHEDULE, GO TO: http://aswm.org/aswm/6774-future-webinars-improving-wetland-restoration-success-project

PRESENTERS



Roy R. "Robin" Lewis, III
President & Wetland Scientist
Lewis Environmental Services, Inc.
& Coastal Resource Group, Inc.

Mark Fonseca
Science Director
CSA Ocean
Sciences, Inc.

A "COOKBOOK" APPROACH TO WETLAND RESTORATION WON'T WORK

There are too many variables.

- *Ingredients are always different*
- *Reason for 'cooking' varies*
- *Recipe isn't always correct*
- *Inexperienced cooks*
- *Cooking time varies*
- *Poor inspection when "cooking"*
- *Additional ingredients may be needed*
- *Is it really done?*

WE NEED TO UNDERSTAND THE PLANNING PROCESS AND VARIABLES FROM SITE TO SITE THAT MUST BE STUDIED, UNDERSTOOD AND ADDRESSED

Temperate and Tropical/Subtropical Seagrass Restoration

IT WILL TAKE US A FEW MOMENTS TO MAKE THE SWITCH…

Temperate and Tropical/Subtropical Seagrass Restoration: *Challenges for the 21st century*

Lewis Environmental

Roy "Robin" Lewis III
President

CSA Ocean Sciences Inc.

Mark S. Fonseca, Ph.D.
Science Director

Outline

- Long history - what have we learned?
- What are the challenges now and in the future?
- Overlooked species
- Suggestions for direction

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What are seagrasses?

- **Flowering plants** – produce seeds
- Over a third of the world's seagrass acreage has been lost
- Approximately 12 species in U.S.
  - All coasts
  - > 8 million acres in U.S. waters (excluding AK and HI)
  - One Threatened under ESA
  - Most grow on unconsolidated substrate
  - Some grow on rock (west coast)
  - Intertidal to over 30m
- Prolific leaf growth (all species)
- Grow vegetatively (branching & tillering)
- Spreading rate (vegetative growth) varies
- Various landscape patterns

C. Pickerell

Why is Seagrass Meadow Restoration so difficult and expensive?

- Open systems
- Vulnerable to many disturbances
  - Water quality
  - Storms
  - Mechanical damage
  - Bioturbation
- Few engineering options

Probability of Success

…High

Estuarine Marshes

Coastal Marshes

Mangrove Forests

Freshwater Marshes

Freshwater Forests

Groundwater/Seepage Slope Wetlands

Seagrass Meadows (SAV)

…Low


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B57066605 A
THE UNITED STATES OF AMERICA
B57066619 A
B57066615 A
B57066614 A
STATES OF AMERICA
B57066620 A
THE UNITED
B57066613 A
THE UNITED STATES
B57066616 A
B57066611 A

Cost of Success

…Low

Estuarine Marshes ($100K/acre)

Coastal Marshes

Mangrove Forests

Freshwater Marshes

Freshwater Forests

Groundwater/Seepage Slope Wetlands

>$ 10X-20X

Seagrass Meadows (SAV)

…High

SITE	YEAR COMPLETED	METHODS	2013 TOTAL COST	2013 COST PER FT²	REFERENCES
1. House Boat Row	2012	Fill and Transplant	$1,614,471*	$14.26	FDOT and Stantec 2013, Phil Frank (pers. comm).
2. Heidi Baby	2005	Fill, Stakes and Transplant	$89,704**	$16.03	NOAA 2009
3 Julia Reanne	2006	Fill, Stakes and Transplant	$73,933**	$35.18	NOAA 2007A
4. Lucky One	2006	Fill, Stakes and Transplant	$27,513**	$50.30	NOAA and FDEP 2006, 2007

Data from Coastal Resources Group, Inc.
Keys Restoration Fund (2014)
Florida Keys Seagrass Restoration Costs Report
To the U.S Army Corps of Engineers, Jacksonville, Florida
Fourteen Project Sites – Range $0.50 to $50.00/sq ft
Mean $21.87/sq ft or **$952,657 per acre**

2 (2 projects)	[illegible]	[illegible]	[illegible]	[illegible]	2013
11. Lignumvitae Phase 3	2013	Fill only	$215.947****	$44.99	Hobbs et al. 2006, KERF 2013, Hobbs 2013
12. Middle Torch Key Circulation Cut	1983	Fill Removal	$11,430	$10.15	Hobbs et al. 2006, KERF 2013
13. Hypothetical FKNMS PEIS Seagrass	2004	Fill, Stakes and Transplant	$28,741	$27.94	NOAA and FDEP 2004
14. Potential Restoration for Federal Court Settlement	1996	Planting only	$566,475	$13.00	Fonseca et al. 2002
Mean of all Per Square Foot Estimates				**$21.45 sq ft⁻¹ or $934, 362 ac⁻¹**	

transition

What is Restoration, Really?

- An attempt to overcome impediments to recruitment and recovery
- Often an economically driven trade-off
- Historically results in a net loss of habitat
- Translating for managers
  - **From**: Ecologists' language that values information:
    - 'Possibly'
    - 'Understand'
    - 'Improve'
    - 'Consider'
  - **To**: Managers' need for absolutes:
    - When?
    - How much (cost / to transplant / time)?
    - Where?
    - Criteria for success?

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What Have We Learned?

- Site selection
    - Stalled at simple observations of depth, and human causality
- Methods – most work, but projects still fail
- Extreme expectations…not crops
- Defining success: persistence and acreage
- Impediments to success
    - Disturbance (water clarity, storms and bioturbation)
    - Grazing
- Applying seagrass biology and ecology
    - Spreading rates
    - Vegetative vs. seeding
    - Compressed succession
- Economic valuation

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What are the Challenges?

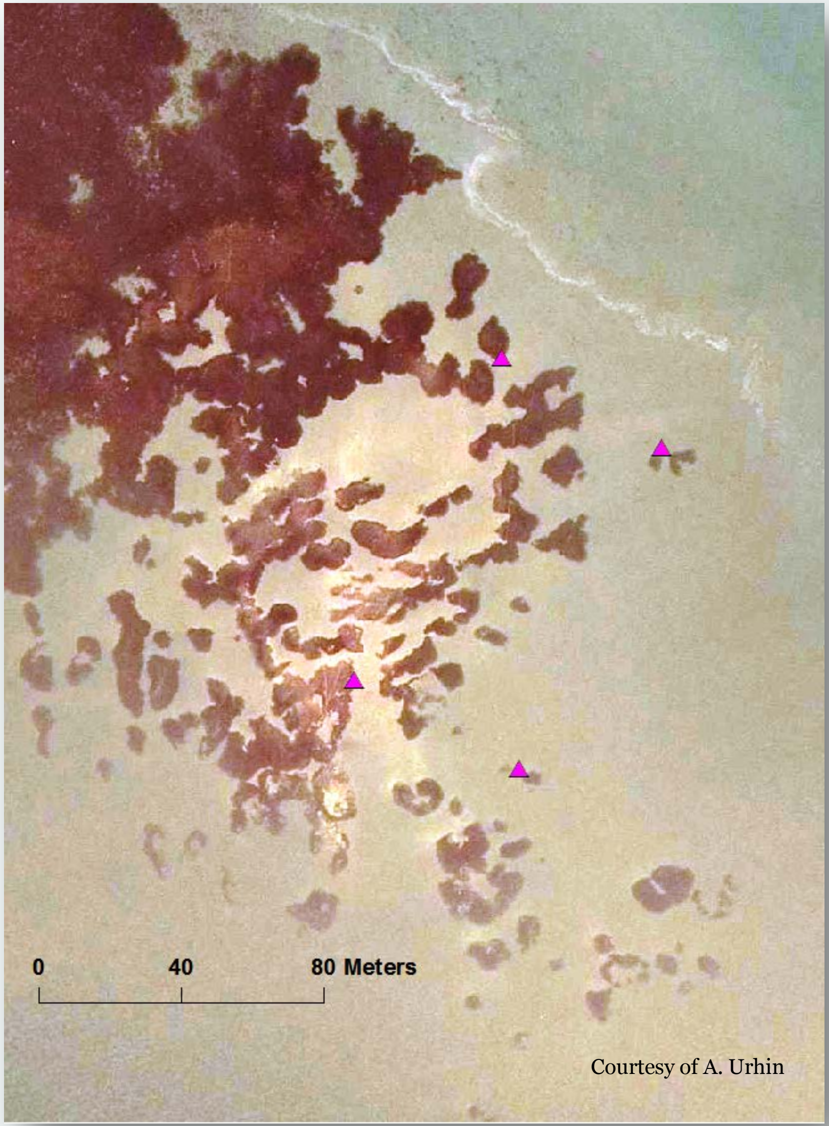
- Site selection
- Economic valuation consistency
- Defining extremes and useful indicators of stress
- Applying landscape organization principles
- Understanding genetic information
- Annual vs. perennial
- Education

Site Selection

- Absence of seagrass – historically a cause for rejection
  - Shifting to overcoming sources of recruitment limitation
- Useful (coarse) indicators
  - Depth is similar to nearby natural beds
  - Not subject to chronic storm disturbance
  - Not undergoing rapid and extensive natural recolonization
  - Restoration successful at similar sites
  - Sufficient acreage to achieve goals
  - Similar quality habitat restored as was lost
- Scale of projects
  - Individual development projects
  - Watershed projects – major state changes
    - More opportunity for large-scale gains
    - Urbanized estuaries - highest opportunity for reclaiming historical acreage

Applying Economics of Seagrass Restoration

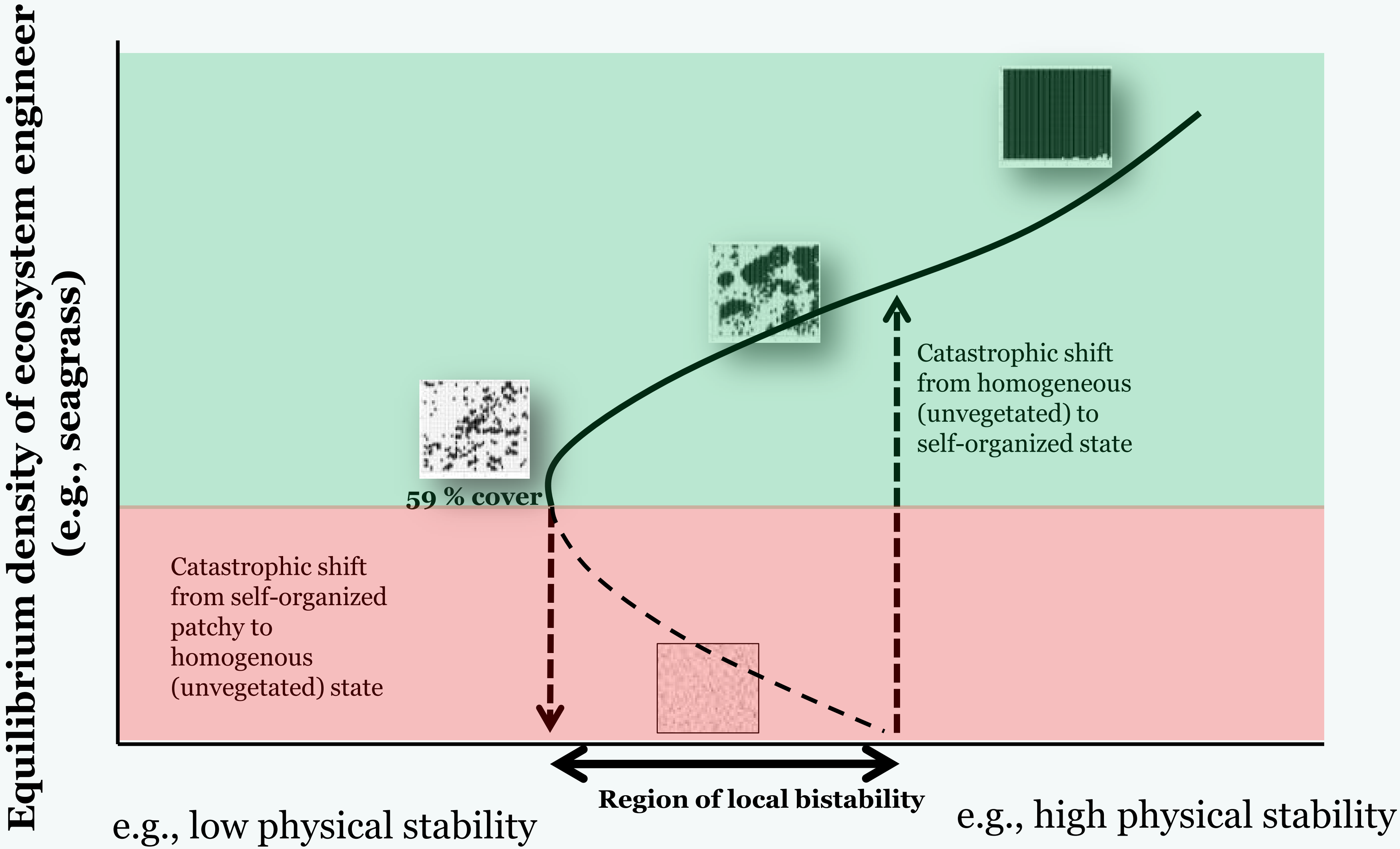
- Beyond "how much does it cost to plant seagrass"
- Value based on ecosystem services– who can argue that seagrasses are not valuable?
- Discount the services to set a realistic cap on value
  - If you borrow a dollar and return it to me tomorrow, it has present day values
  - If you borrow a dollar and do not pay me back for years, then to me, that service has lost present-day value
  - Value of services returned in the future are diminished at a rate determined by society
- Acre-years of discounted lost services – set cost and acreage
- Use cost of restoration as the basis for value
- But wait....not all seagrass beds are alike....



Landscapes

- Seagrass landscapes are structured in response to disturbance
- Sustainable management and recovery of ecosystems… difficult to devise…requires understanding relation between feedback and the 'scale of action'

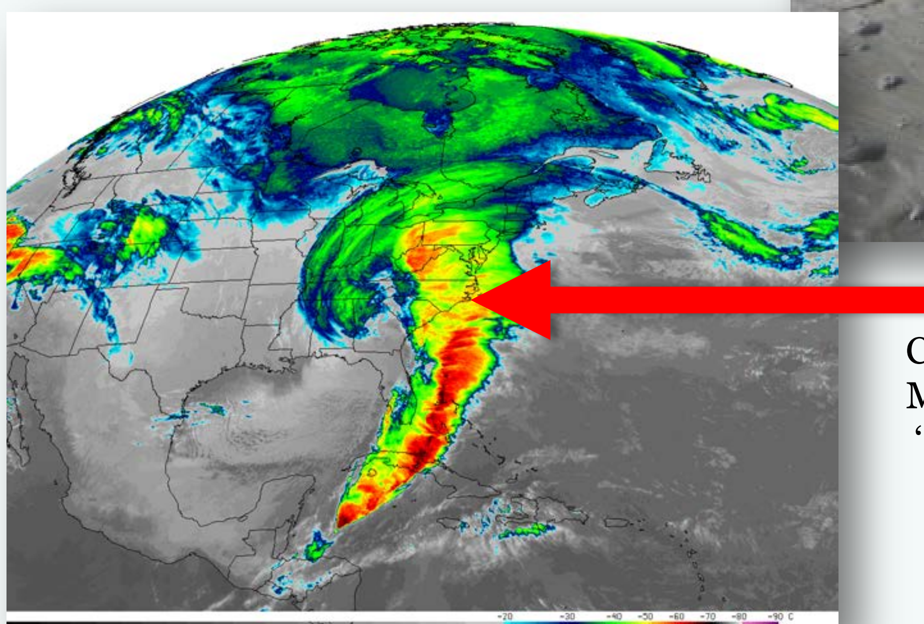
sensu Cao and Lam 1996; Rietkerk et al. 2004



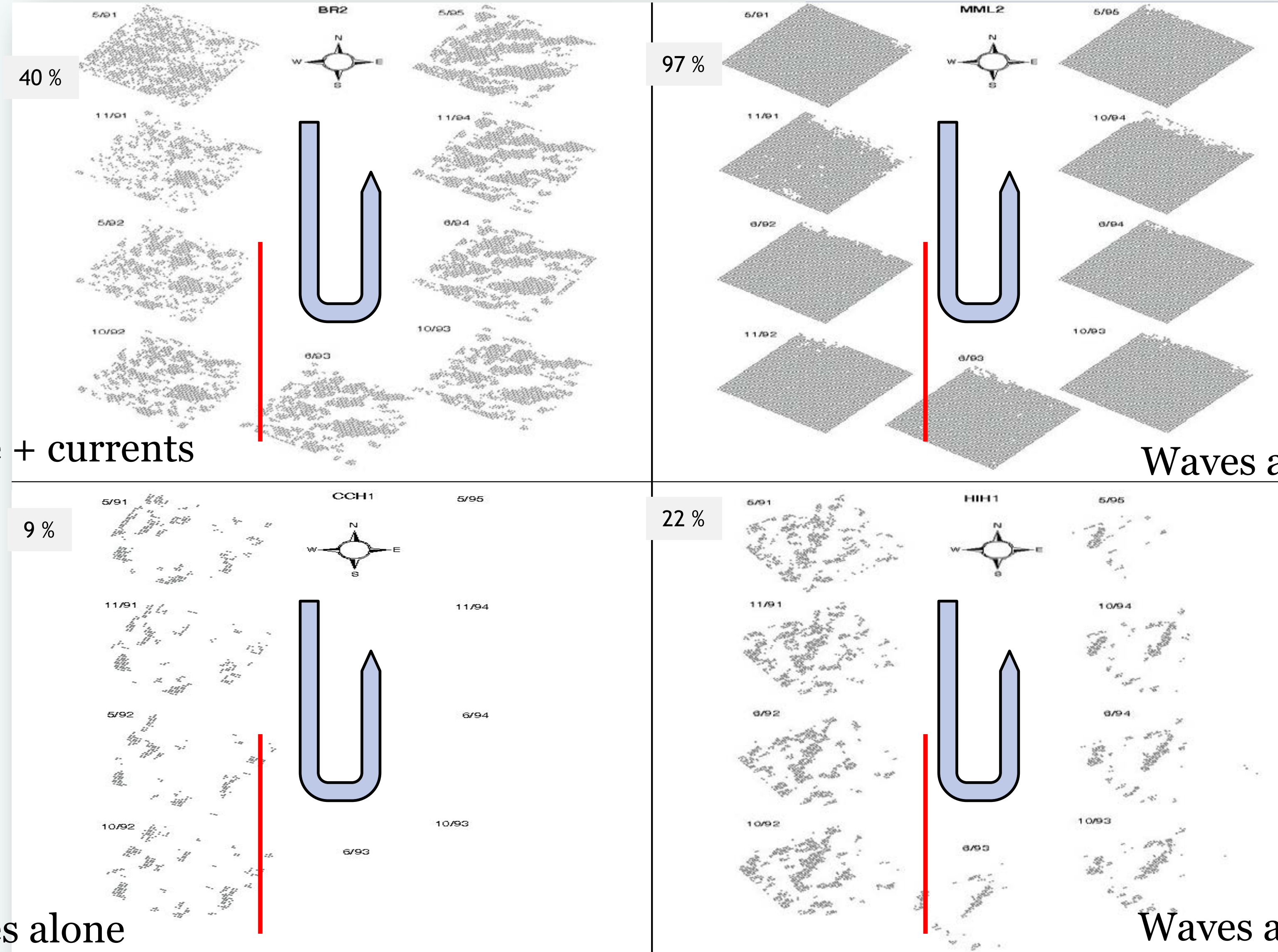
Modified from Rietkerk et al. 2004, Uhrin pers. comm.

Defining Disturbance and Its Role in Seagrass Cover

- Bioturbation / grazing
- Extreme events
  - Extent
  - Duration
  - Intensity
  - Frequency
  - Sequence



Coastal North Carolina
March, 1993
'Storm of the Century'

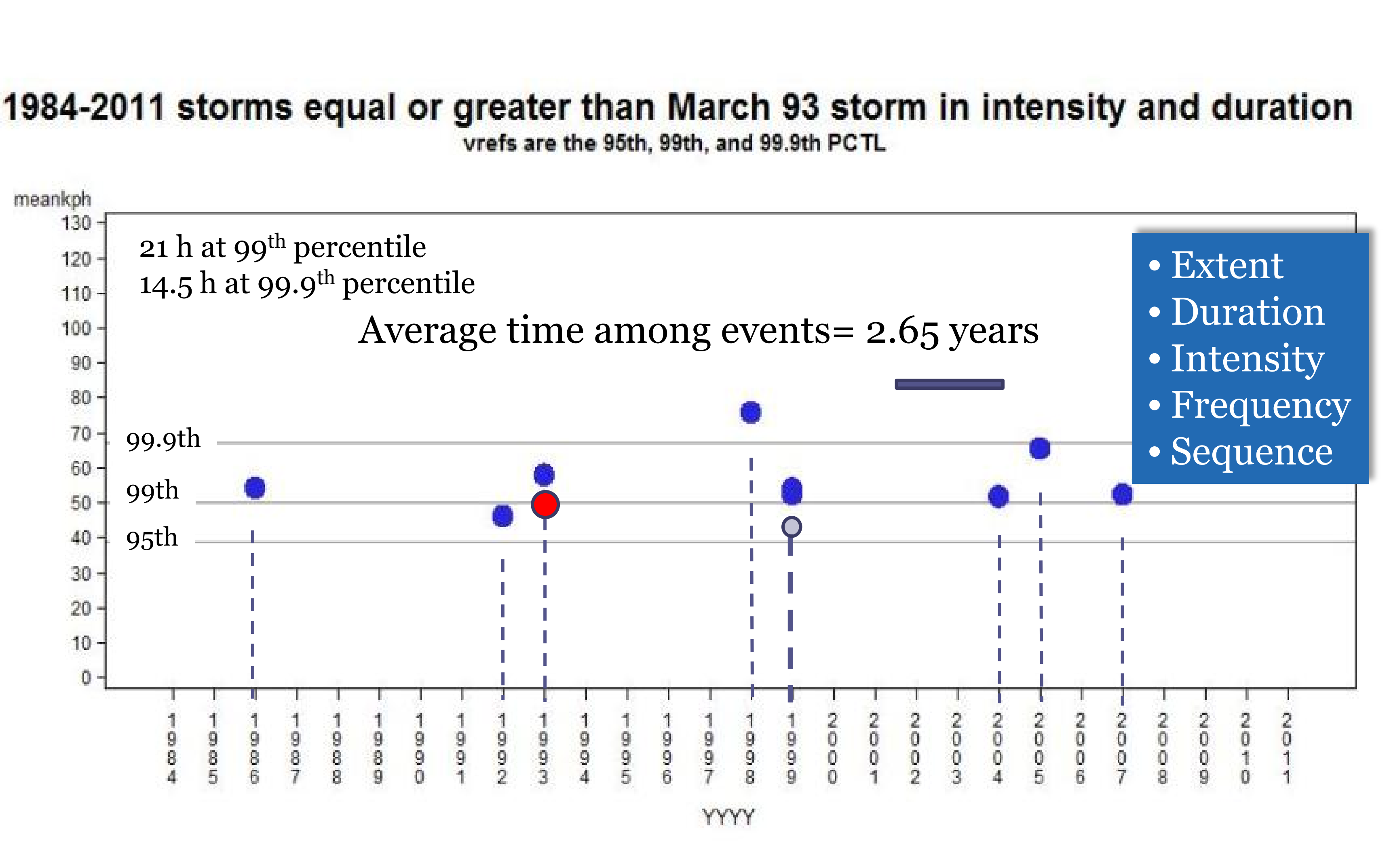


Wave + currents

Waves alone

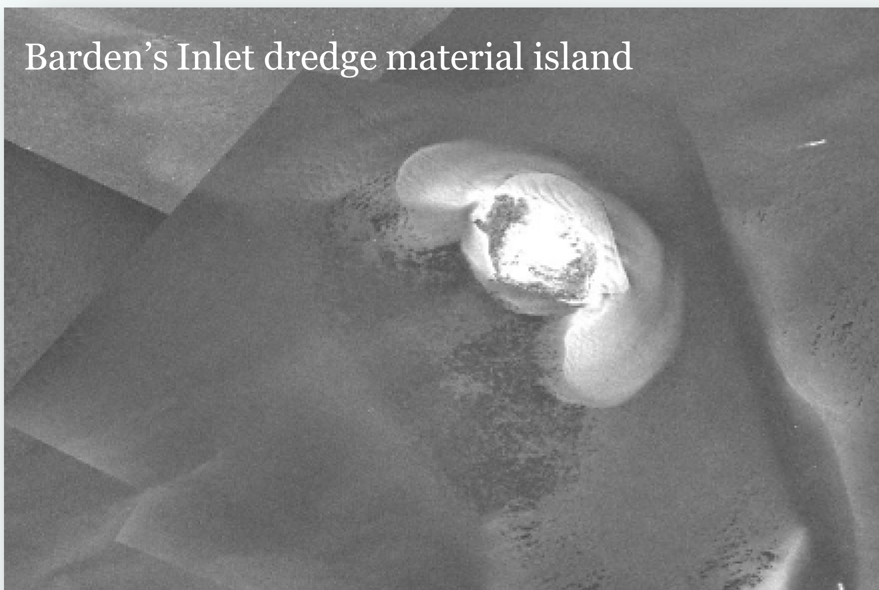
Waves alone

Waves alone

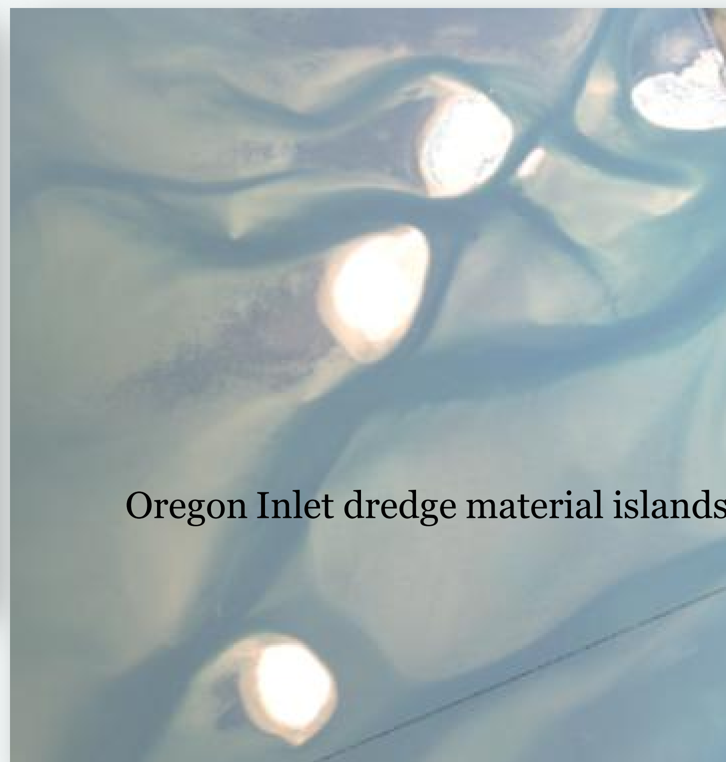

1984-2011 storms equal or greater than March 93 storm in intensity and duration
vrefs are the 95th, 99th, and 99.9th PCTL
meankph
21 h at 99th percentile
14.5 h at 99.9th percentile
Average time among events= 2.65 years
99.9th
99th
95th
• Extent
• Duration
• Intensity
• Frequency
• Sequence
YYYY

How Can We Use Landscape Information in Restoration?

- Reduce wave energy and bioturbation in patchy seagrass beds
- Facilitate bed coalescence & increase cover per unit area seafloor
- Create acre-years of seagrass service


Barden's Inlet dredge material island

North Carolina, USA


Oregon Inlet dredge material islands

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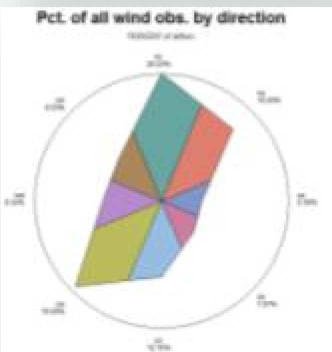
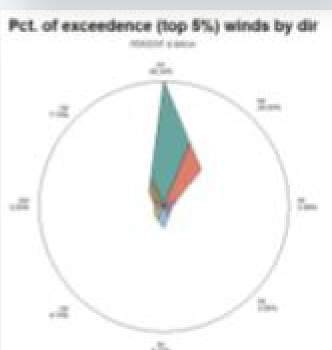
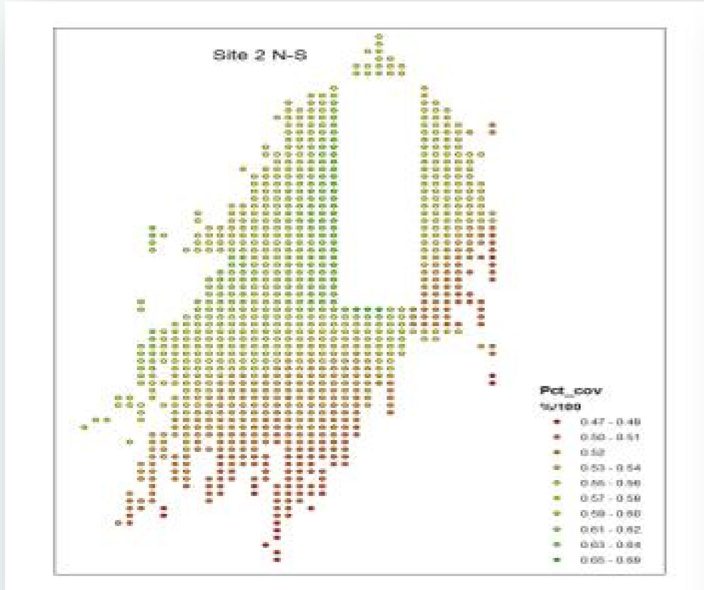
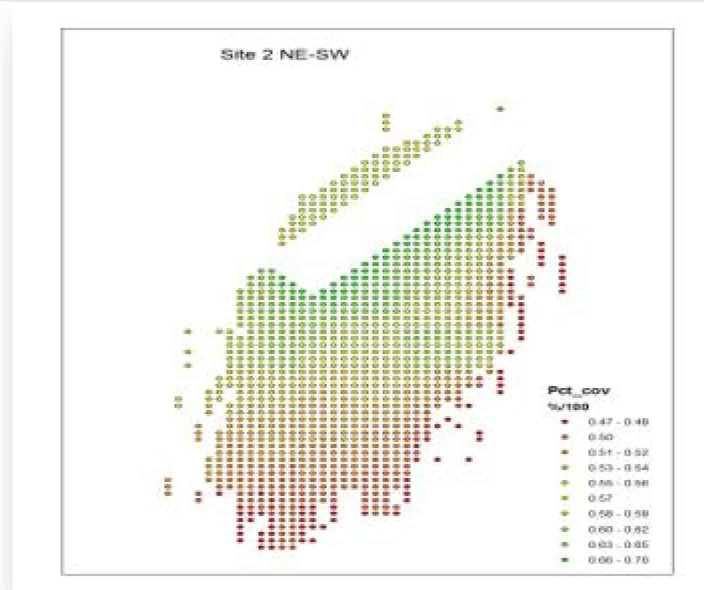
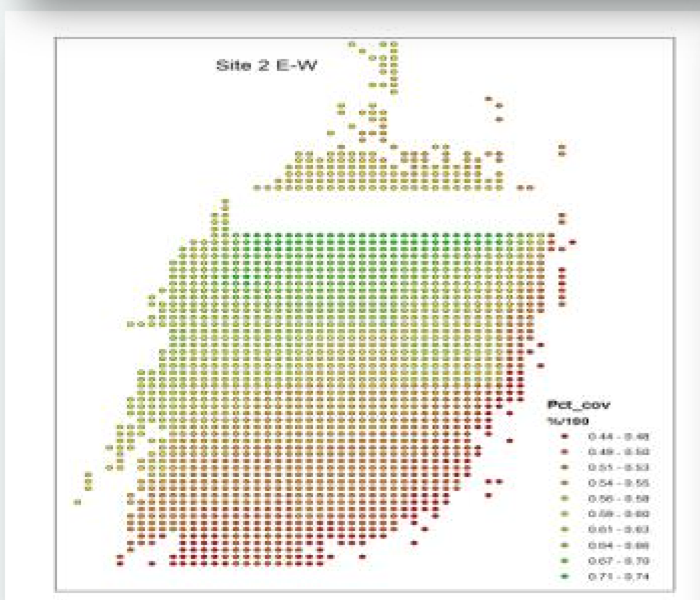
Permanently change factors controlling cover

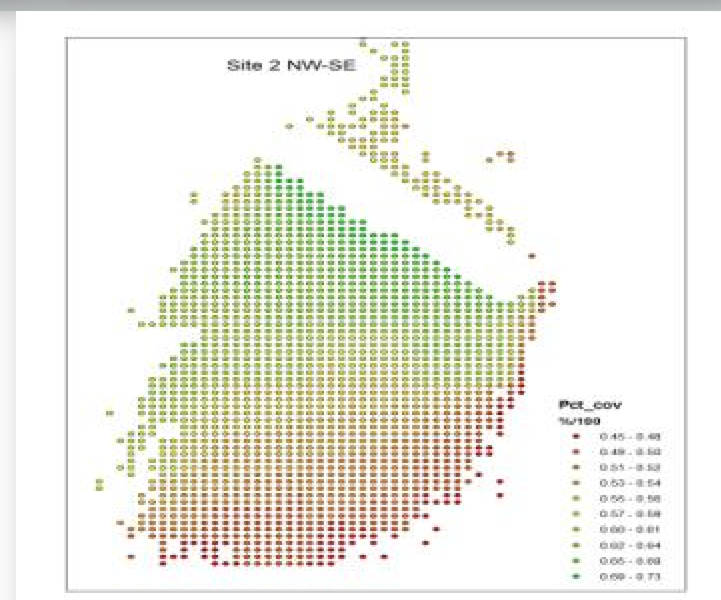




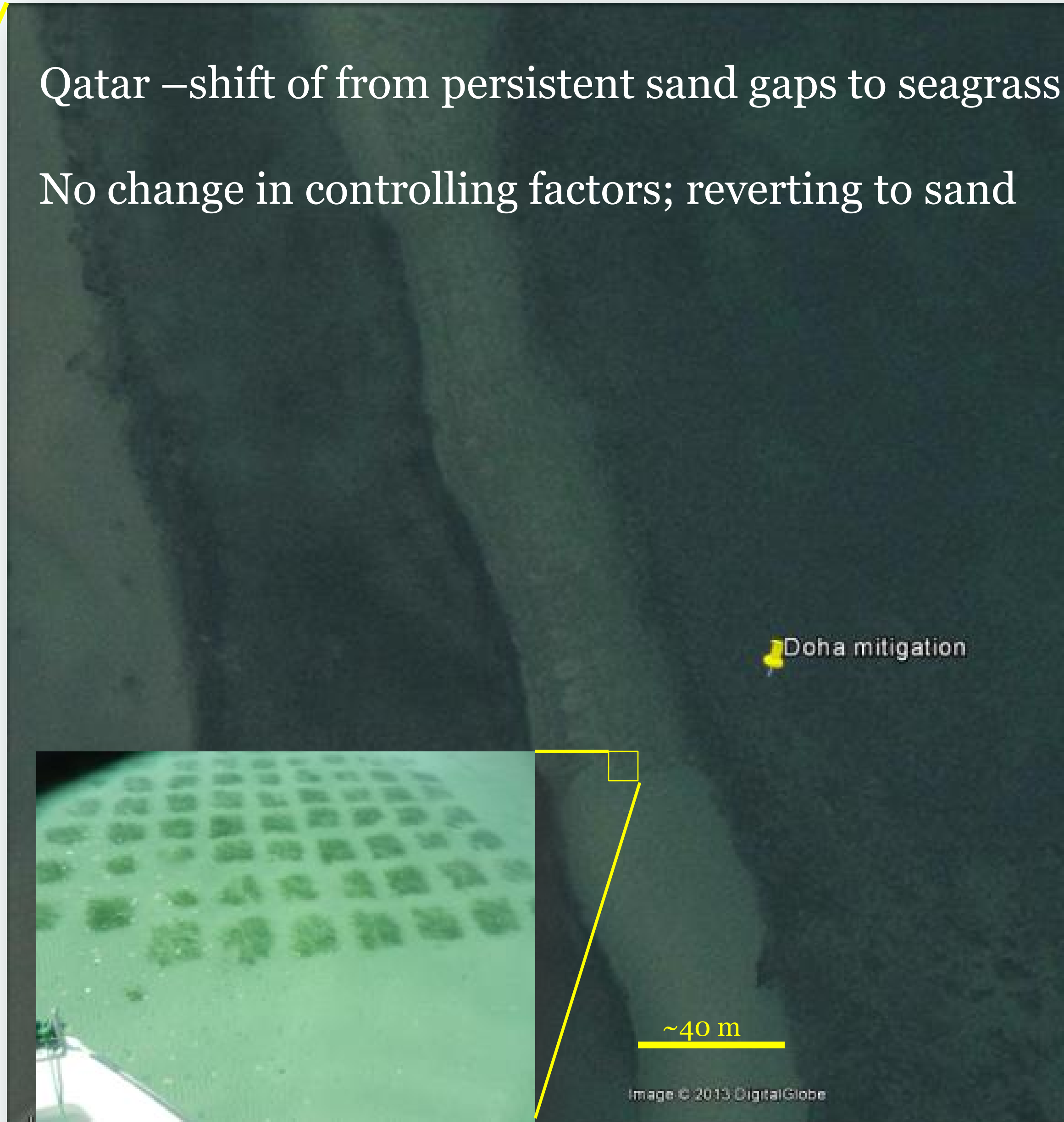









Doha mitigation


Qatar –shift of from persistent sand gaps to seagrass
No change in controlling factors; reverting to sand
Doha mitigation
~40 m
Image © 2013 DigitalGlobe

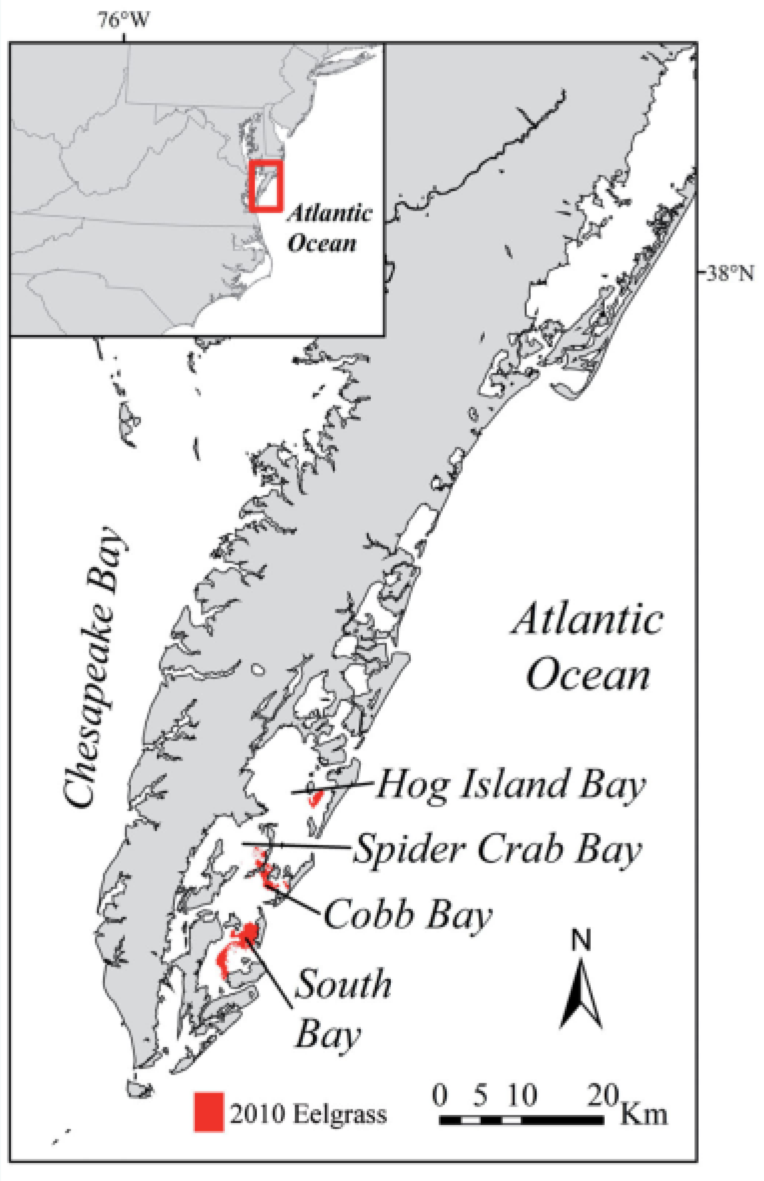
• Thousands of acres of eelgrass created from seed in the Virginia coastal bays

• Areas devoid of seagrass for decades

  • "we recommend that producing new habitat can be termed creation or enhancement whereas re-creating habitat that was present within historical records, **no matter how old**, should be termed restoration.'"

  (emphasis added)

  Orth and McGlathery 2012, citing Elliot et al 2007



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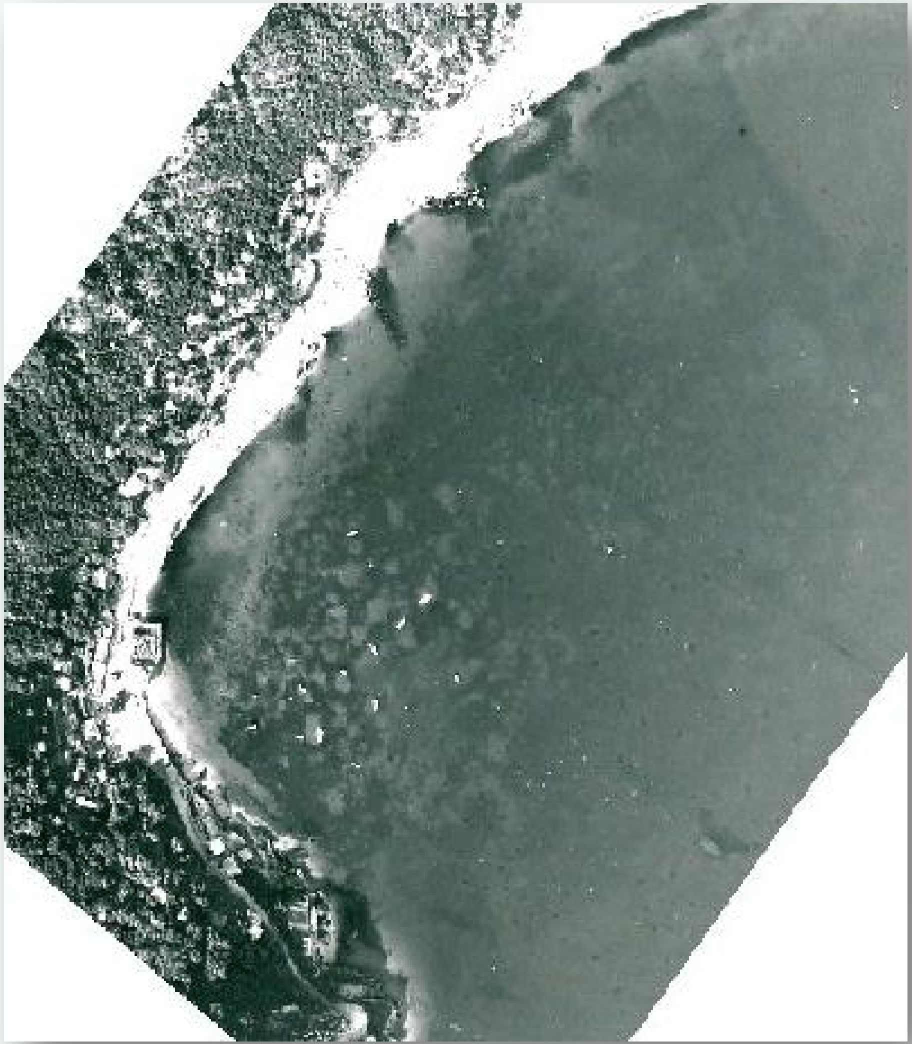
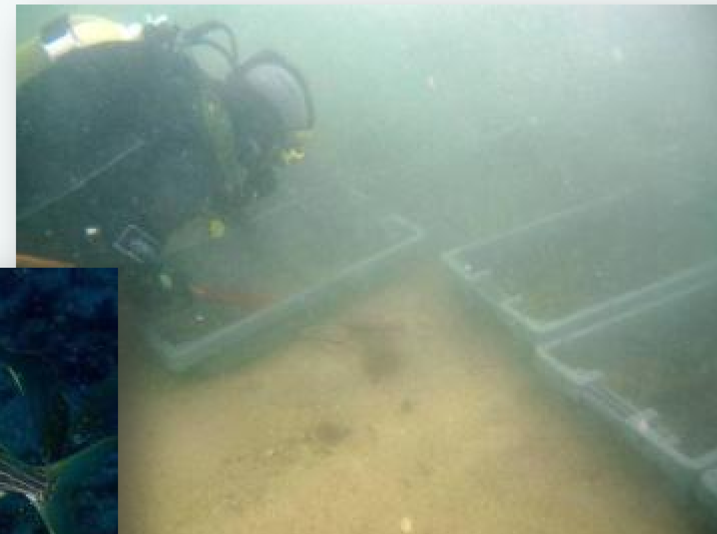
Setubal, Portugal:
Changing Patch Size to Resist Biological Disturbance



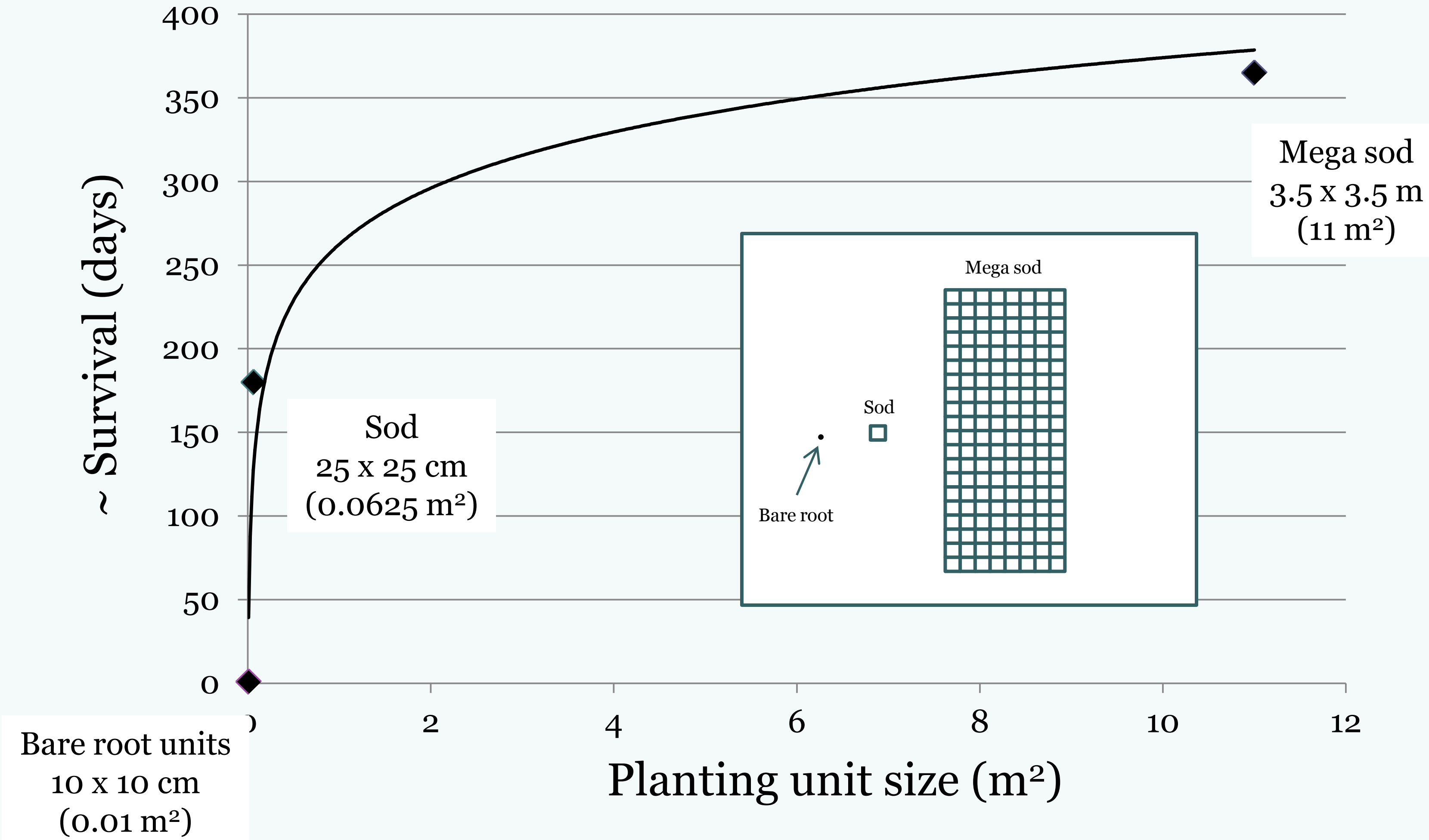
Portinho da Arrábida, Professor Luiz Saldanha Marine Park near Setubal, Portugal – circa 1974?

Setubal, Portugal:

Changing Patch Size to Resist Biological Disturbance



Planting Unit Size Affects Survival



Information Gaps

- Scale of action for resource managers
  - Obtaining baseline ahead of projects
  - Defining geographic scale of management units
  - Focus on higher governmental levels
- Guide restoration
  - How to chose planting stock
  - Success criteria for achieving genetic structure
  - SLOSS issues – linkages and seascape
  - Defining reference sites (controls)
- Define species
  - Defining range extensions vs. invasion

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Information Gap:

Annuals vs. Perennials

- We are biased towards large, long-lived seagrasses
- Acreage of annuals likely exceeds perennial seagrasses, but requires other metrics of persistence and thus, restoration
- Annuals: Highly labile and important food web contributors (~microalgae)
- A huge valuation and educational challenge
- Substantial management paradigm shifts

67. Seagrass beds in general, and Halophila johnsonni in particular, move around. They may be in one spot one year and in another (close-by) location the next.. Therefore, although seagrass may not be presently growing in a particular area, that area may be a potential site for such growth.

Flynn vs. FDEP
State of Florida
Division of Administrative Hearings
96-4737

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Information Gap:
Education

- Renewed effort at awareness
- Drinking from the fire hose
- Focused education of managers and regulators

transition

Information Gap:
Learn from Existing Data and Reports on Successes and Failures - 1

Tampa Bay, Florida, USA

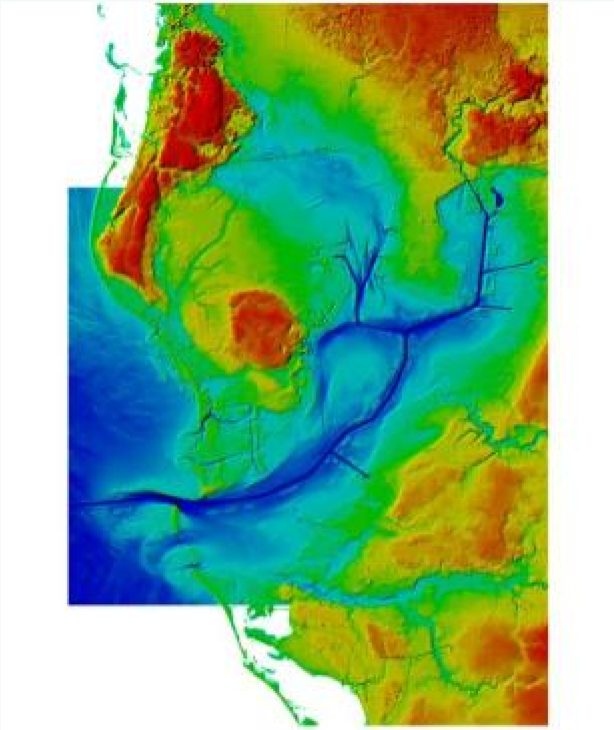

Figure 3: 1-arc-second seamless topographic/bathymetric elevation model for Tampa Bay.

Progress in Seagrass Recovery

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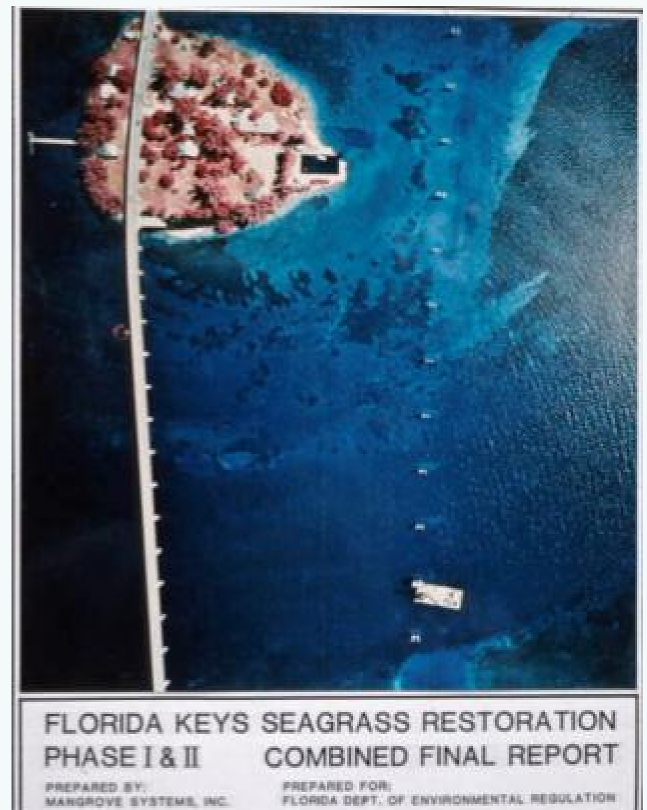
Information Gap:

Learn from Existing Data and Reports on Successes and Failures - 2

Florida Keys, Florida, USA

Data on Seagrass Restoration

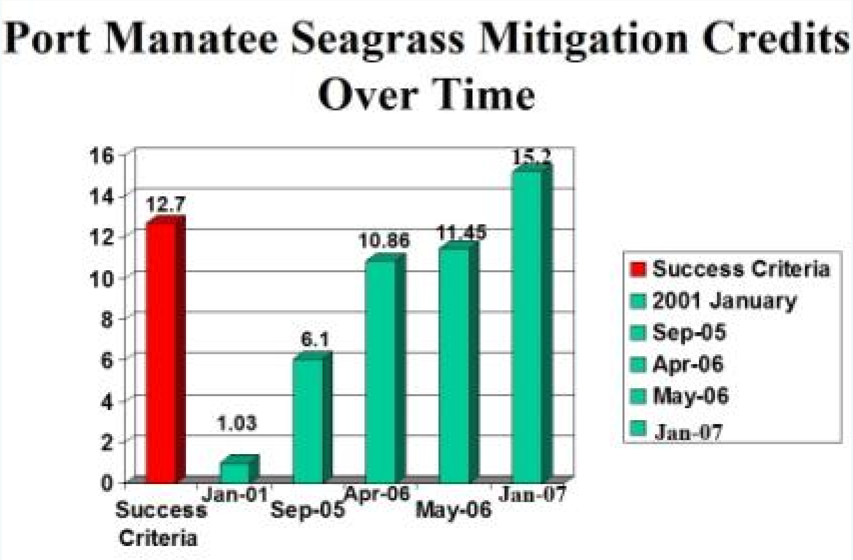


Information Gap:

Learn from Existing Data and Reports on Successes and Failures - 3

Port Manatee, Florida, USA

Credits for Seagrass Restoration



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Conclusions

- What are the challenges/opportunities into the 21st century?
  - Understanding disturbances, defining extremes, multiple interactions and "surprises" (bistability)
  - Forecasting site suitability – manipulate wave energy and/or bioturbation
  - Applying economics
  - Applying landscape principles – draw from terrestrial ecology – scale dependency studies
  - Using genetic information at the scale of action
  - Managing non-charismatic seagrass species

- Suggestions for direction
  - Student support
  - Media engagement
  - Managers (economists and general counsel on the science team)

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Lewis: Top Five Recommendations to Improve Success in Seagrass Restoration and Creation

Challenge	Recommendation	Details
1. Seagrass restoration designed incorrectly	Better training	Provide training for wetland professionals including consultants, regulators and monitoring and enforcement personnel who deal with seagrass restoration issues
2. Use of Inadequate baseline and target restored water quality and oceanography	Establish current oceanography and conceptual target water quality by using a reference condition in a nearby seagrass meadow	Monitor existing water quality and oceanography at a reference site as well as the proposed restoration site. during normal seasonal conditions; Establish reasons for lack of existing seagrass in the proposed restoration site
3. Lack of consideration of the historical context and previously published work on success and failure	Republish Kusler and Kentula (1989) (the USEPA version) with added notes from the authors or substitutes to bring them up to date. Make freely available. (Done)	Simply providing a bibliography is not enough. Wetland professionals and regulators are busy people. It is often difficult or impossible for them to access good free science. This would start to overcome that impediment. Use of the website www.seagrassrestorationnow.com as a starting point is recommended
4. Inadequate respect for the experience of current professionals with proven track records.	Provide a method for precertification by regulatory agencies and requirements for applicants to use trained professionals in seagrass restoration.	In consultation with federal, state and local wetland planning, and design and permitting agencies, develop approved lists of seagrass design and construction professionals who have proven track records of successful restoration and monitoring, and recommend their use.
5. Beef up compliance monitoring and enforcement activities to stop repeated errors in design with distribution of "lessons learned."	Document current seagrass restoration and creation efforts on the regional level to keep professionals apprised on progress in more successful seagrass restoration and creation efforts.	Current progress towards improving the practice of successful seagrass restoration and creation is hampered by the lack of freely availability documentation on who, what and where are the successful projects being done, and what monitoring and reporting is available for professionals to review and learn about these efforts and improve their practices.

Fonseca: Top Five Recommendations to Improve Success in Seagrass Restoration and Creation

Challenge	Recommendation	Details
1. Complex and inappropriate metrics of success.	Utilize simple, parsimonious metrics that are appropriate for the defining success.	**Acreage** and **persistence** are the foundation of success; these are needed for computed discounted lost (or gained) ecosystem services; if you build it, they will come.
2. Site selection	Revise criteria to include emerging understanding of ecosystem bistability	To offset the ongoing loss of seagrass habitat, opportunities for both restoration and mitigation need to include ANY unvegetated seafloor where the factors limiting natural seagrass recruitment (e.g., wave energy, bioturbation) can be manipulated and sustained.
3. Quantifying interim services	Credit interim recovery of services and not just loss	For example, sites that must be periodically disturbed, such as channels and harbors only count the loss of any seagrass recruited in the interim; there is no credit for the interim gain and service of those recruited seagrass.
4. Restoration of dynamic seagrass beds (e.g., *Halophila* spp., and patchy habitats)	Changing the monitoring scale both temporally and spatially to accurately capture the scale of variance	Snapshot and extremely short duration monitoring will not provide defensible assessments of these communities. Regulatory agencies that continue to utilize these methods will fail in their ability to accurately assess both baseline conditions and restoration performance.
5. Recognition of seagrass services by the public	Champions	Seagrasses provide far more ecosystem services to the U.S. than corals – but the public is largely unaware of this. Many of the injuries to and loss of seagrasses likely arise from an uninformed public and their representation

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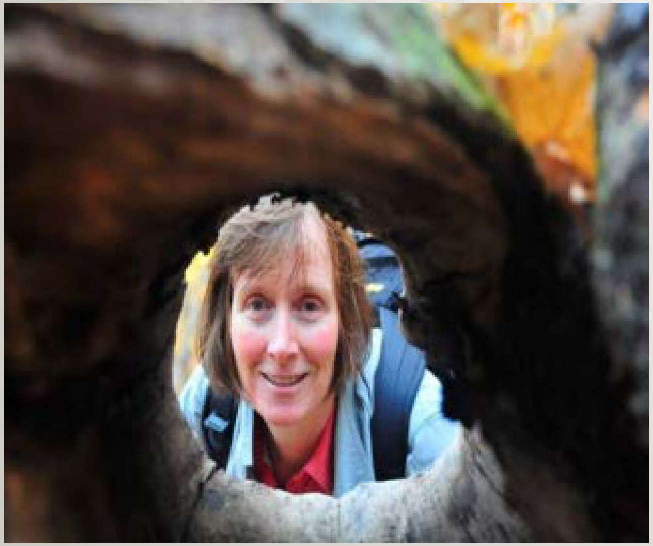

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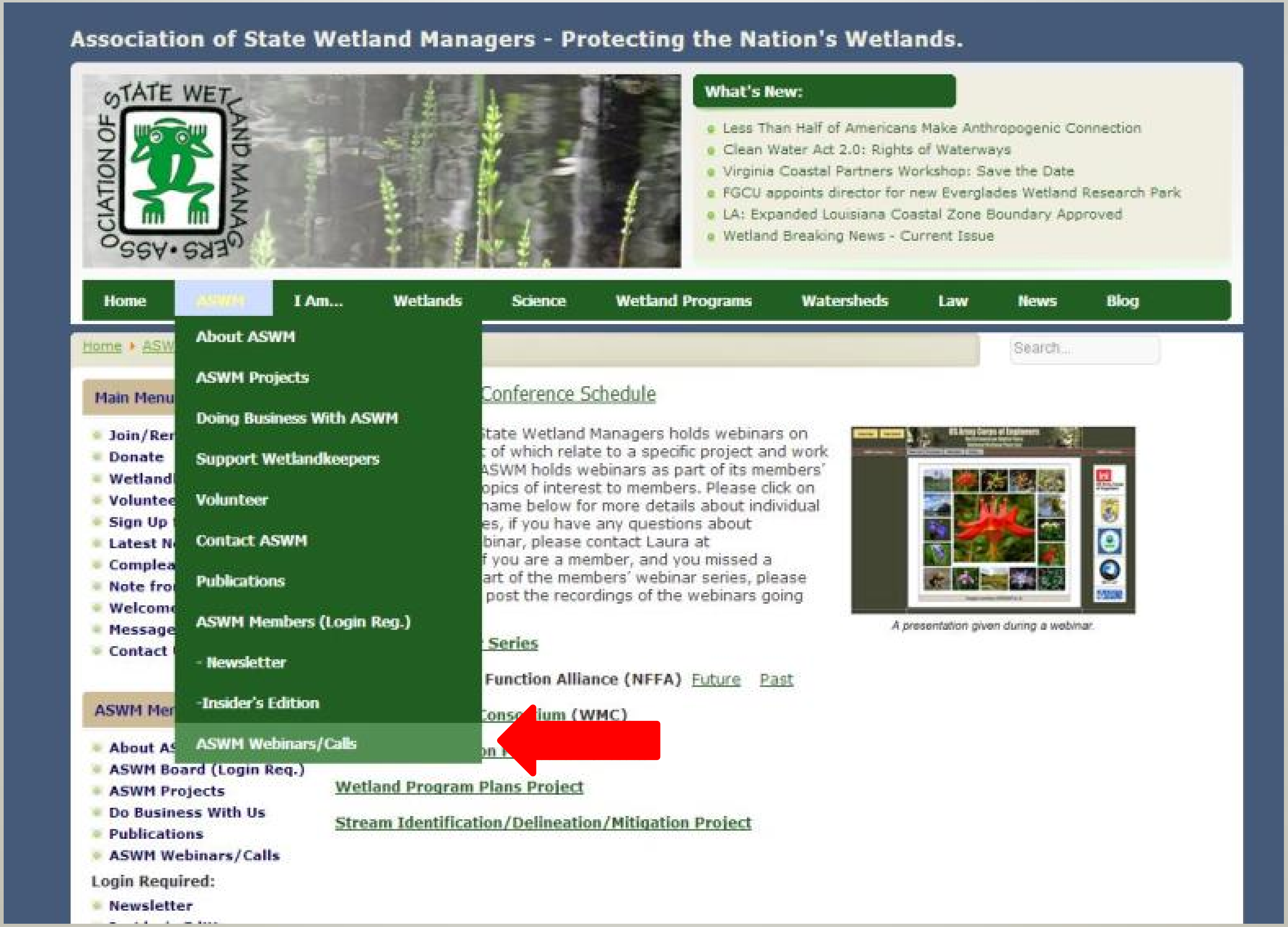


WEBINAR SCHEDULE & RECORDINGS

FUTURE SCHEDULE - 2015

- **Tuesday, February 17, 3:00pm eastern:**
  - **Playa & Rainwater Basin Restoration**

    Presented by:

    Richard Weber, NRCS Wetland Team and,

    Ted LaGrange, Nebraska Game & Parks Commission
- **Tuesday, March 17, 3:00pm eastern:**
  - **Pacific Coast Wetland Restoration**

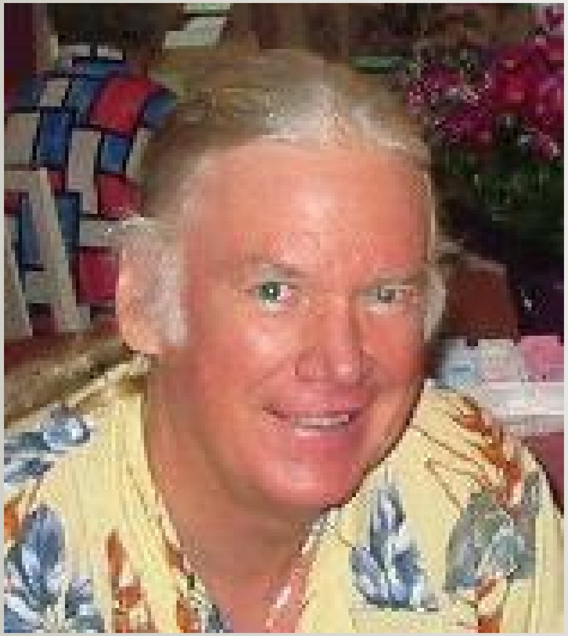
    Presented by:

    Charles "Si" Simensted, University of Washington and

    John Callaway, University of San Francisco

FOR FULL SCHEDULE, GO TO: http://aswm.org/aswm/6774-future-webinars-improving-wetland-restoration-success-project

PRESENTERS



Roy R. “Robin” Lewis, III
President & Wetland Scientist
Lewis Environmental Services, Inc.
& Coastal Resource Group, Inc.

Mark Fonseca
Science Director
CSA Ocean
Sciences, Inc.

A "COOKBOOK" APPROACH TO WETLAND RESTORATION WON'T WORK

There are too many variables.

- *Ingredients are always different*
- *Reason for 'cooking' varies*
- *Recipe isn't always correct*
- *Inexperienced cooks*
- *Cooking time varies*
- *Poor inspection when "cooking"*
- *Additional ingredients may be needed*
- *Is it really done?*

WE NEED TO UNDERSTAND THE PLANNING PROCESS AND VARIABLES FROM SITE TO SITE THAT MUST BE STUDIED, UNDERSTOOD AND ADDRESSED

Temperate and Tropical/Subtropical Seagrass Restoration

IT WILL TAKE US A FEW MOMENTS TO MAKE THE SWITCH…

Temperate and Tropical/Subtropical Seagrass Restoration: *Challenges for the 21st century*

Lewis Environmental

Roy "Robin" Lewis III
President

CSA
CSA Ocean Sciences Inc.

Mark S. Fonseca, Ph.D.
Science Director

Outline

- Long history - what have we learned?
- What are the challenges now and in the future?
- Overlooked species
- Suggestions for direction

What are seagrasses?

- **Flowering plants** – produce seeds
- Over a third of the world's seagrass acreage has been lost
- Approximately 12 species in U.S.
  - All coasts
  - > 8 million acres in U.S. waters (excluding AK and HI)
  - One Threatened under ESA
  - Most grow on unconsolidated substrate
  - Some grow on rock (west coast)
  - Intertidal to over 30m
- Prolific leaf growth (all species)
- Grow vegetatively (branching & tillering)
- Spreading rate (vegetative growth) varies
- Various landscape patterns

C. Pickerell

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Why is Seagrass Meadow Restoration so difficult and expensive?

- Open systems
- Vulnerable to many disturbances
  - Water quality
  - Storms
  - Mechanical damage
  - Bioturbation
- Few engineering options

Probability of Success

…High

Estuarine Marshes

Coastal Marshes

Mangrove Forests

Freshwater Marshes

Freshwater Forests

Groundwater/Seepage Slope Wetlands

Seagrass Meadows (SAV)

…Low


THE UNITED STATES OF AMERICA
B 57066619 A
B 57066620 A
B 57066613 A
B 57066616 A
B 57066611 A
B 57066618 A
B 57066605 A
B 57066615 A
57066614 A
FEDERAL RESERVE NOTE
ONE DOLLAR

Cost of Success

…Low

Estuarine Marshes ($100K/acre)

Coastal Marshes

Mangrove Forests

Freshwater Marshes

Freshwater Forests

Groundwater/Seepage Slope Wetlands

>$ 10X-20X

Seagrass Meadows (SAV)

…High

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SITE	YEAR COMPLETED	METHODS	2013 TOTAL COST	2013 COST PER FT²	REFERENCES
1. House Boat Row	2012	Fill and Transplant	$1,614,471*	$14.26	FDOT and Stantec 2013, Phil Frank (pers. comm).
2. Heidi Baby	2005	Fill, Stakes and Transplant	$89,704**	$16.03	NOAA 2009
3 Julia Reanne	2006	Fill, Stakes and Transplant	$73,933**	$35.18	NOAA 2007A
4. Lucky One	2006	Fill, Stakes and Transplant	$27,513**	$50.30	NOAA and FDEP 2006, 2007

Data from Coastal Resources Group, Inc.
Keys Restoration Fund (2014)
Florida Keys Seagrass Restoration Costs Report
To the U.S Army Corps of Engineers, Jacksonville, Florida
Fourteen Project Sites – Range $0.50 to $50.00/sq ft
Mean $21.87/sq ft or **$952,657 per acre**

2 (2 projects)	2005	Fill, Stakes and Planting	$124,241	$14.20	2013
11. Lignumvitae Phase 3	2013	Fill only	$215.947****	$44.99	Hobbs et al. 2006, KERF 2013, Hobbs 2013
12. Middle Torch Key Circulation Cut	1983	Fill Removal	$11,430	$10.15	Hobbs et al. 2006, KERF 2013
13. Hypothetical FKNMS PEIS Seagrass	2004	Fill, Stakes and Transplant	$28,741	$27.94	NOAA and FDEP 2004
14. Potential Restoration for Federal Court Settlement	1996	Planting only	$566,475	$13.00	Fonseca et al. 2002
Mean of all Per Square Foot Estimates				**$21.45 sq ft⁻¹ or $934, 362 ac⁻¹**	

transition

What is Restoration, Really?

- An attempt to overcome impediments to recruitment and recovery
- Often an economically driven trade-off
- Historically results in a net loss of habitat
- Translating for managers
  - **From**: Ecologists' language that values information:
    - 'Possibly'
    - 'Understand'
    - 'Improve'
    - 'Consider'
  - **To**: Managers' need for absolutes:
    - When?
    - How much (cost / to transplant / time)?
    - Where?
    - Criteria for success?

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What Have We Learned?

- Site selection
  - Stalled at simple observations of depth, and human causality
- Methods – most work, but projects still fail
- Extreme expectations…not crops
- Defining success: persistence and acreage
- Impediments to success
  - Disturbance (water clarity, storms and bioturbation)
  - Grazing
- Applying seagrass biology and ecology
  - Spreading rates
  - Vegetative vs. seeding
  - Compressed succession
- Economic valuation

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What are the Challenges?

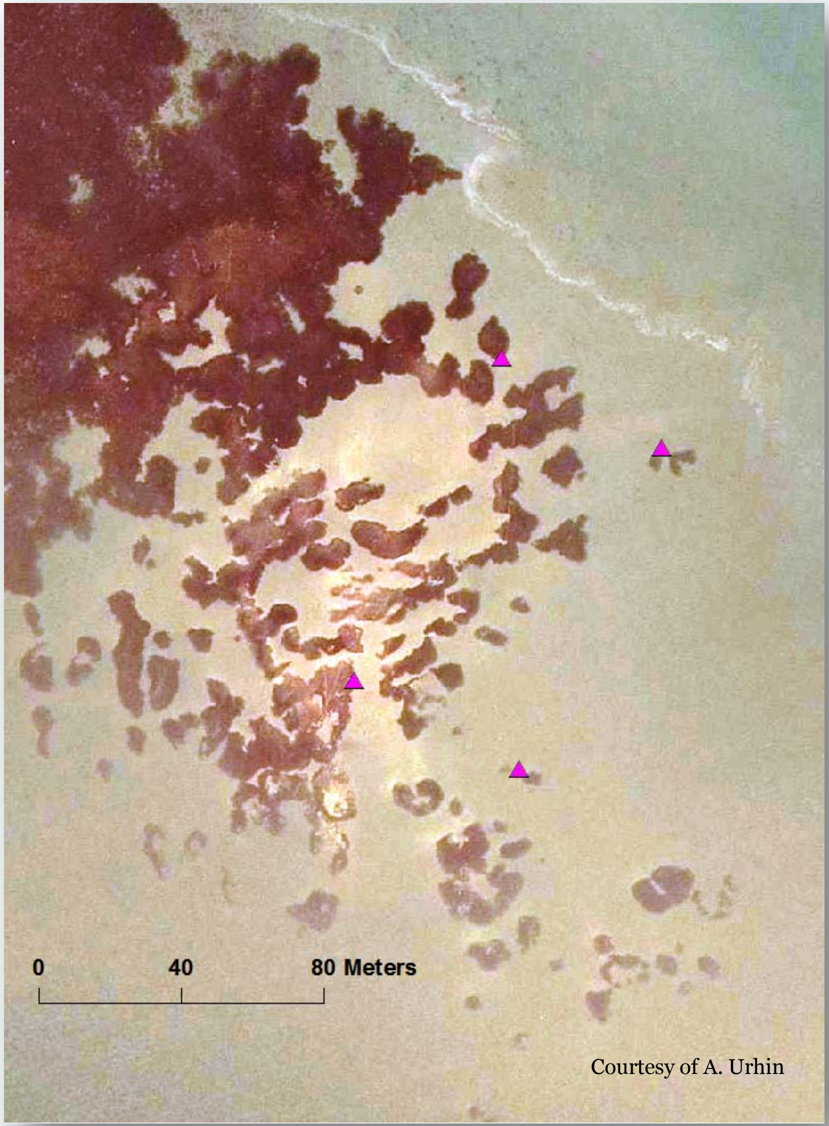
- Site selection
- Economic valuation consistency
- Defining extremes and useful indicators of stress
- Applying landscape organization principles
- Understanding genetic information
- Annual vs. perennial
- Education

Site Selection

- Absence of seagrass – historically a cause for rejection
  - Shifting to overcoming sources of recruitment limitation
- Useful (coarse) indicators
  - Depth is similar to nearby natural beds
  - Not subject to chronic storm disturbance
  - Not undergoing rapid and extensive natural recolonization
  - Restoration successful at similar sites
  - Sufficient acreage to achieve goals
  - Similar quality habitat restored as was lost
- Scale of projects
  - Individual development projects
  - Watershed projects – major state changes
    - More opportunity for large-scale gains
    - Urbanized estuaries - highest opportunity for reclaiming historical acreage

Applying Economics of Seagrass Restoration

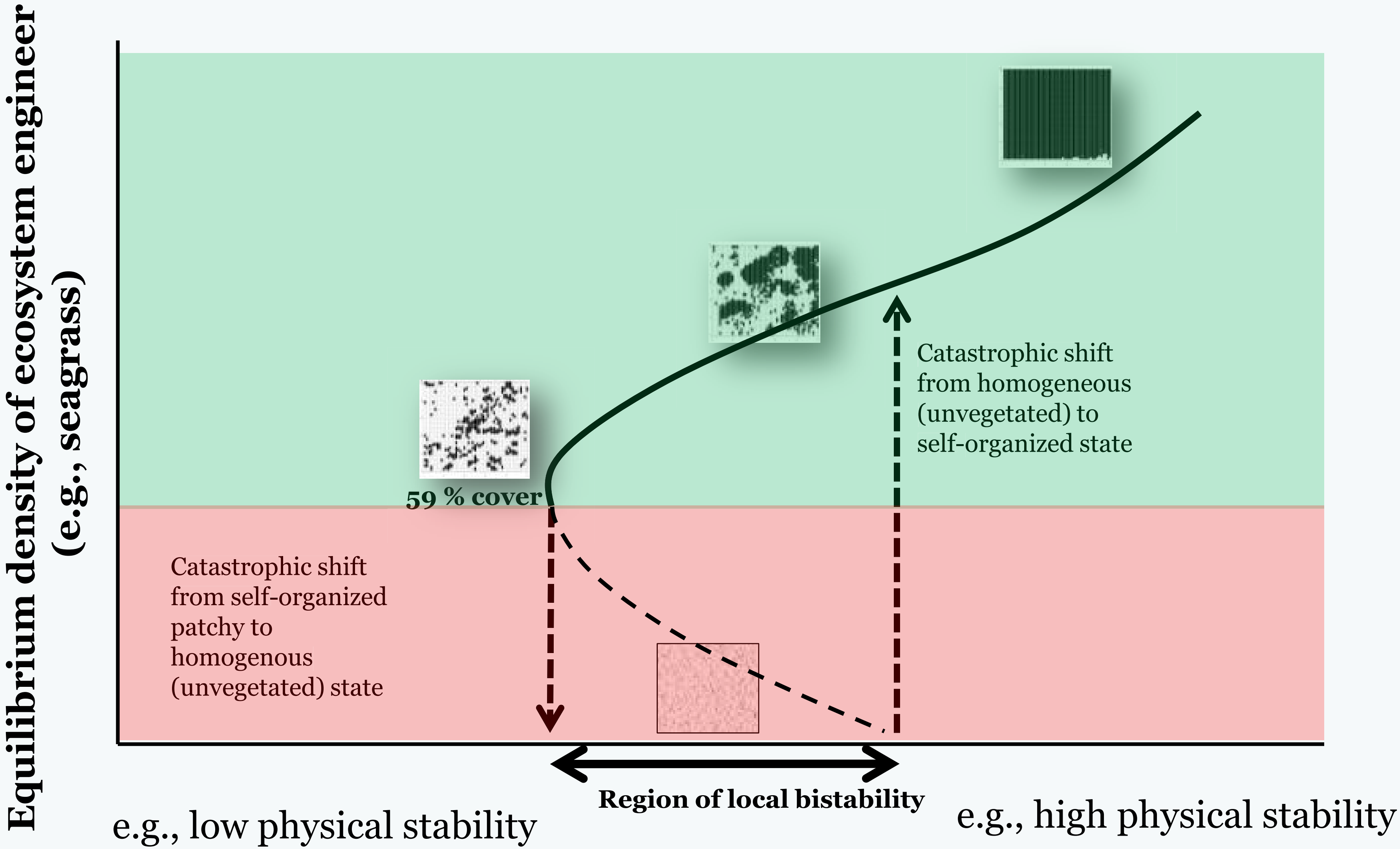
- Beyond "how much does it cost to plant seagrass"
- Value based on ecosystem services– who can argue that seagrasses are not valuable?
- Discount the services to set a realistic cap on value
  - If you borrow a dollar and return it to me tomorrow, it has present day values
  - If you borrow a dollar and do not pay me back for years, then to me, that service has lost present-day value
  - Value of services returned in the future are diminished at a rate determined by society
- Acre-years of discounted lost services – set cost and acreage
- Use cost of restoration as the basis for value
- But wait….not all seagrass beds are alike….



Landscapes

- Seagrass landscapes are structured in response to disturbance
- Sustainable management and recovery of ecosystems… difficult to devise…requires understanding relation between feedback and the ‘scale of action’

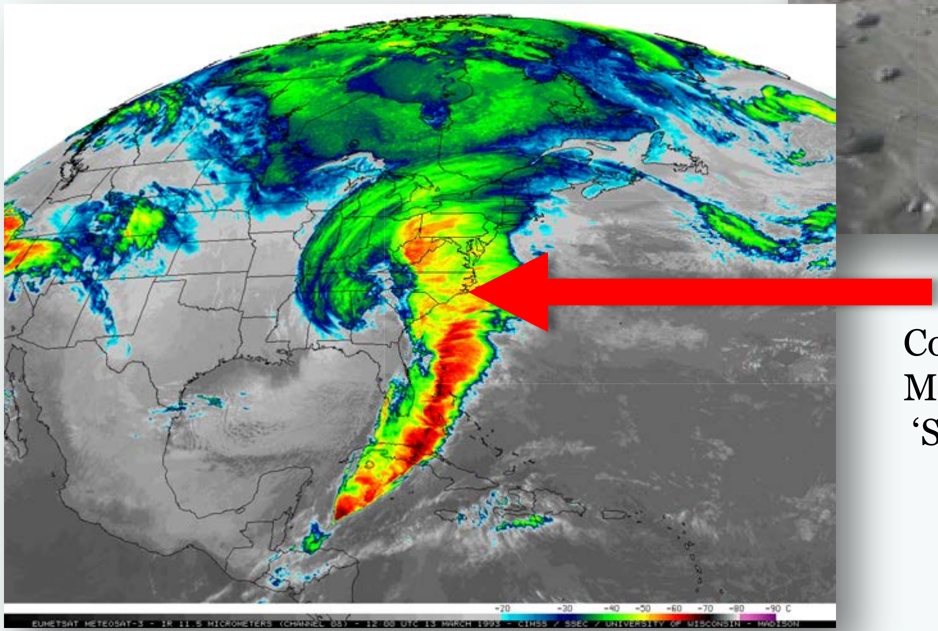
sensu Cao and Lam 1996; Rietkerk et al. 2004



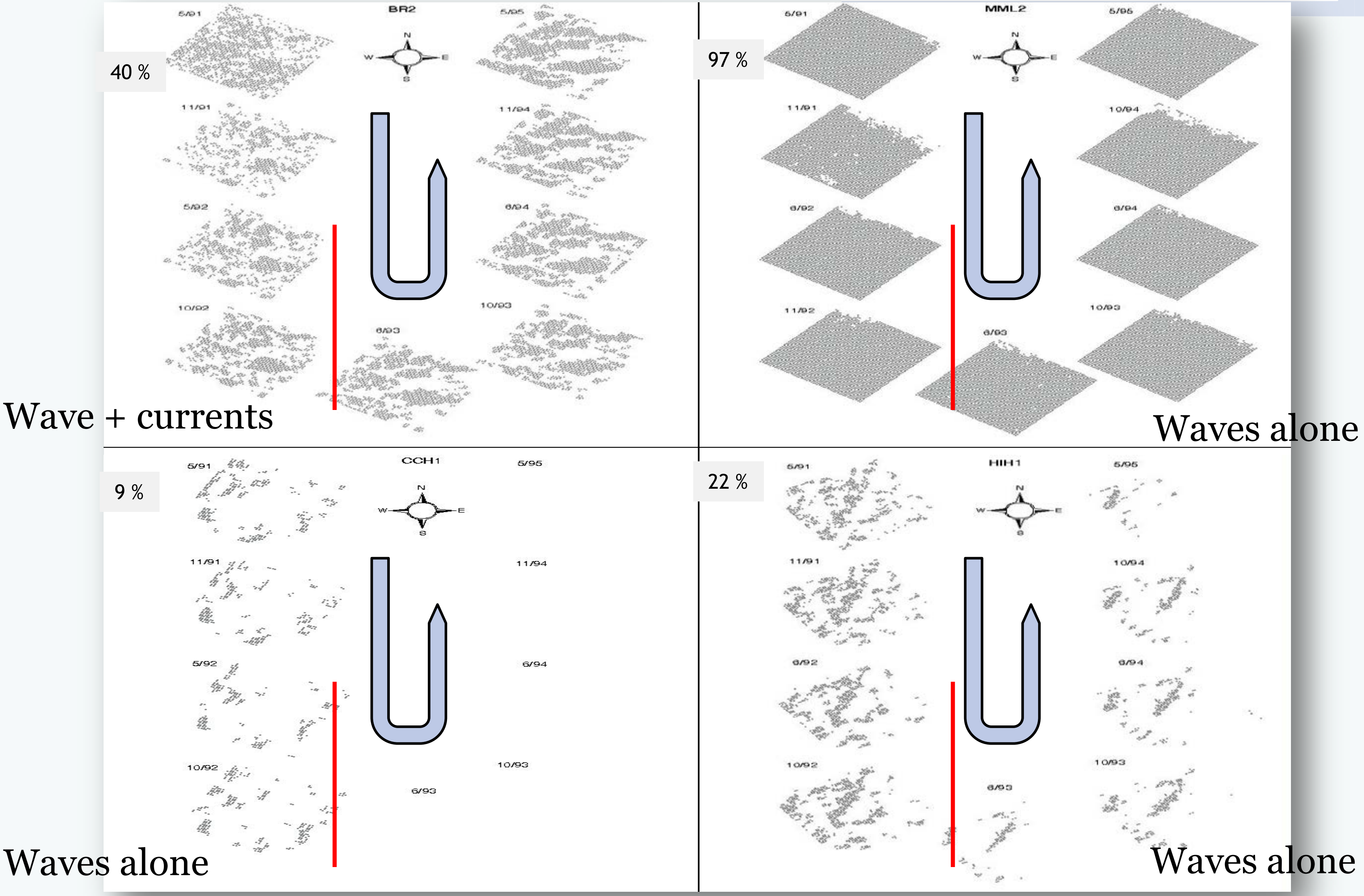
Modified from Rietkerk et al. 2004, Uhrin pers. comm.

Defining Disturbance and Its Role in Seagrass Cover

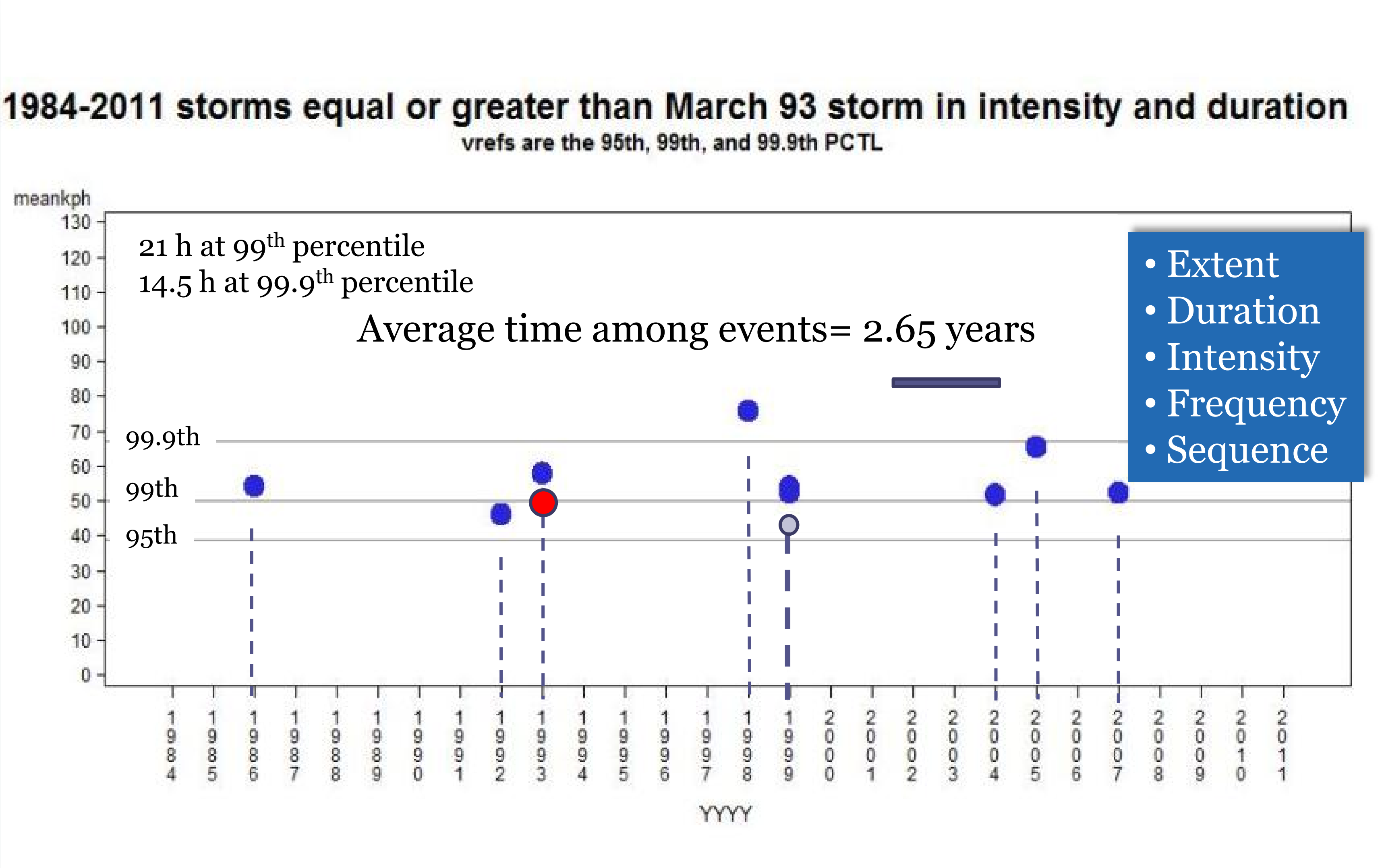
- Bioturbation / grazing
- Extreme events
  - Extent
  - Duration
  - Intensity
  - Frequency
  - Sequence



Coastal North Carolina
March, 1993
'Storm of the Century'



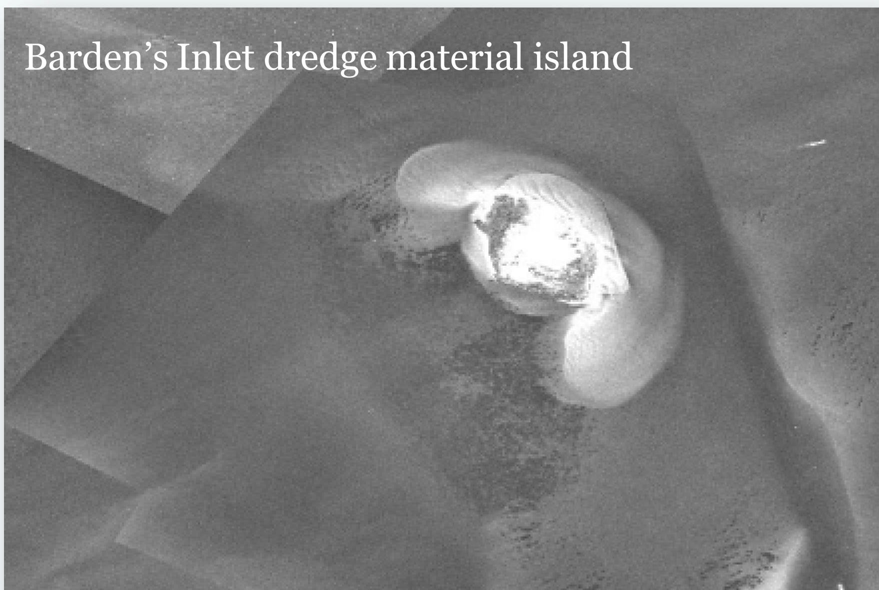
40 %
BR2
97 %
MML2
9 %
CCH1
22 %
HIH1
Wave + currents
Waves alone
Waves alone
Waves alone



1984-2011 storms equal or greater than March 93 storm in intensity and duration
vrefs are the 95th, 99th, and 99.9th PCTL
meankph
21 h at 99th percentile
14.5 h at 99.9th percentile
Average time among events= 2.65 years
99.9th
99th
95th
YYYY
• Extent
• Duration
• Intensity
• Frequency
• Sequence

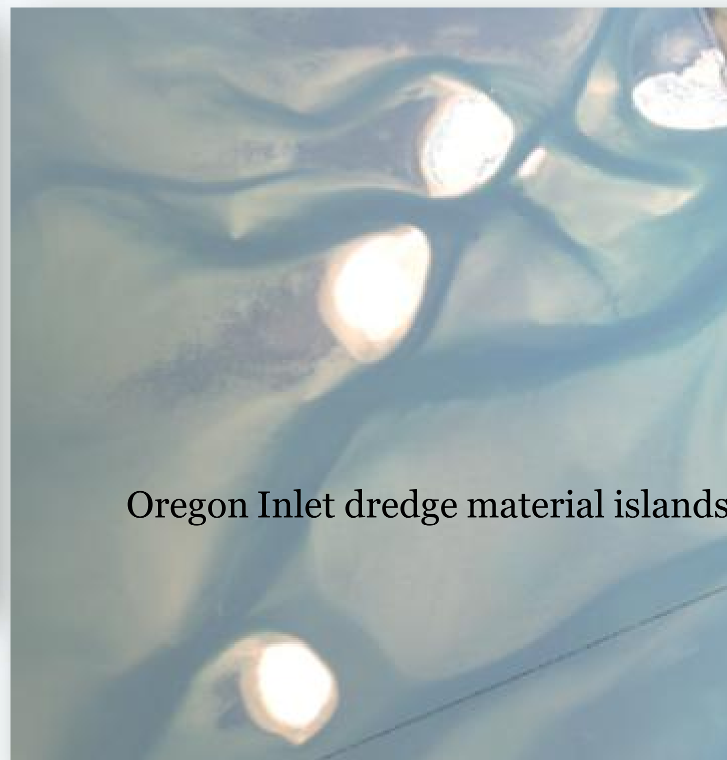
How Can We Use Landscape Information in Restoration?

- Reduce wave energy and bioturbation in patchy seagrass beds
- Facilitate bed coalescence & increase cover per unit area seafloor
- Create acre-years of seagrass service



Barden's Inlet dredge material island

North Carolina, USA



Oregon Inlet dredge material islands

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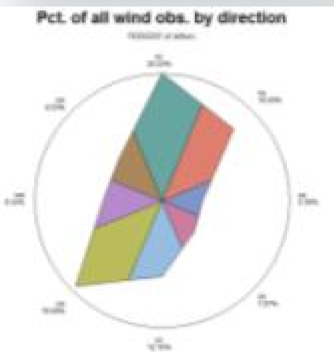
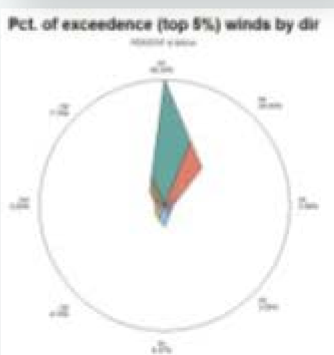
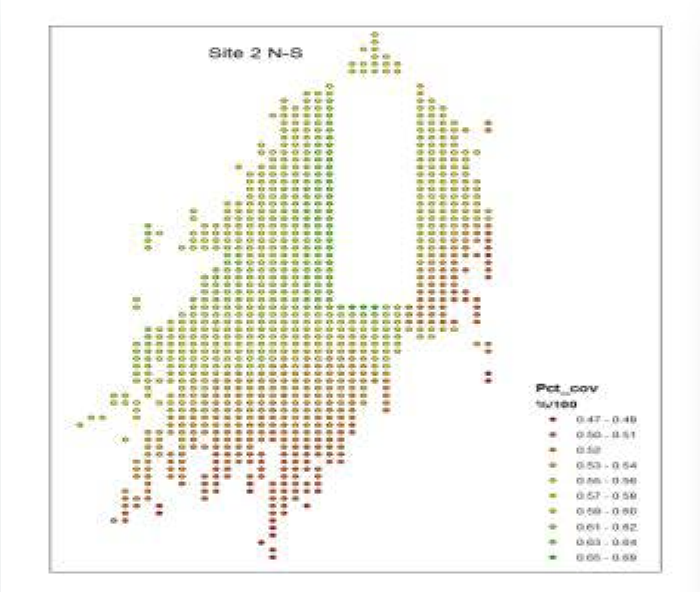
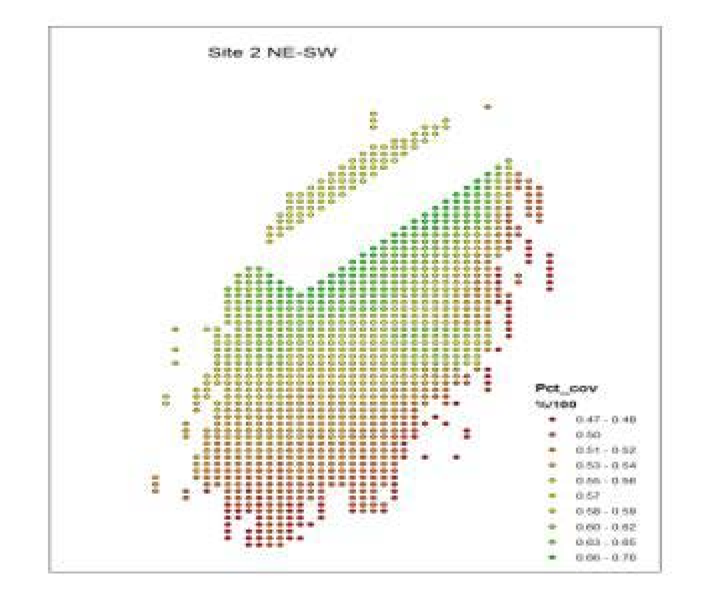
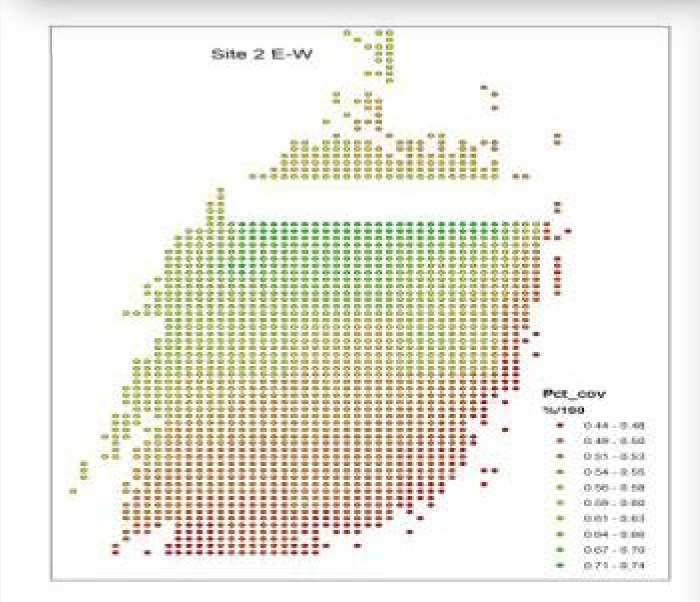
Permanently change factors controlling cover

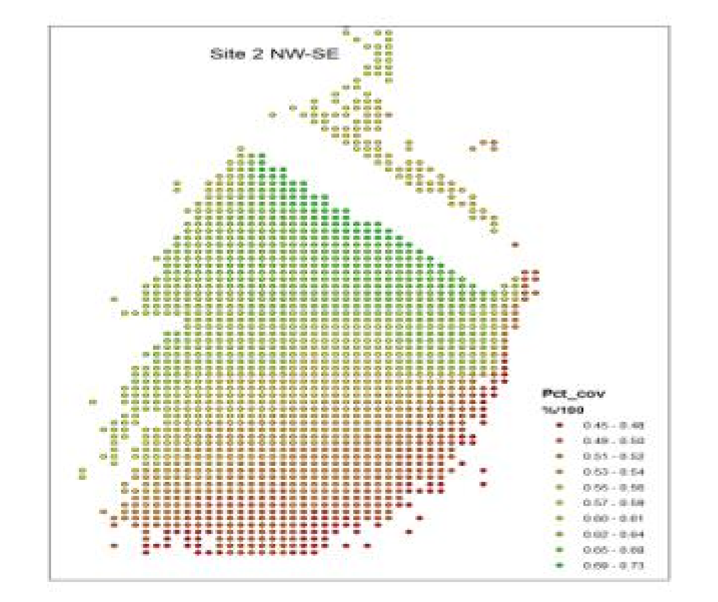


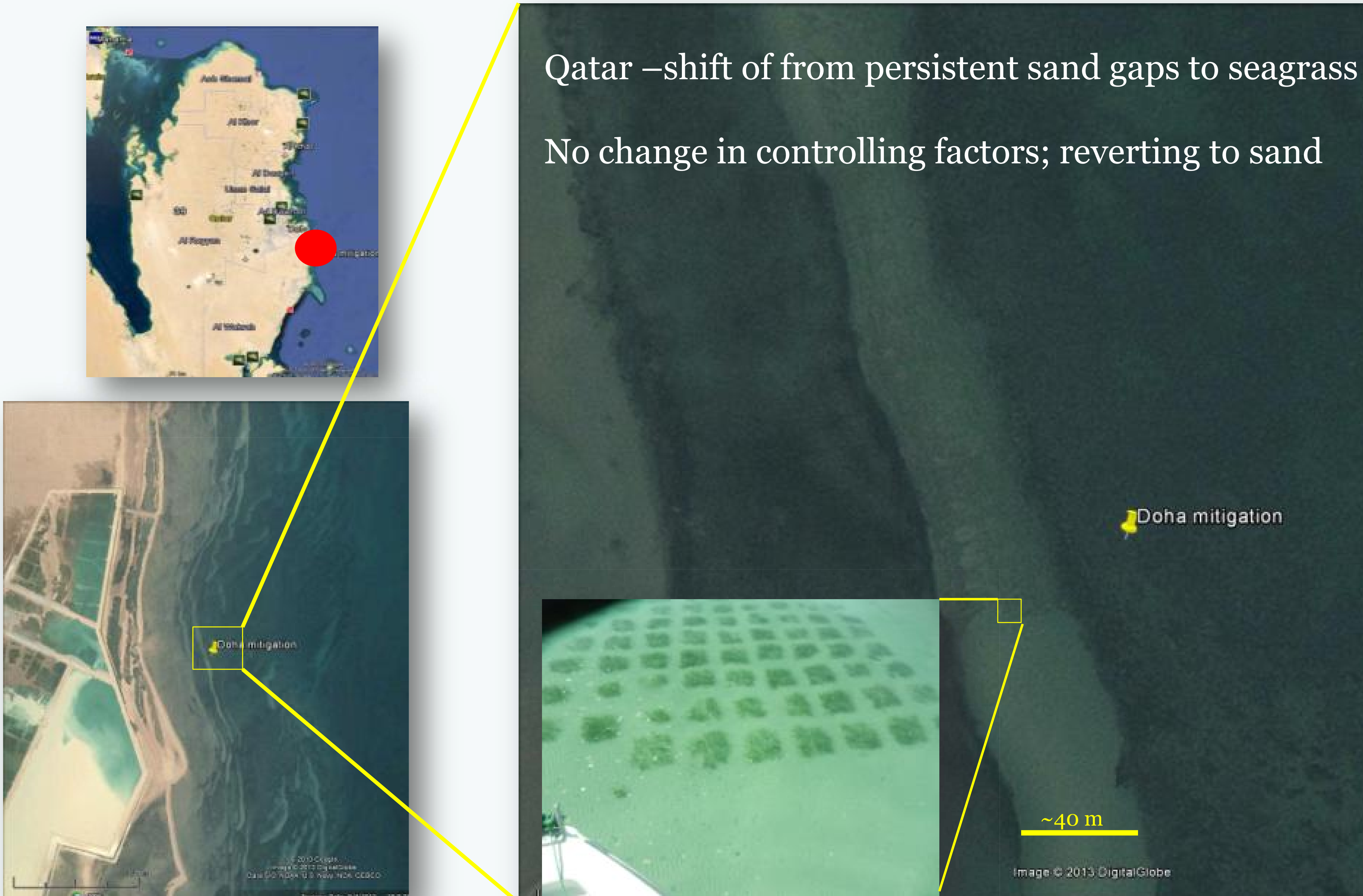








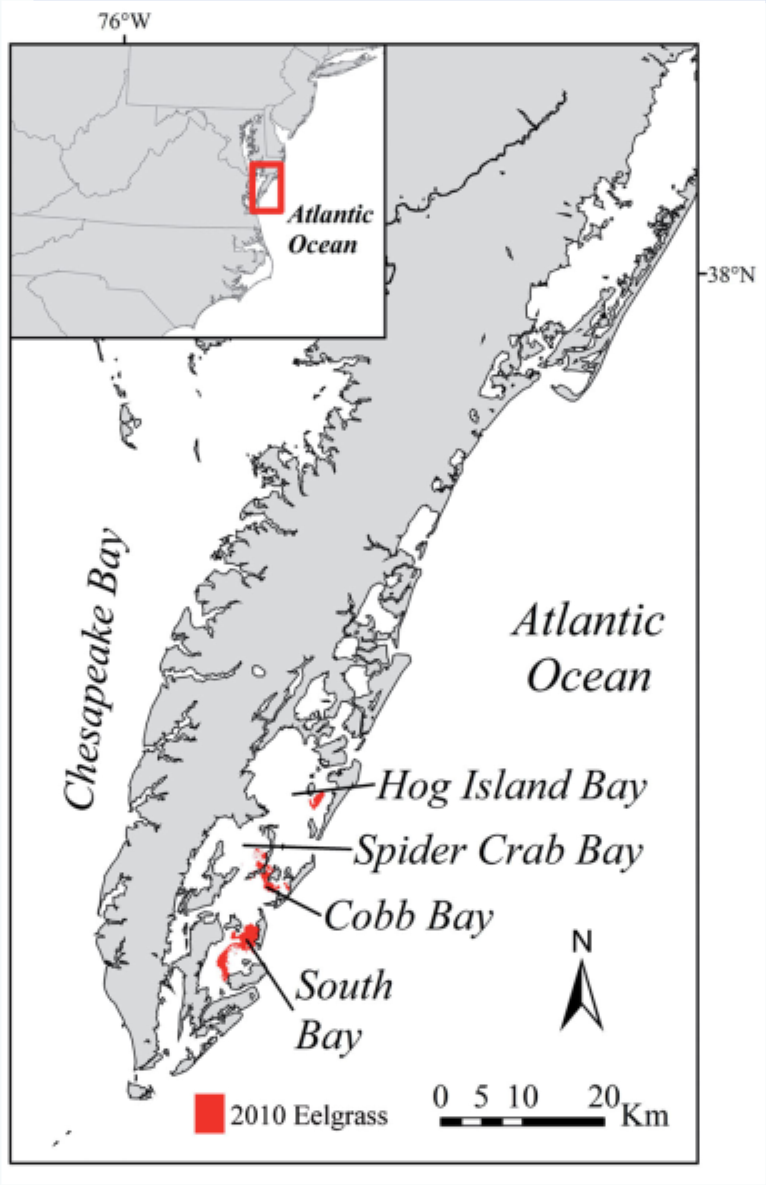



Qatar –shift of from persistent sand gaps to seagrass
No change in controlling factors; reverting to sand
Doha mitigation
Doha mitigation
~40 m
Image © 2013 DigitalGlobe

- Thousands of acres of eelgrass created from seed in the Virginia coastal bays
- Areas devoid of seagrass for decades
  - "we recommend that producing new habitat can be termed creation or enhancement whereas re-creating habitat that was present within historical records, **no matter how old**, should be termed restoration.'"

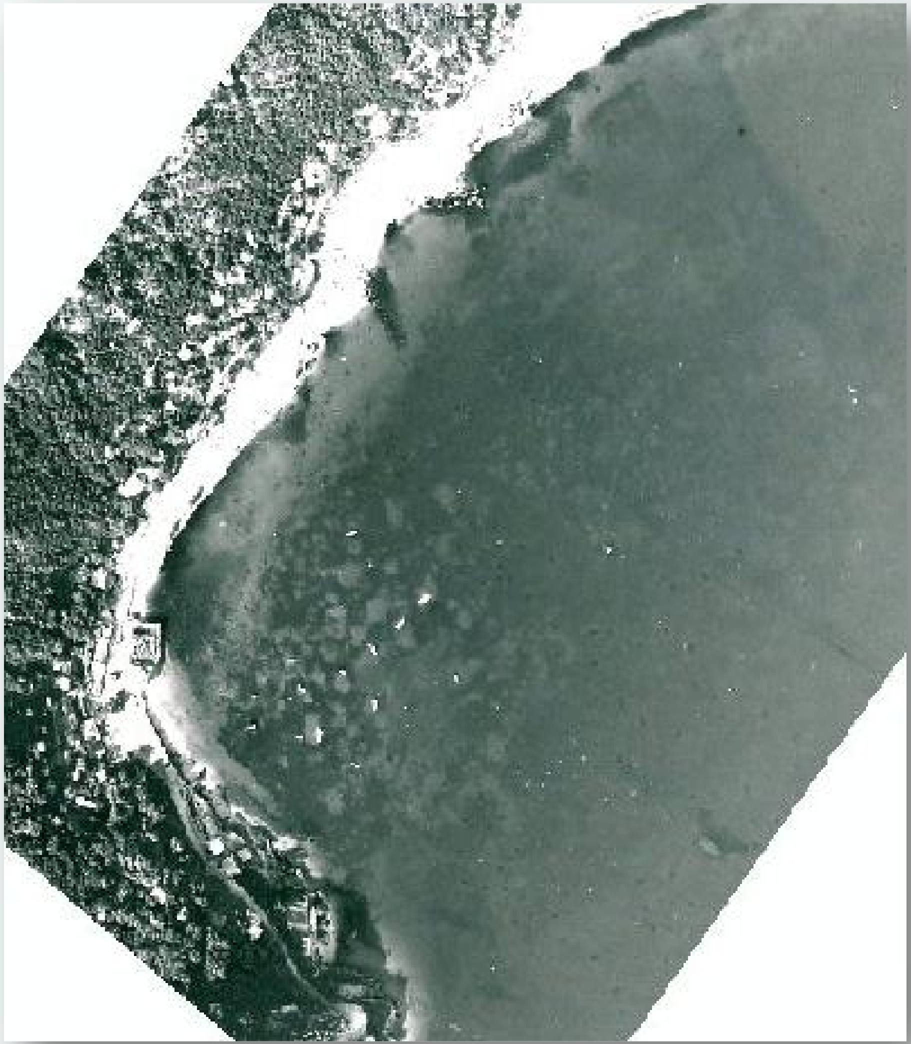
(emphasis added)

Orth and McGlathery 2012, citing Elliot et al 2007



Setubal, Portugal:

Changing Patch Size to Resist Biological Disturbance

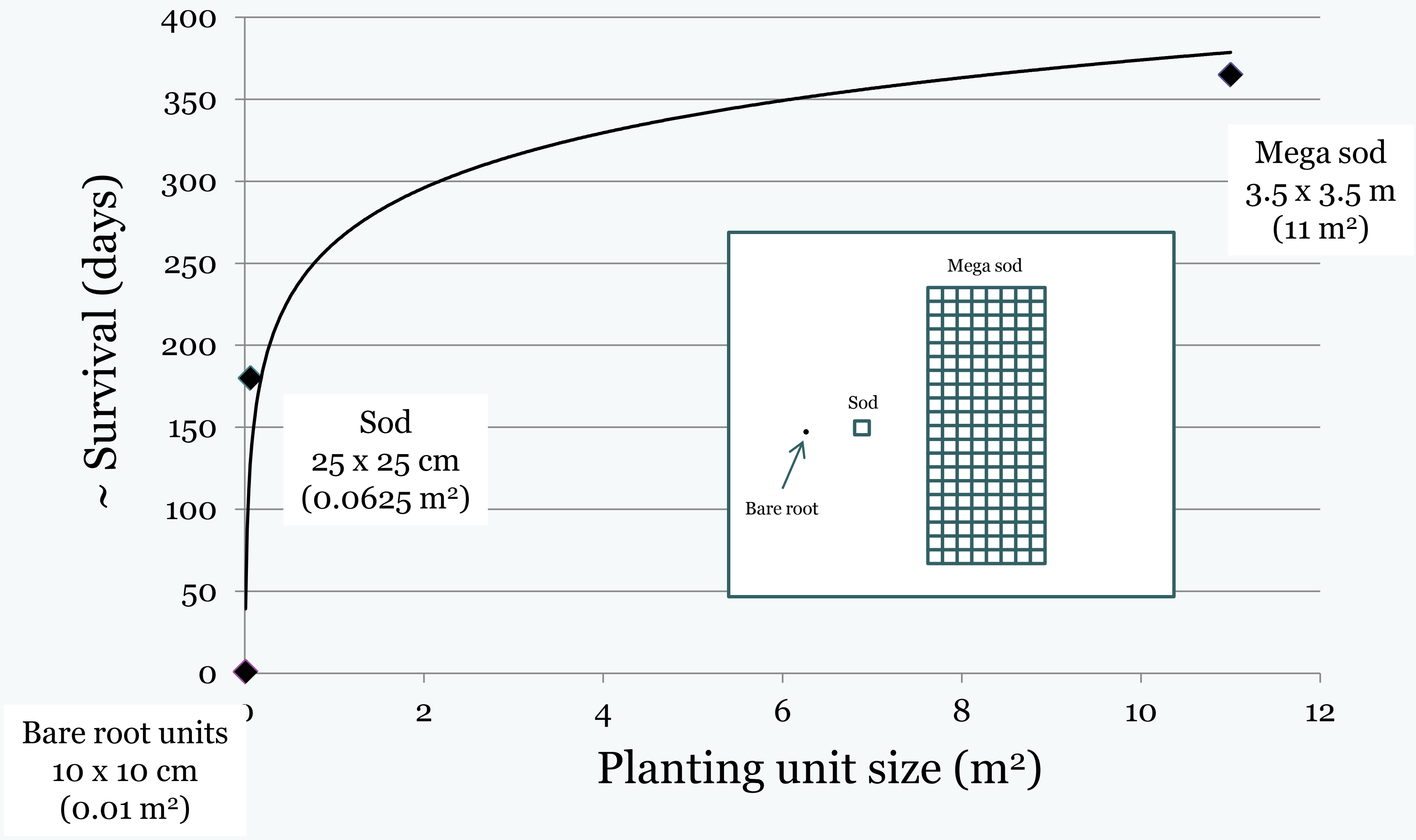


Portinho da Arrábida, Professor Luiz Saldanha Marine Park near Setubal, Portugal – circa 1974?

Setubal, Portugal:

Changing Patch Size to Resist Biological Disturbance

Planting Unit Size Affects Survival



Information Gaps

- Scale of action for resource managers
  - Obtaining baseline ahead of projects
  - Defining geographic scale of management units
  - Focus on higher governmental levels
- Guide restoration
  - How to chose planting stock
  - Success criteria for achieving genetic structure
  - SLOSS issues – linkages and seascape
  - Defining reference sites (controls)
- Define species
  - Defining range extensions vs. invasion


Courtesy A. Urhin

Lewis Environmental

CSA

Information Gap:
Annuals vs. Perennials

- We are biased towards large, long-lived seagrasses
- Acreage of annuals likely exceeds perennial seagrasses, but requires other metrics of persistence and thus, restoration
- Annuals: Highly labile and important food web contributors (~microalgae)
- A huge valuation and educational challenge
- Substantial management paradigm shifts

67. Seagrass beds in general, and Halophila johnsonni in particular, move around. They may be in one spot one year and in another (close-by) location the next.. Therefore, although seagrass may not be presently growing in a particular area, that area may be a potential site for such growth.

Flynn vs. FDEP
State of Florida
Division of Administrative Hearings
96-4737

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Information Gap:
Education

- Renewed effort at awareness
- Drinking from the fire hose
- Focused education of managers and regulators

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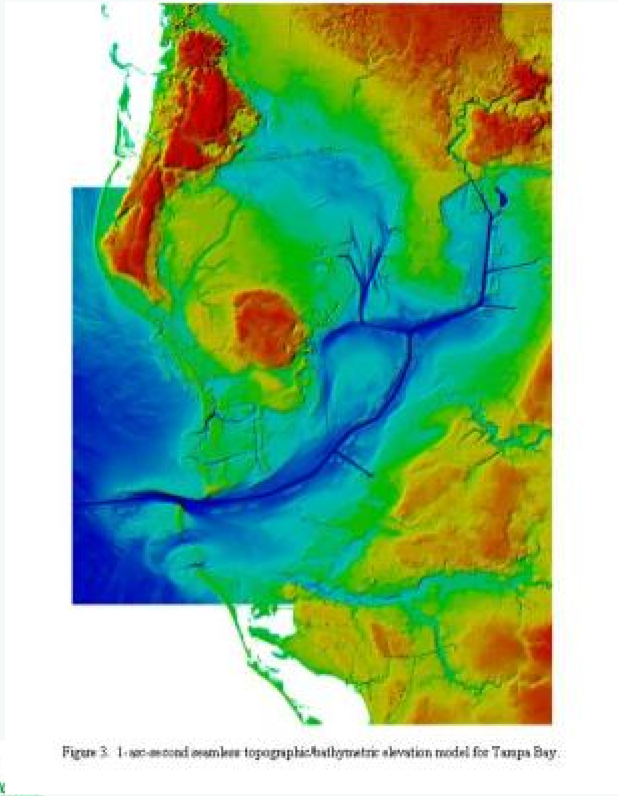
Information Gap:

Learn from Existing Data and Reports on Successes and Failures - 1

Tampa Bay, Florida, USA



Progress in Seagrass Recovery

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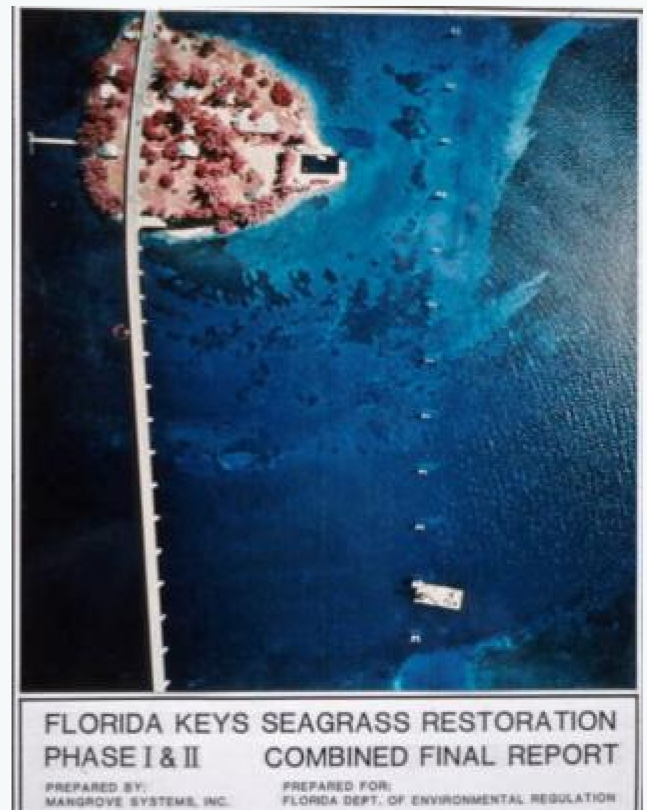
Information Gap:

Learn from Existing Data and Reports on Successes and Failures - 2

Florida Keys, Florida, USA

Data on Seagrass Restoration

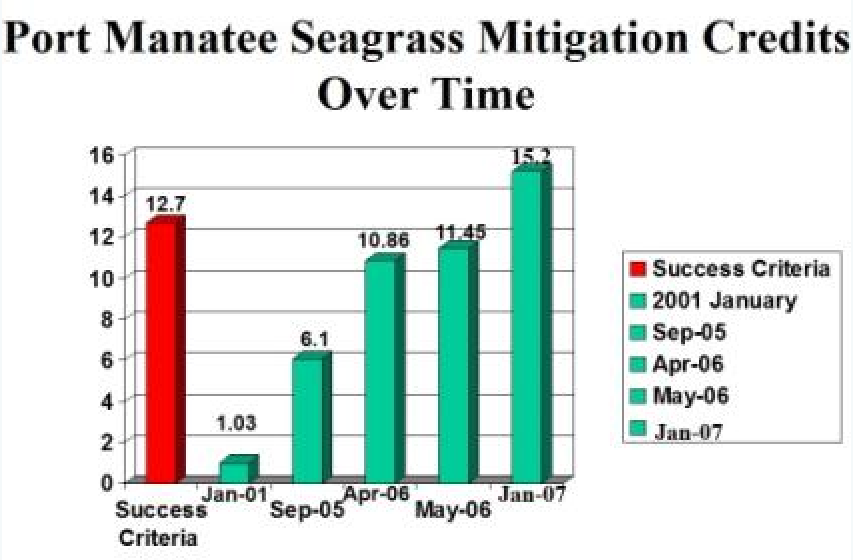


Information Gap:

Learn from Existing Data and Reports on Successes and Failures - 3

Port Manatee, Florida, USA

Credits for Seagrass Restoration



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Conclusions

- What are the challenges/opportunities into the 21st century?
  - Understanding disturbances, defining extremes, multiple interactions and "surprises" (bistability)
  - Forecasting site suitability – manipulate wave energy and/or bioturbation
  - Applying economics
  - Applying landscape principles – draw from terrestrial ecology – scale dependency studies
  - Using genetic information at the scale of action
  - Managing non-charismatic seagrass species

- Suggestions for direction
  - Student support
  - Media engagement
  - Managers (economists and general counsel on the science team)

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