AGENDA

9:00 - 9:15  WELCOME AND INTRODUCTIONS

9:15 - 9:30  Dr. Kiersten Madden, Mission-Aransas National Estuarine Research Reserve
Monitoring Mangroves: Applying the National Estuarine Research Reserve Approach to Texas

9:30 - 10:00 Tom Tremblay, Bureau of Economic Geology, University of Texas at Austin
Baseline Mapping for Mangrove Monitoring in the Coastal Bend, Texas Gulf Coast

10:00 - 10:30 Dr. James Gibeaut, Harte Research Institute for Gulf of Mexico Studies, Texas A&M University – Corpus Christi
Proposed Observatory for Understanding Coastal Wetland Change

10:30 - 10:45 BREAK

10:45 - 11:15 Dr. John Schalles, Creighton University
The Mangroves of Redfish Bay: Field surveys and high resolution imagery to map distribution, canopy height, and vegetation response to the February, 2011 freeze

11:15 - 11:45 Chris Wilson, University of Texas Marine Science Institute
Colonization and age structure of red mangrove (Rhizophora mangle) trees along the coast of Texas

11:45 - 12:15 Dr. Anna Armitage, Texas A&M University – Galveston
Ecological implications of black mangrove expansion into Texas salt marshes: Comparisons among marsh and mangrove habitats

12:15 - 1:00 CATERED LUNCH

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Habitat replacement by mangrove establishment: Implications for Whooping Crane use

2:00 - 2:30 Dr. Rusty Feagin, Texas A&M University - College Station
Historical Reconstruction of Mangrove Expansion in the Gulf of Mexico: Linking Climate Change with Carbon Sequestration in Coastal Wetlands

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  Richard Day, USGS National Wetlands Research Center
  Biogeography of black mangrove and freeze tolerance

  Ken Krauss, USGS National Wetlands Research Center
  Water use characteristics of black mangroves along the Northern Gulf Coast

  Erik Yando, University of Louisiana at Lafayette
  The belowground implications of mangrove forest migration: Plant-soil variability across forest structural gradients in TX, LA, and FL

  Mike Osland, USGS National Wetlands Research Center
  Winter climate change and coastal wetland foundation species: Salt marshes vs. mangrove forests

4:00 - 4:30  DISCUSSION

4:30 - 4:45  WRAP UP AND ADJOURN
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Discussion Notes

**Liz Smith:** Mangrove research needs to concentrate on finding funding that will allow for more information on the types of species that will be impacted by the conversion of salt marsh to mangrove structure; specifically, we need to figure out what will happen with snails, crabs, fish, etc. to get a handle on if the food web will shift, and how.

**Liz Smith:** Research into the potential impact of mangrove establishment higher in the estuary, given that we will have diminishing freshwater inflows (due to climate change, water use, etc.). We already have a narrow band of intermediate marsh, and a lower brackish area. If we lose that, will we have mangroves all the way into the delta? We need to look at the diversity of the system with regard to the replacement of marshes along the salinity gradient.

**Michael Osland:** We have a proposal into the Climate Science Center to quantify the relationship between precipitation and temperature on a gradient from the Florida/Alabama border to Mexico. At Liz's suggestion, we will look into making the Mission-Aransas and San Antonio bay systems Texas priority sites.

**Kiersten Madden:** There is a Gulf workgroup forming for mangroves – would it be possible to form a Texas working group?

**Tom Tremblay:** It might be a good idea to host a special session in conjunction with the 2014 Texas Bays and Estuaries meeting.

**Rusty Feagin:** What's the general consensus on mangrove expansion? If we were going to restore a site, would you plant mangroves?

**Anna Armitage:** We can't answer that question yet, because we don't know enough about the implications, costs, and what you gain or lose when you use mangroves in restoration projects. This is a broad area for future research – understanding how to manage these resources in response to mangrove expansion.

**Liz Smith:** I don't think that we should take mangroves out of the equation if we don't have a good understanding of the impacts yet. We also shouldn't be putting these opinions into our research designs. The public may have one opinion regarding mangrove expansion, but we don't know, and mangrove expansion may be something that we cannot change at all. With regard to whooping cranes, we want to know quantitatively and scientifically what the answer is. However, we need it soon, and we may have to make some management decisions before all of those answers are known.

**Jim Gibeaut:** I want to emphasize Liz's point about the fact that we may not be able to stop mangrove expansion. There are some good points to mangrove expansion: based on data from Rusty and others, the sedimentation rate from mangroves is higher than *Spartina*, and therefore they should be able to keep up with sea level rise better than marshes. Given the future rates for sea level rise, it might be a question of whether we have any kind of vegetation habitat rather than
simply open water. Having mangroves in the mix might maintain that intertidal vegetation habitat. More research is needed on mangrove expansion in the face of sea level rise and sedimentation.

**Chris Wilson:** People don’t necessarily see mangroves as a positive thing – they see mangroves as an invasive species. The ecotone is changing, and mangroves don’t directly cause the loss of salt marsh.

**Lauren Hutchison:** We’ve conducted focus groups and based on those preliminary results, people don’t know what mangroves are, and the only ones who do are recreational users of those areas.

**Rusty Feagin:** What about restoration managers? We are making large changes in physical landscape by agencies completing restoration projects (mitigation banks, etc.); there is a fair amount of wetland created. It could be possible that the ecosystem services from using mangroves are higher – maybe those services make the use of mangroves a net positive.

**Beau Hardegree:** That might be the case, but we shouldn’t be too hasty and put mangroves in all of our restoration projects. In the past, when mitigation occurs we haven’t used mangroves because mitigation is usually completed in perpetuity – mangroves freeze. New research is showing that mangroves don’t freeze and die off completely as previously thought, so we are looking at mangrove restoration as an option. However, we need to think about where we’re placing them – maybe they shouldn’t be planted in Whooping Crane habitat.

**John Schalles:** No one has brought this up yet, but does the expansion of mangroves present issues for human health and an increase of vector-borne diseases? Are there any implications for avian health? There is currently no research being done on this.

**Tom Tremblay:** There was a previous planting effort in Bajilla Grande when it was realized that Mother Nature was spreading mangroves better than any planting could. Maybe we don’t need to be promoting restoration projects using mangrove, because it will happen anyhow; if we have a choice, maybe we should plant *Spartina*.

**Kiersten Madden:** Do restoration practitioners know this?

**Beau Hardegree:** There’s a recent feeling that people are using mangroves for in-kind projects.

**Kiersten Madden:** Does that responsibility fall to you to make those decisions?

**Beau Hardegree:** Resource management agencies and the Army Corps of Engineers normally make the decision.

**Kiersten Madden:** We need a representative from the Corps here.

**Tom Tremblay:** Future research might look into morphology classifications (clumps, singular, linear formations along inlets) to determine if certain forms are less intrusive than others. We are also currently focusing a lot on Harbor Island, which could possibly be a unique case because of its origin as a relic-ed tidal fan delta, which is unusual for the proliferation of mangroves. There are other forms of expansion (linear, etc.) found elsewhere. We need more research in general, not just here in Harbor Island.
Monitoring Mangroves
APPLYING THE NERRS APPROACH IN TEXAS

Kiersten Madden
Stewardship Coordinator
Mission-Aransas National Estuarine Research Reserve

Mission-Aransas Reserve
The Mission-Aransas NERR brings together scientists, landowners, policy-makers, & the public to ensure that coastal management decisions benefit flora & fauna, water quality, and people.

Sectors
- **RESEARCH**: Improve understanding of Texas coastal zone ecosystem structure and function
- **STEWARDSHIP**: Promote public appreciation and support for stewardship of coastal resources
- **EDUCATION**: Increase understanding of coastal ecosystems by diverse audiences
- **TRAINING**: Increase understanding of coastal ecosystems by coastal decision makers

Research
System Wide Monitoring Program

System Wide Monitoring Program
Standardized Protocols

The NERRS monitoring protocol for vegetation communities is designed to:

1. Quantify vegetation patterns and their change over space and time;
2. Be consistent with other monitoring protocols used nationally and worldwide;
3. Be consistently used over a wide range of estuarine sites and habitats, and for a variety of reserve specific purposes;
4. Be used as a foundation for quantifying relationships among the various edaphic factors and the processes that are regulating the patterns of distribution and abundance in these communities;
5. Provide detailed information that can be used to support comprehensive remotely sensed mapping of vegetation communities and other NERRS System Wide Monitoring Program data collection, as well as NERRS/NOAA education, stewardship and restoration efforts.

Vegetation Monitoring Protocol

Mangrove Protocols

Sampling Site

Mangrove Protocols
Trunk Height

Average Trunk Height (cm)

Transect 1

Transect 2

Transect 3

Transect 4

Transect 5

GTM Reserve

2 Transects per site

Transects (2 per site):

I. Whole Plots, 10 x 10 m — 5 evenly spaced
II. Sub-Plots, 1 x 1 m — 5 within each whole plot
III. Individual Mangrove Trees — 10 ind / app / whole plot

Is annual monitoring sufficient?
Do we need to be monitoring this many “individuals”?
Is the GTM approach better suited for this type of mangrove habitat?

What’s the best approach?

Kiersten Madden, Ph.D.
Stewardship Coordinator
Mission-Aransas NERR

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Sentinel Sites

Focused on understanding changes in sea level and inundation and the associated responses of marsh, mangrove, and submerged aquatic vegetation.
Sea Level
Upland
Initial Wetland Surface

Bench Mark with
Geodetic Control
(NAD88, etc.)

Surface Elevation
Table (SET)

Tide Gauge

Elevation Change

Surface
Accretion

Initial Wetland Surface

Upland

Marker
Horizon

Shallow
Subsidence

Deep Subsidence

Observed Changes

- 1930: 25%
- 1979: 58%
- 1995: 39%
- 2004: 58%

From: Montagna et al., 2011
Baseline Mapping for Mangrove Monitoring in the Coastal Bend, Texas Gulf Coast

Thomas A. Tremblay
Bureau of Economic Geology, UT
Amy L. Neuenschwander
Applied Research Laboratories, UT
Daniel Gao
Texas General Land Office
Erosion 1950s-1979
Erosion 1979-2001
Accretion 1950s-1979
Accretion 1979-2001
0 1 2 3 4 5 Kilometers
Conclusions

- Salt marsh and mangroves have been increasing in area since the mid-1950’s with marshes increasing at higher rates.
- Within the washover fan/tidal delta complex on San Jose Island, marsh is expanding with a net loss of low marsh and a net increase of high marsh.
- Wetland change is probably caused by relative sea level rise where low marsh is inundated and high marsh moves into flats or upland.

Summary

- Focus on Matagorda Island and San Jose Island.
- Dynamic area affected by sea-level rise and erosion/accretion, with wetland trends similar to those found on much of the Lower Texas Coast.
- Objective is to establish methods and protocol for automated mangrove monitoring using the hyperspectral platform.
The End...?

The Order of the Straight Arrow

Season 1, episode 3
Proposed Observatory for Understanding Coastal Wetland Change

James Gibeaut
Harte Research Institute for Gulf of Mexico Studies
Texas A&M University – Corpus Christi

Barrier Island Environments

- Interior upland
- Salt flats
- Algal flats
- Intertidal marsh
- Mangroves
- Seagrass

Wetland Transition Model

1. DEM (original)
2. Classify habitat types (elevation)
3. Habitat grid
4. Future dates reached?
5. Yes
6. No
7. Adjusted DEM
8. Habitat grid
9. 1-year loop
10. Apply vertical accretion adjustment
11. Habitat grid
12. Output habitat grid
13. Compute terrestrial forest growth
14. Maps, histograms, graphs

Wetland Response to Sea Level Rise

Sediment Supply

- High
  - Organic high
  - Mineral low
- Low
  - Organic low
  - Mineral high

Slope to Terrestrial Forest Growth

Processes Affecting Marsh Elevation

- Elevation
- Mineral and organic ground plant processes
- Sediment supply
- Hydroperiod
- Root zone
- Soil volume
- Auto compaction
- Deep subsidence
- Consolidated basement

Topographic relationship of habitat types

Graph showing sea level change with habitat types.
Observatory

Aerial multi/hyper spectral imagery, photography and Lidar

Terrestrial Lidar & Microsoft Kinect sensor

RTK transect survey & Deep set benchmark

Surface Elevation, Tables

Water-level loggers

Transect photography and sampling

Marker horizons

Wetland Observatory

Airborne lidar for topographic mapping

Detection and removal of shrubs and building

Vegetation mapping

• Aerial photography
• Multi/hyperspectral

Elevation control: deep set benchmarks

Image credit: Greg Hauger
Record vegetation height and type

Real-time Kinematic Surveys

Transect monitoring of wetland vegetation change

Terrestrial Laser for topographic mapping

Surface Elevation Tables (SET) for measurement of elevation change

Future Exploration: low-cost lidar sensor

Microsoft Kinect
- IR projector & camera for depth map
- 30 cm to 15 m range
- Spatial resolution ~7 mm at 5 m
- Cheap < $150, open source tools

Potential Metrics
- Micro-topography time series
- Water inundation
- Near-IR & RGB camera

Challenges
- Field deployment
- Power, environmental conditions
- Will change signal be detectable?
- Telemetry
Marker horizons for measurement of sedimentation rates

Coring for accretion measurements

- **Field Methods**
  - Coring & compaction
  - GPS observations

- **Lab Methods**
  - Grain size analysis
  - Bulk density
  - Gamma spectroscopy
  - Cesium (Cs) 137

 Accretion Rate Calculation

\[
\text{Accretion Rate} = \frac{\text{Depth to 137Cs Peak}}{\text{Years since 1963}}
\]

- Is 1963 peak present and above minimum detectable activity (is it really there)?
- Correct peak depth for grain size influence
- Correct peak depth for core compaction

Water-level measurements

Marker horizon locations

Total of 168 Marker Horizons

Wetland Observatory

Aerial multi/hyper spectral images, photography, and LIDAR
Terrestrial LIDAR & Microsoft Kinect sensor
RTK transect survey & Deep set benchmark

Surface Elevation Tables
Marker horizons
Water level loggers
Transect photography and sampling
Relative Sea-level Rise

Mustang Island Inundation by Year 2100
Based on IPCC (2007) sea-level rise projections plus local land subsidence estimate

Accretion Rate Calculation
- Accretionary deficit makes wetland susceptible to submergence
- Higher environments at higher risk
- **Marsh** accretion is directly correlated with elevation

Source: Gibeaut et al. (2009)
The Mangroves of Redfish Bay: Field Surveys and High Resolution Imagery to Map Distribution, Canopy Height, and Vegetation Response to the February, 2011 Freeze

John Schalles1, Alista Hart2, Adam Altrichter3, and Eryn Carpenter1

1Creighton University, Omaha, NE
2Loyola University, Chicago, IL
3Virginia Tech, Blacksburg, VA

JohnSchalles@creighton.edu

Spring Break Research Trip:
• Depart Omaha early AM Sat, Mar 5
• First night lodging ~ North Texas
• Arrive Port Aransas, TX in PM, Sun, Mar 6
• Field work at Mission Aransas NERR from Mon, Mar 7 to Thurs, Mar 10 and housing (tentative) at U.T Marine Inst. apartment
• Drive to Grand Bay, MS on Fri, Mar 11 drop boat off, overnight stay at GB NERR
• Depart in AM on Sat, Mar 12
• Last night lodging ~ SE Missouri
• Arrive back in Omaha in early evening on Sunday, March 13

We’re Pleased to Acknowledge Help From:
• Field Surveys: Anna Armitage, Wayne Carpenter, Tyler Craven, Kiersten Madden, Shanna Madsen, Tyler Monahan, John O’Donnell, John Oley, Drew Seminara, Liz Smith
• AISA Eagle hyperspectral imagery and initial processing: Rick Perk, Paul Merani & Don Rundquist (CALMIT – Univ. Nebraska); Jeffrey Vincent (University of Texas – Austin)
• Field logistics, and explanations of Texas coastal ecology: Sally Morehead, Kiersten Madden, Dennis Pryden, Liz Smith, Wes Tunnell, John Woods, Ed Zielinski, Captain Frank
• Financial and logistical support: NOAA-NCCOS Environmental Cooperative Science Center, Texas Parks and Wildlife, Mission-Aransas NERR, University of Texas Marine Science Institute, NASA Nebraska Space Institute

Outline for My Presentation
• Airborne Imaging Campaign at Mission-Aransas NERR in 2008 with CALMIT-University of Nebraska AISA-Eagle Sensor
• Mapping products for research and management at MANERR and imagery processing work-flow
• Field Survey Methodologies – transect approach used in July, 2008
• Delineation of Black Mangrove stands in Redfish Bay, and VARI-green algorithm for estimation of canopy height
• Follow-up field survey work in 2011 and detection of significant mangrove freeze damage and gradient of damage
• January, 2013 site revisit to evaluate mangrove recovery and above-ground regrowth patterns
• Conclusions and next phases of our geospatial work at MANERR, including seasonal WorldView 2 satellite imagery in 2015.
AISA – Eagle Flight Line Mosaic
Aransas NWR and inshore waters
October, 2008
CALMID-University of Nebraska
Creighton Geospatial Analysis Lab

Schalles & Hladik, 2012, Israel Journal Plant Science: VIS and IR Spectroscopy in Plant Science


Figures showing GPS point (yellow) and actual location (red). Also the field collection of GPS points on a narrow peninsula of land is a natural feature that is useful for testing accuracy.

Black Mangrove (Avicennia germinans) Image versus In-Situ Endmembers

AISANS NWR
CHL μg/L
0.0 – 5.0
5.0 – 10.0
10.0 – 15.0
15.0 – 20.0
20 – 30
30 – 40
40 – 50
50 – 60
60 – 80
80 – 100
100 – 120
120 – 140
140 – 180

Aransas NWR
NOAA-ECSC AISNA Imagery
October, 2008
Provisional Aboveground Plant Biomass
g dry wt/m²

In-Situ (narrow FOV of leaves)
Image Spectra
Example of flight line imagery, flown as NE / SW diagonals in parallel tracks with ~30% overlap (imagery acquired in late October, 2008)

Imagery Acquisition
- In October, 2008, 1m hyperspectral images were obtained with an AISA Eagle at MANERR
- These images were then processed using ENVI software
  - Masking: all non-mangrove components were masked out
  - The GVI Vegetation Index was applied to assess plant density/canopy height, using Band Math in ENVI:
    \[ \text{GVI} = \frac{(\text{Green} - \text{Red})}{(\text{Green} + \text{Red} - \text{Blue})} \]
  - Color Density Slicing used to display different size classes


1. NDVI: \( \frac{R_{\text{NIR}} - R_{\text{red}}}{R_{\text{NIR}} + R_{\text{red}}} \)
2. Green VARI: \( \frac{(R_{\text{green}} - R_{\text{red}})}{(R_{\text{green}} + R_{\text{red}} - R_{\text{blue}})} \)
3. NIR / GRN: \( \frac{R_{\text{NIR}}}{R_{\text{green}} - 1} \)

AISA Bands
- Blue: 8 (463 nm)
- Green: 18 (554 nm)
- Red: 31 (675 nm)
- NIR: 50 (856 nm)
Survey transects & AISA imagery

- 8 transects: 3 x 22 m
- 22 plots per transect
- 1 m² plots outlined with PVC frame
- Checkerboard pattern
- Nadir digital photography
- 6 measures of canopy height per plot
- Estimations of percent cover by plant species and other habitat conditions

Redfish Bay Subscenes
- Gvari Index was the best predictor of canopy height (R² = 0.583)
- Median canopy height for all mangrove pixels was approximately 78.5 cm
- Mangroves were generally taller near larger channels and lagoons (older specimens and/or more favorable for growth?)
Initial histogram of Black Mangrove canopy height frequency distribution at Redfish Bay. Note: taller trees are not being properly captured in this analysis, but median size appears realistic based on 2008 and subsequent field surveys.

Estimated median canopy height 78.5 cm

Freeze Damage Encountered in March, 2011

- We discovered extensive areas of mangroves killed by 2 hard freezes in early February, 2011
- A gradient of decreasing damage was documented from north to south in Redfish Bay
- Damage patterns and recovery were analyzed by comparing new high resolution satellite imagery with our 2008 baseline map and transect data

Comparison of (L) December, 2009 versus (R) November, 2011 (upper – Traylor; lower – Harbor)

Shellbank Island Site
Intermediate Damage Site at Redfish Bay
First Survey in January, 2013 – Eryn Carpenter
**Example of Vegetation Fraction Calculation**

1. Load field digital photograph (shown here is frame DSC00069 taken by Eryn Carpenter at Traylor Island North; Transect 1 – Plot 19, Canopy Heights: 85 cm – dead, 57 cm – live) (27° 57’ 14.094” N, 97° 4’ 24.930” W)

2. Process through “Veg Fraction” custom software (Bryan Leavitt, CALMIT - Univ. of Nebraska) to identify green pixels as fraction of all pixels in the image.

3. In this case, the fraction was 0.450 (45.0% of 262,144 pixels; range across all calculations for 7 transects in January, 2013 was 0.069 – 0.758)

**Conclusions and Next Steps**

* Most of “suitable” wetland habitat in Redfish Bay is now colonized by Black Mangrove; herbaceous vegetation cover generally less than 5% or non-existent

* Median canopy height of mangroves estimated at 78.5 cm; our technique and VARI-green algorithm is underestimating the rather limited but important occurrence of taller plants (esp above ~ 1.8 m)

* The Coastal Bend Black Mangroves appear to be quite “hardy”, and are recovering rapidly in areas of severe damage in 2011 freeze event

* In 2015, the NOAA-ECSC and MANERR plan to acquire 3 sets of World View 2 imagery in winter, early, and late growing seasons (2 m pixels, 8 bands – very useful for detailed spatial mapping at substantially lower cost than our AISA-Eagle system)
The colonization and age structure of red mangrove (R. mangle) trees along the coast of Texas

Christopher Wilson, Kimberly Jackson and Kenneth Dunton

Worldwide Mangrove Distributions

Most recent northern limit described for R. mangle (29° 42' 90' N) by Zomlefer et al. (2006).

Harbor Island, Texas lies at 27° 51' 40' N!

How is this plant boundary enforced?

Frozen Mangrove = Dead Mangrove

Red Mangroves in Texas

Continuous account in Texas since 1980's:
- Sherrod et al. 1986
- Tunnell 2002
- Montagna et al. 2007
- Montagna et al. 2011 (Pictures)

Sherrod et al., 1986
Methods: Survey Location

Methods: Aging Mangroves

Calculating Node Production Rate

Survey Results: Demographics

Why the recent plant explosion?

Mangrove Growth: Juvenile Reserves

*Plant and Wait*
- 4 propagules were planted in UTMSI WEC
- Plantings included sun and shade plots
- After two years, the total node number was quantified for each plant
- The node production rate (4.08 ± 0.74 nodes year⁻¹) was used to extrapolate tree age

* Error becomes larger as you extrapolate further in time

r² = 0.94
Annual growth rate = 0.31

Reserves likely supplement plant growth during initial year of establishment
Mangrove Growth: Annual Patterns

Although mangroves exhibit indeterminate growth, red mangroves in TX have a pronounced annual signal that is subject to perturbation.

Mangrove Growth: Rate and Maximum

Red mangroves typically achieve site-specific maximum canopy heights (TX < 3m).

How cold is too cold?

Infrequent freezing temperatures are likely limiting the maximum canopy height of red mangroves.

New Hypothesis Alert: Black mangrove trees facilitate the expansion of red mangrove trees through insulation.

Documented Mangrove Facilitation

How did R. mangle get here?

- Propagules are positively buoyant
- Prevailing SW winds in spring and summer
- Numerous eddies spinning off of loop current
- Harbor Island is easy target
Future Directions in Research

1. Persistence and Reproduction
   a. How cold is too cold?
   b. Quality and quantity of propagules

2. Trajectory of population
   a. Carrying capacity TBD
   b. Reproduction vs. immigration
   c. Potential to serve as a source population

3. Nutrient Cycling
   a. No soil aeration?
   b. OM likely different

4. Fauna
   a. Canopy
   b. Intertidal structure

Questions?
Ecological implications of black mangrove expansion into Texas salt marshes: Comparisons among marsh and mangrove habitats

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Habitat change in Texas: One perspective

- Has vegetation composition in Texas coastal wetlands changed?
  - Where?
  - By how much?
  - On what time scale?

→ One perspective: Use of remote sensing to identify “hot spots” of expansion over the last 20 years (courtesy W. Highfield, TAMUG)

Mangroves expanded by 74%
Marshes decreased by 24%

- Gulf of Mexico coastal wetlands are transitional between marshes and mangroves
- Mangrove expansion rate may be accelerating
  - Temperature (Osland et al. 2013)
  - Sea level rise (Doyle et al. 2010)
  - Atmospheric CO₂
  - Herbivory
  - Other stressors

Has vegetation changed?
Yes!

Landsat TM 5 images from 1990 and 2010
- Used Artificial Neural Networks to classify 10 land cover types
  - Specifically targeted black mangrove (Avicennia germinans) and salt marsh (various species) coverage

Selected Changes
1990 - 2010
- Saltmers to Mangrove
- Salt Marshes to Other - Water
- Salt Marshes to Other - Vegetation
- Salt Marshes to Wetland
- Salt Marshes to Substrate
- Salt Marshes to Wetland
Mangrove increase

- Mangroves increased by 74%
  - 16 km² increase
- Mostly conversion from:
  - Upland pasture – indicates upland migration of salt marsh?
  - Salt marsh
  - Other wetland
  - Water – probably salt marsh at low tide in 1990
- Mangroves expansion occurred in areas of marsh or upland

Marsh decrease

- Salt marshes decreased by 24%
  - 77.8 km² decrease
- Mostly converted to:
  - Upland pasture
  - Water – submergence
  - Other wetland
  - Bare
- Only 7.7% of the salt marsh loss was due to mangrove expansion
- Mangrove area small relative to marshes
- Marsh loss largely due to habitat loss

Questions

- Mangroves are increasing, marshes are decreasing
- What are the species- and process-level implications of these vegetation shifts?
- Are there ecological differences between marsh and mangrove habitats?
  1. Comparisons among stands of marshes and mangroves
  2. Experimental mangrove removal/marsh revegetation

Approach

- Study sites in “hot spot” of expansion, Port Aransas vicinity
  - 3 marsh
  - 4 mangrove-dominated (mix)
- Advantage: Communities established
- Disadvantage: Spatial separation
**Approach**

- Transects along elevation gradient perpendicular to shoreline
  - Used relative elevation as a covariate
  - Marshes had slightly higher elevation at upper end
- Sampled edaphic, vegetation, and nekton characters in Sept. 2012
  - 5 evenly spaced stations:
    - Soil: moisture, salinity, CNP, pH, mV
    - Plant presence/absence every 10 m
    - Nekton in seine nets at water's edge
      - Pit traps
      - Light traps

**Edaphic characteristics: grain size**

- Mangrove sites sandier
  - Located on barrier island
- No elevation change

**Edaphic characteristics: sediment CNP**

- Soil P higher in marsh sites
  - No significant elevation pattern
- C and N higher in marsh sites, but not significantly
- Nutrient availability may be linked to sediment and/or vegetation type
- Nitrogen competition between *Avicennia* and *Spartina* (McKee & Rooth 2008)
  - P competition?
  - Analyses of leaf tissue ongoing
  - Concurrent enrichment experiments

**Edaphic characteristics: elevation gradient**

- Soil moisture decreased at higher elevations
  - No vegetation type effect
- Other soil characters that varied only with elevation:
  - Soil salinity (↑)
  - Redox (↑)
- pH not affected by elevation or vegetation type

**Vegetation characteristics: Richness**

- Species richness similar
  - No habitat type effect
  - No elevation gradient

**Vegetation characteristics: Composition**

- Species composition distinct at low elevation
Vegetation characteristics: Composition

High elevation

- Species composition heterogeneous at high elevation

Nekton characteristics

- Abundance and richness similar
- Composition different... May be linked to seagrass density

Summary

- Edaphic characteristics:
  - Few differences definitively linked to vegetation type
  - Some elevation patterns
- Vegetation:
  - Richness similar, composition different, especially at low elevation
  - Ongoing studies: Linked to processes such as accretion, nutrient storage?
- Nekton:
  - Richness and abundance similar, composition different
  - Linked to seagrass?
  - Ongoing studies: trophic relationships

Next steps

- Still many questions left to be answered!
- More sites, wider spatial array
- Seasonal measurements: plant and fishery productivity
- More process- and ecosystem-level measurements
- Integrate with experimental approach

Acknowledgements

Funded by Texas Sea Grant (NOAA)
Ecological implications of black mangrove expansion into Texas salt marshes: Insights from a large-scale mangrove removal experiment

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University of Houston
Texas A&M University, Galveston

Thank You Texas Sea Grant!

Mangroves are expanding

Natural versus manipulative experiments

- Natural - large spatial and temporal scale
- Experimental - better control of confounding variables
Selected experimental plots after mangrove clearing: A: Plot 2 (0% mangrove cover); B: Plot 9 (11% mangrove cover); C: Plot 8 (44% mangrove cover).

Plant percentage cover (by species) in the experimental plots before the mangrove clearing. Data shown are averages of the 84 1×1m quadrats in each plot.

Changes in percentage cover for *Batis maritima* and *Salicornia virginica* before (in May 2012) and after (in November 2012) mangrove tree clearing in plot 2 (0% mangrove cover plot; cleared in July 2012). Data are means ± SE.

Before (2012) data for soil water content, porewater salinity, organic content.

After data to be collected summer 2013.
Daily average wind speed across plots before mangrove tree clearing (June 5-July 5, 2012). Data are means ± SE. Analyses only included wind data with wind directions from channel into each plots.

One-way ANOVA $P=0.26$

Average wind speed across plots after mangrove tree clearing (September 10-November 10, 2012). Analyses only included wind data with wind directions from channel into each plots.

One-way ANOVA $R^2=0.73$ $P<0.01$

Standard deviation (SD) of wind speed across plots before mangrove tree clearing (June 5-July 5, 2012). Analyses only included wind data with wind directions from channel into each plots.

SD of wind speed (m/s) $P=0.70$

Standard deviation (SD) of wind speed across plots after mangrove tree clearing (September 10-November 10, 2012). Analyses only included wind data with wind directions from channel into each plots.

SD of wind speed (m/s) $P=0.70$

Daily average air temperature at 1m aboveground across plots before mangrove tree clearing (June 5-July 5, 2012). Data are means ± SE.

One-way ANOVA $P=0.37$

Daily average air temperature at 1m aboveground across plots after mangrove tree clearing (September 10-November 10, 2012). Data are means ± SE.

One-way ANOVA $P=0.64$
Standard deviation (SD) of air temperature at 1 m aboveground across plots before mangrove tree clearing (June 5-July 5, 2012). 

Daily average air relative humidity at 1 m aboveground across plots before mangrove tree clearing (June 5-July 5, 2012). Data are means ± SE.

Standard deviation (SD) of air relative humidity at 1 m aboveground across plots before mangrove tree clearing (June 5-July 5, 2012).

Daily average air relative humidity at 1 m aboveground across plots after mangrove tree clearing (September 10-November 10, 2012). Data are means ± SE.

Standard deviation (SD) of air relative humidity at 1 m aboveground across plots after mangrove tree clearing (September 10-November 10, 2012).
Conclusions (so far)

Marsh vegetation increasing where mangroves removed
Mangrove density has strong effects on microclimate at 1m.
  Reduces wind
  Reduces wind SD
  Increases temperature SD
  Increases humidity SD
Appears to be a threshold between 22 and 33 percent cover
Not much happening with soil temperature so far.
We hypothesize that effects on temperature and humidity may vary seasonally.

Future work

Next 2 years
  Continue plant and climate measurements

Next 3-5 years:
  Soil salinity
  Wave environment
  Vegetation
  Arthropods
  Benthic macrofauna
  Nekton
  Birds

Long-term:
  Soils
  Carbon cycle
  Soil infauna

Collaborators welcome!
“Habitat Replacement by Mangrove Establishment: Implications for Whooping Crane use”

Elizabeth H Smith, PhD
Whooping Crane Conservation Biologist
Nicole A. Davis, M.S.
Ph.D. Graduate Research Assistant

Whooping Crane Annual Cycle

Whooping Crane Ecological Requirements in Wintering Range

Primary Food Items
- Blue Crab
- Wolfberry Fruits
- Clams, Snails, Shrimp
- Acorns, Snakes, Lizards, Insects, Small Rodents

Aransas National Wildlife Refuge
Blackjack Peninsula
Whooping Crane Territories 1950
31 Individuals
7 Territories

Whooping Crane Territories 1961
36 Individuals
9 Territories

Whooping Crane Territories 1971
49 Individuals
17 Territories

Whooping Crane Territories 1979
76 Individuals
18 Territories

Whooping Crane Territories 1985
84 Individuals
26 Territories

Whooping Crane Territories 1990
146 Individuals
37 Territories

Data Source: FWS (Stehn & Prieto 2010)
**Whooping Crane Territories 2000**

- Woodlands
- Rangeland
- Coastal Flat
- Coastal Marsh
- Mangrove
- Seagrass

180 Individuals
57 Territories

**Whooping Crane Territories 2006**

- Woodlands
- Rangeland
- Coastal Flat
- Coastal Marsh
- Mangrove
- Seagrass

237 Individuals
66 Territories

**Mangrove Establishment**

- Indicator species: sensitive to environmental changes
- Increasing temperature
- Decreasing freeze event frequency
- Decreasing dissolved oxygen in water
- Sensitive to sea-level changes

Montagna et al. 2011 Coastal Impacts in The Impact of Global Warming on Texas

**Mangrove Establishment**

- Habitat conversion from marsh to mangrove reduces habitat availability
- Whooping cranes cannot walk through mangroves to forage
- Predators may have an advantage within mangrove/upland areas

**What ICF is Doing**

- Provide support letters for mangrove research
- Assist in mapping current mangrove establishment in whooping crane winter territory
- Assess mangrove habitat use by whooping cranes
- Predict future mangrove expansion

**TOP 2008 Natural Color**
TOP 2008 Color Infrared

Tx Ecological Systems Database

National Wetland Inventory

Tx Benthic Habitat Database

Whooping Crane Territories 2006

Long Island: 2006 Territories

Data Source: FWS (Stehn & Prieto 2010)

237 Individuals

66 Territories

Split Territories

Split Territory
Whooping Crane Territories 2006

Whooping Crane Recovery Goals
(Downlist Criteria)

- 1000 individuals
- 250 nesting pairs
- 10 years
- 250 winter territories @ 500 ac each = 125,000 ac

Future Whooping Crane Expansion

Brazos Basin
Central Coast System

Lavaca-Lower Colorado Basin
Matagorda Bay System
Conservation Questions

- Does habitat conversion = essential habitat lost?
- Is loss primarily related to habitat structure changes?
- Are primary food resources impacted?
- How will sea level rise affect habitat type and extent?
- Where will Whooping Crane expansion occur?

Effects of plants as

- Sediments modifiers
  - light, temperature, chemistry regulators of benthic habitats
- Food source
  - Fresh and detrital organic matter
- Structural support
  - Nursery habitat, coastal stabilization, run-off filtration

Literature Summary by (Alfaro 2010)

Habitat Conversion Trend

- Flats > Marshes
- Marshes > Mangroves
- Upland > Marsh/Mangrove?

Drivers
- Relative sea level rise
- Lack of sediment supply
- Temperature shifts
- Freshwater inflows

Friess et al. 2011
Coastal Habitat Availability

Elevation: 0-9 ft
Tidal Range: 1-2 ft

Oak Woodland
Fresh Marsh
Coastal Prairie
Shallow Flat
Mangroves
Bay

Temporal-Spatial Scales

Day et al., 2008

Next Steps

• Comprehensive mapping project (multispectral, extensive groundtruthing)
• Understand mangrove establishment, ecology, expansion rates
• Evaluate use of mangrove habitats by Whooping Cranes, preferred prey items, potential predators
• Predict how climate change will affect habitat availability for conservation prioritization

Thank You!

PLEASE CONTACT:
Liz Smith, Whooping Crane Conservation Biologist
International Crane Foundation
Texas Office, 361-543-0003
Questions

1. Can we determine when mangroves historically colonized a site?

2. Is there a difference in the carbon sequestration rate between *A. germinans* and *S. alterniflora*, at a common site?
Methods

- Coring (sectioning, bulk density)
- Sediment accumulation rates (radionuclides)
- Elemental analysis (TOC, TN, $\delta^{13}$C, $\delta^{15}$N)
- Biomarkers (lignin phenol metrics)
- Aerial image interpretation

1. Can we determine when mangroves historically colonized a site?
C3 plants (like woody mangroves) = -35 to -20 (-28 = A. germinans)
C4 plants (like herbaceous marsh) = -19 to -9 (-13 = S. alterniflora)

Marsh benthic algae = 16 to -27.7
Coastal phytoplankton = -18 to -24

Lignin phenols (per 100 mg OC)
Λ₆ = vanillyl + syringyl phenols
Λ₈ = vanillyl + syringyl + cinnamyl phenols

Plant sources of lignin
C/V = cinnamyl/vanillyl
S/V = syringyl/vanillyl

• The most obvious differences in TOC are between the two sites
• For biomarkers and isotopic composition, there are no big differences between mangroves and marsh core locations

• TOC and C:N ratio increased around 1960s
• Biomarkers also record changes around 1960s
• Aerial images show changes around 1960s
2. Is there a difference in the carbon sequestration rate between A. germinans and S. alterniflora, at a common site?

Indices of lignin decay
\[ \frac{AD}{AI} = \text{vanillic acid:vanillin} \]
\[ \frac{P}{(V+S)} = \frac{\text{p-hydroxy} (\text{vanillyl+syringyl})}{} \]

Conclusions

- Both sites converted from unvegetated flats (likely some algal cover) to vegetated wetland in the 1960s

- Biomarkers and mobile materials likely represent the ‘regional’ vegetation dynamics, rather than what is under a particular plant

- Lignin deposition (wood) and accretion rate increase under A. germinans plants (compared to S. alterniflora). Lignin carbon pool is stable, compared with other TOC components.

- Carbon sequestration rate is likely higher under A. germinans vs. S. alterniflora, over the long-term