The Mid-Atlantic Coastal Wetland Assessment: Linking Tidal Wetland Status and Water Quality for New Jersey

Danielle Kreeger
Partnership for the Delaware Estuary

Presented at: NJ Water Monitoring Council Meeting
May 19, 2010
Importance of Tidal Wetlands
Delaware Estuary *Spartina* Marsh
Tidal Range up to 9’
Salinity <0.5 ppm
High Production
Nursery Habitat
Tidal Wetlands

A Signature Trait of System

Near Contiguous Band
Diverse:  *Freshwater Tidal Marshes*
  *Brackish Marshes*
  *Salt Marshes*

Nature’s Benefits
  *Flood Protection*
  *Fish and Wildlife*
  *Natural Areas*
  *Carbon Sequestration*
  *Water Quality*
## Wetland Benefits (Ecosystem Services)

<table>
<thead>
<tr>
<th>Millenium Ecosystem Assessment 1° Service</th>
<th>2° Service</th>
<th>3° Service</th>
<th>4° Service</th>
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<tbody>
<tr>
<td>Provisioning</td>
<td>Food</td>
<td>Fisheries Support</td>
<td>livelihoods</td>
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<tr>
<td></td>
<td>Genetic Materials</td>
<td>Phragmites control research</td>
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<td></td>
<td>Biochemical Products</td>
<td>Research in Antifungal Agents</td>
<td>health</td>
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<td></td>
<td>Fiber and Fuel</td>
<td>Cellulose stock</td>
<td></td>
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<tr>
<td>Regulating</td>
<td>Sequestration</td>
<td>Carbon</td>
<td>Carbon Caps, mitigation</td>
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<td></td>
<td>Sediment Stabilization</td>
<td>Erosion control</td>
<td>Meet TMDLs for sediment</td>
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<td></td>
<td>Storm Protection/ Wave Attenuation</td>
<td>Protect Property Values and infrastructure</td>
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<td></td>
<td>Flood Protection</td>
<td></td>
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<td></td>
<td>Gas Regulation</td>
<td>Carbon Sequestration</td>
<td>TMDLs: Nutrients, Pollutants</td>
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<td></td>
<td></td>
<td>Oxygen production</td>
<td></td>
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<tr>
<td></td>
<td>Water Quality</td>
<td>Health</td>
<td></td>
</tr>
<tr>
<td>Cultural/ Spiritual Human Well Being</td>
<td>Recreation</td>
<td>Bird watching, hunting, boating</td>
<td>Health</td>
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<tr>
<td></td>
<td>Spiritual and Inspirational</td>
<td>Native American Uses</td>
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<td></td>
<td>Educational</td>
<td>University research &amp; school projects/trips</td>
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<tr>
<td></td>
<td>Aesthetic Value</td>
<td>Landscape pictures, paintings, open space</td>
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<tr>
<td>Supporting</td>
<td>Habitat</td>
<td>Wildlife, shellfish, insects</td>
<td>Health</td>
</tr>
<tr>
<td></td>
<td>Biodiversity</td>
<td>Maintain Plant Communities</td>
<td></td>
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<tr>
<td></td>
<td>Production</td>
<td>Primary Production</td>
<td></td>
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<td>Water Cycling/Hydrologic Regime</td>
<td>Maintain trophic cycles, soil building</td>
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<tr>
<td></td>
<td>Nutrient Cycling/Biogeochemical Processes</td>
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</table>
e.g., Carbon Sequestration

Temperate wetlands accumulate 1.42 tons C ha\(^{-1}\) yr\(^{-1}\)

Wetlands represent the largest component of the terrestrial biological C pool

Average soil organic carbon density (Denmark)
- Wetlands: 35.6 kg m\(^{-2}\)
- Forests: 16.9 kg m\(^{-2}\)
- Agricultural areas: 14.0 kg m\(^{-2}\)

Conversion of agricultural lands to wetlands can enhance C sequestration

In contrast to other wetlands, tidal salt marshes release negligible amounts of greenhouse gases and store more carbon per unit area
Valuation of New Jersey’s Natural Capital and *Ecosystem Services*

New Jersey Department of Environmental Protection

*Slide from Bill Mates, NJDEP*
Water Quality - Wetland Interactions

• Alter Vegetation Types
• Impair Condition
• Affect Accretion
• Enhance Vulnerability
• Sinks for Sediments
• Sinks for Nutrients
• Detoxify Some Contaminants
• Sinks for Pathogens?
Tidal Wetlands

A Signature Trait of the Delaware Estuary System

Ecological Values:

Structural
  habitat for fish and wildlife
  nurseries for imperiled taxa

Functional
  food web
  water quality
  flood protection

Concerns:
  Degradation
Rich History as a “Working River”

1762 map showing Philadelphia on the Delaware River

Slide adapted from Jonathan Sharp’s
### Sudden Wetland Dieback – Marsh Browning

#### Summer, 2006

Angola Neck – Rehoboth Bay, DE

<table>
<thead>
<tr>
<th>Stress Level</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimally or Not Stressed</td>
<td>17%</td>
</tr>
<tr>
<td>Moderately Stressed</td>
<td>48%</td>
</tr>
<tr>
<td>Severely Stressed</td>
<td>35%</td>
</tr>
</tbody>
</table>
Changes in Wetland Function
Natural versus Restored

Reference Wetland Condition

Existing Wetlands

Restored Wetlands

Function

time

Slide from Amy Jacobs (DE DNREC)
Tidal Wetlands

Ecological Values:

Structural
  \textit{habitat}

Functional
  \textit{food web}
  \textit{water quality}
  \textit{flood protection}

Concerns:
  Degradation
  \textbf{Conversion \& Loss}
Freshwater Tidal Wetland Acreage

Past and Present

Pre-Settlement  ?

1973 (Patrick et al.)  2310 ha

1981 (NWI)  9347 ha (all classes)
            597 ha (emergent)

1988 (Tiner & Wilen) 1000 ha

New data soon (NWI, States, LU/LC)

Estimated < 5% remains
Tidal Wetlands

Ecological Values:

Structural
  habitat
Functional
  food web
  water quality
  flood protection

Concerns:
  Degradation
  Conversion & Loss
  Sea level rise
  Salinity rise
Shoreline Erosion

Maurice River Mouth
2002 aerial photograph

1890 shoreline

Courtesy J. Gebert, ACOE

Courtesy D. Bushek, Rutgers
Tidal Wetlands

Ecological Values:

Structural
- habitat

Functional
- food web
- water quality
- flood protection

Concerns:
- Degradation
- Conversion & Loss
- Sea Level Rise

Storms
Tidal Wetlands

Ecological Values:

- Structural
  - habitat
- Functional
  - food web
  - water quality
  - flood protection

Concerns:

- Degradation
- Conversion and Loss
- Sea Level Rise
- Storms

** Sediment budget**
Tidal Wetlands

Concerns:
- Degradation
- Conversion and Loss
- Sea Level Rise
- Storms

Sediment budget
Global changes—future

Source: Church et al. (2008)
Slide: Ray Najjar, PSU (2009)
Future regionality due to changing ocean currents

Projected 21st century change in dynamic sea level from the GFDL CM2.1 model (A2 scenario)

Source: Yin et al. (2009)
Slide: Ray Najjar, PSU (2009)
Future regionality due to changing ocean currents

Dynamic sea level changes over 21st Century from 10 AR4 models under the A1B scenario.

+ Subsidence

Source: Yin et al. (2009)
Slide: Ray Najjar, PSU (2009)
Climate & Other Changes Together

- Marcellus Shale
- Ecological Flows
- Dredging
- Withdrawals
- Wind Farms
- Land Use Change
- Development
- Emerging Pollutants

Added Complexity
# White Paper Top Ten

1. **Contaminants** (forms, sources, fates & effects for different classes)

2. **Tidal Wetlands** (status, trends and relative importance of different types)

3. **Ecologically Significant Species & Critical Habitats** (benthos, horseshoe crabs)

4. **Ecological Flows** (effects of flow changes on salt balance & biota)

5. **Physical-Chemical-Biological Linkages** (e.g., sediment budgets, toxics & biota)

6. **Food Web Dynamics** (key trophic connections among functional dominant biota)

7. **Nutrients** (forms, concentrations and balance of macro- and micronutrients)

8. **Ecosystem Functions** (assessment and economic valuation of ecosystem services)

9. **Habitat Restoration and Enhancement** (science & policy)

10. **Invasive Species** (monitoring, management & control)
So What Are We Doing?

Priority
What Can We Do?

1. Build Resiliency
   Protect and Conserve (CCMP)
Tidal marshes need to move:

1) horizontally (landward)

and/or

2) vertically (to keep pace)

Titus and Wang, 2008
http://maps.risingsea.net/New_Jersey.html
Land Use in Tidal Marsh Buffer Zone in the Lower Estuary of NJ (LE3)

Buffers Buffers Buffers = Resiliency
What Can We Do?

2. Maintain, Enhance, Restore...
…But Smartly

Regional Restoration Planning

US Climate Change Science Program
Draft Prospectus Section 4.1

Coastal Elevations and Sensitivity to Sea Level Rise

http://www.climatescience.gov/

Titus and Wang, 2008
http://maps.risingsea.net/New_Jersey.html
Restoration for the Future

Restore, conserve or otherwise enhance ecosystem structure and function, targeting areas that can sustain maximum natural capital value.
Case Studies

Tidal Marshes

Future Status

Vulnerability and Options

Rankings

Recommendations

Bivalve Shellfish

Drinking Water

Delaware Estuary Pilot
More warming in summer than winter
Scenario differences minor until late century
However, late century scenario differences very important for life
Due to climate momentum, we must plan for warmer conditions
Growing Season Length

Opposite pattern for number of frost days
Tidal Wetland Projections - IEc

SLAMM V.6 Findings:
• 26% loss of 42,558 hectares of tidal wetlands
• loss of 50,236 hectares of adjacent uplands and non-tidal wetlands
• gain of 106,529 hectares of open water and tidal flats
• net loss of >60,000 metric tons/year of primary production services
Water Quality - Wetland Interactions

• Alter Vegetation Types
• Impair Condition
• Affect Accretion
• Enhance Vulnerability

• Sinks for Sediments
• Sinks for Nutrients
• Detoxify Some Contaminants
• Sinks for Pathogens?

Would Nutrient Criteria Need to be More Protective Without Wetlands?
Tidal Wetland Vulnerability?

**Freshwater Tidal Marshes**
- Salinity Rise Causes Conversion to Brackish
- Barriers to Landward Migration
- Others

**Salt Marshes**
- Sea Level Rise, Subsidence and Sediment Deficits Lead to Drowning
- Storms and Wind Wave Erosion
- Barriers to Landward Migration
- Others
Tidal Wetlands Adaptation Planning

**Goal:** Maximize long-term ecosystem health and resiliency

**Tough Choices**
- Where will wetlands will be converted to open water?
- Where can we save them?
- Where is strategic retreat the best option?
What Can We Do?

3. Monitor & Study
Status, Trends, Vulnerability?
We Couldn’t Say

Slide from Chris Bason (Center for Inland Bays, DE)
Monitoring Infrastructure

The Delaware Estuary Watershed to Ocean Observing System (DEWOOS)

A Planning Concept from:
Delaware River Basin Commission
University of Delaware
Rutgers University
US Geological Survey
NOAA
States of New Jersey and Delaware
Partnership for the Delaware Estuary
DE, NJ and PA Sea Grant

Wetland Component Included
Delaware Estuary Wetland Monitoring & Assessment Program (DEWMAP)

Freshwater Tidal Marsh

Salt Marsh
The Delaware Estuary Wetland Monitoring and Assessment Program (DEWMAP):

- **Sample Frame**
  all tidal wetlands in the Delaware Estuary

- **Subpopulations**
  wetland type (oligohaline, mesohaline, polyhaline) state (DE, NJ, PA)
Guidance from EPA

- **Level I**: Stratified Random field site selection
  - Census of all NWI mapped wetlands

- **Level II**: Stratified random selection of wetlands for site stressor checklist site visit

- **Level III+**: Direct measurement of ecological services

- **Level IV**: Intensive monitoring at fixed stations
<table>
<thead>
<tr>
<th>Design Component</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tier 1</strong></td>
<td>Wetland Extent</td>
<td>wetland acreage (hectares) per subpopulation and NWI attribute type</td>
</tr>
<tr>
<td></td>
<td>Wetland Buffer Condition</td>
<td>adjacent land use (e.g., % natural vs. developed in 100m band)</td>
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<td>Wetland Contiguosity</td>
<td>connectivity (inter/intra); patch sizes and fragmentation</td>
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<td>loss or gain in acreage for different subpopulations &amp; attributes</td>
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<td>edge status (e.g., hardening, erosion)</td>
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<tr>
<td></td>
<td>Anthropogenic Alterations</td>
<td>channel straightening, ditching, tide gates, groundwater withdrawals</td>
</tr>
<tr>
<td>Tier 2</td>
<td>Plant Community Integrity</td>
<td>vegetation community type (description of species assemblage)</td>
</tr>
<tr>
<td></td>
<td>Primary Production</td>
<td>invasive species (percent cover of <em>Phragmites</em>)</td>
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<td>Invertebrate Community Integrity (sessile species)</td>
<td>species list (floristic quality assessment index)</td>
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<td>Wildlife Habitat Integrity (mobile species)</td>
<td>vegetation structure board</td>
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<td>Hydrological and Shoreline Integrity</td>
<td>below and above ground biomass</td>
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<tr>
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<td>Elevation and Sediment Budget</td>
<td>presence and relative abundance of functional dominant and bioindicator species</td>
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<tr>
<td><strong>Tier 3</strong></td>
<td>Water Quality</td>
<td>evidence of fish and mobile shellfish; avian IBI</td>
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<td></td>
<td>Biogeochemical Cycling</td>
<td>evidence of hydrological alterations or impairment (e.g. depressions, dikes, rip rap)</td>
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<td></td>
<td>Carbon Storage</td>
<td>percent organic matter and sediment description</td>
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<td>Elevation and Sediment Budget</td>
<td>relative elevation, evidence of accretion or subsidence, wrack accumulation</td>
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<td>Plant Community Integrity</td>
<td>fixed monitoring stations in second order tidal creek (temperature, specific conductivity, pH, turbidity, DO, water level)</td>
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<td>Functional Dominant Fauna Integrity</td>
<td>grab samples in tidal creek for dissolved nutrients and seston quantity &amp; quality, ebb &amp; flood tides (TSS, chlorophyll, proximate biochemistry and stoichiometry)</td>
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<td>sediment porewater nutrient concentrations, forms, stoichiometric ratios; denitrification rates</td>
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<td>carbon sequestration in belowground biomass; litter accumulation</td>
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<td>Sediment Elevation Table (SET), elevation relative to sea level (in addition to Tier 2 metrics)</td>
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<td>vegetation robustness (percent cover and stem counts per species) (in addition to Tier 2 metrics)</td>
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<td></td>
<td>invertebrate and vertebrate species lists along intertidal edge and high marsh, biofiltration capacity of bivalves</td>
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</tbody>
</table>
Satellite Data – Kearney and Riter

Tier 1

1993

Percent vegetation

2006
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| Plant Community Integrity |                    | vegetation community type (description of species assemblage) |
| Primary Production |                          | invasive species (percent cover of *Phragmites*) |
| Wetland Morphology |                            | species list (floristic quality assessment index) |
| Invertebrate Community Integrity (sessile species) |                  | vegetation structure board |
| Wildlife Habitat Integrity (mobile species) |                      | below and above ground biomass |
| Hydrological and Shoreline Integrity |                | percent open water; edge to area ratios |
| Substrate Integrity |                     | presence and relative abundance of functional dominant and bioindicator species |
| Elevation and Sediment Budget |            | evidence of fish and mobile shellfish; avian IBI |

| Water Quality | fixed monitoring stations in second order tidal creek (temperature, specific conductivity, pH, turbidity, DO, water level) |
| Biogeochemical Cycling | grab samples in tidal creek for dissolved nutrients and seston quantity & quality, ebb & flood tides (TSS, chlorophyll, proximate biochemistry and stoichiometry) |
| Carbon Storage Elevation and Sediment Budget | sediment porewater nutrient concentrations, forms, stoichiometric ratios; denitrification rates |
| Plant Community Integrity | carbon sequestration in belowground biomass; litter accumulation |
| Functional Dominant Fauna Integrity | Sediment Elevation Table (SET), elevation relative to sea level (in addition to Tier 2 metrics) |

### Tier 1
Rapid Assessments

### Tier 2
Fixed Station Monitoring

### Tier 3
Tier 3/4 Fixed Station Monitoring
National Wetland Monitoring & Assessment Work Group

NWMAWG

Mid-Atlantic Wetland Work Group

MAWWG

STAC Wetland Work Group

DEWWWG

• Focus on Tidal Marshes
• Link to Adjacent Estuaries (Network)
The Mid-Atlantic Coastal Wetland Assessment (MACWA)

- **Sample Frame**
  all tidal wetlands in the sub-region from coastal NJ to coastal MD including the Delaware Estuary

- **Subpopulations**
  wetland type (oligohaline, mesohaline, polyhaline) state (DE, MD, NJ, PA)

  Capture diverse stressor gradients and types
MACWA
Delaware Estuary
Barnegat Bay
DE Inland Bays
MD Coastal Bays
Others?
Other NJ Coastal
RAM Efforts

- MidTRAM Training
- QAPP Modification
- Buying/Building Gear
- Tests in Vicinity of Fixed Stations

- **2010** – Broadkill, PA
- **2011** – Maurice, Christina, Barnegat
Fixed Station Efforts

- Site Selection
- QAPP
- Coordination
  - ANSP on phys/chem
  - NEPs on bio
- **2010**
  - Baseline monitoring
  - SETs
  - WQ Meters
- **2011**: Expansion
Fixed Station Assessment Area
## Tier 4 Example Metrics

<table>
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<th>Elevation and Sediment Budget</th>
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## Tier 4 Fixed Stations:

<table>
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<tr>
<th>Station</th>
<th>Location</th>
<th>State</th>
<th>Lead Entities</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tinicum NWR</td>
<td>PA</td>
<td>PADEP/ANSP</td>
<td>Oligohaline, freshwater tidal marsh</td>
</tr>
<tr>
<td>2</td>
<td>Christina River</td>
<td>DE</td>
<td>DNREC/ PDE</td>
<td>Mesohaline, brackish tidal marsh</td>
</tr>
<tr>
<td>3</td>
<td>St. Jones River</td>
<td>DE</td>
<td>DNREC</td>
<td>Euryhaline, <em>Spartina</em> salt marsh</td>
</tr>
<tr>
<td>4</td>
<td>Maurice River</td>
<td>NJ</td>
<td>Rutgers</td>
<td>Euryhaline, <em>Spartina</em> salt marsh</td>
</tr>
</tbody>
</table>

**NJ Expansion** - up to 3 stations in Barnegat Bay and up to 3 more in the Delaware Estuary
- Crosswicks Creek, Dennis Creek, Stow Creek
Heislerville WMA
MACWA Partners (so far)

Academy of Natural Sciences
Barnegat Bay Estuary Program
DNREC
EPA HQ, Regions 2 and 3
NJDEP + NJ Coast Zone Program
PADEP
PDE (Coordinator)
Rutgers University
Villanova University
Wetland Associates
One size fits all?

No: include both “Core” and “Supplemental” metrics for both RAM and station monitoring

- Compare only core metrics for climate and other sub-regional monitoring needs
- Use core + supplemental metrics for local or watershed specific needs
Wetland Monitoring Informs Other NEP Programs

- Regional Restoration
- Regulatory Decision-Making
- Water Quality Management
- Targeted On-the-Ground Projects
- Climate Adaptation
- Fish and Wildlife Management
- State of Estuary Reporting

MACWA
Summary

- Wetlands are a hallmark feature of the Delaware Estuary and coastal mid-Atlantic, particularly tidal marshes.
- These wetlands provide critical services that sustain lives and livelihoods.
- Improved efforts to monitor wetland status and trends will assist in managing and sustaining them into the future.
- Sub-regional coordination will strengthen information products and funding.
Water Quality - Wetland Interactions
More precipitation, especially in cooler seasons

Models are less in agreement for summer
Shellfish as Natural Breakwaters

- Reduce wave energy
- Trap silt
- Reduce bank erosion
- Protect salt marsh

Slide from Dave Bushek, Rutgers
Delaware Estuary Living Shorelines

![Bar chart showing elevation increase for different treatments: Log, Double Log, Shellbag + Log, Control. The Double Log treatment has the highest elevation increase, followed by the Shellbag + Log treatment. The Log and Control treatments have lower elevation increases.]