Attachment C

Presentation of Question 3; Don Cahoon, USGS

Question 3

What is a plausible range for the ability of wetlands to vertically accrete, and how does this range depend on whether shores are developed and protected, if at all?
That is: will sea level rise cause the area of wetlands to increase or decrease?

Outline

- Review environmental drivers and biogeomorphic processes influencing wetland elevation dynamics
- Review scaling issues (local to regional to national) and inadequacies of current modeling approaches
- Describe Expert Panel approach, applied in lieu of modeling
- Findings of Expert Panel approach

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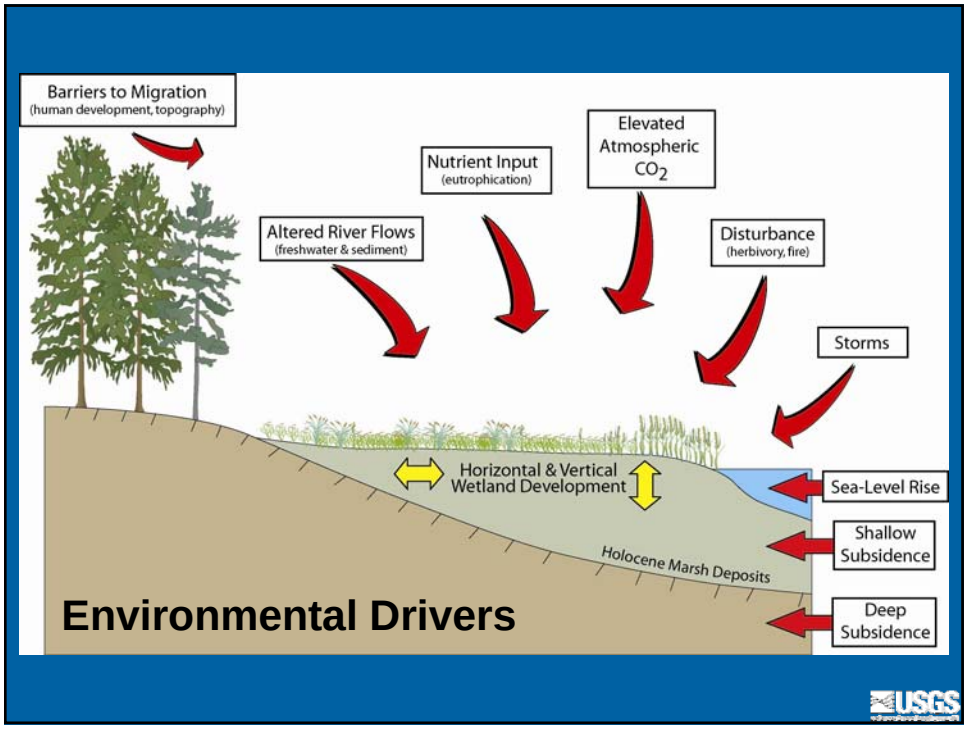
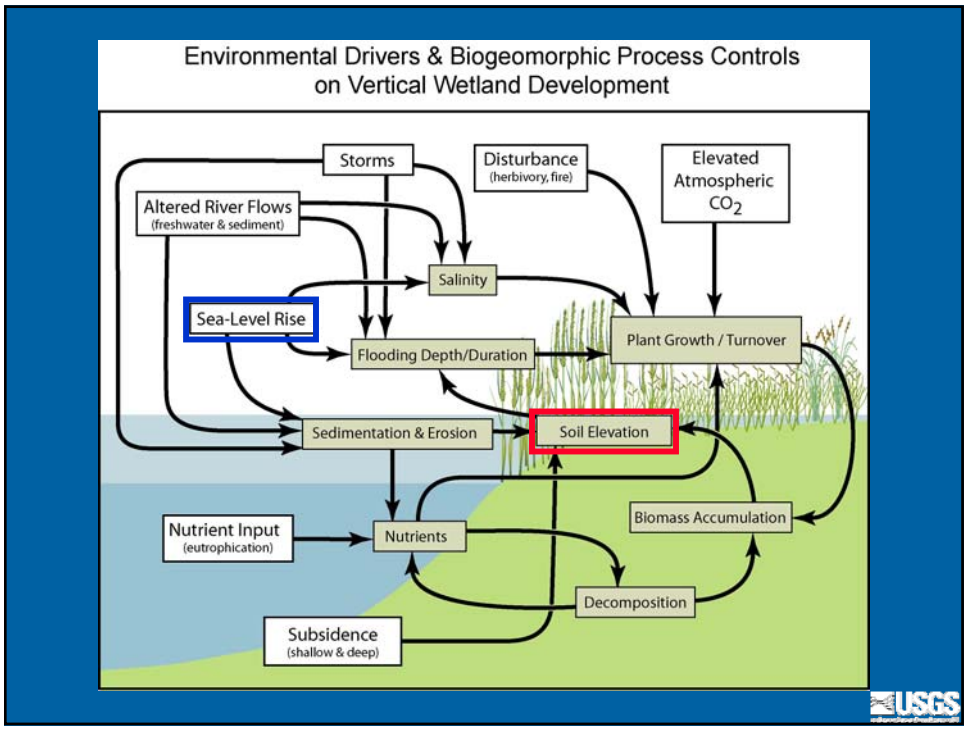
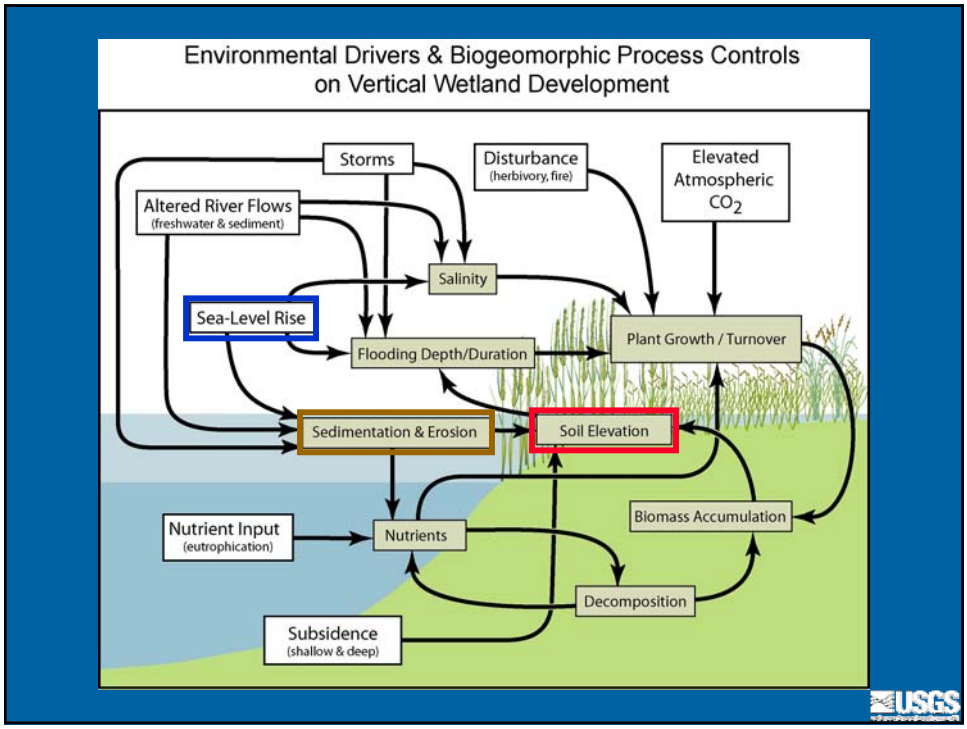

Barriers to Migration
(human development, topography)
Nutrient Input
(eutrophication)
Elevated
Atmospheric
CO_2
Altered River Flows
(freshwater & sediment)
Disturbance
(herbivory, fire)
Storms
Horizontal & Vertical
Wetland Development
Sea-Level Rise
Shallow
Subsidence
Holocene Marsh Deposits
Deep
Subsidence
Environmental Drivers
USGS


Environmental Drivers & Biogeomorphic Process Controls
on Vertical Wetland Development
Storms
Disturbance
(herbivory, fire)
Elevated
Atmospheric
CO_2
Altered River Flows
(freshwater & sediment)
Salinity
Sea-Level Rise
Flooding Depth/Duration
Plant Growth / Turnover
Sedimentation & Erosion
Soil Elevation
Biomass Accumulation
Nutrient Input
(eutrophication)
Nutrients
Decomposition
Subsidence
(shallow & deep)
USGS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Nutrients
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(shallow & deep)
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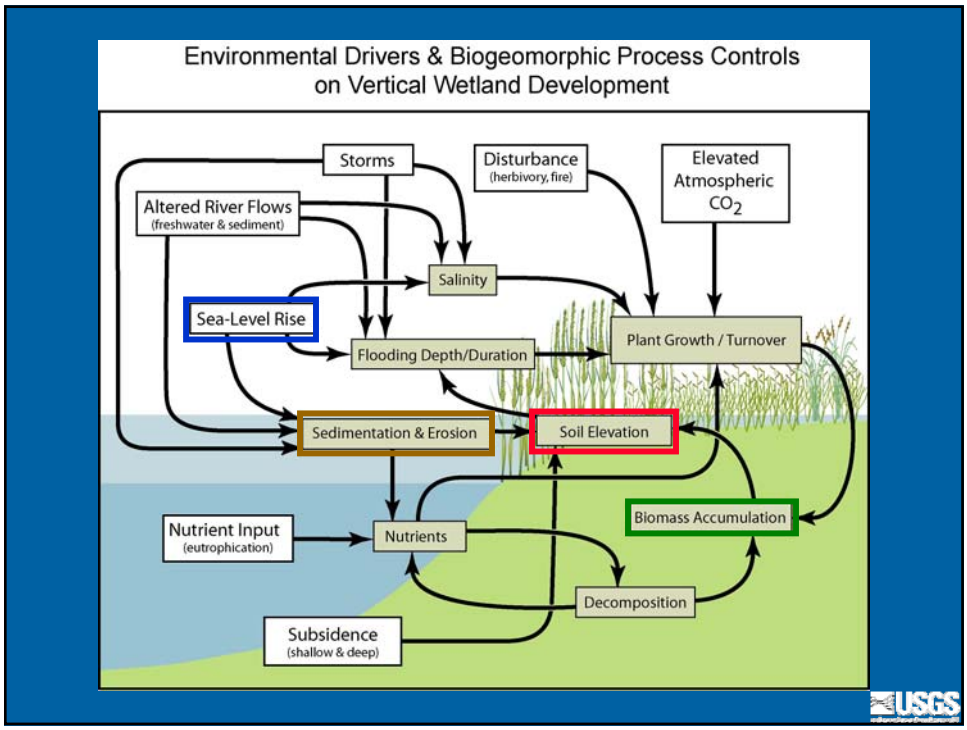
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Nutrient Input
(eutrophication)
Nutrients
Decomposition
Subsidence
(shallow & deep)
USGS

Processes Driving Vertical Wetland Development

Global and Regional Processes:

- Glacial isostatic adjustment
- Subsidence and fault activation – subsurface fluid withdrawal

Wetland Scale Processes:

Sediment import and export – storms, tides, fluvial, ice, oceanic

Peat accumulation – tidal marshes (burning, floods)
mangroves (storms, slr)
forested wetlands

Marsh Vertical Development vs. Current RSLR

Local Wetland Biogeomorphic Data

Geomorphic Setting

Wetland Type

Accretionary Processes:

minerogenic, organogenic

Drivers: storms, tides, fluvial, oceanic

Marsh Vertical Development vs. Current RSLR

Scale Up Spatially

Local Wetland Biogeomorphic Data

- *Geomorphic Setting*
- *Wetland Type*
- *Accretionary Processes*:
  - minerogenic, organogenic
- *Drivers*: storms, tides, fluvial, oceanic

No Regional/National Wetland Biogeomorphic Data Sets

- *Geomorphic Settings*
- *Wetland Types*
- *Accretionary Processes*
- *Drivers*

Marsh Vertical Development vs. Future RSLR

Scale Up Temporally

Short-term Wetland Biogeomorphic Data

Marsh Vertical Development vs. Future RSLR

Short-term Wetland Biogeomorphic Data

Feedbacks: elevation, flooding, sedimentation
Major Events: storms, floods, droughts

Marsh Vertical Development vs. Future RSLR

Short-term Wetland Biogeomorphic Data

Numerical Models: Rybczyk & Cahoon 2002

Feedbacks: elevation, flooding, sedimentation
Major Events: storms, floods, droughts

Numerical Models

Future Changes in Accretionary Processes

Changes in Magnitude with Future Sea-Level Rise:

- Storm intensity and frequency (?) will increase
- Storm sedimentation will likely increase
- Storm sediment resuspension in nearshore could lead to greater import of oceanic sediments
- Soil organic matter accumulation will likely increase
- Decomposition could increase (sulfate reduction) where sea water intrudes
- Sediment import/export & tidal flux – shift to ebb dominance may export more sediment
- Ice-rafting will diminish with increased temperatures
- Precipitation and river flows may become more flashy

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Marsh Vertical Development vs. Future RSLR

Scale Up Spatially & Temporally

Local Wetland Biogeomorphic Data

- *Geomorphic Setting*
- *Wetland Type*
- *Accretionary Processes*: minerogenic, organogenic
- *Drivers*: storms, tides, fluvial, oceanic

→ Numerical Models: Rybczyk & Cahoon 2002

X

→ No Regional/National Wetland Biogeomorphic Data Sets

- *Geomorphic Settings*
- *Wetland Types*
- *Accretionary Processes*
- *Drivers*

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Marsh Vertical Development vs. Future RSLR

Scale Up Spatially & Temporally

Local Wetland Biogeomorphic Data

- *Geomorphic Setting*
- *Wetland Type*
- *Accretionary Processes*: minerogenic, organogenic
- *Drivers*: storms, tides, fluvial, oceanic

→ Models: Rybczyk & Cahoon 2002

→ Expert Panel Mid-Atlantic Region

- *Geomorphic Settings*
- *Wetland Types*
- *Accretionary Processes*
- *Drivers*

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Expert Panel

- Denise J. Reed, Chair, University of New Orleans
- Donald R. Cahoon, U. S. Geological Survey
- Jeffrey Donnelly, Woods Hole Oceanographic Institution
- Michael Kearney, University of Maryland
- Alexander Kolker, State University of NY, Stony Brook
- Lynn L. Leonard, University of North Carolina, Wilmington
- Richard A. Orson, Orson Environmental Consultants
- J. Court Stevenson, University of Maryland

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Expert Panel Approach – SLR Scenarios

- Divided Mid-Atlantic region into a series of subregions based on similarity of process regime and current sea-level rise rate
- Evaluated wetland response to 3 sea-level rise scenarios
  - **Current SLR Rates**: determined for each subregion from local tide gauge records
  - **Current + 2 mm/yr** (~ twice current rate)
  - **Current + 7 mm/yr** (~ 3 – 4 times current rate)

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Expert Panel Approach – SLR Scenarios

Future sea-level rise scenarios used by panel:

- Approximate IPCC sea-level rise scenarios
- Represent discrete values, not a continuum of 2 to 7
  - Very few estimates from literature of maximum accretion rates

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Expert Panel Approach – Fate of Wetlands

Geomorphic settings were delineated and the fate of wetlands within each subregion under three sea-level rise scenarios was agreed upon

- **Keeping pace**: wetlands will not be submerged by rising sea levels and will be able to maintain their relative elevation
- **Marginal**: wetlands will be able to maintain their elevation only under optimal conditions
- **Loss**: wetlands will be subject to increased hydroperiod beyond that normally tolerated by the vegetative communities, leading to deterioration and conversion to open water

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Expert Panel Approach – Fate of Wetlands

Caveats of Expert Panel Interpretations:

- Expert regional scale projections identify likely trends and areas of major vulnerability; and do not replace local assessments based on biogeomorphic data – local exceptions are known to exist
- Back barrier marsh projections assume the island remains stable
- Future sea-level rise scenarios: discrete not continuum
- Severe limits on downscaling to local setting: low level of confidence in such projection in the absence of local biogeomorphic data

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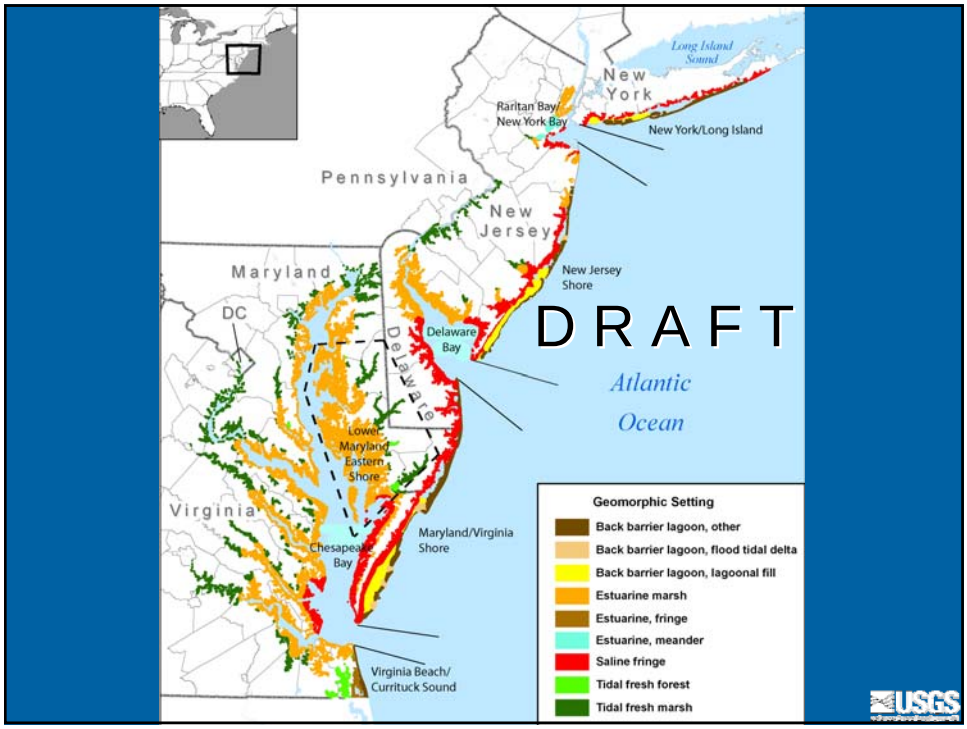
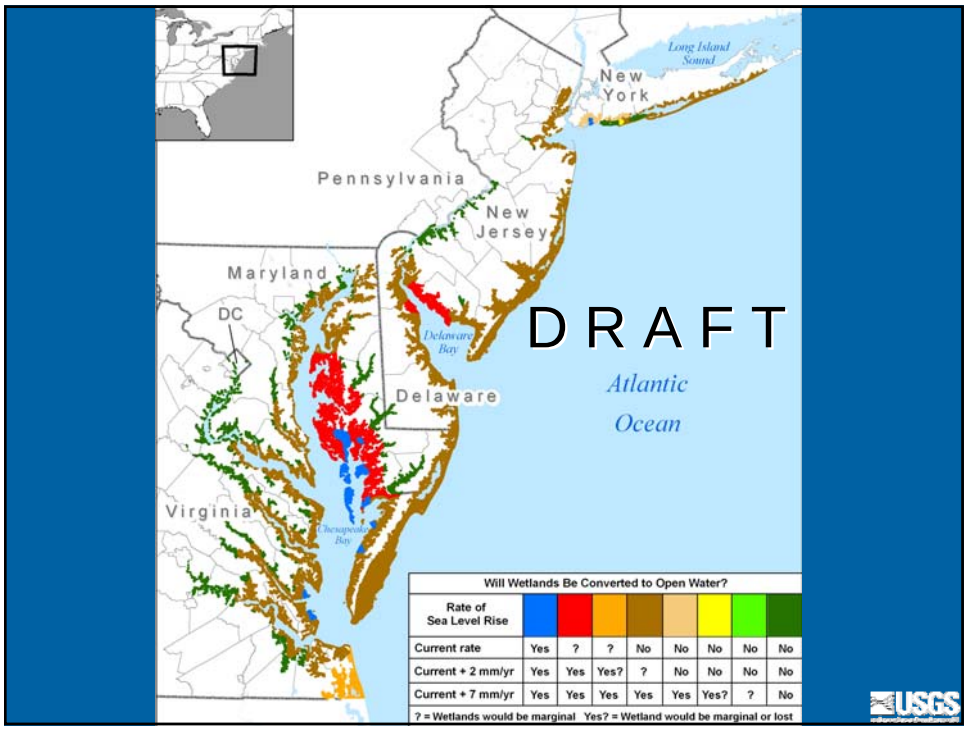

Long Island Sound
New York
Raritan Bay/ New York Bay
New York/Long Island
Pennsylvania
New Jersey
Maryland
New Jersey Shore
DC
Delaware Bay
Delaware
DRAFT
Atlantic Ocean
Lower Maryland Eastern Shore
Virginia
Maryland/Virginia Shore
Chesapeake Bay
Virginia Beach/ Currituck Sound
Geomorphic Setting
Back barrier lagoon, other
Back barrier lagoon, flood tidal delta
Back barrier lagoon, lagoonal fill
Estuarine marsh
Estuarine, fringe
Estuarine, meander
Saline fringe
Tidal fresh forest
Tidal fresh marsh
USGS


Long Island Sound
New York
Pennsylvania
New Jersey
Maryland
DC
Delaware Bay
Delaware
DRAFT
Atlantic Ocean
Virginia
Chesapeake Bay
Will Wetlands Be Converted to Open Water?
Rate of Sea Level Rise
Current rate Yes ? ? No No No No No
Current + 2 mm/yr Yes Yes Yes? ? No No No No
Current + 7 mm/yr Yes Yes Yes Yes Yes Yes? ? No
? = Wetlands would be marginal Yes? = Wetland would be marginal or lost
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Wetland Responses to Sea-Level Rise in the Mid-Atlantic Region

Majority of wetlands are keeping pace with current sea-level rise:

Exceptions: marshes in Delaware and Chesapeake Bays that are marginal (red) or being lost (blue)

Under accelerated sea-level rise, wetland survival would very likely depend on optimal hydrology and sediment supply conditions:

Exceptions: locales where sediment inputs are substantial (e.g., over wash or river floods)

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Wetland Responses to Sea-Level Rise in the Mid-Atlantic Region

Wetland responses to sea-level rise are typically complex:

Marshes from all geomorphic settings responded differently to sea-level rise both within and/or among sub-regions, underscoring the variability in the influence of local processes and drivers.

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