Salt Marsh Dieback

A literature review

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History

- Florida (1990-1993)
- Louisiana (1968-1970) Small patches presumably caused by waterlogging
- Louisiana (2000-2003)- Dieback affects S. alterniflora and S. patens in interior of marsh
  - Standing dead vegetation, which turned to exposed mud flats over winter
  - Two years later only 7% of brown marsh areas showed little or no recovery
  - Marsh bare in 2001 was completely green in 2003

History

- Mississippi (2000)
- Georgia (2002)- Dieback occurred along tidal creeks and affects S. alterniflora and J. roemerianus.
  - Spring 04- Some natural recolonization had occurred at dieback sites
- New England (1999,2002)- Dieback occurred along channel banks and affects S. alterniflora, S. patens, and D. spicata
  - Marshes have not shown signs of recovery

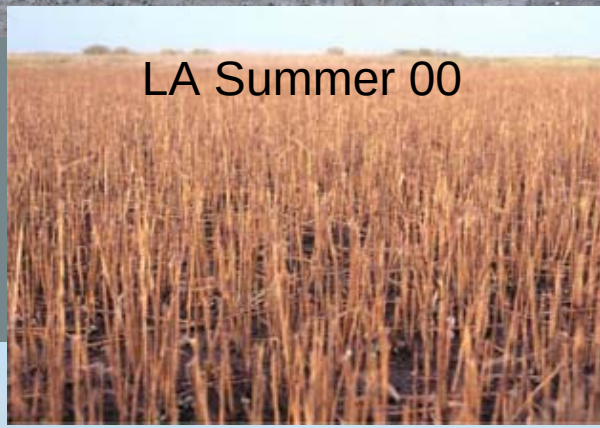
History

- Inland Bays (2006)- Dieback affects S. alterniflora in interior of marsh
  - Standing dead vegetation

MA 03

GA 02

LA Winter 00


LA Summer 00

DE 06

DE 06

Stressors

- Waterlogging
  - Sea-level Rise
  - Hydrologic Alterations
- PH fluctuation
- Drought/ Low water
- Increased Salinity
- Decreased Sediment Input
- Nutrients
- Toxins
  - Heavy Metals
  - Hydrogen Sulfide
- Herbivory
  - Snails
  - Waterfowl

Theories

- Plant pathogens
- Genetics
- Herbivores
- Water level extremes
- Salinity
- Sulfide accumulation
- Pollution or chemical spills
- Changes in soil metals

Types of dieback

- 1-3 m wide strips parallel to the banks of tidal creeks
- Mid marsh dieback areas
- Berm dieback characterized by the formation of scallop-shaped barren areas on or behind a bank levee
- Adjacent to upland border of marsh where wrack disturbance is common

Spartina Alterniflora

- Tolerant
  - Anoxic soils
  - Salinity
  - Low fertility
  - Fire
  - PH 5.5-7.5
  - Cold Temp. (-13)
- Not Tolerant
  - Drought
  - Shade
  - Hedging by wildlife
  - $CaCO_3$

Spartina and Overwintering

- A 1988 experiment in Lewes, DE revealed that when dead and live shoots were removed during the dormant season, no growth was experienced the following season
- Removal of only the dead or live shoots did not kill the plant
- In general, a decrease in oxygen supply leads to reduced growth of shoots, roots or both

Pathogens

- Bacterial, fungal or viral pathogens can cause widespread plant mortality
  - Supporting evidence
    - In Texas and Florida, a fungal involvement has been identified in connection with S. Alterniflora dieback, but was associated with stressed vegetation
  - Contradictory evidence
    - Narrow range of potential pathogens
    - Black leaf spot does not cause plant death under normal conditions
    - No pathogens have been associated with dieback in other regions, including Louisiana and Delaware

Genetics

- Greater genetic diversity general results in lower ecological vulnerability. Sudden extreme changes may exceed the genetic capacity of a single species to adjust.
  - Supporting evidence
    - Research in Europe demonstrates that competition between two genetic groups of Phragmites can result in dieback between surviving population
  - Contradictory evidence
    - Genetic diversity of Spartina in healthy sites and among dieback re-growth was relatively similar

Herbivores

- Herbivores can clear large areas of vegetation in a short period of time
  - Supporting evidence
    - Some dieback areas have large concentrations of snails
    - In Delaware some areas showed signs of grasshopper damage
  - Contradictory evidence
    - Not all dieback areas have evidence of snail feeding
    - No evidence of unusual insect outbreaks or damage in most regions
    - No periwinkles found in Delaware samples
    - Periwinkles prefer consuming dead Spartina shoots

Sea Level Rise

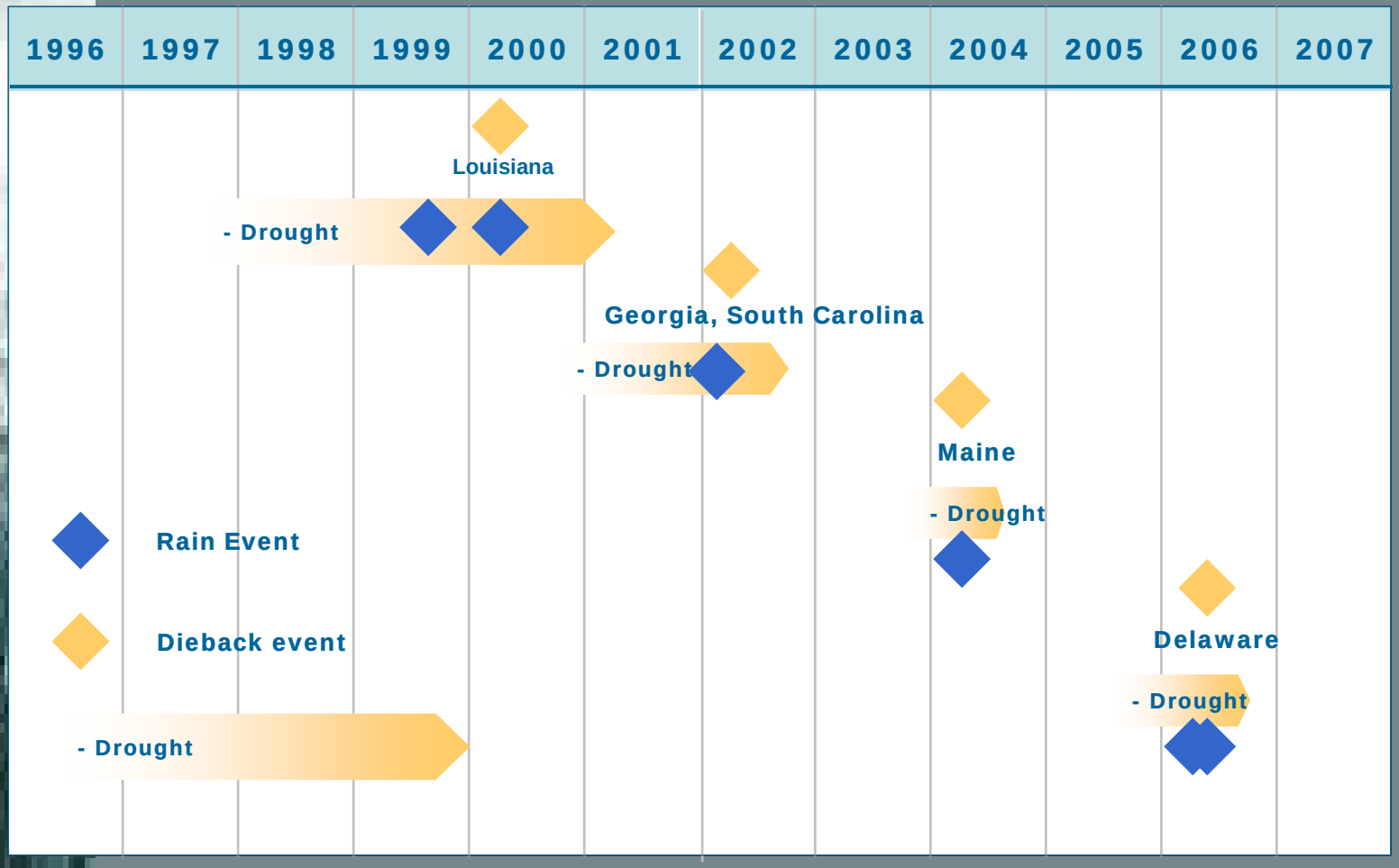
- Spartina alterniflora is very flood tolerant, but there are limits to its tolerance. When oxygen is cut off from the plant roots for 24 hours, the meristems will begin to die and the entire plant can succumb within a few days

- Supporting evidence
  - The lower marsh areas in the interior marsh are experiencing extensive mortality
- Contradictory evidence
  - Other species that are equally of less flood tolerant than Spartina have survived
  - Dieback is sudden and followed by recovery which does not seem to correlate with a gradual rise in sea level,

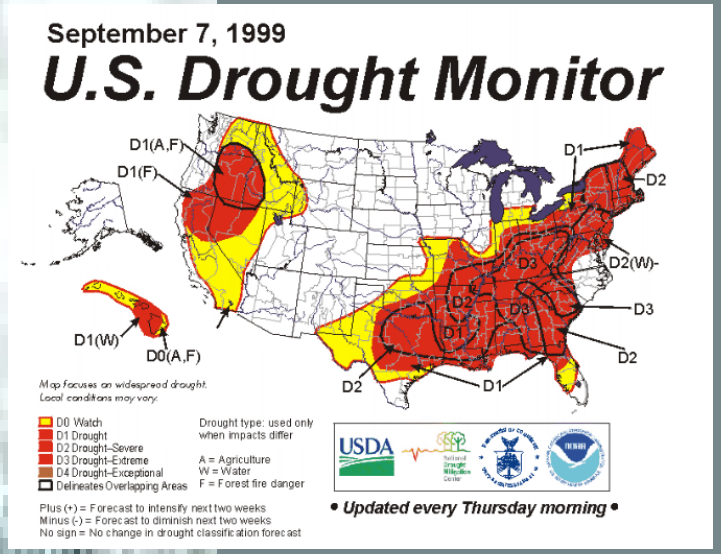
Low Water Levels and Drought

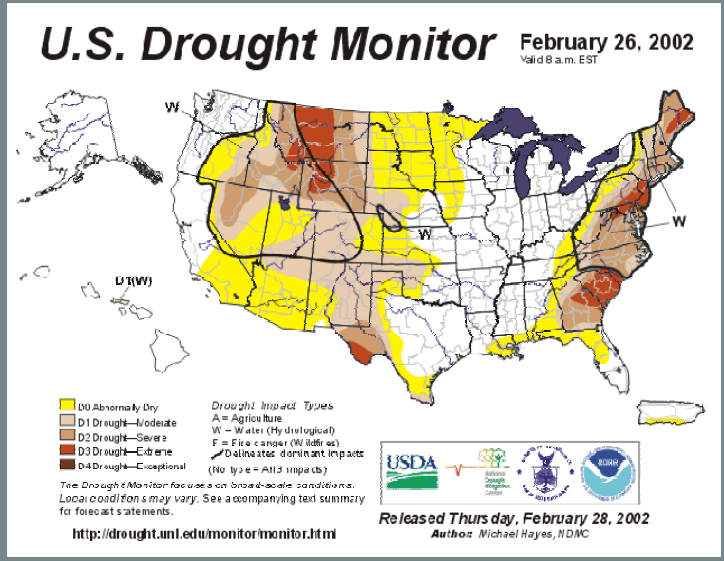
- Spartina is highly vulnerable to drought
  - Supporting evidence
    - Many areas recorded low water levels at dieback sites
  - Contradictory evidence
    - Low elevation sites appear to be more affected than high elevation sites

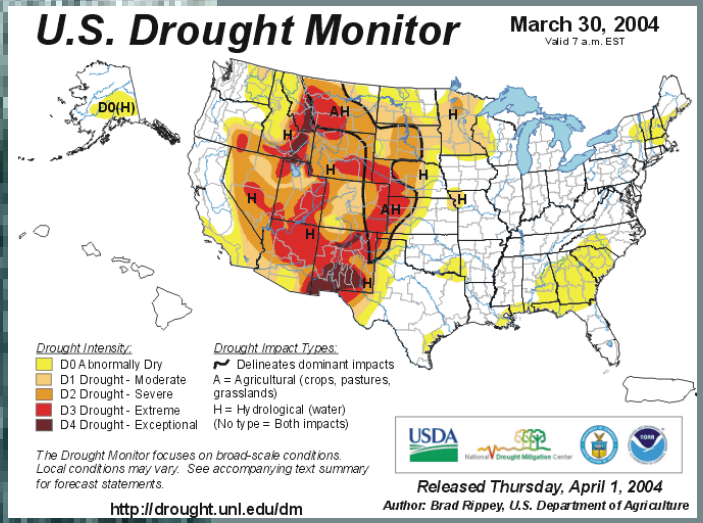
Drought and Storm Event Patterns

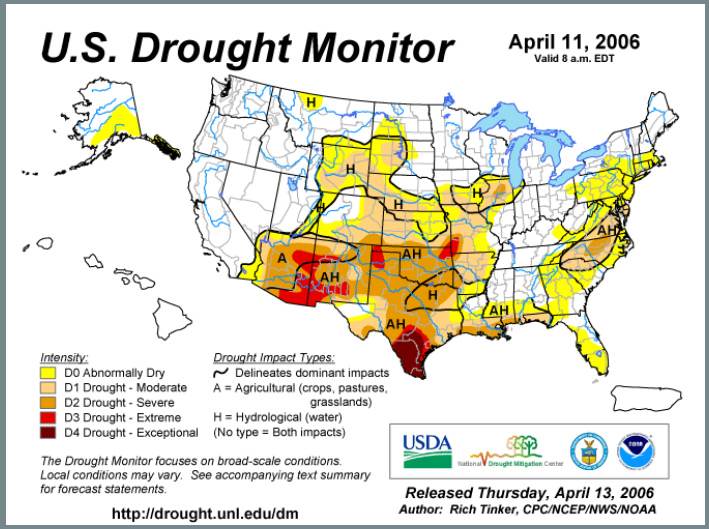


Drought Monitor









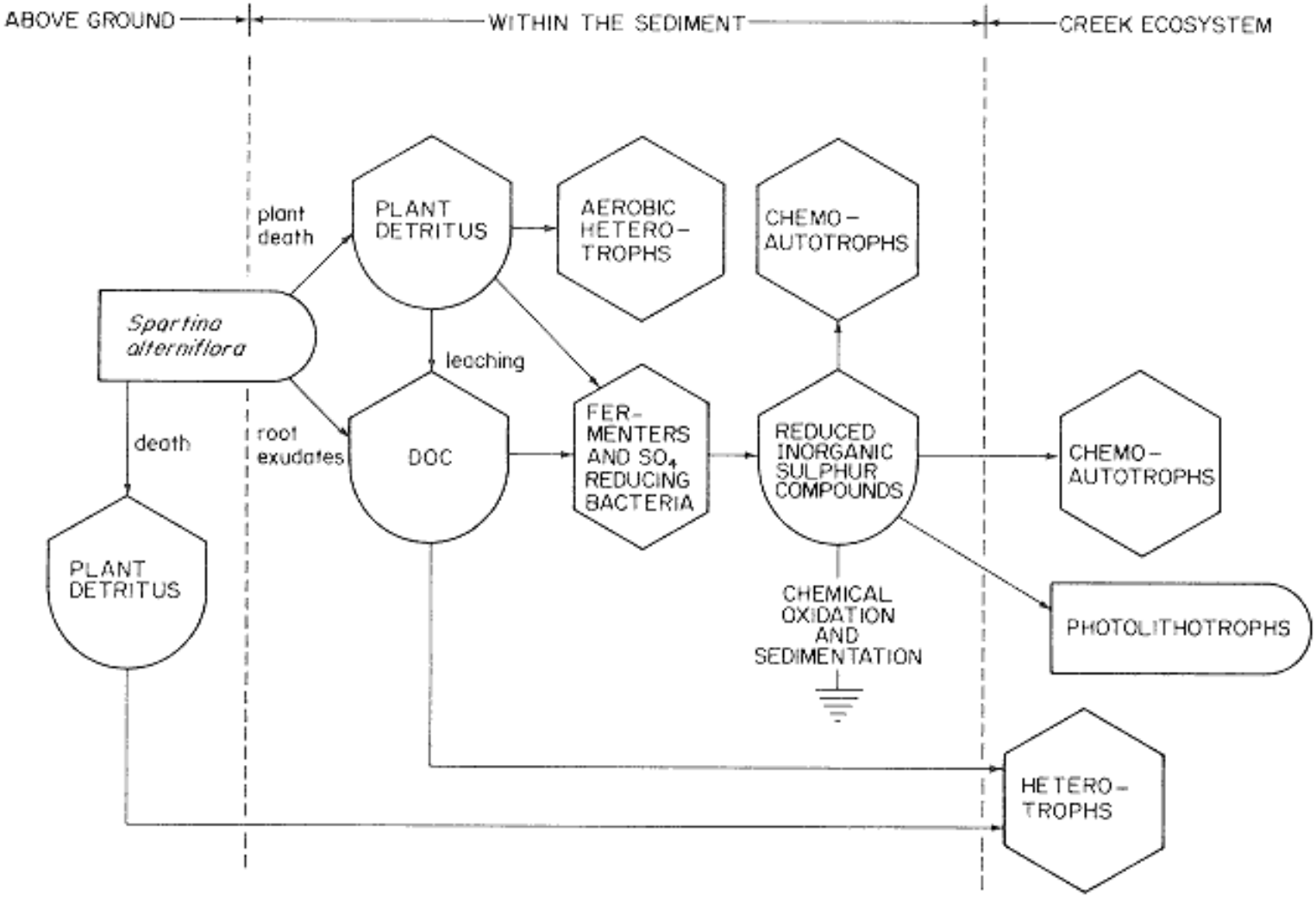
High Salinity

- Severe drought may have increased salinity in dieback marshes
  - Supporting evidence
    - In some regions where dieback occurred, surface salinities did increase
    - Some regions also observed elevated porewater salinity in dead marshes
    - Plants with a greater salt tolerance have survived alongside dead Spartina
  - Contradictory evidence
    - The salinities measured, while elevated, did not exceed tolerance limits of *S. alterniflora*
    - Less salt tolerant species have also survived in dieback areas

Sulfides

- Anaerobic carbon decomposition in wetland sediments produces fermentative products that can be toxic and create high soil oxygen demand
  - Supporting evidence
    - Some cases of dieback in Louisiana have been linked to sulfide accumulation
    - Other regions also exhibit elevated concentrations
  - Contradictory evidence
    - Plant death can generate these compounds and does not prove a cause and effect relationship
    - Species more vulnerable to sulfide have survived
    - Tests in some dieback regions revealed non-lethal sulfide levels

Cycle


ABOVE GROUND
WITHIN THE SEDIMENT
CREEK ECOSYSTEM
plant death
PLANT DETRITUS
AEROBIC HETERO-TROPHS
CHEMO-AUTOTROPHS
Spartina alterniflora
leaching
death
root exudates
DOC
FER-MENTERS AND SO_4 REDUCING BACTERIA
REDUCED INORGANIC SULPHUR COMPOUNDS
CHEMO-AUTOTROPHS
PLANT DETRITUS
CHEMICAL OXIDATION AND SEDIMENTATION
PHOTOLITHOTROPHS
HETERO-TROPHS

Pollution

- Chemical spills can kill large areas of marsh in a short period of time
  - Supporting evidence
    - No evidence of any spills
  - Contradictory evidence
    - No dieback marshes exhibited any signs of chemical spills or pollution damage
    - Pattern and extent of dieback is not consistent with observed dieback areas

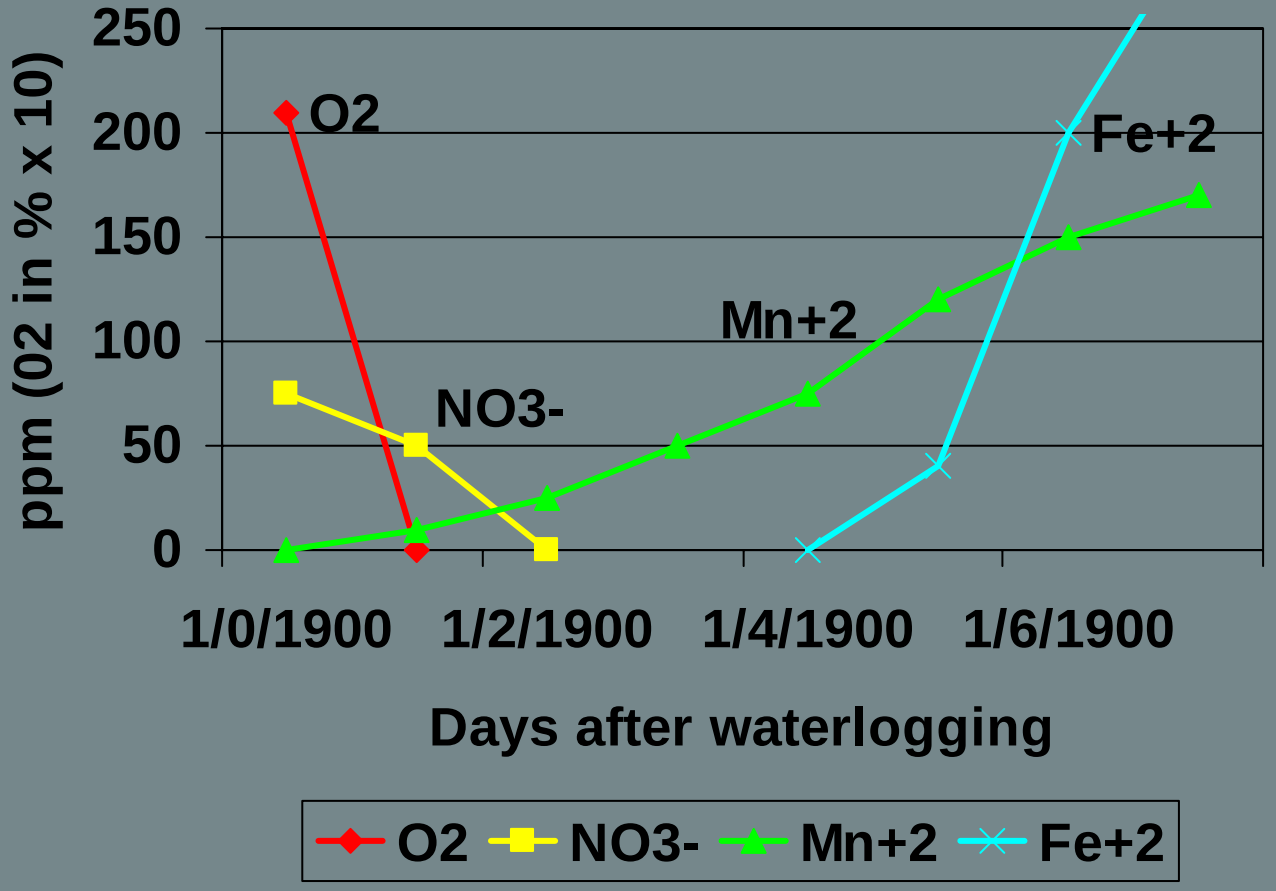
Metal Toxicity or Deficiency

- Increased salinity could change metal bioavailability and result in deficiencies in plants, decreased soil water could concentrate metals to toxic levels
  - Supporting evidence
    - Metal mobilization due to acidification caused by re-flooding of a desiccated marsh has been reported
    - Deposit patterns correspond with marsh dieback pattern
  - Contradictory evidence
    - No concrete evidence against changes in metal concentration or plant responses to these changes

Oxidation/Reduction Sequence

Redox Potential	Element	Reaction
+350 mV	Oxygen	O_2 ~H_2O
+220 mV	Nitrogen	NO_3- ~ NO_2-, N_2, NH_4+
+200 mV	Manganese	Mn_{+4} ~ Mn_{+2}
+120 mV	Iron	Fe_{+3} ~ Fe_{+2}
-150 mV	Sulfur	SO_4 ~ H_2S
-250 mV	Carbon	CO_2 ~CH_4

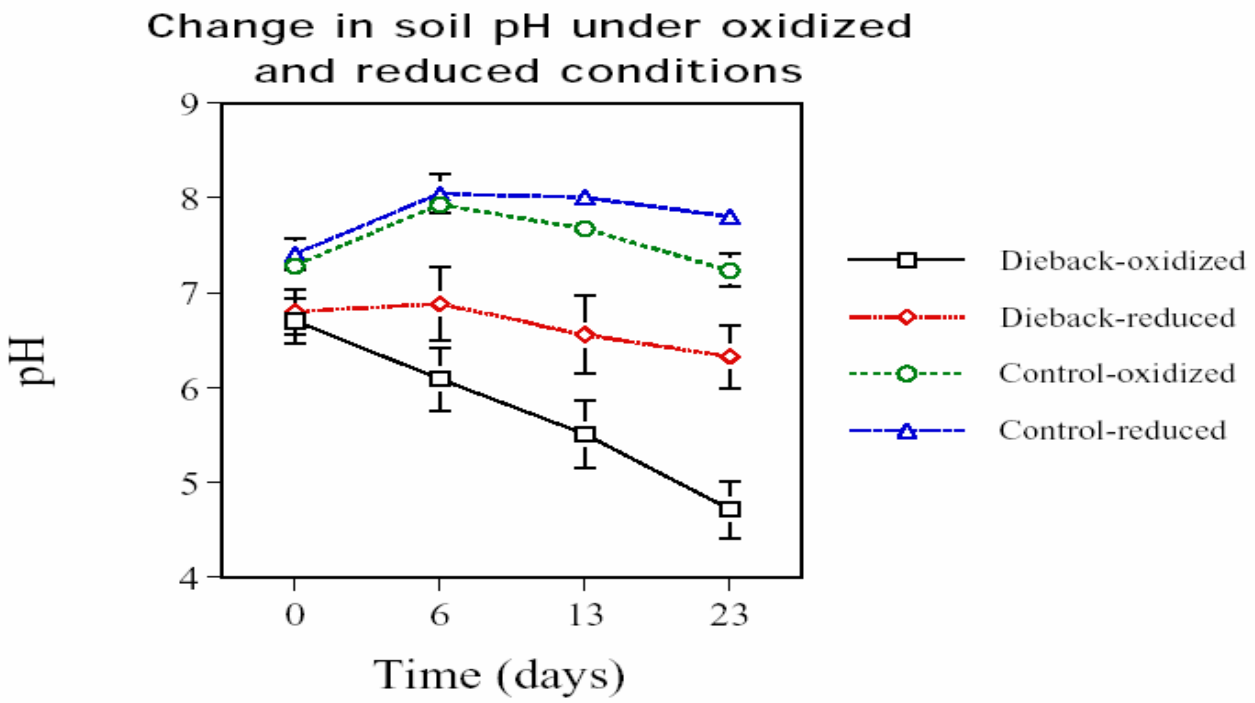
Laboratory Studies of Time Sequence for Oxidation/Reduction



PH

- Increased salinity could change metal bioavailability and result in deficiencies in plants, decreased soil water could concentrate metals to toxic levels
  - Supporting evidence
    - Soil pH of the affected marshes was typically acidic
  - Contradictory evidence
    - The measured levels in Delaware were within the range tolerable to the plants
    - Species less tolerant to higher PH were not effected

PH



U.S. Geological Survey-National Wetlands Research Center; Karen L. McKee, Principal Investigator; Collaborators: Irving A. Mendelssohn, Louisiana State University, Michael D. Materne, Natural Resources Conservation Service; Task I.6: Ground Assessment of Marsh Dieback Conditions and Plant Recovery; Funded by National Oceanic and Atmospheric Administration through a grant from Louisiana Department of Natural Resources

Plant Characteristics

	Drought Tolerance	PH	Moisture Use/ Flood Tolerance	Sulfide Tolerance	Salinity Tolerance	Precipitation range
Spartina alterniflora	None	5.5-7.5	High		High	40-60 in
Avicennia germinans				Less tolerant	High (more tolerant)	
Batis maritima	Medium	4.0-7.9	Medium		High (more tolerant)	28-60 in
Distichlis spicata	Medium	6.4-10.5	Medium		High	5-70 in
Juncus roemerianus	None	4.0-7.0	High		High (less tolerant)	40-60 in

General Observations

- Recovery correlates with increased acetylene reduction activity
- Survival of transplants equal in dieback and healthy areas
- Sulfide accumulation noted in Louisiana
- Concentration of NH_4 has been observed to be significantly higher in dieback areas
- All dieback events occurred during extreme drought conditions
- Root zone soil was oxidized in the healthy site and reduced at the dieback sites

Delaware Observed Measures

- Indian River- 10 sites
- pH Range: 6.3-7.6
- Salinity Range: 14.5-28.8ppt
- No periwinkles observed within plots

Restoration

- Louisiana shows recovery, while New England States have little recovery
- Seeding has been the most effective method in Louisiana
- Live planting and coconut mat planting also used to some success

Summary

- Least likely factors
  - Chemical Spill
  - Pathogens
  - Low genetic diversity
  - Sea level rise
  - Mosquito ditches
  - Snails
  - Snow Geese
- More likely factors
  - Stresses during the dormant period
  - Drought and water level extremes
  - Natural Toxins

Although the cause of dieback is currently unknown, plant and soil characteristics in most areas were consistent with temporary soil desiccation that may have reduced water availability, increased soil salinity, caused soil acidification or increased uptake of toxic metals such as Fe or Al.

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Web Resources

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