Consequences of Interspecific Variation in N and C Pools of Salt Marsh Plants

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How and why marsh plants differ in function may be most important in the context of:

1. Environmental change
   - species composition
   - alter processes
2. How we have altered the landscape
3. Why we *need* these functions!!
   - nutrient filtration
   - carbon storage

Climate change

Mid-Atlantic region

Relative to 1990 levels

	Year		
	2030	2095	Source
CO_2 (%)	+ 25	+ 92	*Houghton et al. 1996*
Sea level (cm)	+ 19	+ 66	*Warrick et al. 1996*
Temperature (°C)	+ 1.3	+ 4.0	*Polsky et al. 2000*
Precipitation (%)	+ 4	+ 15	*Polsky et al. 2000*
Streamflow (%)	+ 2	+11	*Neff et al. 2000*

How climate change will affect marsh plant community structure

1. Sea-level rise
   A. Erode at the waterward boundary

   B. Drown in place and convert to open water

   C. Marshes vertically keep pace
      - Sedimentation
      - Peat formation

   D. Migrate inland as areas above the tide become inundated
      - Landward edge unhindered by hard structure

Sea level rise

Landward migration hindered by hard structures

Response:

- high marsh shrubs die first
- mid-marsh squeezed
- low marsh dominates

How climate change will affect marsh plant community structure

2. Increase in temperature

Response:

more southerly species move northward

3. Increase in CO_2 concentration

Response:

increase coverage of C3 species at the expense of C4 species (Drake et al. 1996)

How climate change will affect marsh plant community structure

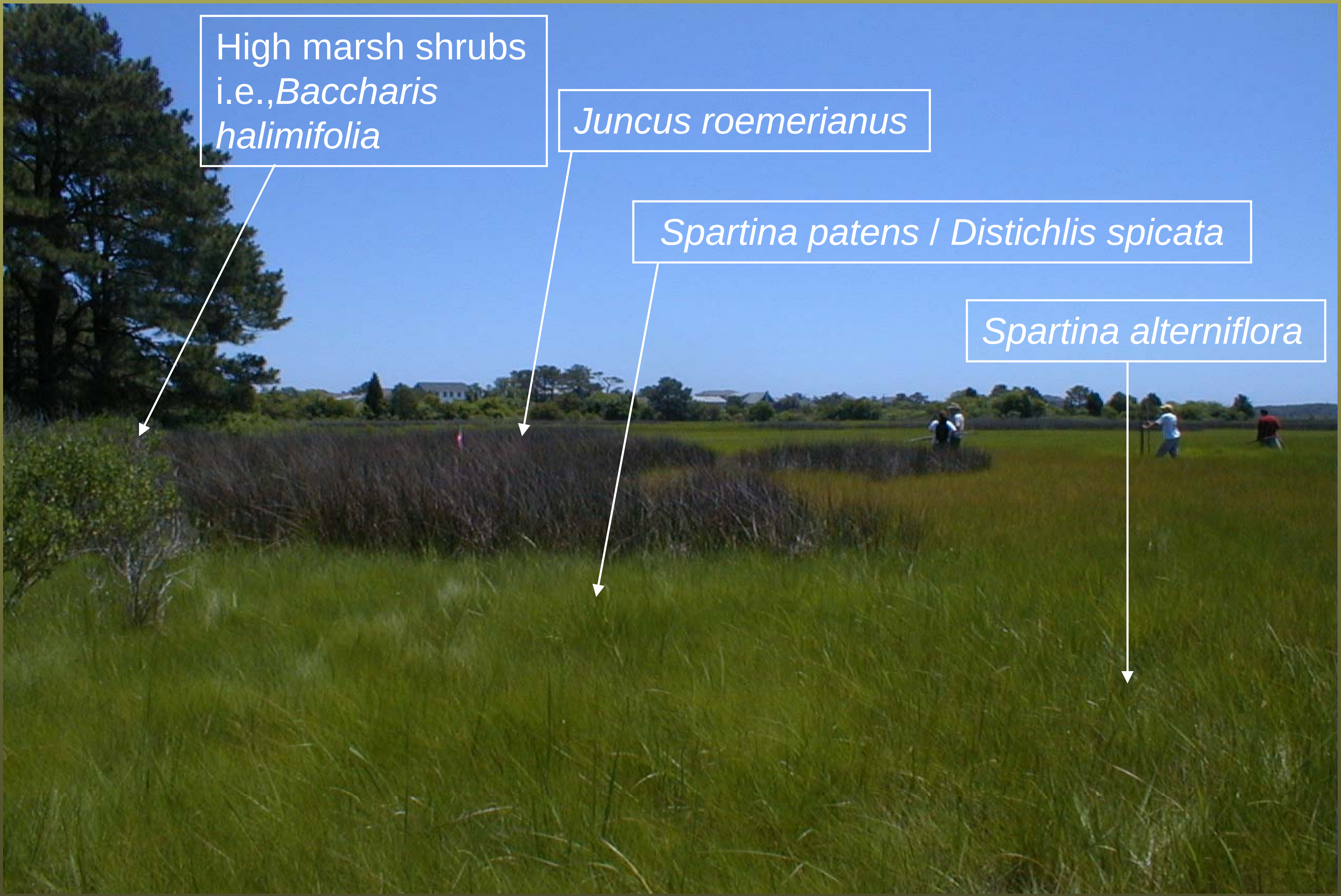
3. Increase in precipitation and streamflow

Response:

- neutralize salinity in the high marsh

- decrease salinity levels in the high marsh

Delaware's fringing marshes



Juncus roemerianus - dominated southern marsh

C3 species

Grows in moderate salinities

Potential for increasing coverage in mid-Atlantic marshes

OBJECTIVES

Differences among species:

1. Potential for sediment trapping
   - Stem density

2. N & C storage
   - Seasonal pool size
   - Nitrogen translocated to belowground
   - Loss (decomposition)
   - Soil storage

Plants enable sediment trapping

- Attenuating tidal flows and wave activity
- Adherence onto plants
- Preventing resuspension of fine grained deposits (Yang et al. 2008)

Depend on:

- – Distance from the marsh edge
- – Stem densities

Stem density (# stems/m^2)

	Month			
	March	June	August	November
Juncus roemerianus	1798 ± 421	3090 ± 735	1838 ± 203	2386 ± 430
Spartina patens	7528 ± 918	14000 ± 1831	8136 ± 881	8392 ± 2066
Spartina alterniflora	876 ± 109	1062 ± 217	1056 ± 275	766 ± 247

N and C pools in marsh plants

Juncus roemerianus

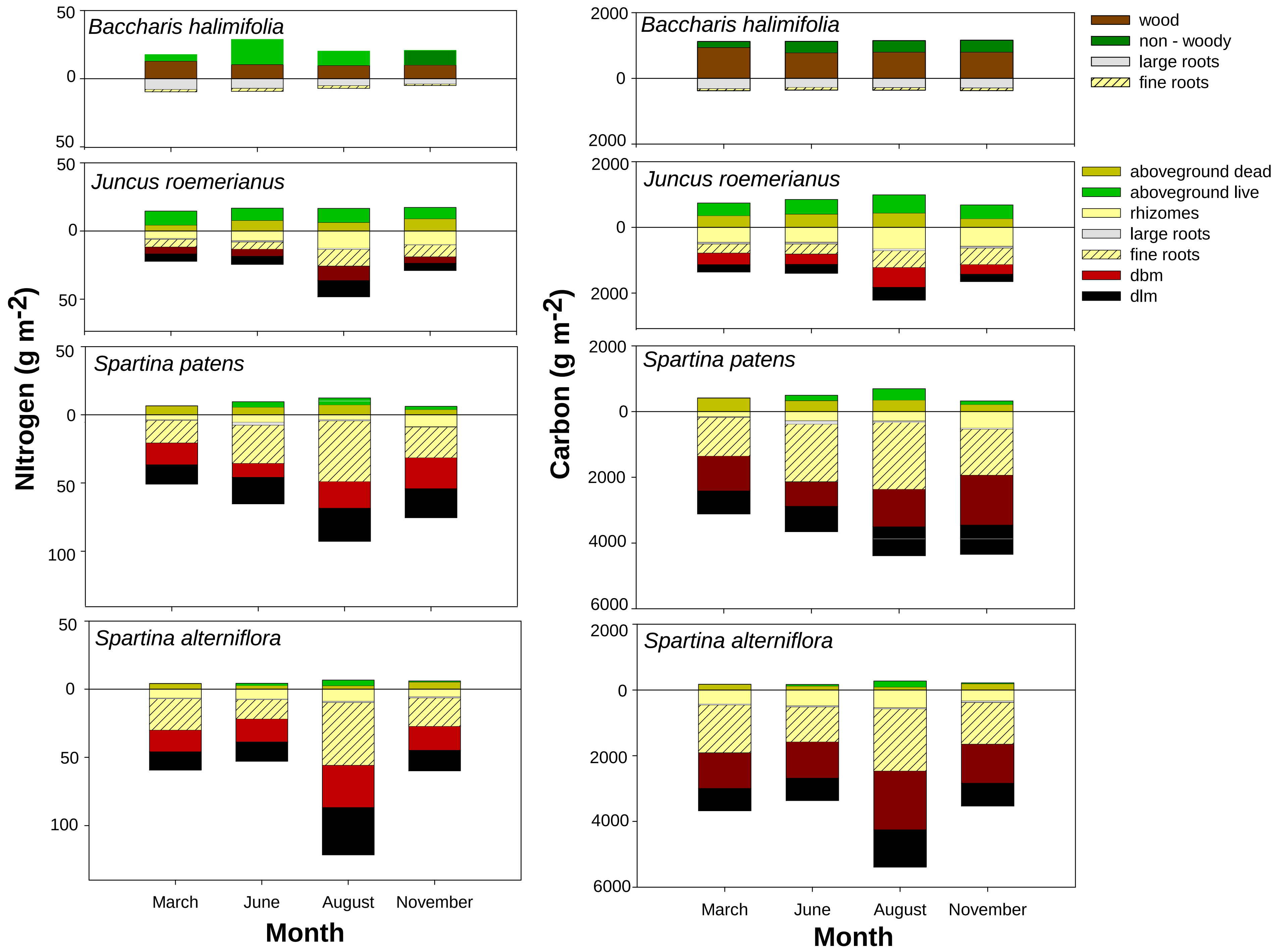
Biomass * N or C concentration

- seasonal
- allocation
  (above- vs. belowground)
  (live vs. dead)

Stem bases

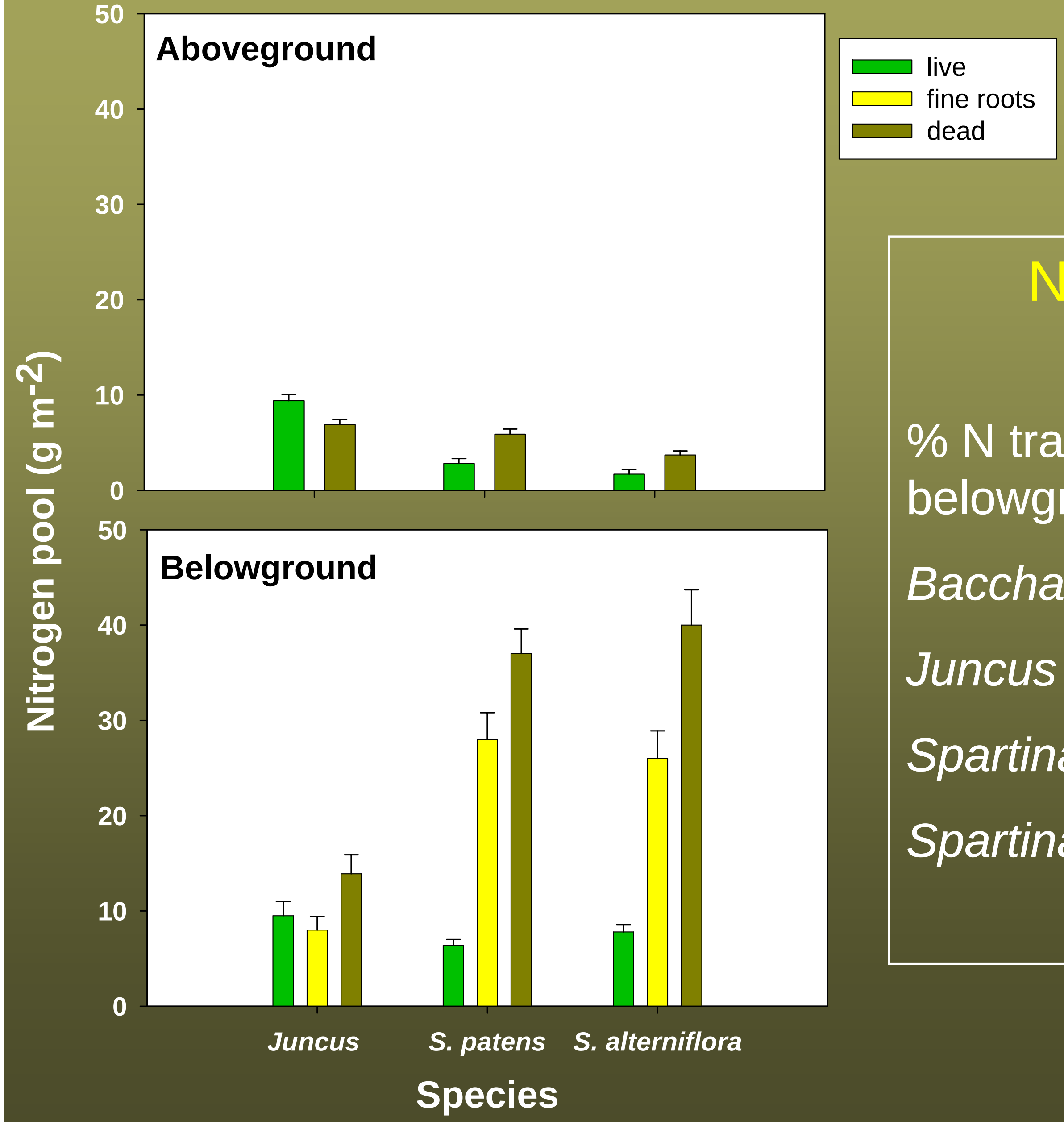
Fine roots

Dead big OM



Baccharis halimifolia
Juncus roemerianus
Spartina patens
Spartina alterniflora
NItrogen (g m-2)
Carbon (g m-2)
50
0
100
2000
4000
6000
March
June
August
November
Month
wood
non - woody
large roots
fine roots
aboveground dead
aboveground live
rhizomes
dbm
dlm

Live vs. Dead N pools

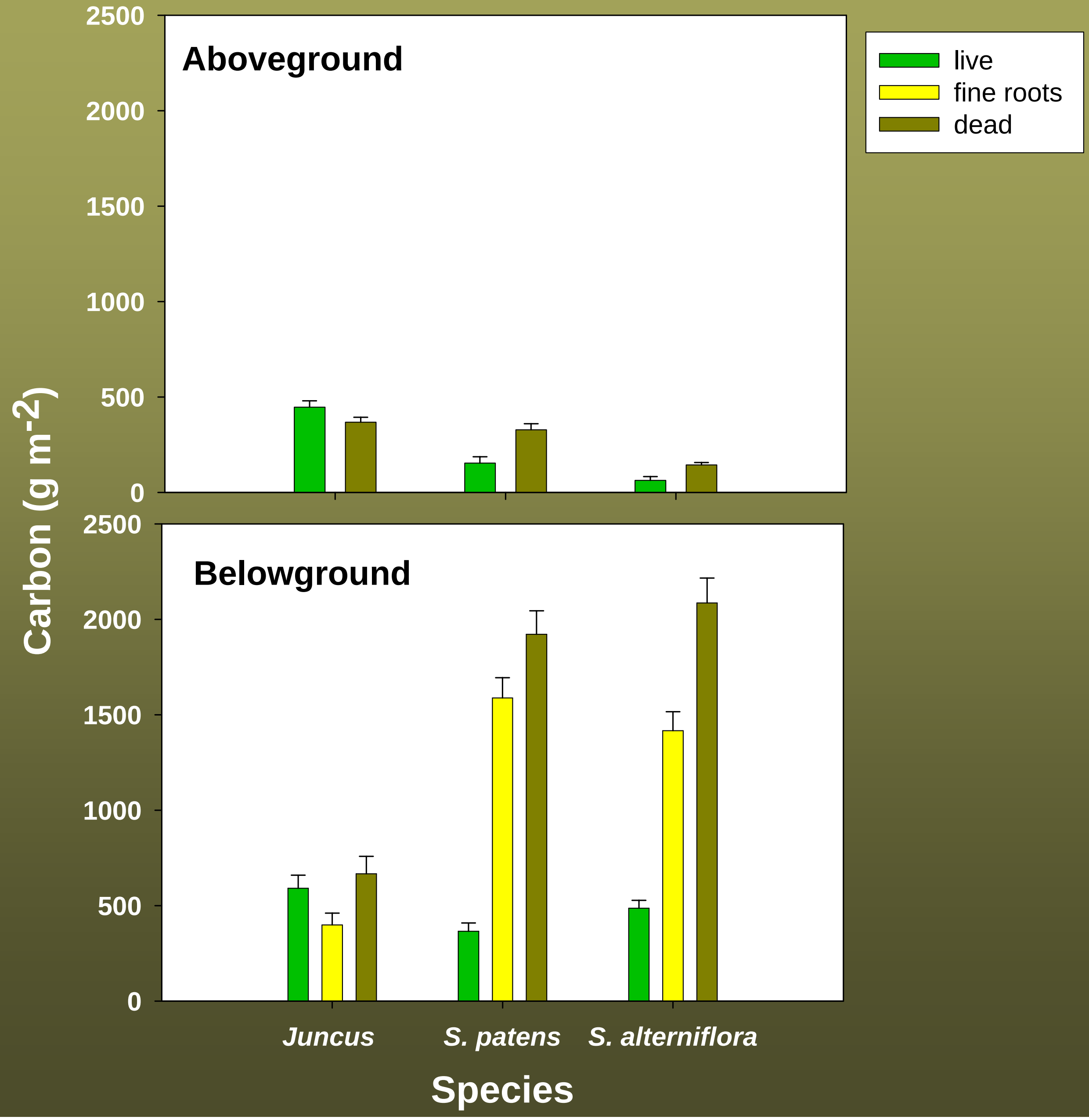


Nitrogen Resorption Efficiency

% N translocated from above- to belowground

Baccharis halimifolia	41
Juncus roemerianus	24
Spartina patens	32
Spartina alterniflora	56

Live vs. Dead C pools



Dead N pools and losses

Aboveground

	N pool (g m^{-2})	N pool loss (g g^{-1} day^{-1})	Turnover (days)
Baccharis halimifolia	0.3 ± 0.07	*	*
Juncus roemerianus	26 ± 0.5	0.0030	333
Spartina patens	32 ± 0.5	0.0027	367
Spartina alterniflora	13 ± 0.4	0.0074	135

* microbial colonization

Belowground

	0 – 15 cm	5 cm	
	N pool (g m^{-2})	N pool loss (g g^{-1} day^{-1})	Turnover (days)
Juncus roemerianus	5.6 ± 0.9	0.0029	350
Spartina patens	10.3 ± 1.1	0.0021	470
Spartina alterniflora	14.8 ± 1.3	0.0009	1057

Dead C pools and losses

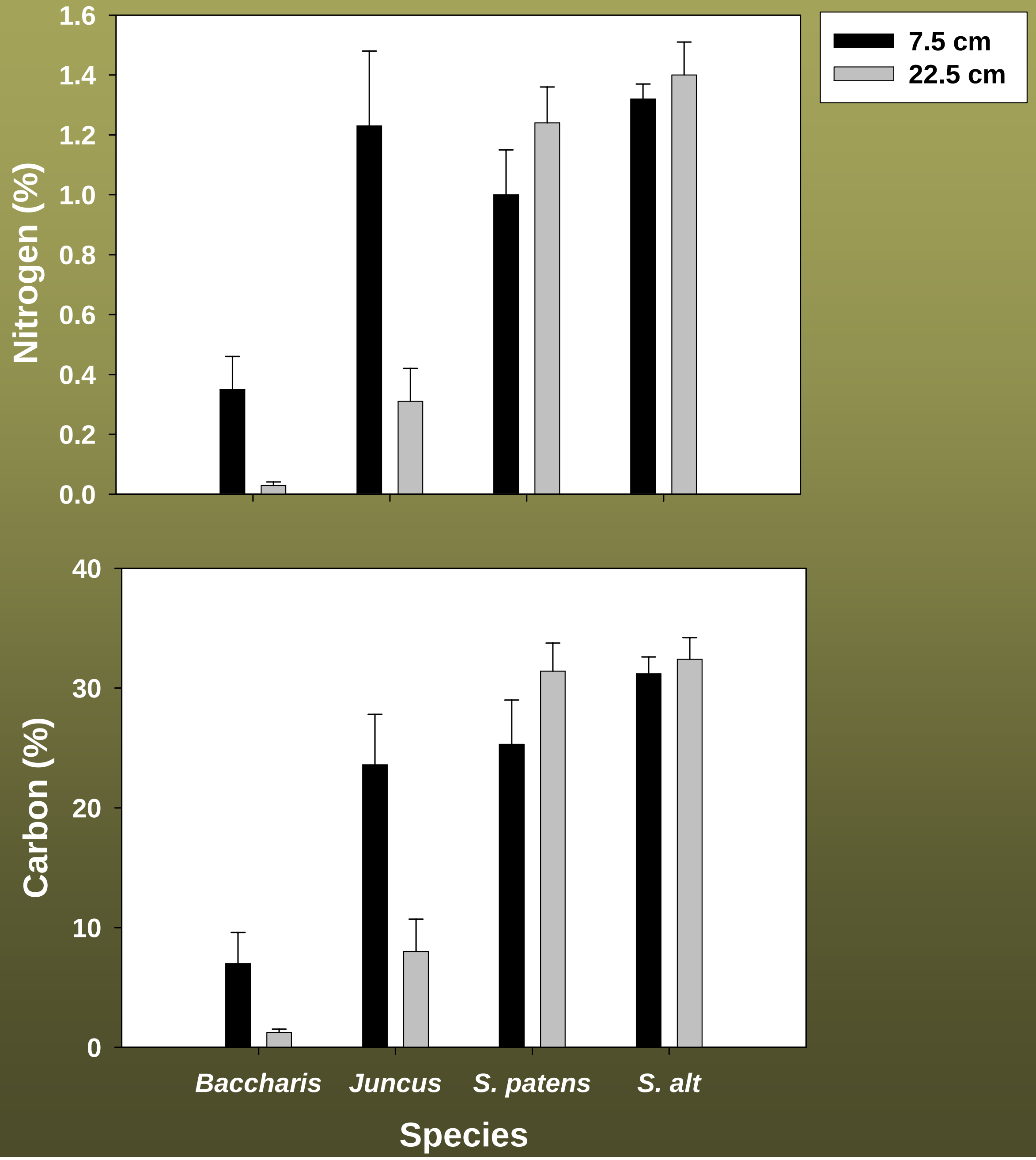
Aboveground

	C pool ($g\ m^{-2}$)	C pool loss ($g\ g^{-1}\ day^{-1}$)	Turnover (days)
Baccharis halimifolia	12 ± 3	0.0015	810
Juncus roemerianus	368 ± 7	0.0034	307
Spartina patens	328 ± 6	0.0010	993
Spartina alterniflora	144 ± 4	0.0076	131

Belowground

	0 – 15 cm	5 cm	
	C pool ($g\ m^{-2}$)	C pool loss ($g\ g^{-1}\ day^{-1}$)	Turnover (days)
Juncus roemerianus	308 ± 41	0.0015	684
Spartina patens	685 ± 72	0.0011	938
Spartina alterniflora	983 ± 66	0.0019	552

Soil N & C



7.5 cm
22.5 cm
Nitrogen (%)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Carbon (%)
0
10
20
30
40
Baccharis
Juncus
S. patens
S. alt
Species

Scenarios

Marshes vertically keep pace with sea level rise

Increase temp, CO_2, precip, streamflow

Response:

Increase in coverage of *Juncus roemerianus*

Competition with *Spartina patens*

Implications:

Stem density: reduced by 78%

N & C pools: Belowground → Above = Below

Lower NRE (25%)

Faster N & C loss rates belowground

Soil N: 1.2 → 0.3%

Soil C: 30 → <10%

Scenarios

Hindered landward migration

Response:

High marsh shrubs die out first

Implications

Aboveground storage of N and C

Litterfall minor and loss of N and C very slow

Scenarios

Hindered migration

Response

Low marsh dominates (short *Spartina alterniflora*)

Encroachment into *Spartina patens* community

Implications

Lowest stem density – affect sedimentation

High NRE

Fast loss of N and C pools aboveground

Similar slow loss of large OM belowground

Similar large C pool stored in dead material

Conclusions

- Changes to plant community structure imply changes to the functioning of salt marshes

  - nutrient filtering

  - C storage

Ex: Delaware

21% marshland flooded with rise of 2’

< 1% developed – potential for horizontal migration


Questions?