Above- and Belowground Biomass and Net Primary Productivity Landscape Patterns of Mangrove Forests in the Florida Coastal Everglades

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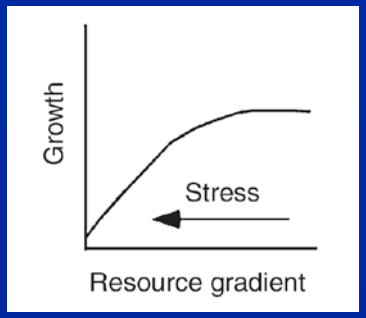
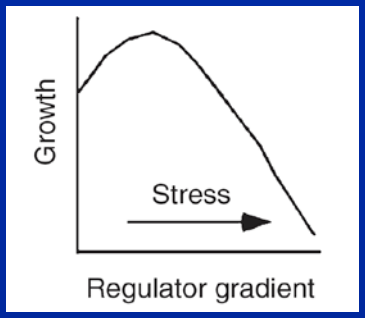
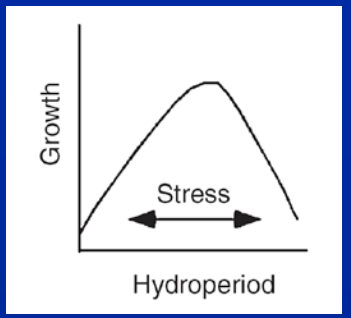
Riverine Mangrove Forests



Nutrients, Light



Salinity and Sulfide



Frequency, Duration, Depth

Environmental Gradients

Landscape Vegetation Patterns

Scrub Mangrove Forests

Hurricane Disturbances

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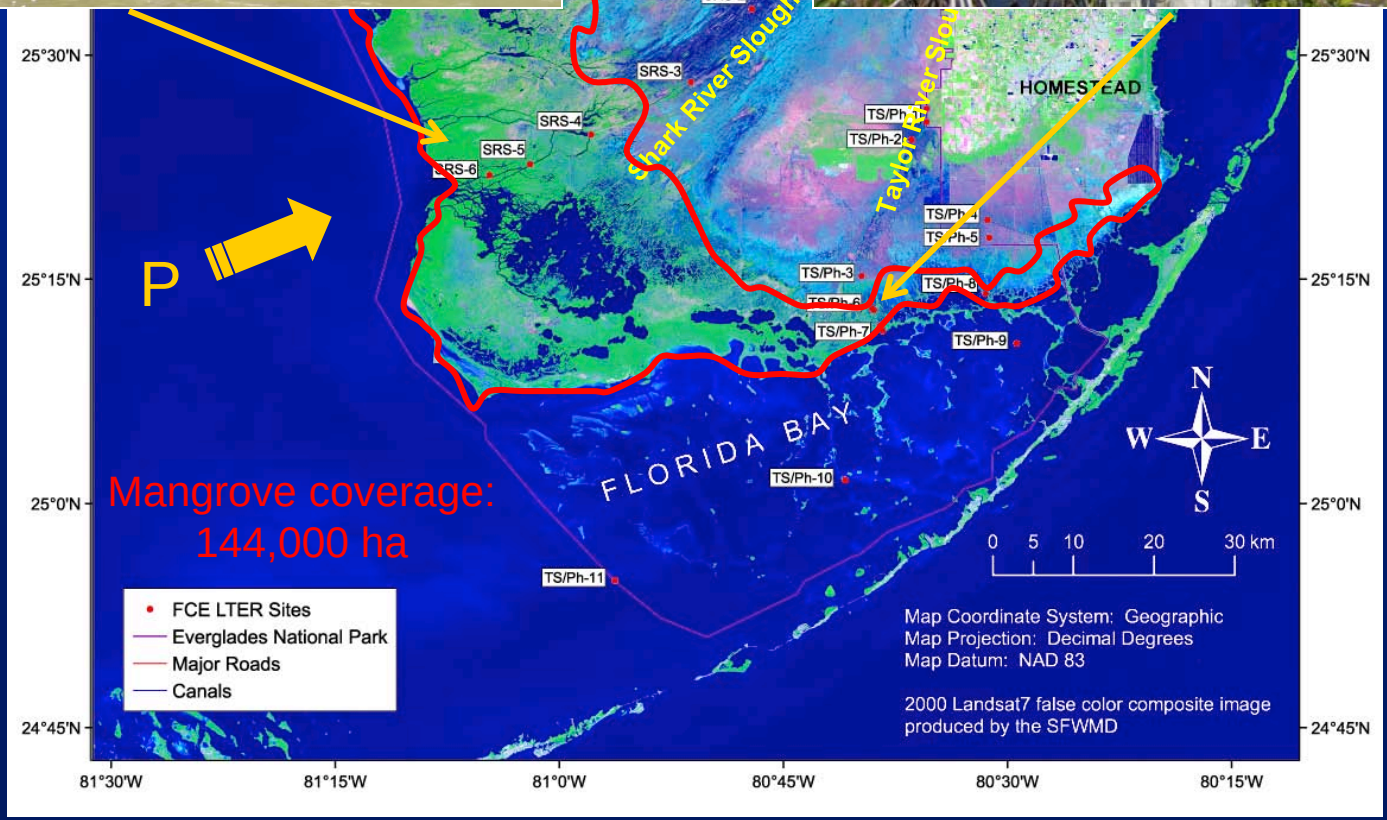
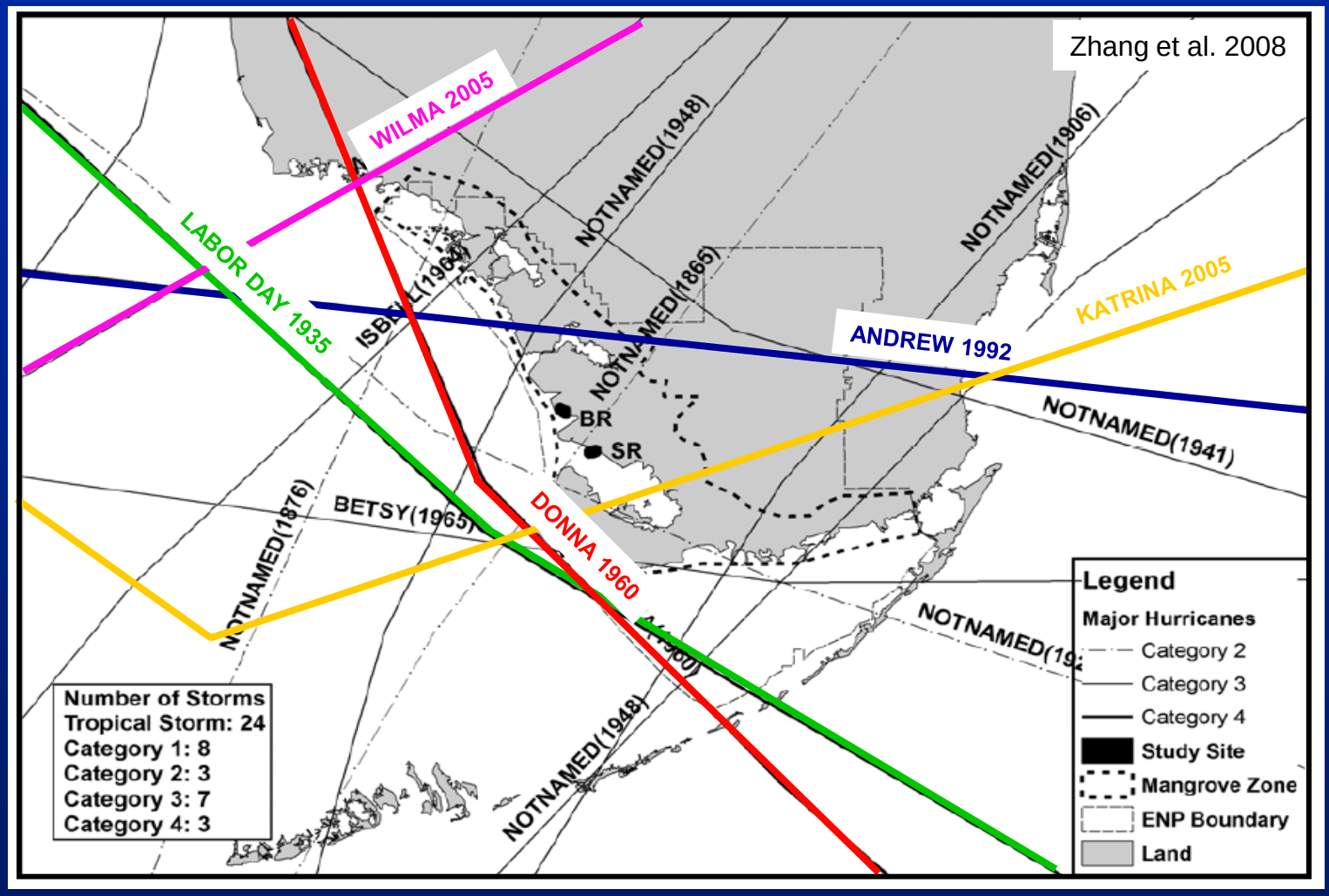
Shark River, SRS-6


Taylor River, TS/Ph-6

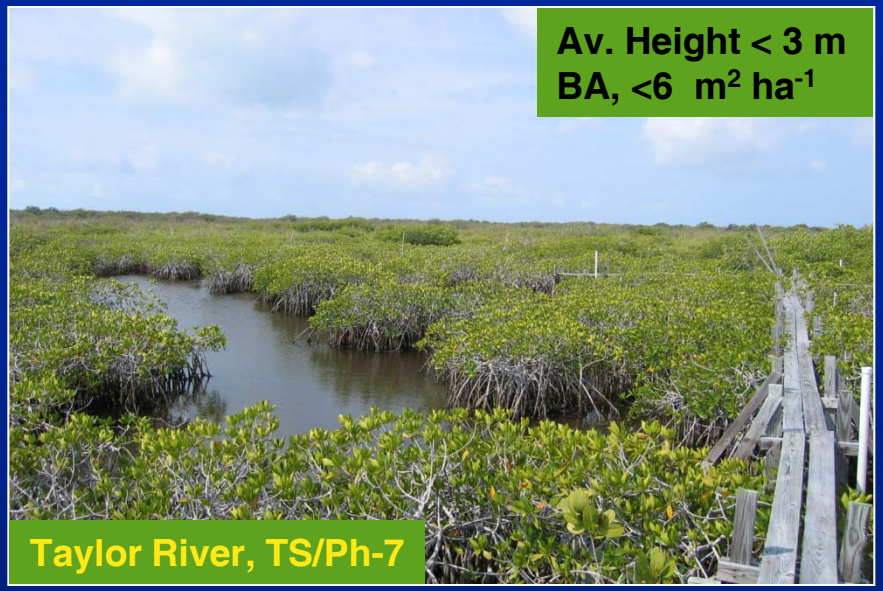

80°45'W
SRS-1a,b
SRS-2
SRS-3
SRS-4
SRS-5
SRS-6
Shark River Slough
Taylor River Slough
HOMESTEAD
TS/Ph-1
TS/Ph-2
TS/Ph-3
TS/Ph-4
TS/Ph-5
TS/Ph-6
TS/Ph-7
TS/Ph-8
TS/Ph-9
TS/Ph-10
TS/Ph-11
P
FLORIDA BAY
Mangrove coverage:
144,000 ha
FCE LTER Sites
Everglades National Park
Major Roads
Canals
N
W
E
S
0 5 10 20 30 km
Map Coordinate System: Geographic
Map Projection: Decimal Degrees
Map Datum: NAD 83
2000 Landsat7 false color composite image
produced by the SFWMD
25°30'N
25°15'N
25°0'N
24°45'N
81°30'W
81°15'W
81°0'W
80°45'W
80°30'W
80°15'W

High Recurrence of Tropical Storms and Hurricanes in South Florida



- South Florida has been struck by 40 hurricanes since 1851.
- Three category 4 hurricanes have impacted the mangrove zone in FCE since 1851.
- The frequency of direct hits by category 3-5 hurricanes in South Florida is ~once every 20-30 years.

Landscape Gradients in Resources (Nutrients), Regulators (H_2S), and Hydroperiod



- Hydroperiod: Tide-dominated
- P gradient: downstream → upstream
  (N:P = 28) → (N:P = 110)
- PW Sulfide: Negligible (<0.06 mM)
- Soil Redox: Slightly reduced
- PW Salinity: 5-27 g kg^{-1}

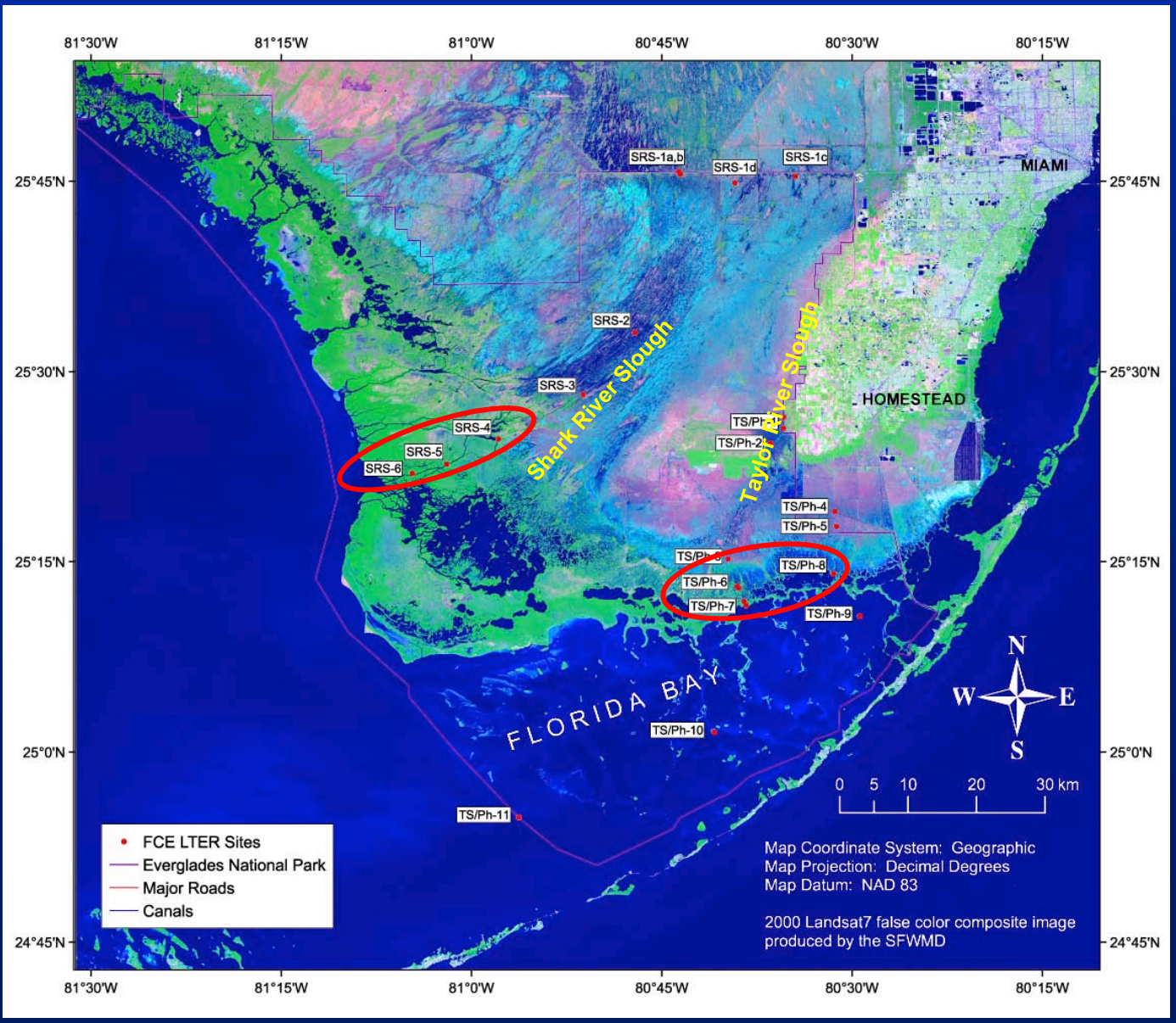
- Permanently or seasonally flooded
- P limitation (N:P = 66 to 110)
- High (1.0-2.3 mM)
- Moderate reduced
- 17-20 g kg^{-1}

Castaneda (2010)

Research Questions

- What are the landscape patterns of above- and belowground biomass and NPP of mangrove forests across the P-limited conditions of FCE?
- What are the main soil factors controlling these patterns?
- What are the carbon accumulation rates in mangrove forests of the Florida Everglades?

Study Area: FCE-LTER Sites



Mangrove Sites

- Shark River:
  - SRS-4 (upstream)
  - SRS-5 (upstream)
  - SRS-6 (downstream)
- Taylor River:
  - TS/Ph-6 (upstream)
  - TS/Ph-7 (upstream)
  - TS/Ph-8 (downstream)

Root Biomass

PVC coring (10 x 90 cm)

- Dec 2000 and Dec 2002
- Depth:

- 0-45 cm (shallow root zone)
- 45-90 cm (deeper root zone)

- Live roots: Fine (<2 mm), Small (2-5 mm), and Coarse (>5mm)

Root Production

Ingrowth bags (10 x 45 cm)

- ***Ingrowth Core Technique***
- Harvest periods:

- 1-year (Dec 2003)
- 3-year (Feb 2006)

Wood Biomass-Production

- Shark River sites and TS/Ph-8

- Plots: Two 20 x 20 m plots

- Transects: Two 100-200 m in length

- Trees (DBH > 2.5 cm) were tagged and measured (May 2001 to May 2004).

- DBH and allometric equations (Smith and Whelan 2006).

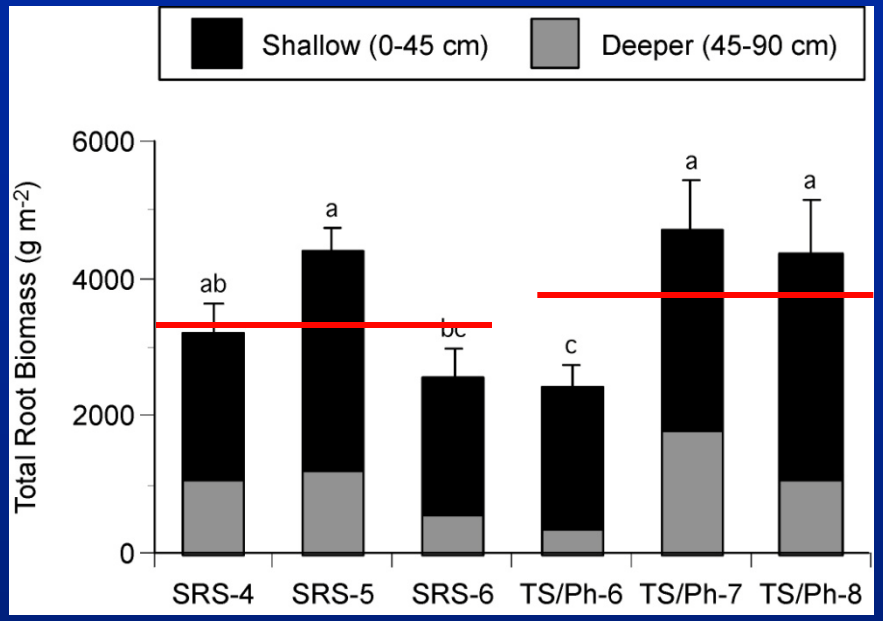
Litterfall Production

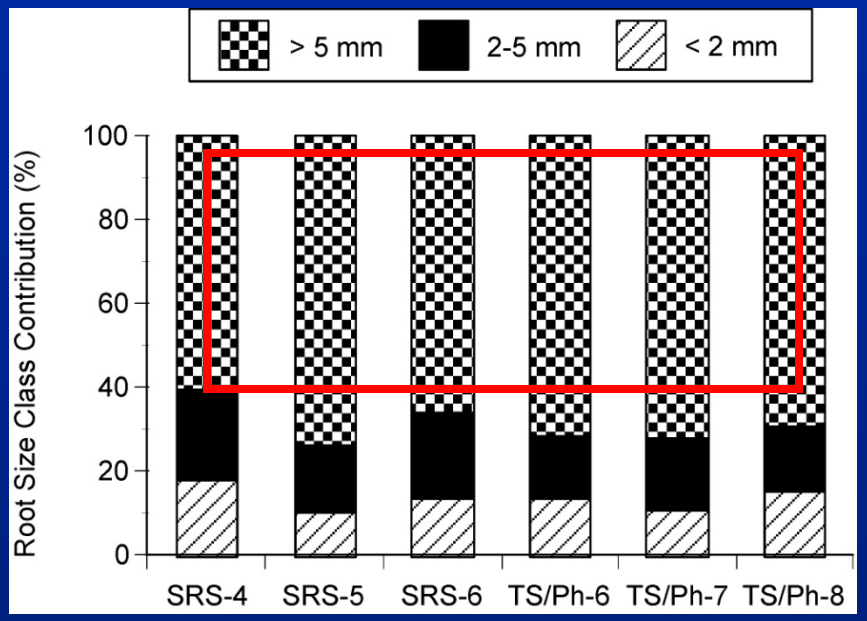
- Five litter baskets (0.25 m^2) per plot; total of 10 per site.

- Monthly collections (Jan 2001 to Dec 2005).

- Plant material sorted by species components (leaves, reproductive parts, and woody material).

Total Root Biomass and Root Size Distribution





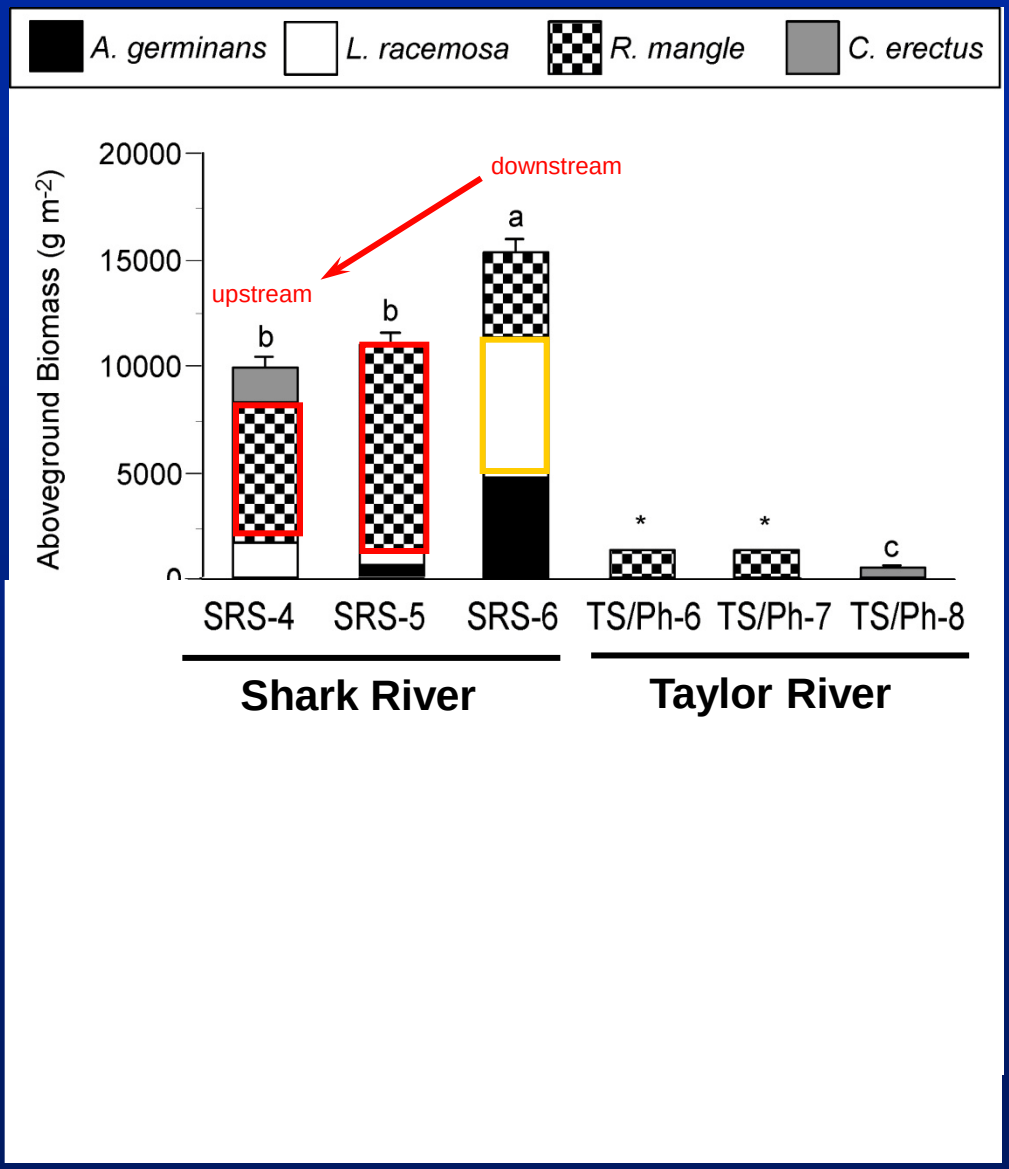
- Total (0-90 cm) mean biomass:

- Shark River: 3368 ± 544 g m^{-2}
- Taylor River: 3811 ± 710 g m^{-2}

- 62-85% of total biomass in the shallow (0-45 cm) root zone.

- 69% of the total root biomass was distributed in the larger (> 5 mm) size class.

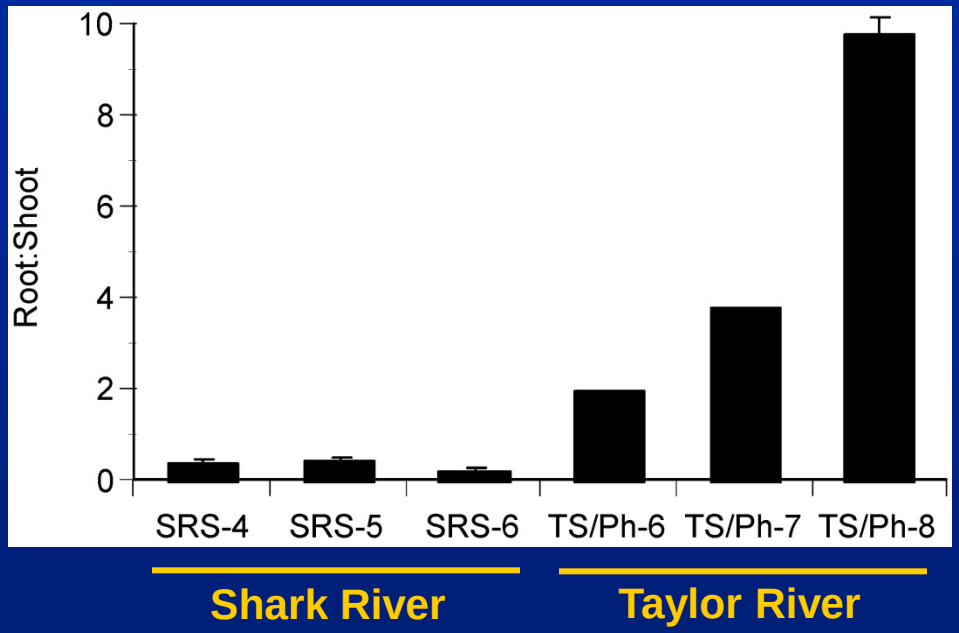
Aboveground Wood Biomass

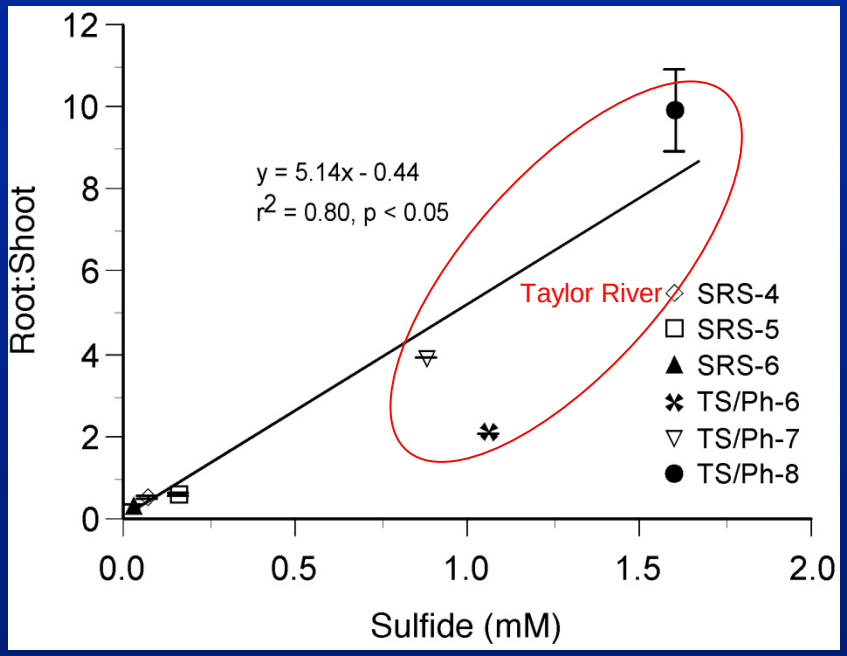


- Wood biomass:
  - Shark River = 11,952 ± 1658 g m^{-2}
  - Taylor River = 982 ± 268 g m^{-2}
- *R. mangle*: 70-80% of total biomass in upstream sites.
- *L. racemosa*: 43% of total biomass in SRS-6.

* TS/Ph-6 & 7: Coronado-Molina et al. (2004)

Higher Allocation of Biomass to Roots in Taylor River



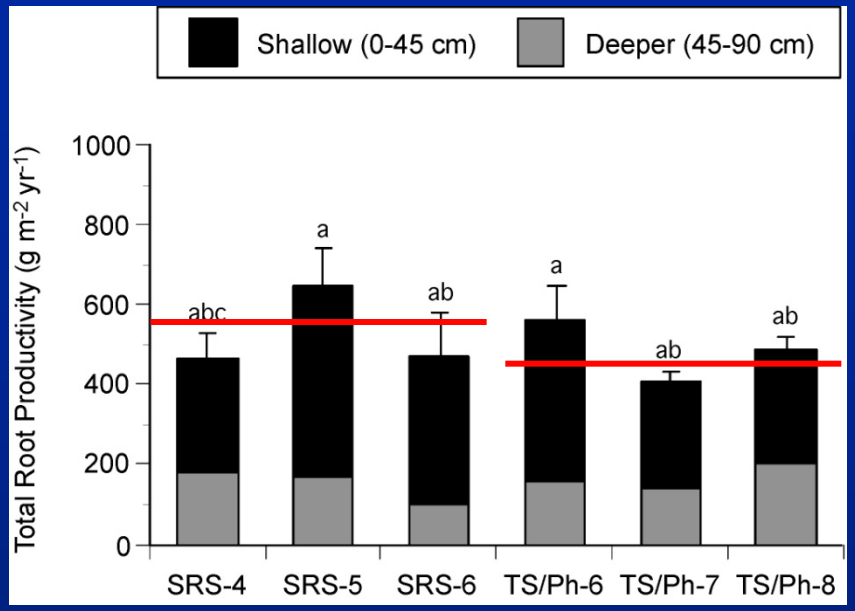


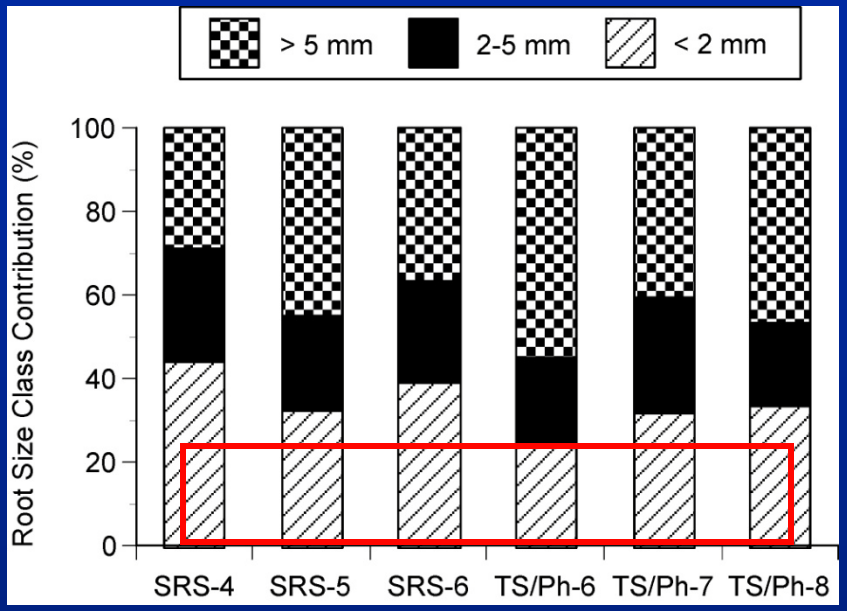
- Root:shoot ratios:
  - Shark River: 0.17 to 0.33
  - Taylor River: 1.9 to 9.8

- Scrub mangroves in Taylor River allocated 3.8x more biomass to roots relative to AG.

- Higher Root:Shoot ratios in Taylor River are associated to P limitation and flooded hydroperiods.

Total Root Production and Root Size Distribution





- Total (0-90 cm) root production:

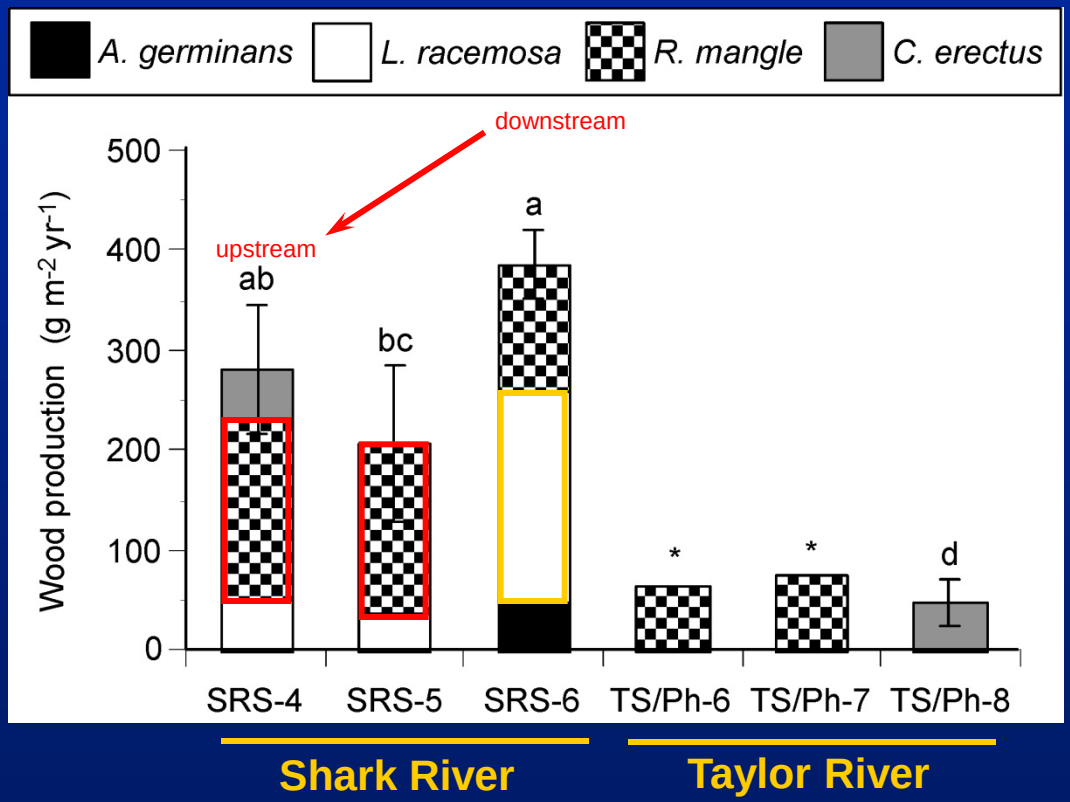
- Shark River: 526 ± 89 g m^{-2} yr^{-1}
- Taylor River: 482 ± 49 g m^{-2} yr^{-1}

- 57-78% of total production in the shallow (0-45 cm) root zone.

- Fine roots contributed 25-44% of the total production.

- Small and coarse roots accounted for 24% and 41% of the total root production.

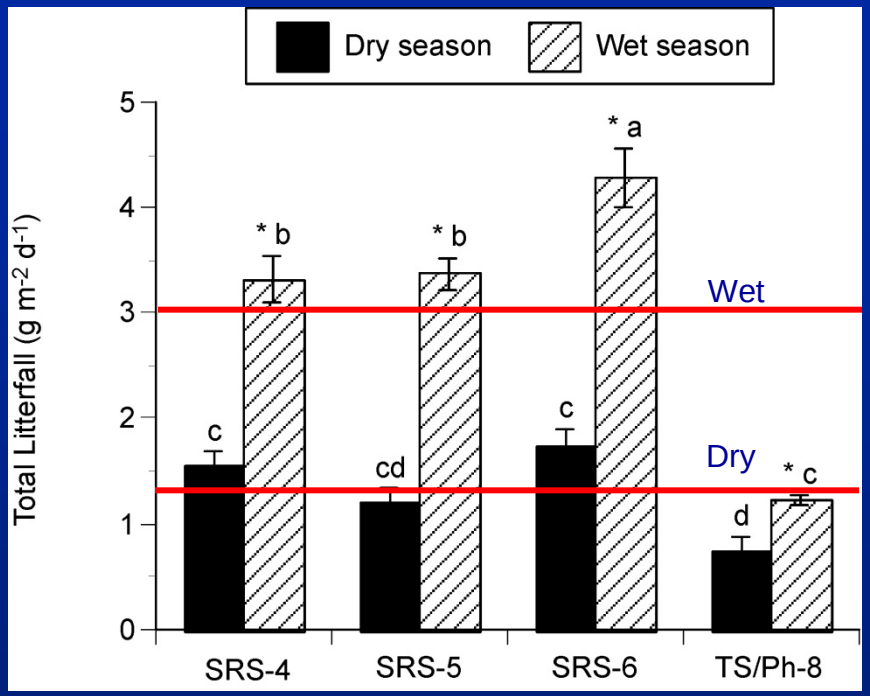
Aboveground Wood Production



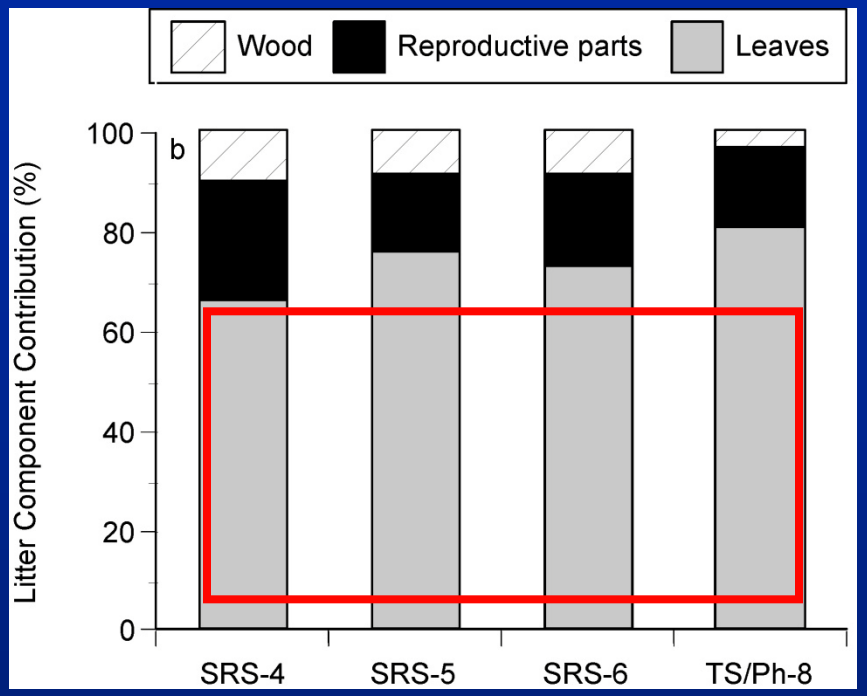
- Wood production:
  - Shark River: 290 ± 52 g m^{-2} yr^{-1}
  - Taylor River: 62 ± 8 g m^{-2} yr^{-1}
- *L. racemosa*: Highest production (210 g m^{-2} yr^{-1}) in SRS-6.
- *R. mangle*: Highest production in upstream sites of Shark River (180 to 167 g m^{-2} yr^{-1}).

* TS/Ph-6 & 7: Ewe et al. (2006)

Litterfall Production (2001-2004)



Shark River



- Mean rates:

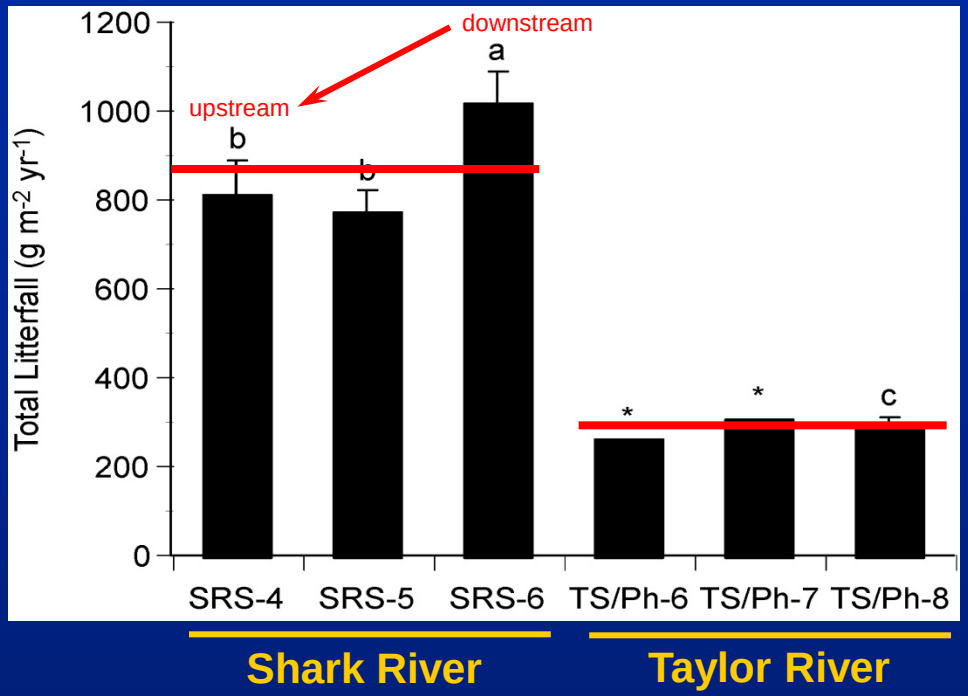
- Dry season: 1.3 ± 0.1 g m^2 d^{-1}
- Wet season: 3.0 ± 0.2 g m^2 d^{-1}

- SRS-6 had the highest litterfall rate and TS/Ph-8 the lowest.

- Leaf fall comprised 66-81% of the total production.

- Woody material and reproductive parts: <15%.

Annual Litterfall Rates (2001-2004)



- Annual rates:

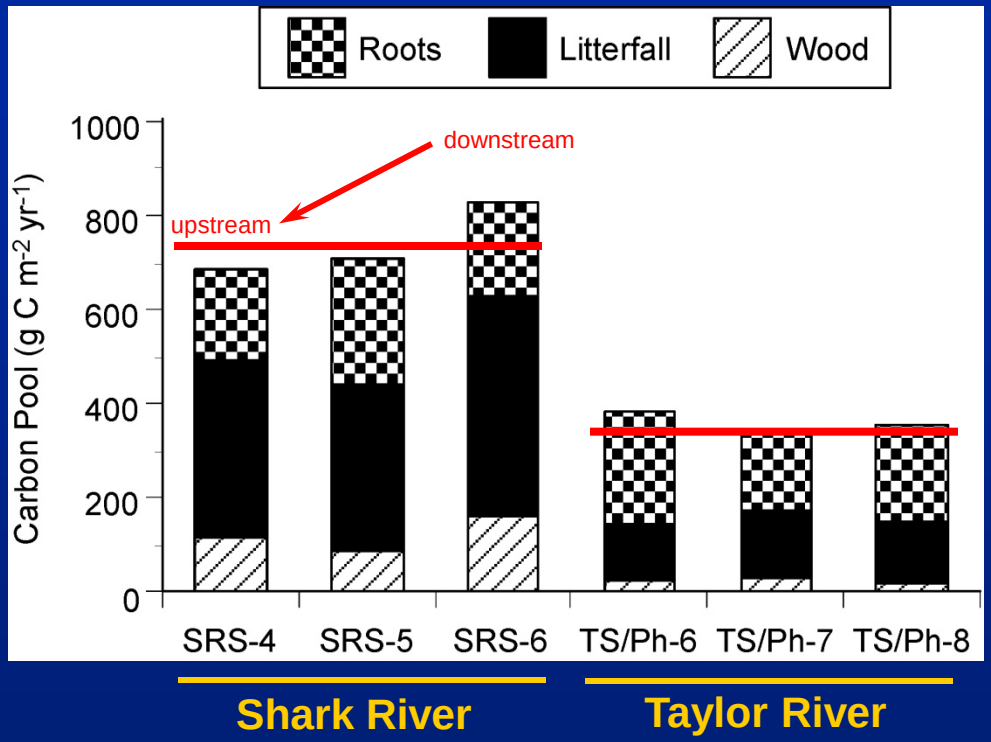
- Shark River = 864 ± 57 g m^{-2} yr^{-1}

- Taylor River = 282 ± 25 g m^{-2} yr^{-1}

- SRS-6: Highest (1014 g m^{-2} yr^{-1}) litterfall.

* TS/Ph-6 & 7: rates from Ewe et al. (2006)

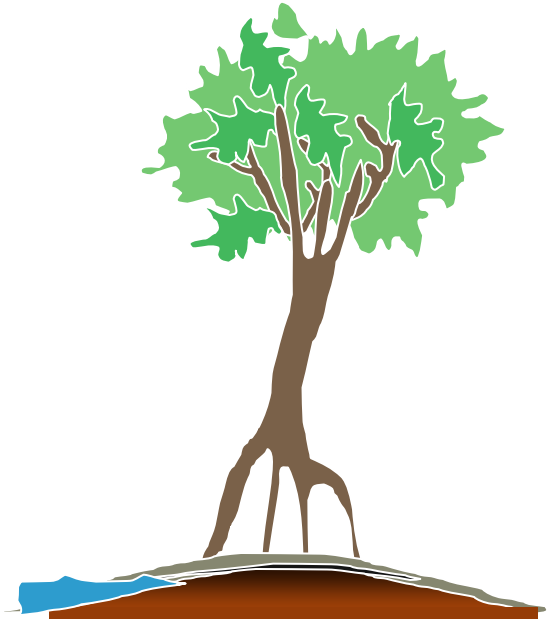
Carbon Accumulation Rates



Carbon content:
- Litterfall = 46%
- Wood = 42%
- Roots = 41%

- Total mean Carbon pool:
  - Shark River: 734 ± 43 g C m^{-2} yr^{-1}
  - Taylor River: 355 ± 11 g C m^{-2} yr^{-1}
- SRS-6: Highest (818 g C m^{-2} yr^{-1}) C pool.

Shark River
Riverine Mangroves



Total C
734 ± 43 g C m^{-2} yr^{-1}

Litterfall
398 ± 35 g C m^{-2} yr^{-1}

Wood
120 ± 21 g C m^{-2} yr^{-1}

Roots
216 ± 24 g C m^{-2} yr^{-1}

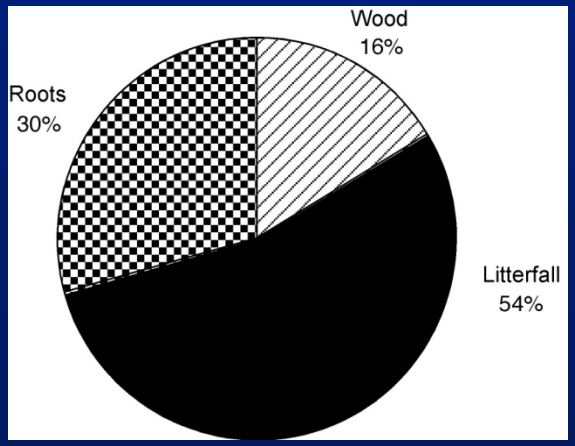
Taylor River
Scrub Mangroves

Total C
355 ± 11 g C m^{-2} yr^{-1}

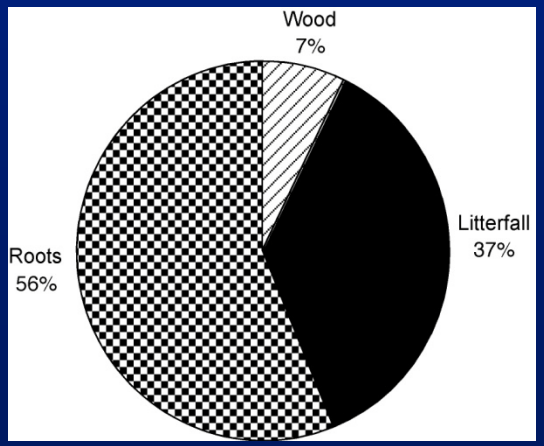
Litterfall
130 ± 6 g C m^{-2} yr^{-1}

Wood
26 ± 3 g C m^{-2} yr^{-1}

Roots
199 ± 18 g C m^{-2} yr^{-1}

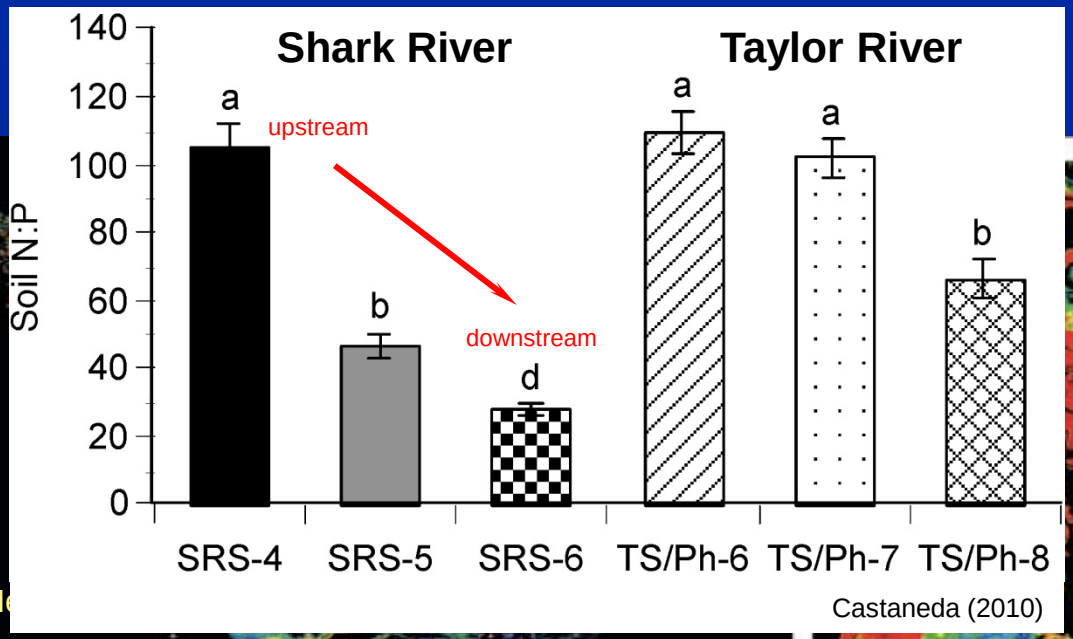


Shark River



Taylor River

Landscape Patterns of Mangrove Vegetation across FCE



Castaneda (2010)

Gulf of M

Standing Biomass (Mg/ha)
200
175
150
125
100
75
50
25
0

518 g C m^{-2} yr^{-1}

SRS-4
SRS-5
SRS-6

TS/Ph-6
TS/Ph-7
TS/Ph-8

156 g C m^{-2} yr^{-1}

0 10 20 Km

Florida Bay

Rivera-Monroy et al. in press

Summary

- The contrasting landscape patterns of above- and belowground biomass and NPP of FCE mangroves are regulated by a combination of P fertility and hydroperiod gradients.

- The decrease in aboveground biomass and NPP, and shift in species dominance from downstream to upstream areas of Shark River represent P limitation conditions and shorter hydroperiods upstream (SRS-4 & 5) in the estuary relative to SRS-6.

- The higher allocation of carbon to roots (56%) in Taylor River is associated to an adaptation of scrub mangroves to allocate more belowground biomass (i.e., high root:shoot) and production relative to aboveground compartments in response to P limitation and high soil stress conditions.

- The significant contribution of fine root production (25-44%) to total NPP and the higher allocation (~70%) of root biomass to coarse roots, suggest the significant role of belowground allocation to carbon sequestration in mangroves of south Florida.

Ongoing Research

- Developing C and nutrient (N, P) budgets (storage, production, allocation) for mangrove forests (Shark River and Taylor River) in FCE.

- Comparing C and nutrient (N, P) budgets before (2001-2004) and after (2005-2010) hurricane disturbances (Wilma, October 2005).

- Comparing our C budget with other techniques (Eddy Covariance Flux Tower at SRS-6).