Mangrove Leaf Litter and Root Decomposition Dynamics as a Function of Fertility and Hydroperiod Gradients in Shark River Estuary, southwestern Florida Everglades


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Research Problem
Landscape vegetation patterns of mangrove vegetation in the Florida Coastal Everglades (FCE) reflect an interaction of resources, regulators, and hydroperiod gradients. Yet, the mechanisms controlling belowground processes such as decomposition in this region are poorly understood.

Since decomposition is a critical ecosystem function regulating carbon and nutrient dynamics in mangrove forests, information on how decomposition responds to environmental gradients across mangrove ecotypes in the FCE is fundamental to calibrate, validate, and test above- and belowground biomass allocation ecological models and complex biogeochemical processes in mangrove forests across different latitudes.

Research Questions
1. What are the leaf litter and root decomposition rates along the P fertility and hydroperiod gradients in Shark River estuary?
2. What is the difference in root decomposition rates with soil depth across mangrove sites?
3. What is the difference in decay rates between leaf litter (species) and roots across Shark River sites?

Approach
LEAF LITTER DECOMPOSITION
- Leaf litter decomposition rates were compared among Shark River sites and mangrove species using a standard mesh bag (1mm, 20 x 20 cm) technique.
- Senescent leaves (5 g air-dried) from each site and species were collected in May 2009, placed in mesh bags, and deployed in the soil surface 50 m from the water edge at each site.
- Duplicate decomposition bags for each species were collected every 3 months at all sites.
- Changes in leaf mass and nutrient content were monitored during 1 year.
- Decay rates were calculated using an exponential decay model, \( y = x e^{-kt} \), where \( y \) is the dry mass at time \( t \), \( X \) is the original dry mass, and \( k \) is the decay constant.

ROOT DECOMPOSITION
- Root decomposition rates were compared among Shark River sites and soil depths (0-20 and 20-40 cm) using a standard mesh bag (1mm, 10 x 40 cm) technique.
- Mesh bags were divided into 20 cm sections. Each section contained 10 g (air-dried) of root material with an equal mixture of three size classes: 1-4, 4-8, and 8-12 mm from each site.
- Root decomposition bags were buried in each site approximately 50 cm from the water edge in May 2009.
- Duplicate decomposition bags were collected every 6 months at each site during 1.5 years.
- Root decay rates were calculated using the same exponential model as in the leaf litter study.

LEAF LITTER NUTRIENT RATIOS
- \( K_p \) values followed the P fertility gradient along the estuary.
- SRS-6 (0.1043 d^-1) had the highest \( K_p \) value and SRS-4 (0.0261 d^-1) the lowest.
- \( R. \) mangle had the lowest \( K_p \) at all sites.

LEAF LITTER DECAY RATES
- Root C:N ranged from 92-107 at the beginning of the study and decreased to 53-63 across depths and sites, indicating N enrichment of decomposing roots.
- Root N:P slightly increased with time for all sites and depths.
- SRS-4 showed the highest N:P of decomposing roots over time.

Conclusions
- The higher frequency of inundation and nutrient availability (i.e., P) at SRS-6 promote faster decomposition rates relative to the more P-limited upstream site (SRS-4) in Shark River.
- Differences in decay rates among mangrove species are not only regulated by the initial stoichiometry of leaf material, but also by hydroperiod and soil fertility site differences.
- Root decay rates showed a significant interaction between site and depth: SRS-6 had the highest decay rate in the top soil section.
- Leaves (0.0140 d^-1) decay rates were 2-4 times higher across all sites compared to those of root material (0.0049 d^-1), indicating strong differences in substrate quality and thus C and nutrient dynamics during decomposition.

Acknowledgments
- National Science Foundation (NSF); FCE-LTER, Florida International University (FIU); Everglades National Park (ENP).

Analysis of Resources, Regulators, and Hydroperiod
- Resources
- Regulators
- Hydroperiod

Results and Discussion
LEAF LITTER MASS LOSS
- Mass loss of litter varied among species and sites, with the highest losses in SRS-6 and the lowest in SRS-4.
- Between 70-80% of mass loss occurred during the first 3 months.
- \( R. \) mangle (Rm) showed the lowest mass loss of all species.
- C:N ratios decreased from 40-70 at the beginning of the study to approximately 20 across sites, indicating N enrichment of decomposing leaves for all mangrove species.
- \( N/P \) ratios of litter had an opposite trend, increasing with time and suggesting P immobilization by decomposing litter.
- SRS-6 had the highest initial leaf N (low C:N) and P (low N:P) content for all species.
- \( K_p \) values were negatively correlated with the initial leaf litter C:N ratios. A. germinans showed the lowest C:N and highest \( K_p \) value in SRS-5 & 6.

ROOT MASS LOSS
- Mass loss increased with time at all sites, with ~67% of mass loss occurring during the first 6 months.
- Mass loss showed similar trends among sites and between depths.

ROOT DECAY RATES