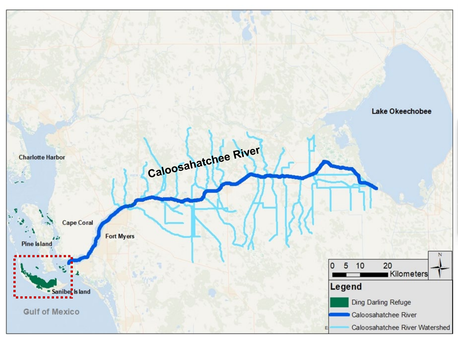
Nutrient Loading and Mangrove Forest Response at Ding Darling NWR, Sanibel Island, Florida

Ken W. Krauss[1], Jeremy R. Conrad[2], Jamie A. Duberstein[3], Eric J. Ward[1], Karen Thorne[4], Kevin Buffington[4], Haley J. Miller[3], Natalie T. Faron[5], Brian W. Benscoter[5,6], Judith Z. Drexler[7], Zhiliang Zhu[8]

[1] U.S. Geological Survey, Wetland and Aquatic Research Center; [2] U.S. Fish and Wildlife Service, Inventory and Monitoring Program; [3] Clemson University, Baruch Institute of Coastal Ecology and Forest Science; [4] U.S. Geological Survey, Western Ecological Research Center; [5] Florida Atlantic University, Department of Biological Sciences; [6] U.S. Department of Energy, Office of Science Biological and Environmental Research Program (current); [7] U.S. Geological Survey, California Water Science Center; [8] U.S. Geological Survey, Land Management Research Program

INTRODUCTION

The Caloosahatchee River flows from the Everglades Agriculture Area toward the southwest Florida coast. This river contains seasonally high concentrations of nutrients from agricultural run-off, which periodically stimulate aquatic algal blooms within otherwise clear waters around Sanibel Island. While media focus is often directed toward water quality issues during periods of low water clarity, managers at Ding Darling NWR are as concerned with the influence that increased future N and P loading rates will have on the long-term persistence of Sanibel Island's mangrove forests.



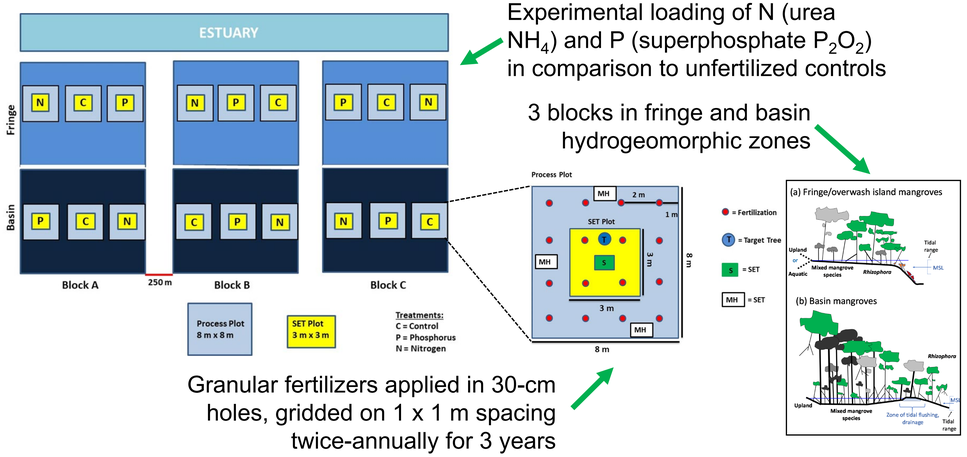
The refuge was established as an NWR in 1945, and covers ~ 2,571 ha of primarily open water, beach strand, and estuarine habitat, including prominent mangrove forests.

OVERVIEW

Issue: Sea-level rise resilience is conferred to mangroves through a combination of sediment delivery and primary plant productivity (above- and belowground), which can be compromised by excessive nutrient delivery (eutrophication).

Research question: How might future potential increases in nutrient loading to the mangroves add to current concentrations of nutrients to affect productivity, soil metabolism, and surface elevation change?

Management question: If nutrient concentrations increase in the future, as expected, would additional regulations for nutrient discharge into the Caloosahatchee River from upstream sources be justified as a necessary measure to preserve mangrove health and persistence into the future beyond their current exposure to high nutrients, especially of P?



SYNTHESIS

Contrary to our expectations, experimental loading of N and P had only modest influences on primary productivity and soil metabolism, and did not influence soil surface elevation change. Greater nutrients do not always affect productivity.

Mangroves at Ding Darling NWR are currently eutrophic from decades of nutrient loading, having 3-4 times the total P in soils than other Caribbean basin mangroves. Basin mangroves have ~50% the standing root biomass of fringe mangroves; a trend that is often reversed in other mangrove forests.

Additional N and P loading to the mangroves may have limited negative influences on how these mangroves persist with continued sea-level beyond the stress they are currently experiencing, unless N and P loading far exceeds what we tested.

PRODUCTIVITY

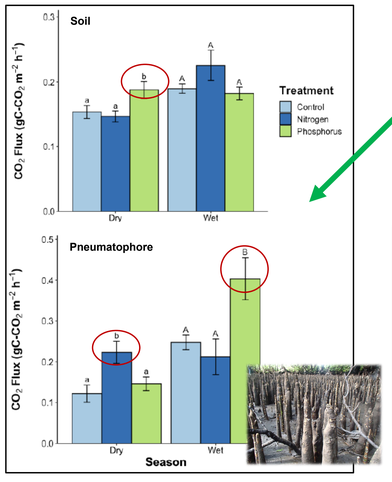
Productivity was generally greater in fringe than in basin, with variable responses to N or P fertilization, as follows:

Measurement	N vs. Control	P vs. Control
Litterfall (g/m²/y)	ns	↓
Lateral stem growth (cm²/y)	ns	ns
Root growth (g/m²/y)	ns	ns
Root turnover (1/y) and longevity (y)	ns	ns

- P fertilization reduced rates of litterfall, possibly related to greater eco-physiological constraints on water uptake to the canopy?

- Sapflow was reduced in P-fertilized relative to N-fertilized trees for both species in one or both years studied, depending on species.

SOIL METABOLISM



CO_2 flux represents soil and live root respiration

P stimulated CO_2 flux from soils in dry season and from pneumatophores in wet season

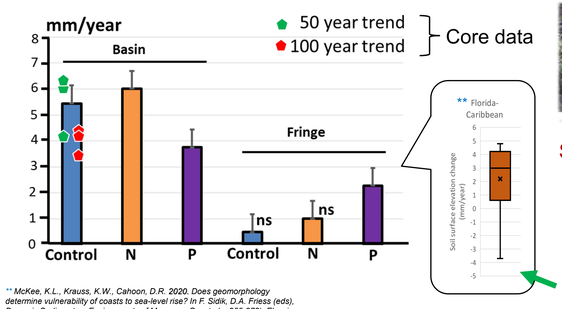
N stimulated CO_2 flux through pneumatophores in dry season

Litter and fine root decomposition represent capacity for N, P, and C mineralization

Overall decomposition was greater in fringe than in basin

Decomposition did not differ for leaves or fine roots by nutrient treatment

SOIL SURFACE ELEVATION CHANGE (SEC)



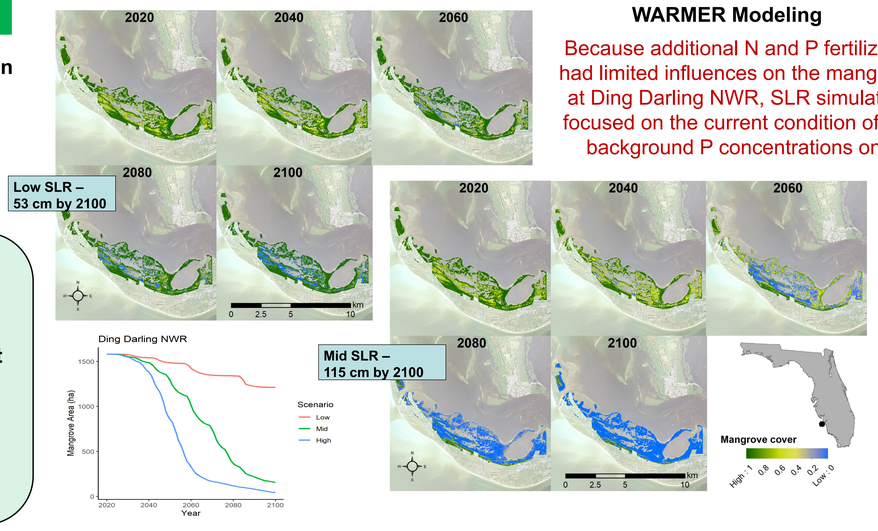
** *McKee, K.L., Krauss, K.W., Cahoon, D.R. 2020. Does geomorphology determine vulnerability of coasts to sea-level rise? In F. Sidik, D.A. Friess (eds), Dynamic Sedimentary Environments of Mangrove Coasts (p. 255-272), Elsevier.*

SEC greater in basin than in fringe

No SEC differences conferred by additional N or P loading

SEC from sites at Ding Darling NWR match or exceed (basin) those from the wider Caribbean

SEA-LEVEL RISE (SLR) VULNERABILITY



WARMER Modeling

Because additional N and P fertilization had limited influences on the mangroves at Ding Darling NWR, SLR simulations focused on the current condition of high background P concentrations only.