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Mangrove Restoration and Migration in a Changing Climate: Climatic Drivers and Shifting Ecotones

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GCPO
Gulf Coastal Plains & Ozarks
Landscape Conservation Cooperative

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Global mangrove forest loss: ~1-2% per year in recent decades

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LETTERS

edited by Etta Kavanagh

A World Without Mangroves?

AT A MEETING OF WORLD MANGROVE EXPERTS HELD LAST YEAR IN Australia, it was unanimously agreed that we face the prospect of a world deprived of the services offered by mangrove ecosystems, perhaps within the next 100 years.

Mangrove forests once covered more than 200,000 km^2 of sheltered tropical and subtropical coastlines (*1*). They are disappearing worldwide by 1 to 2% per year, a rate greater than or equal to declines in adjacent coral reefs or tropical rainforests (*2*–*5*). Losses are occurring in almost every country that has mangroves, and rates continue to rise more rapidly in developing countries, where >90% of the world's mangroves are located. The veracity and detail of the UN Food and Agriculture Organization data (*2*) on which these observations are based may be arguable, but mangrove losses during the last quarter century range consistently between 35 and 86%. As mangrove areas are becoming smaller or fragmented, their long-term survival is at great risk, and essential ecosystem services may be lost.

Where mangrove forests are cleared for aquaculture, urbanization, or coastal landfill or deteriorate due to indirect effects of pollution and upstream land use (*3*, *4*), their species richness is expected to decline precipitously, because the number of mangrove plant species is directly correlated with forest size (*6*, *7*). Examples from other ecosystems have shown that species extinctions can be followed by loss in functional diversity, particularly in species-poor systems like mangroves, which have low redundancy per se (*8*). Therefore, any further decline in mangrove area is likely to be followed by accelerated functional losses. Mangroves are already critically endangered or approaching extinction in 26 out of the 120 countries having mangroves (*2*, *9*).

Deforestation of mangrove forests, which have extraordinarily high rates of primary productivity (*3*), reduces their dual capacity to be both an atmospheric CO_2 sink (*10*) and an essential source of oceanic carbon. The support that mangrove ecosystems provide for terrestrial as well as marine food webs would be lost, adversely affecting, for example, fisheries (*11*). The decline further imperils mangrove-dependent fauna with their complex habitat linkages, as well as physical benefits like the buffering of seagrass beds and coral reefs against the impacts of river-borne siltation, or protection of coastal communities from sea-level rise, storm surges, and tsunamis (*12*, *13*). Human communities living in or near mangroves would lose access to sources of essential food, fibers, timber, chemicals, and medicines (*14*).

We are greatly concerned that the full implications of mangrove loss for humankind are not fully appreciated. Growing pressures of urban and industrial developments along coastlines, combined with climate change and sea-level rise, urge the need to conserve, protect, and restore tidal wetlands (*11*, *13*). Effective governance structures, socioeconomic risk policies, and education strategies (*15*) are needed now to enable societies around the world to reverse the trend of mangrove loss and ensure that future generations enjoy the ecosystem services provided by such valuable natural ecosystems.

Emerging from the embrace of a mangrove tree–lined channel in northern Brazil, these pescadores, like coastal fishers worldwide, know that healthy mangroves mean good fishing and a secure livelihood.

CREDIT: N. C. DUKE

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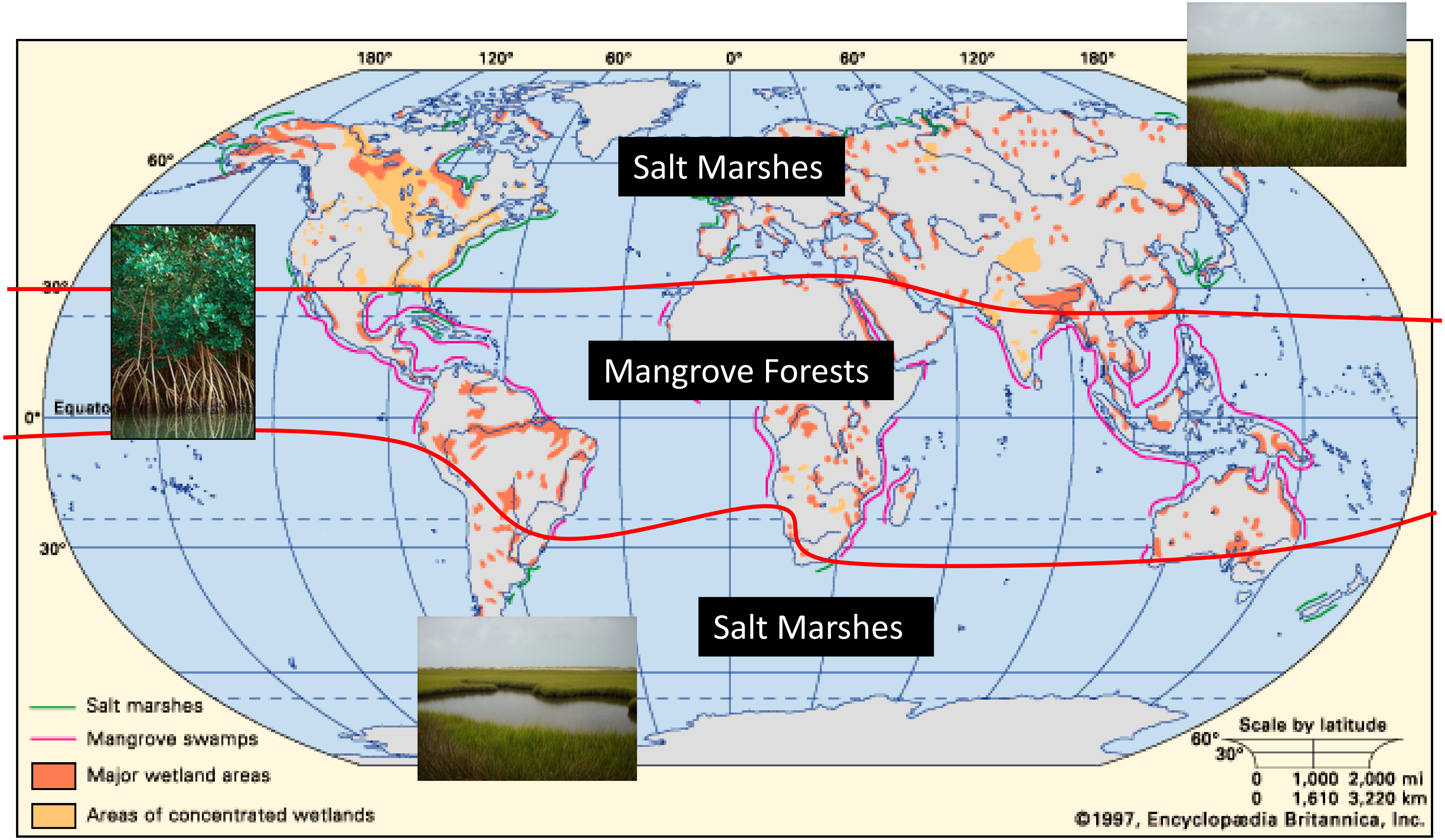
Large-scale mangrove restoration projects across the globe

roi-harleydavidson-malaysia.blogspot.com

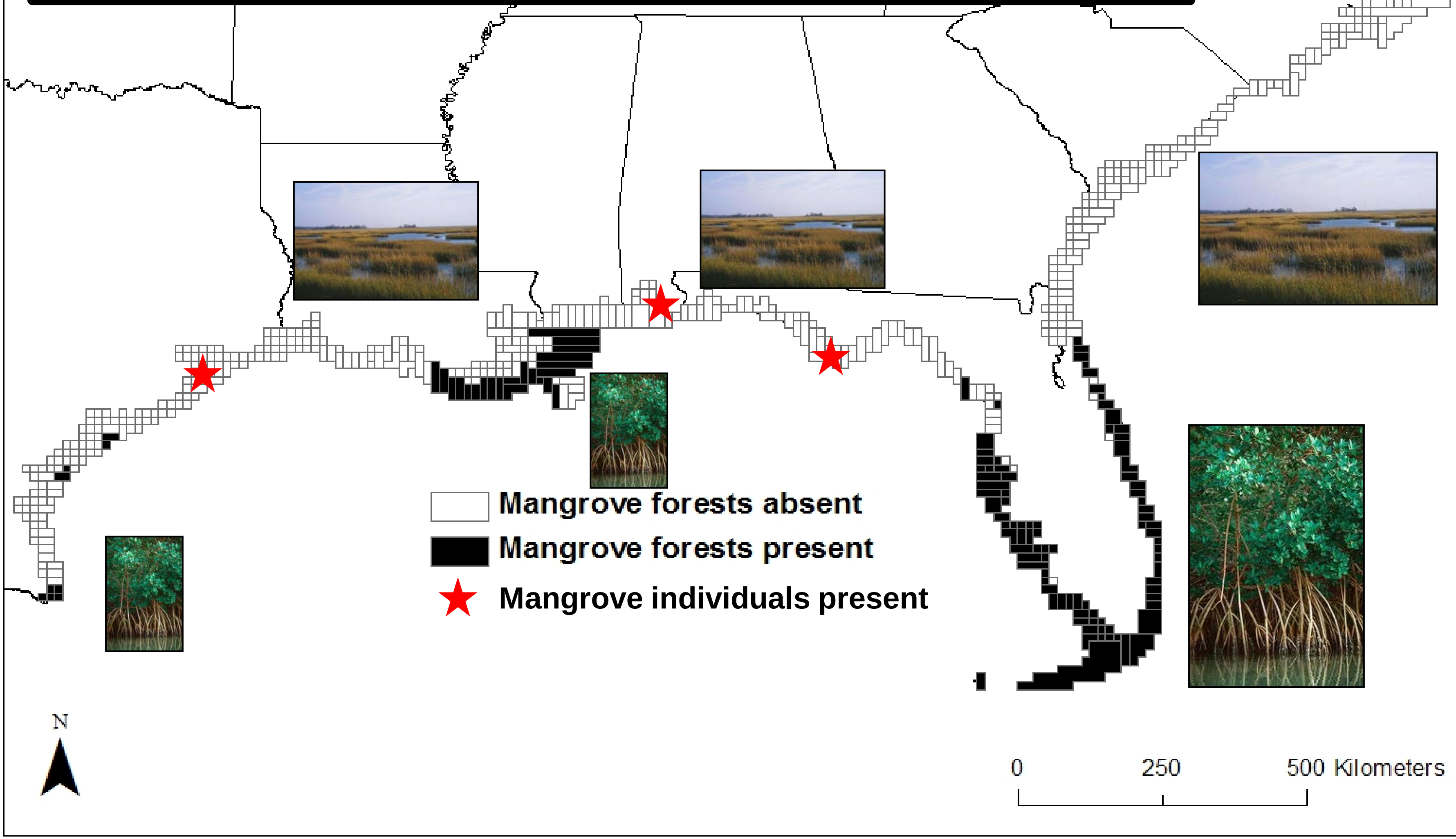
thailand.wetlands.org

volunteercamotes.org

The global distribution of mangrove forests and salt marshes



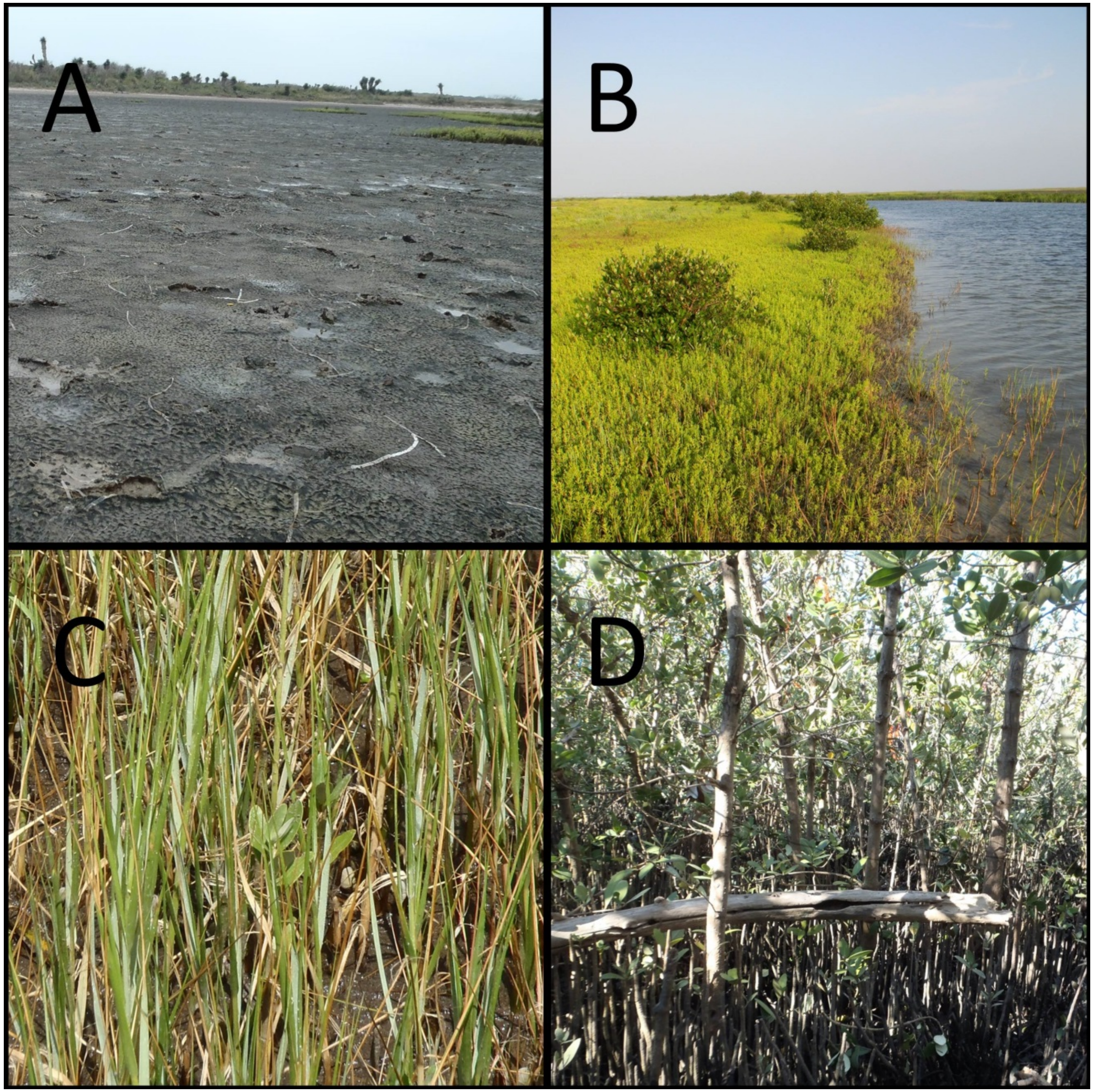
Winter climate is an important driver of salt marsh-mangrove forest interactions in the southeastern U.S.



Regional climate variability: temperatures and rainfall greatly influence coastal wetlands

Algal mats & salt flats

Graminoid plants (salt marsh)



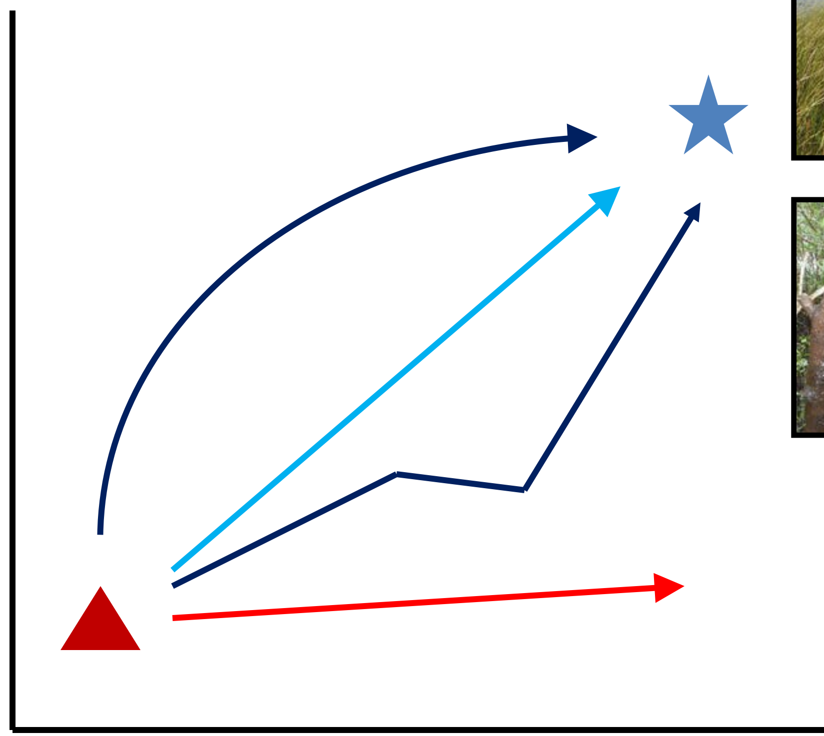
Succulent plants (salt marsh)

Mangrove trees and shrubs (mangrove forests)

Restoration targets and practices differ across the Gulf of Mexico

Restoration outcomes and trajectories

Ecosystem Property



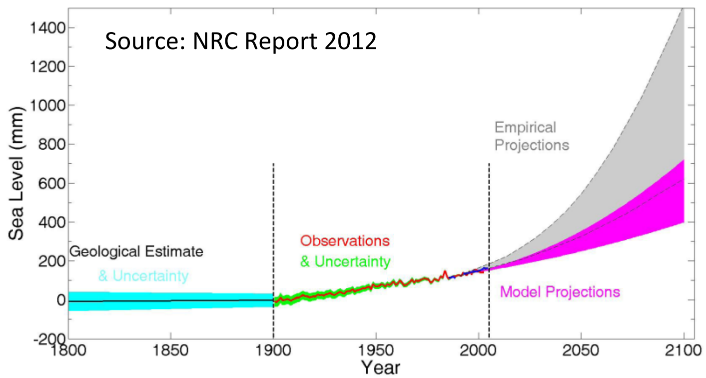
Time

= desired condition

= initial condition

Climate change effects upon restoration outcomes are diverse

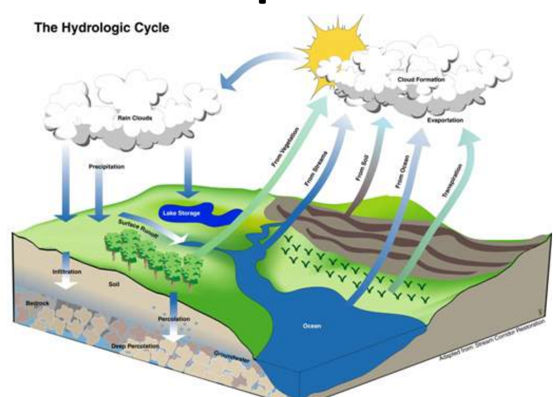
Sea level rise



Saltwater intrusion

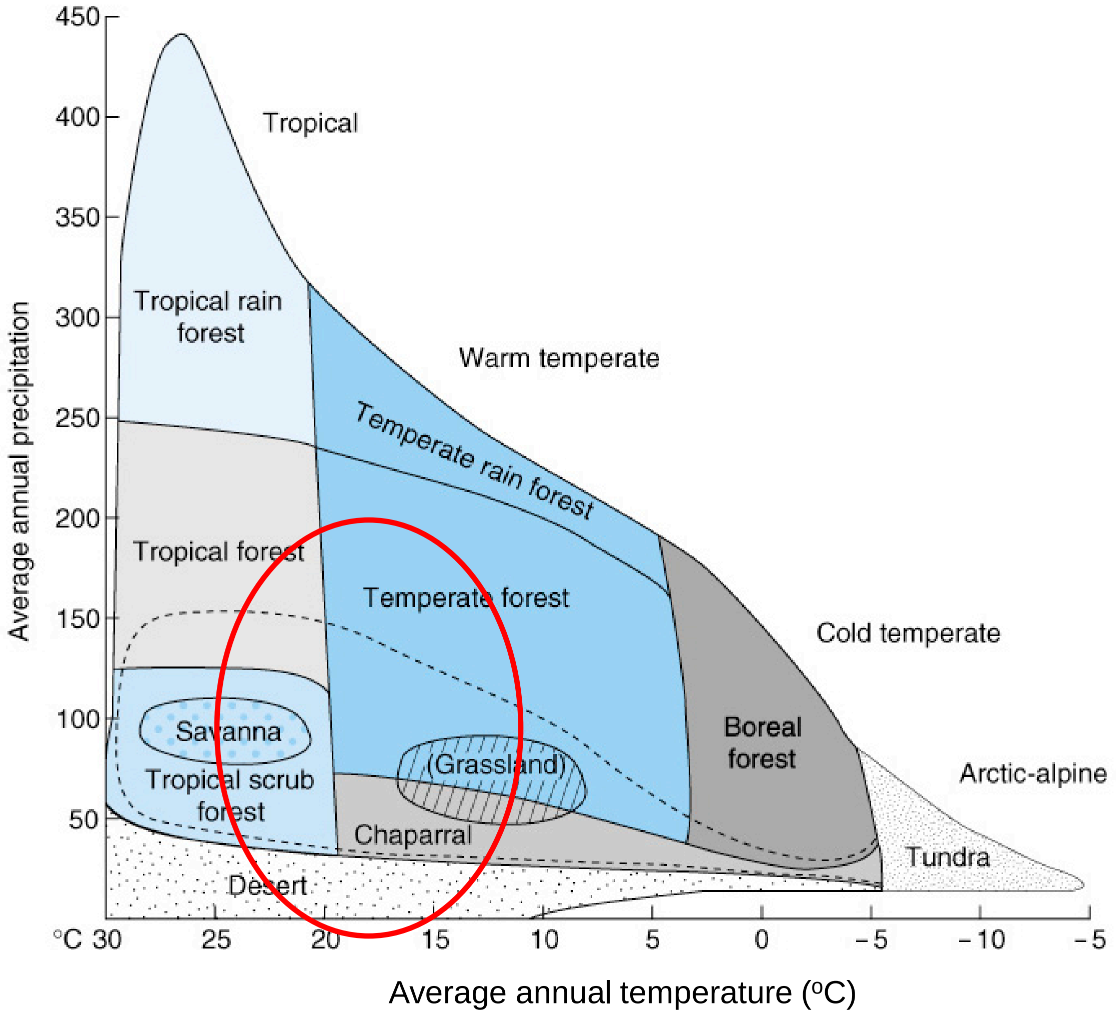
Elevated CO_2

Precipitation



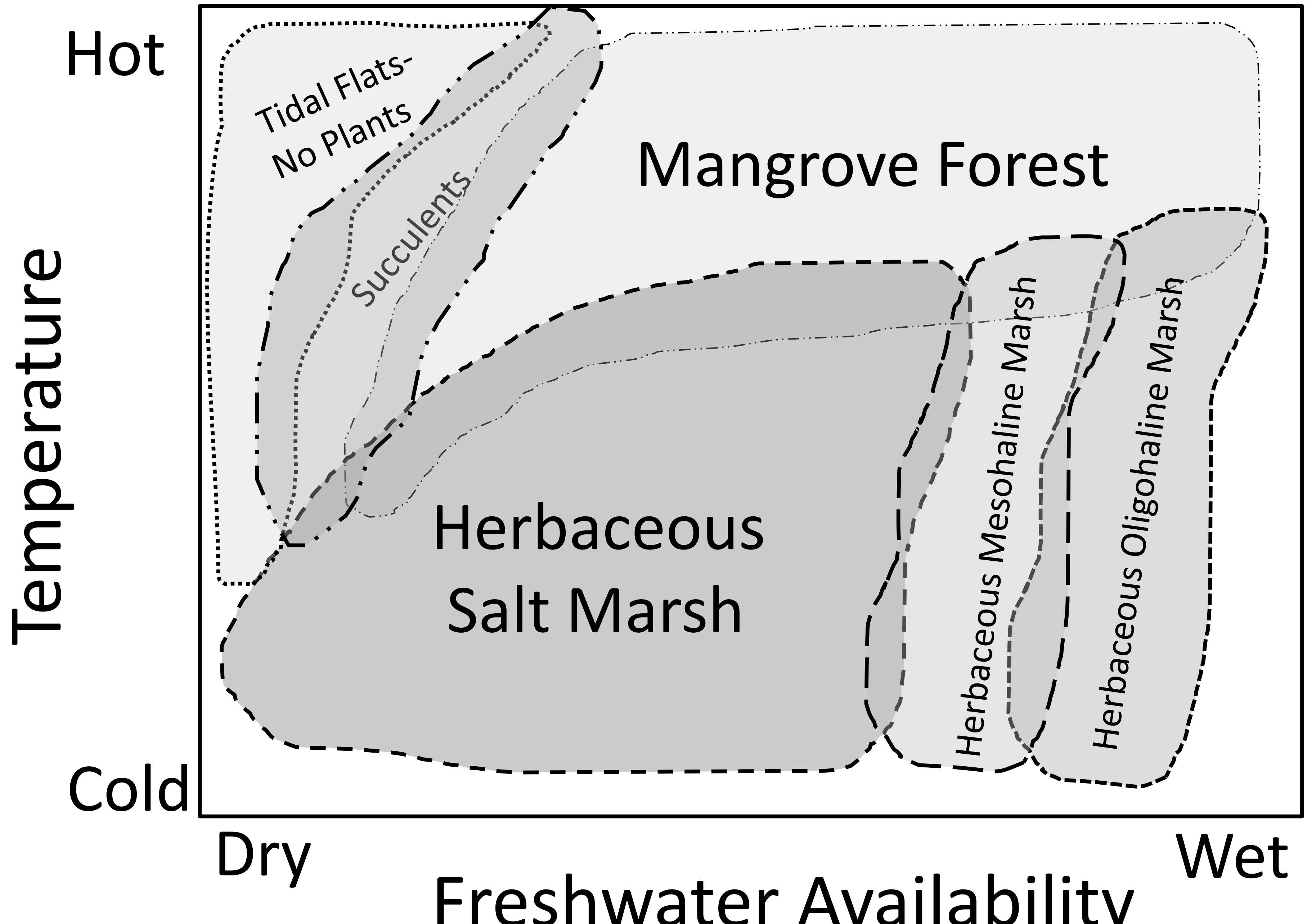
Temperature

Climatic drivers shape the world's terrestrial biomes

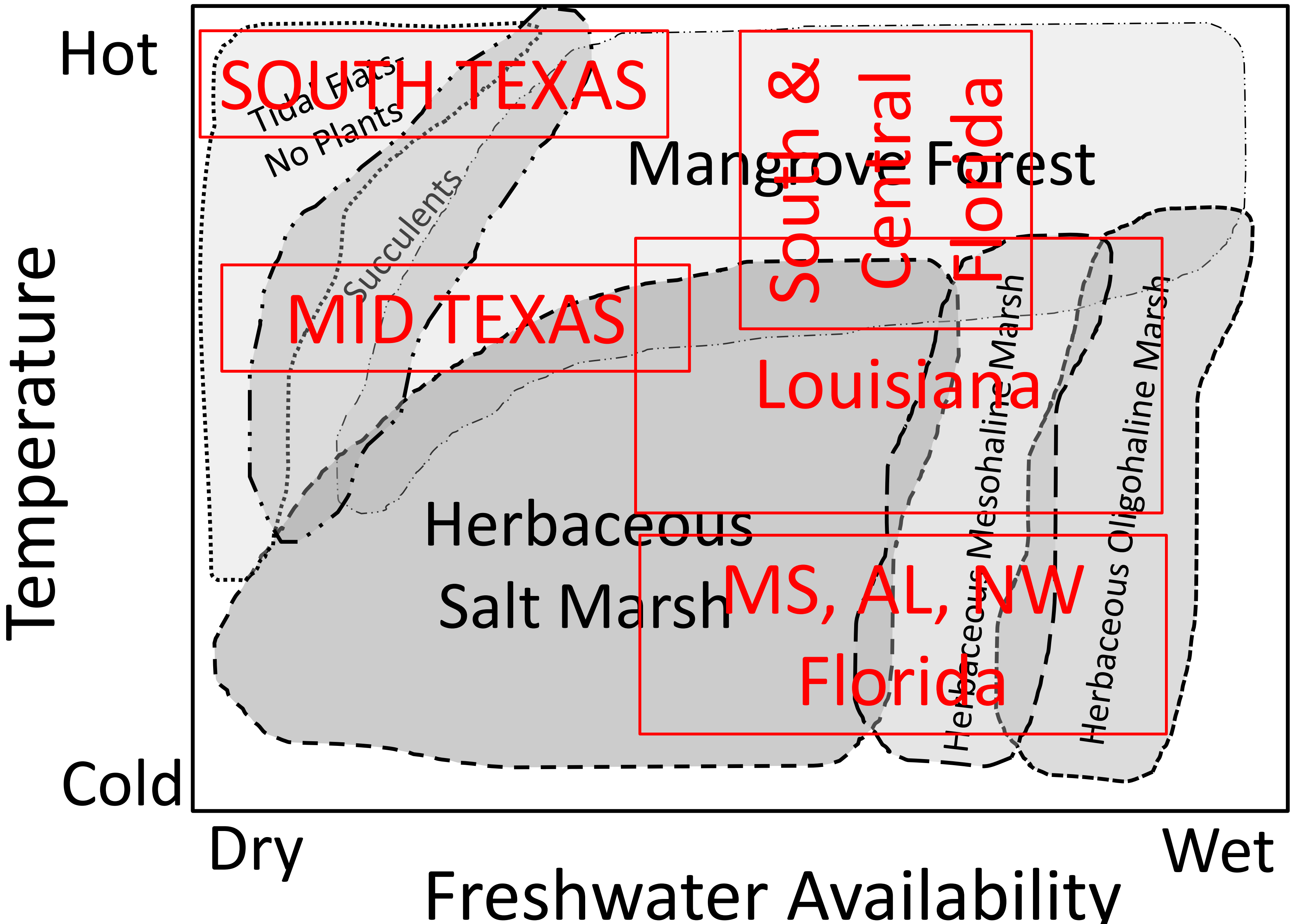


Adapted from Whittaker 1975; by Bush 2002

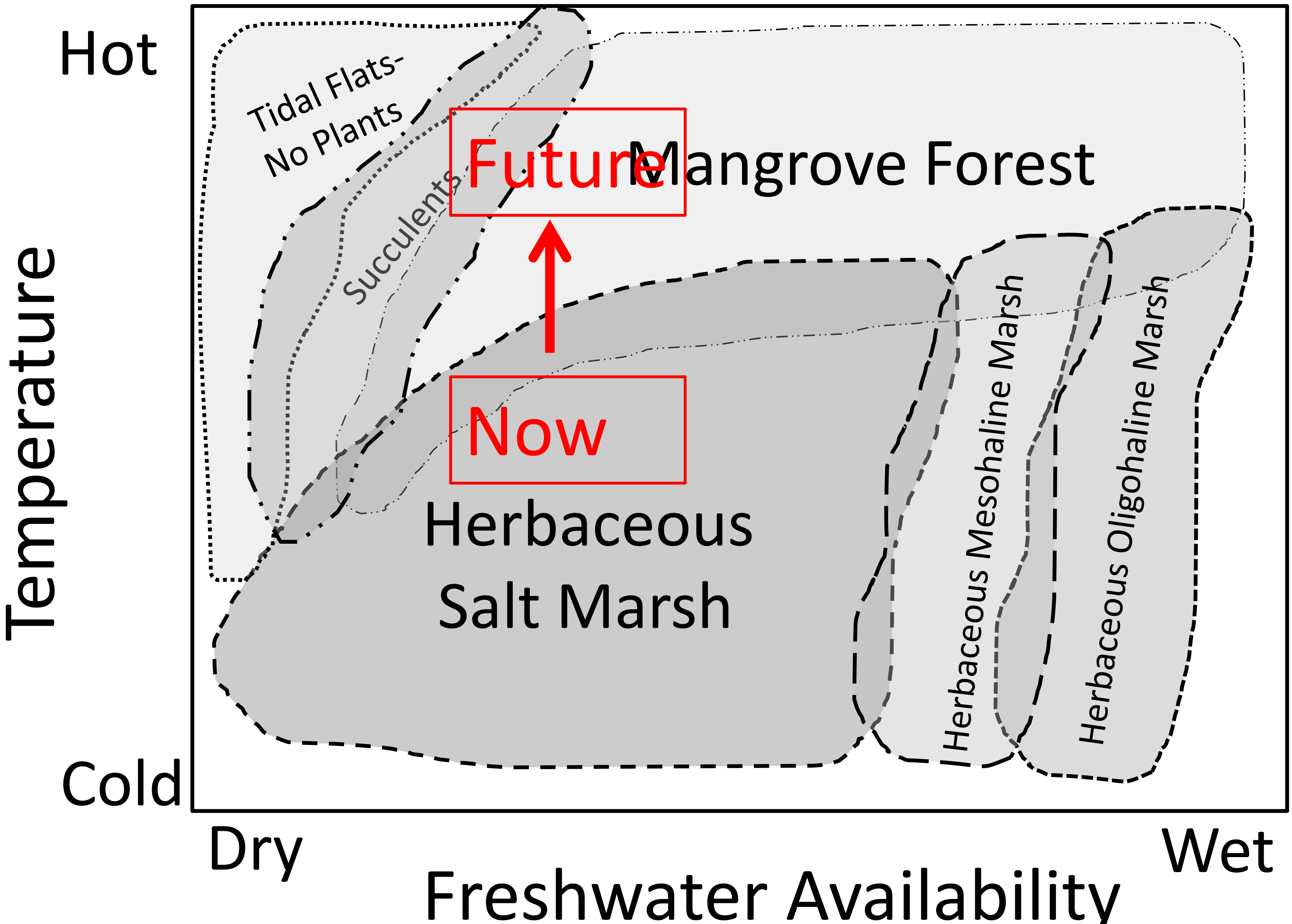
Climatic drivers shape the GOM's coastal wetland "biomes"



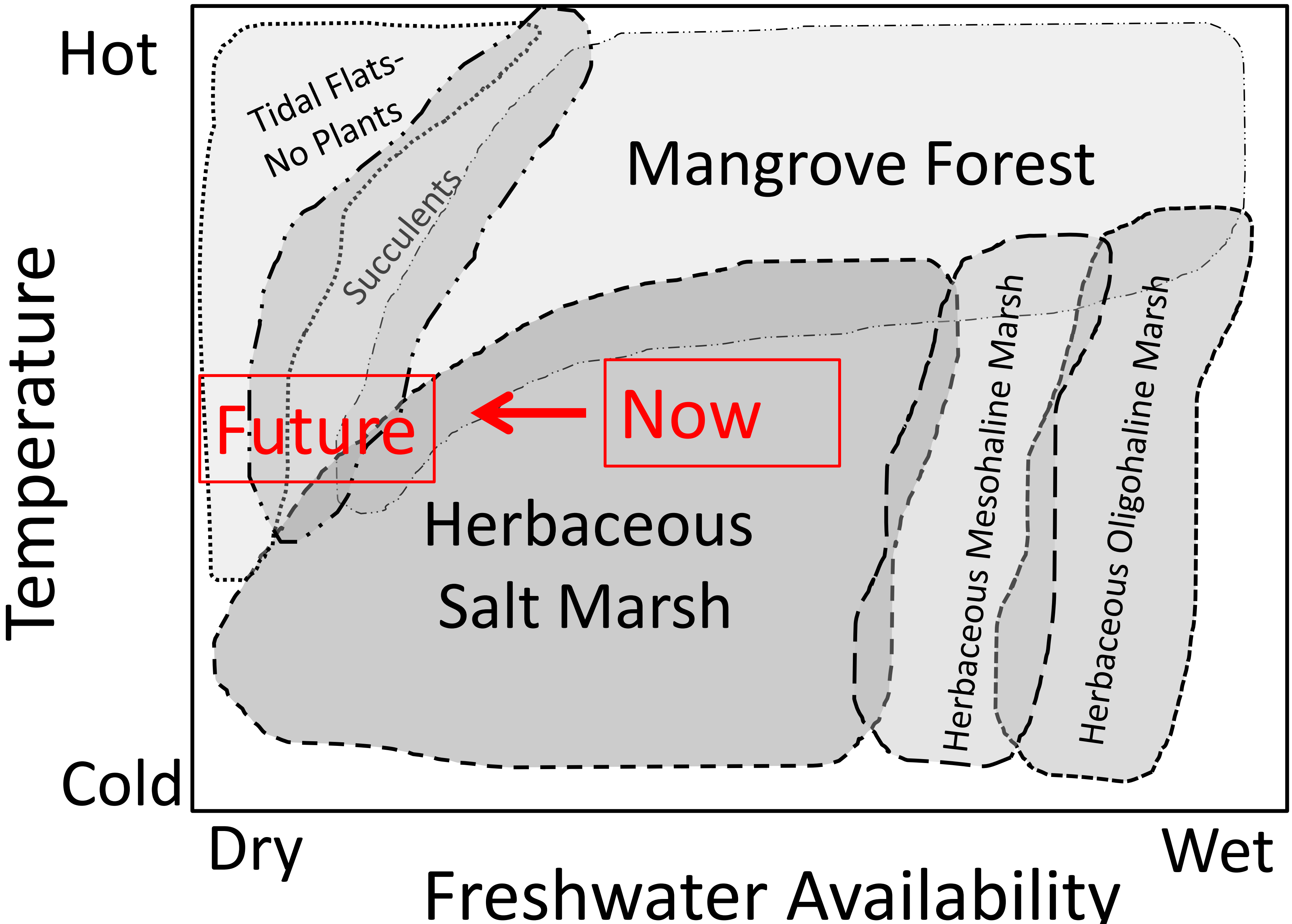
Climatic drivers shape the GOM's coastal wetland "biomes"



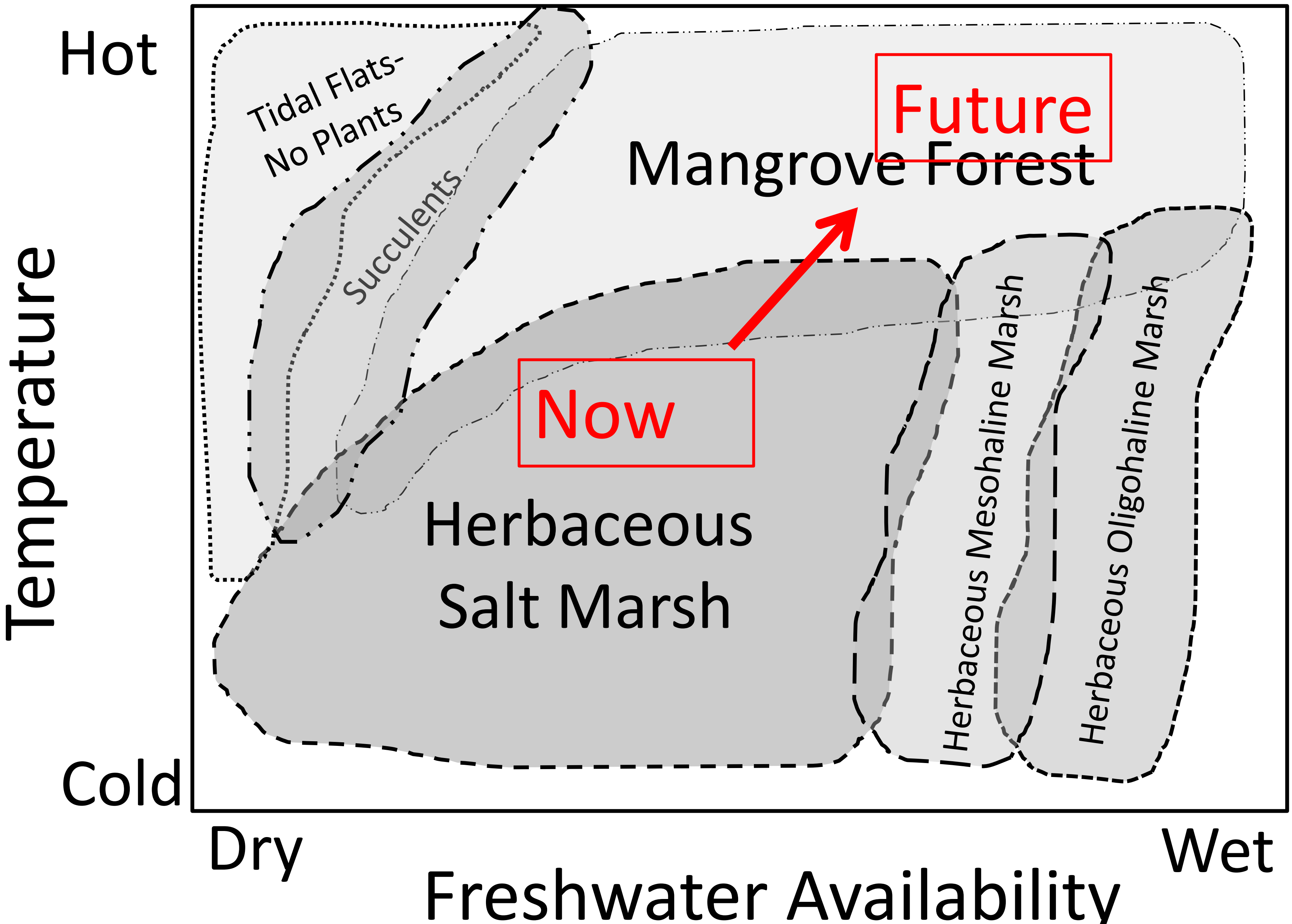
Alternative scenario: a hotter future



Alternative scenario: a drier future



Alternative scenario: a hotter and wetter future



Two Studies

1. Winter climate change: salt marshes vs. mangrove forest

2. Ecological transitions across a rainfall gradient

Global Change Biology

Global Change Biology (2013) **19**, 1482–1494, doi: 10.1111/gcb.12126

Winter climate change and coastal wetland foundation species: salt marshes vs. mangrove forests in the southeastern United States

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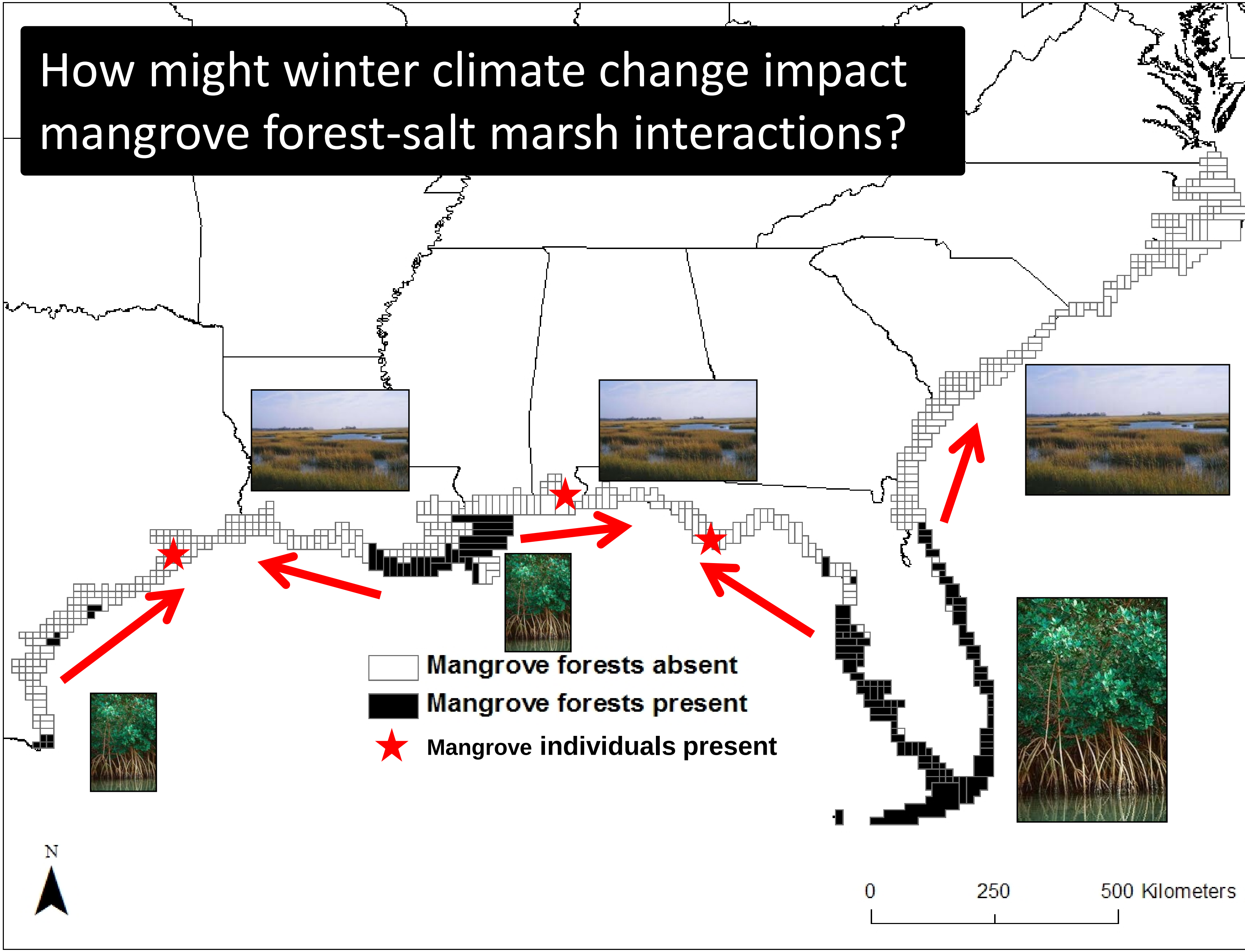
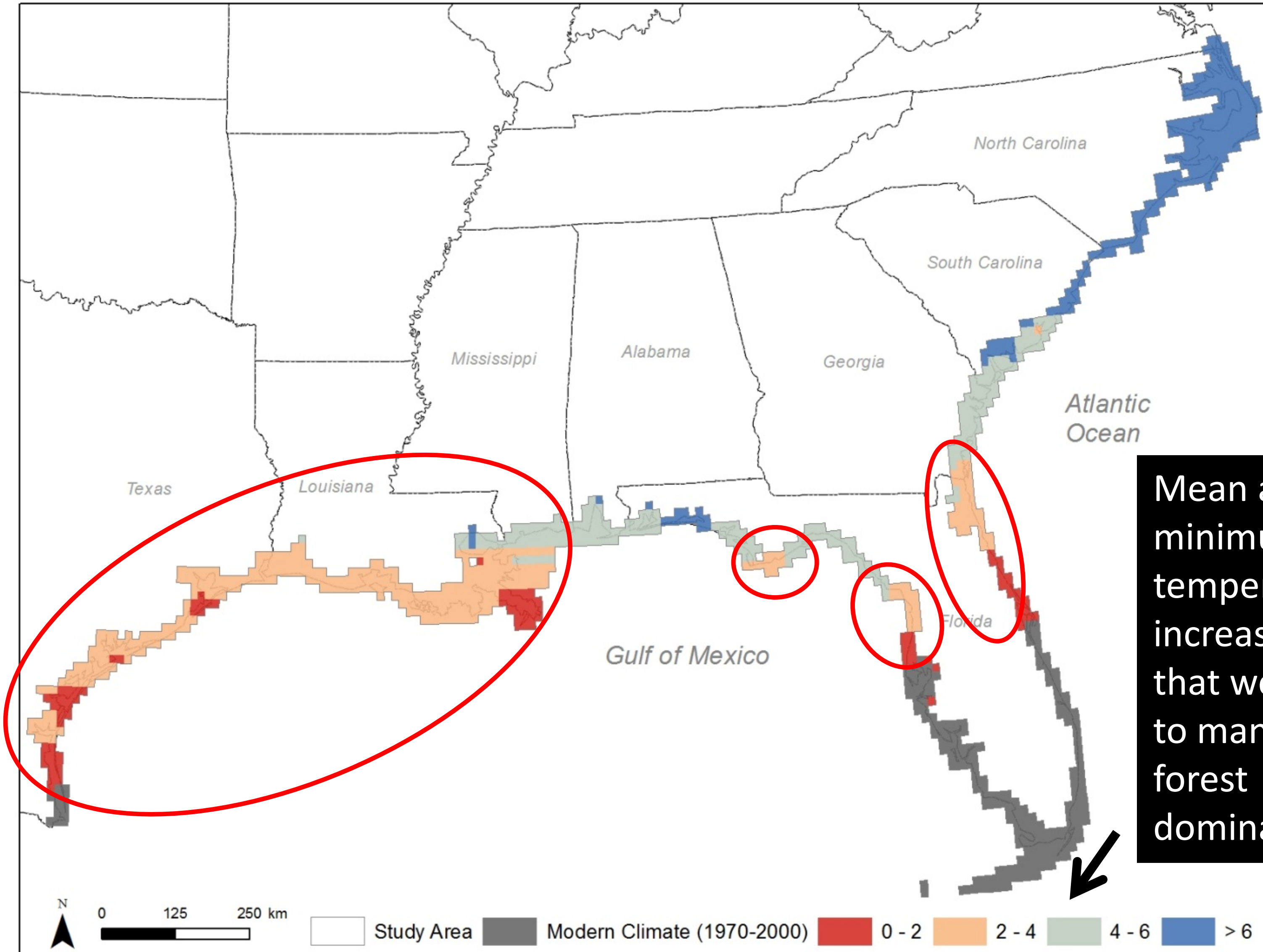
Abstract

We live in an era of unprecedented ecological change in which ecologists and natural resource managers are increasingly challenged to anticipate and prepare for the ecological effects of future global change. In this study, we investigated the potential effect of winter climate change upon salt marsh and mangrove forest foundation species in the southeastern United States. Our research addresses the following three questions: (1) What is the relationship between winter climate and the presence and abundance of mangrove forests relative to salt marshes; (2) How vulnerable are

How might winter climate change impact mangrove forest-salt marsh interactions?

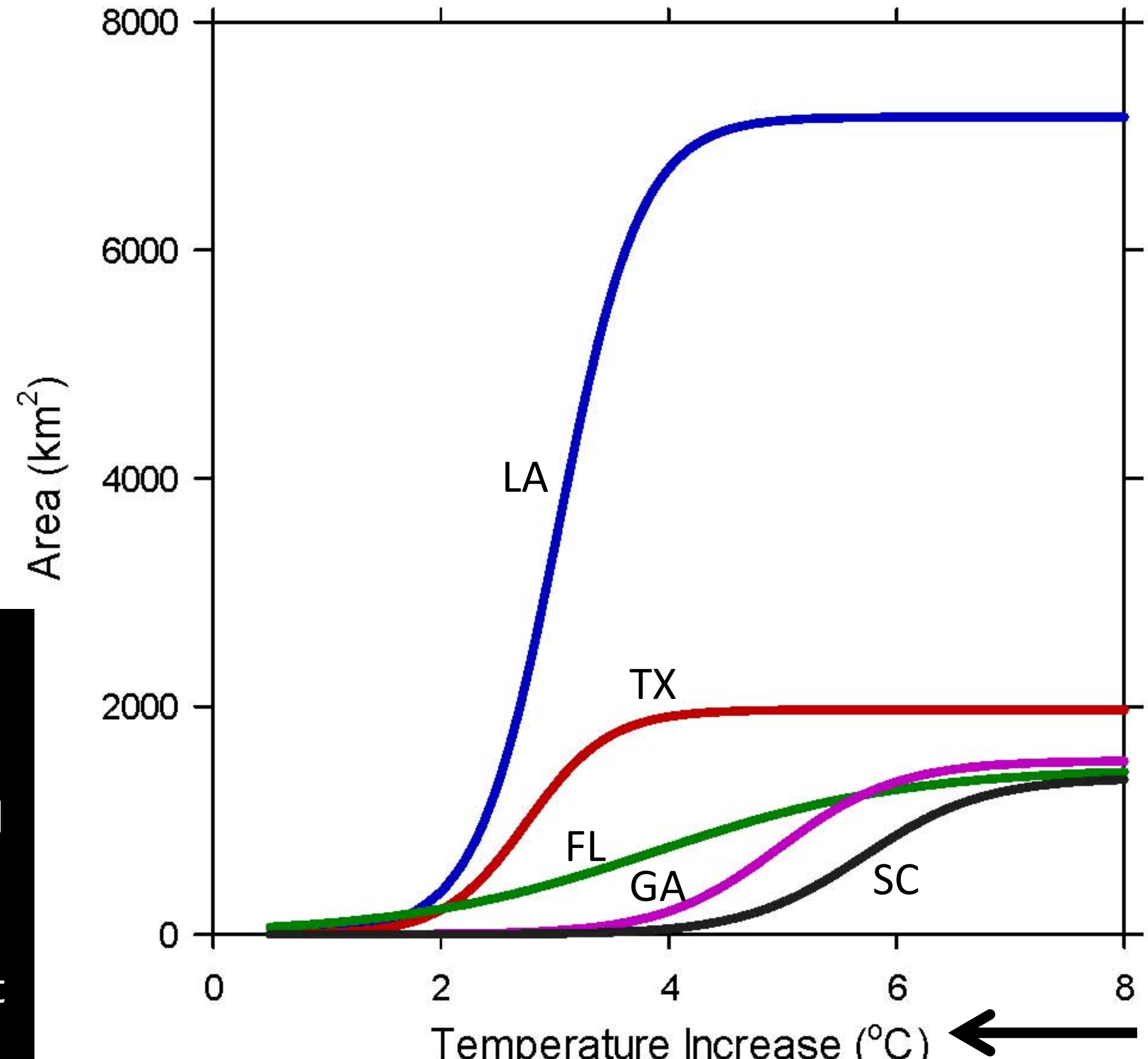


Salt marsh sensitivity to winter climate change-induced mangrove forest range expansion



Mean annual minimum temperature increase (°C) that would lead to mangrove forest dominance

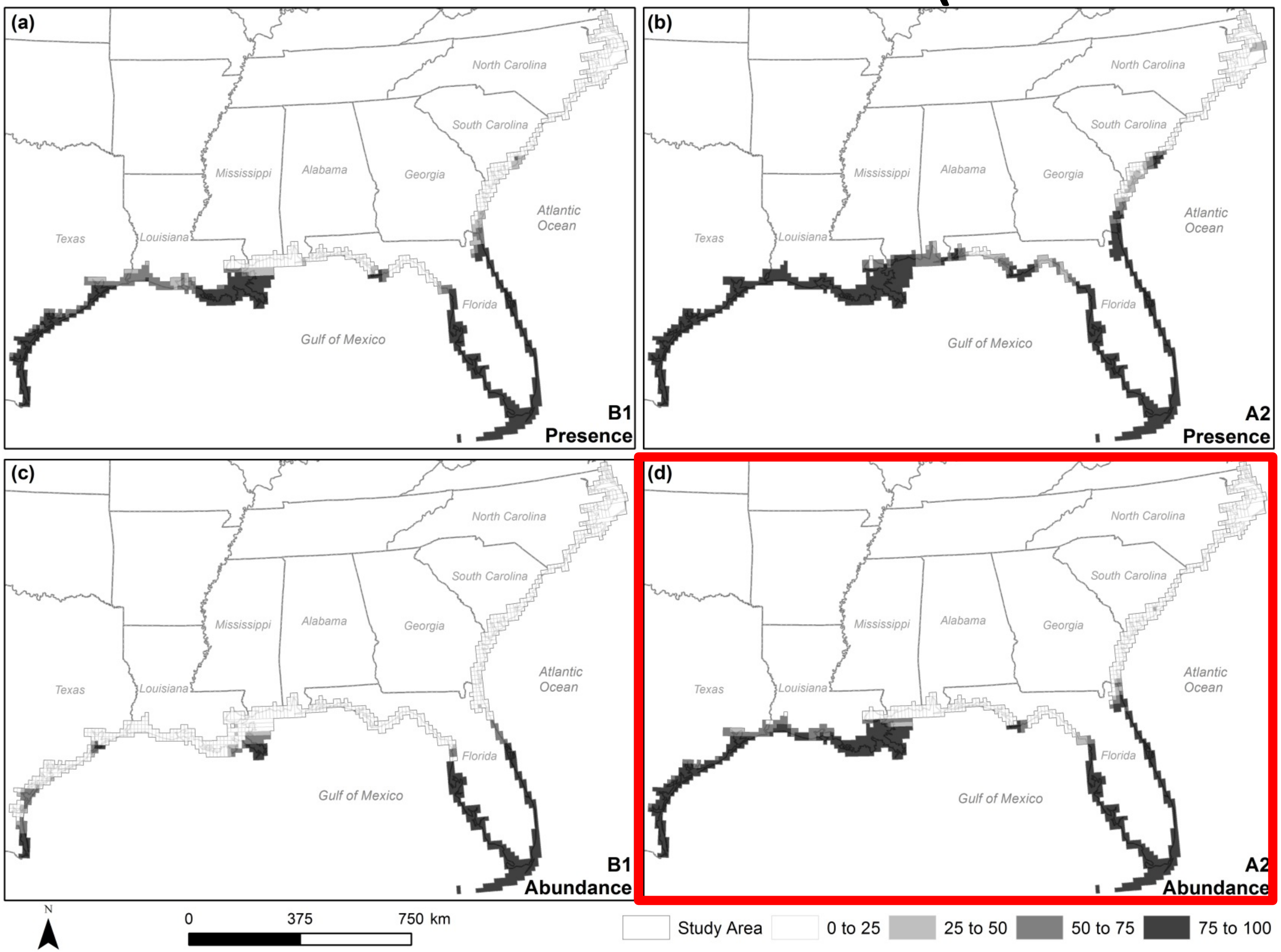
Salt marsh sensitivity to winter climate change-induced mangrove forest range expansion



Amount of salt marsh area within each state that would become vulnerable to mangrove forest replacement

Mean annual minimum temperature increase (°C) that would lead to mangrove forest dominance

Predicted future mangrove forest presence and abundance (2070-2100)



Study #2: Ecological transition across a rainfall gradient (in press, Ecology)

Title: Freshwater availability and coastal wetland foundation species: ecological transitions along a rainfall gradient

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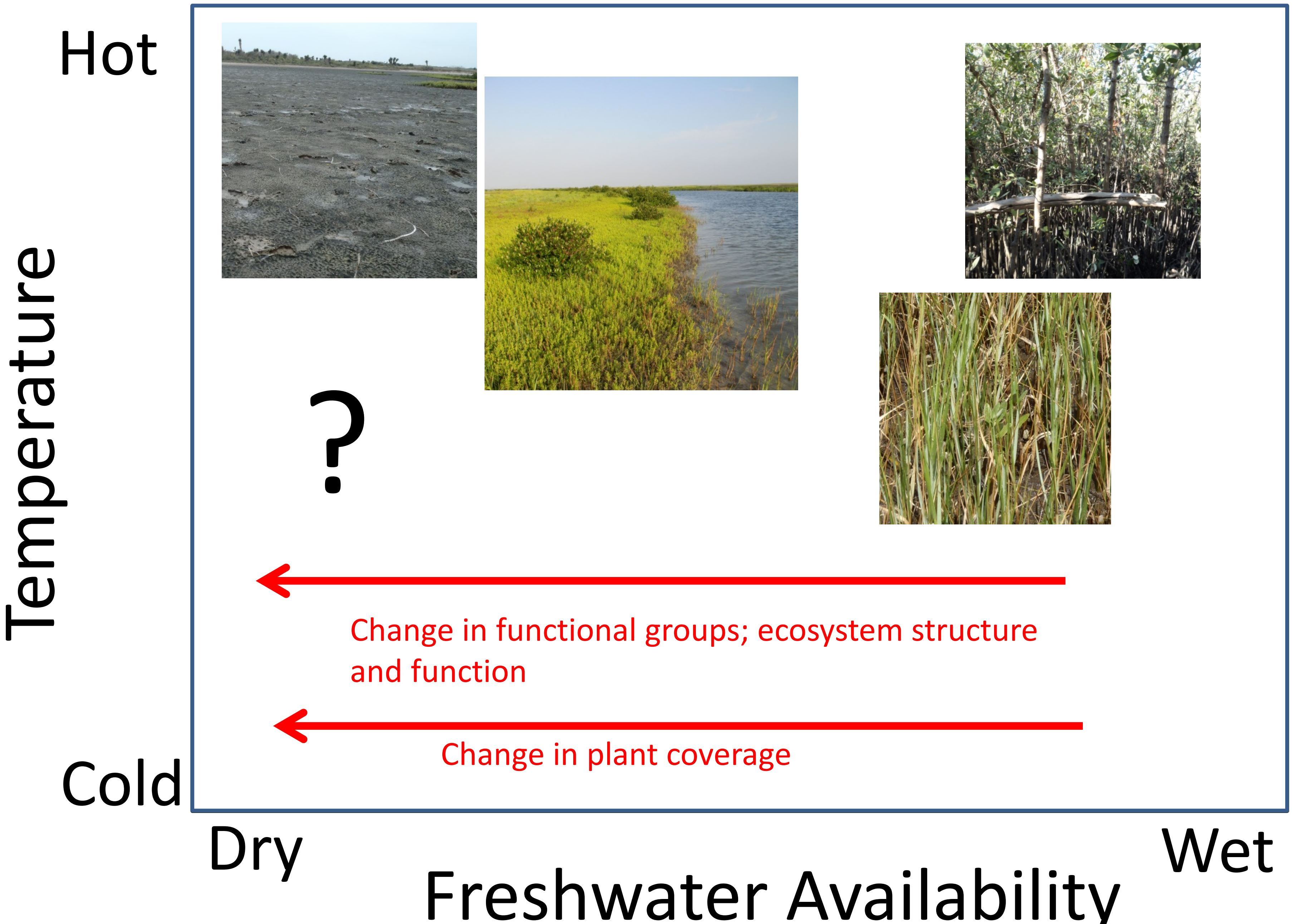
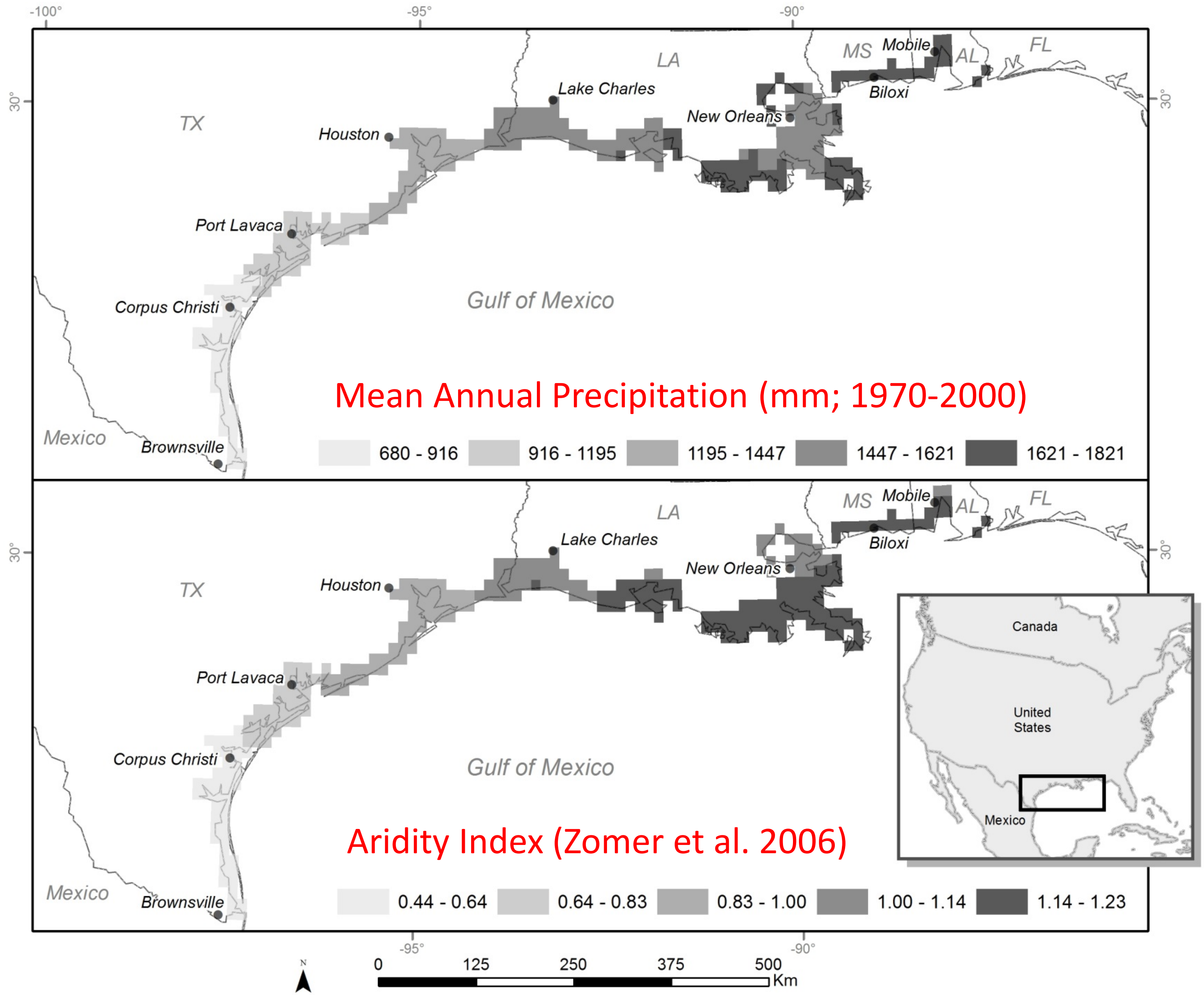
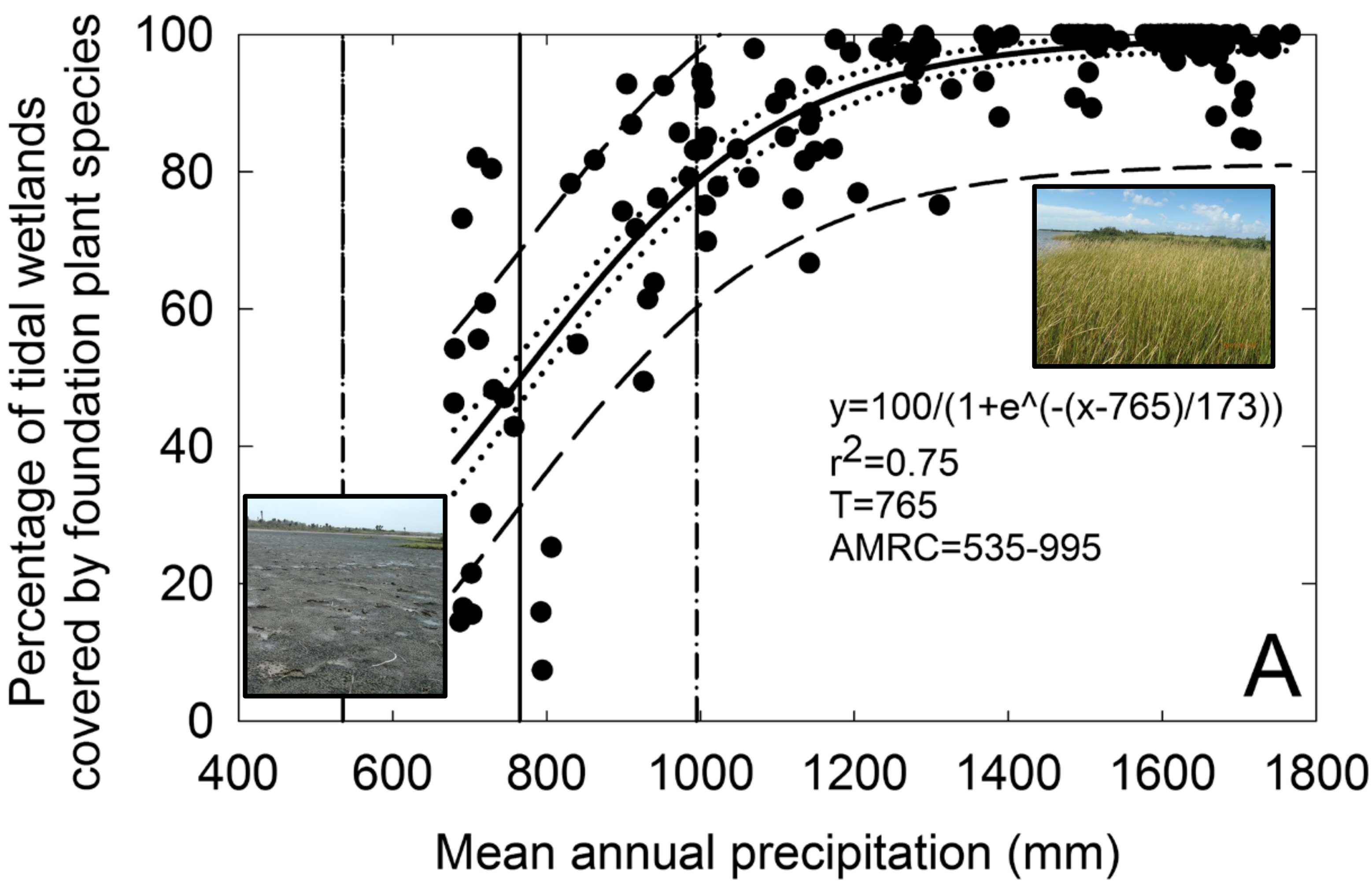
How does freshwater affect tidal wetland ecosystems?



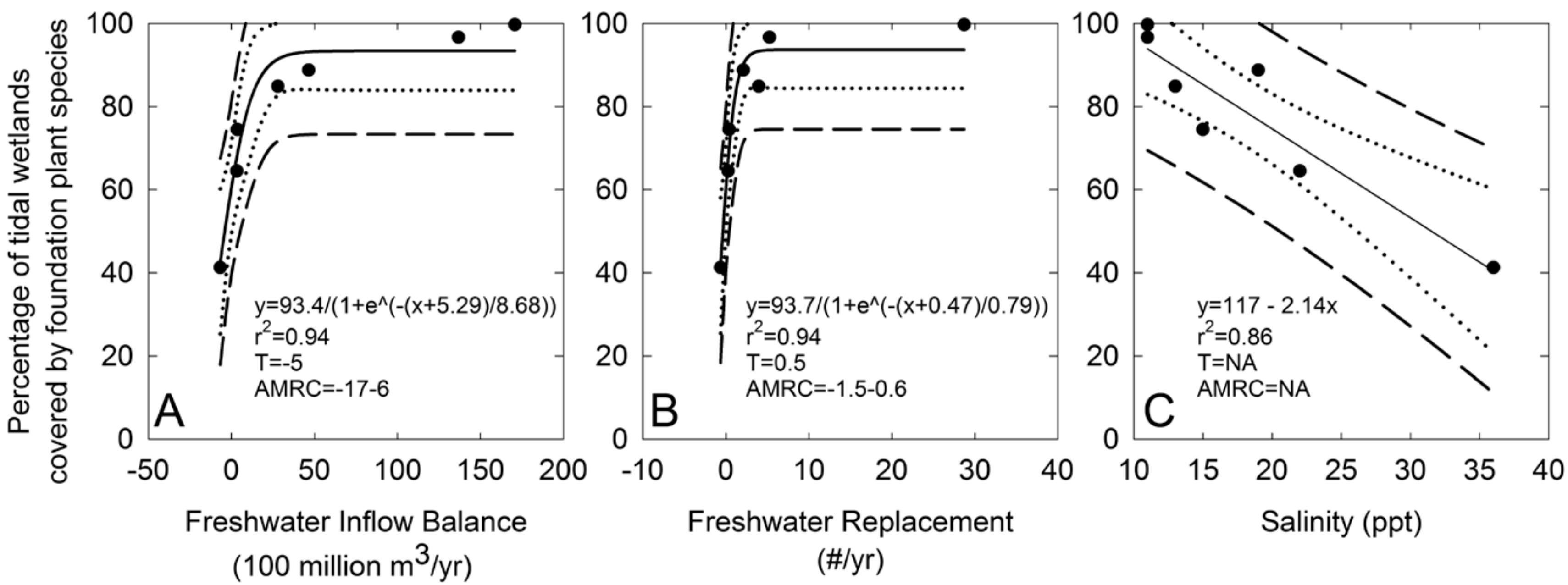
The Rainfall Gradient



Plant cover transitions along the rainfall gradient

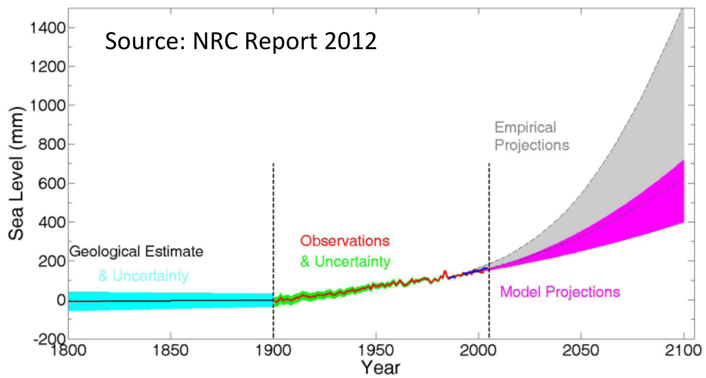


Estuarine level analyses



Climate change effects upon restoration outcomes are diverse

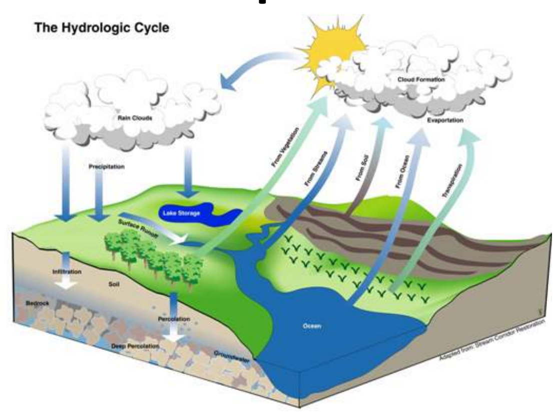
Sea level rise



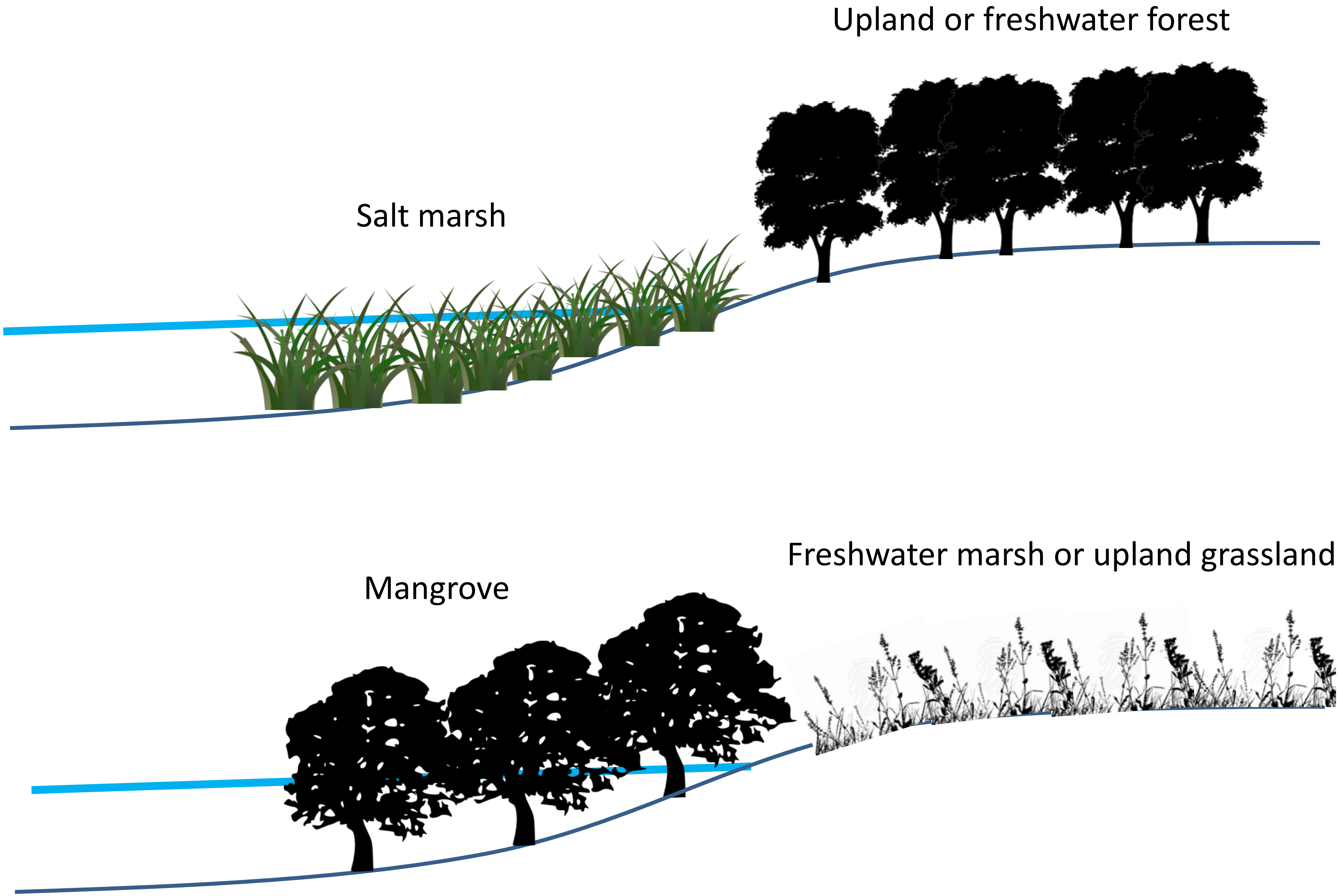
Saltwater intrusion

Elevated CO_2

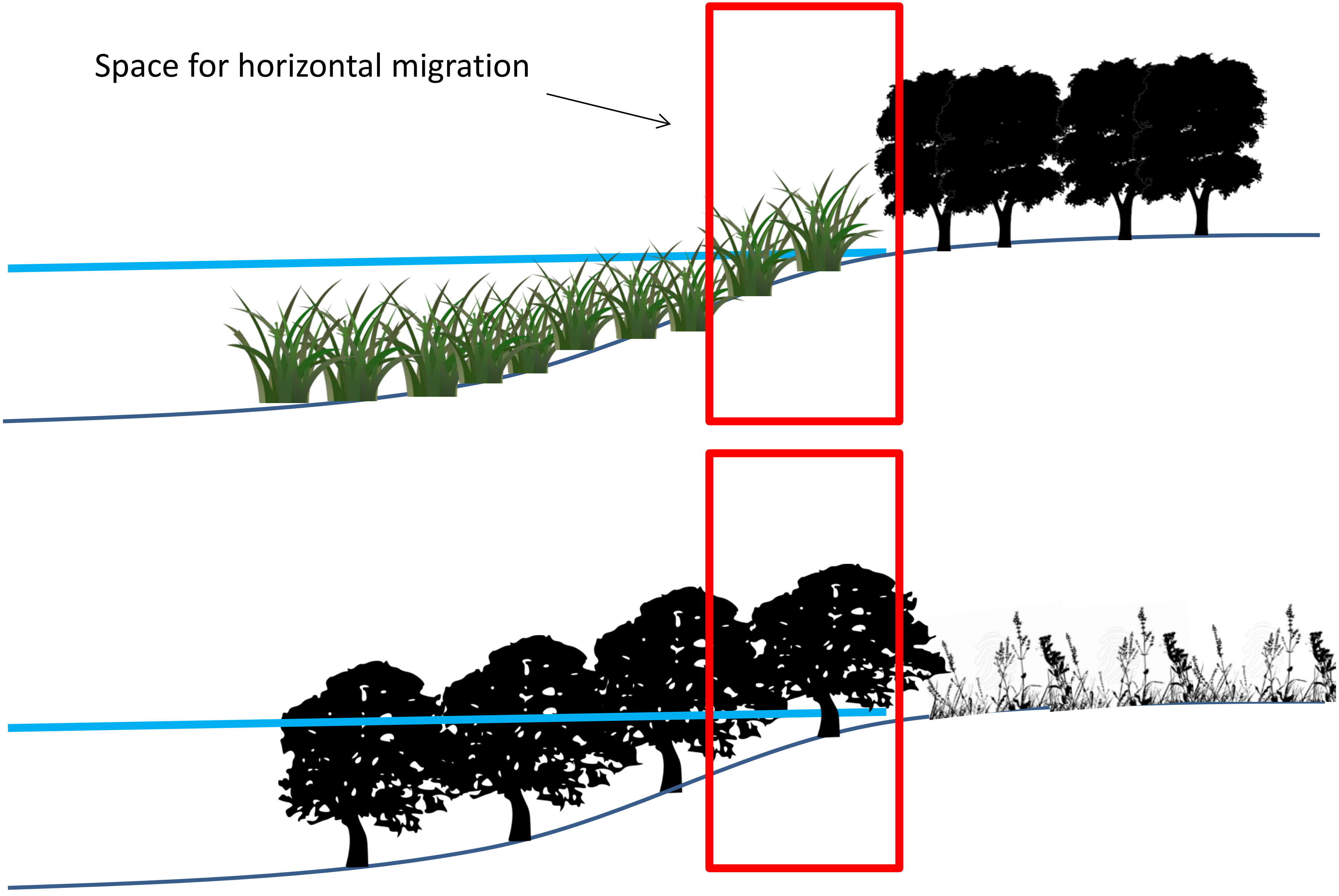
Precipitation



Temperature



Ecosystems and ecotones depend upon climate and landscape position
(i.e., it’s not the same across the Gulf)


Space for horizontal migration

What are the ecological implications?

- **Fisheries** (nursery and breeding habitat; food web linkages)
- **Avian habitat** (land bird migration; colonial nesting wading birds; marsh birds)
- **Biogeochemistry** (C, N, sediment , water quality)
- **Stability and resilience** (sea level rise; drought)
- **Coastal protection** (storms; erosion)

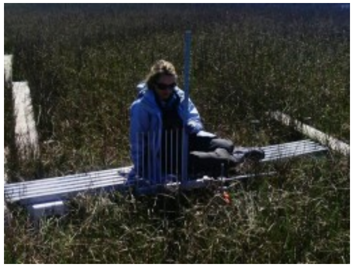
The ecological effects of and attitudes towards mangrove restoration and migration differ across the Gulf of Mexico

Much can be gained via a regional perspective and exchange of information

Colleagues and coauthors

- Michael Osland
- Richard Day
- Camille Stagg
- Jim Grace
- Nicholas Enwright
- Tom Doyle
- Chris Gabler (Postdoctoral Fellow)
- Steve Hartley
- Andy From
- Jennie McLeod (Student)
- Meagan McLemore (Recent Student)
- Erik Yando (Graduate Student)
- Ken Krauss
- Mark Hester
- Jonathan Willis

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Thank you

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