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Forecasting the impact of winter climate change on salt marsh-mangrove forest interactions

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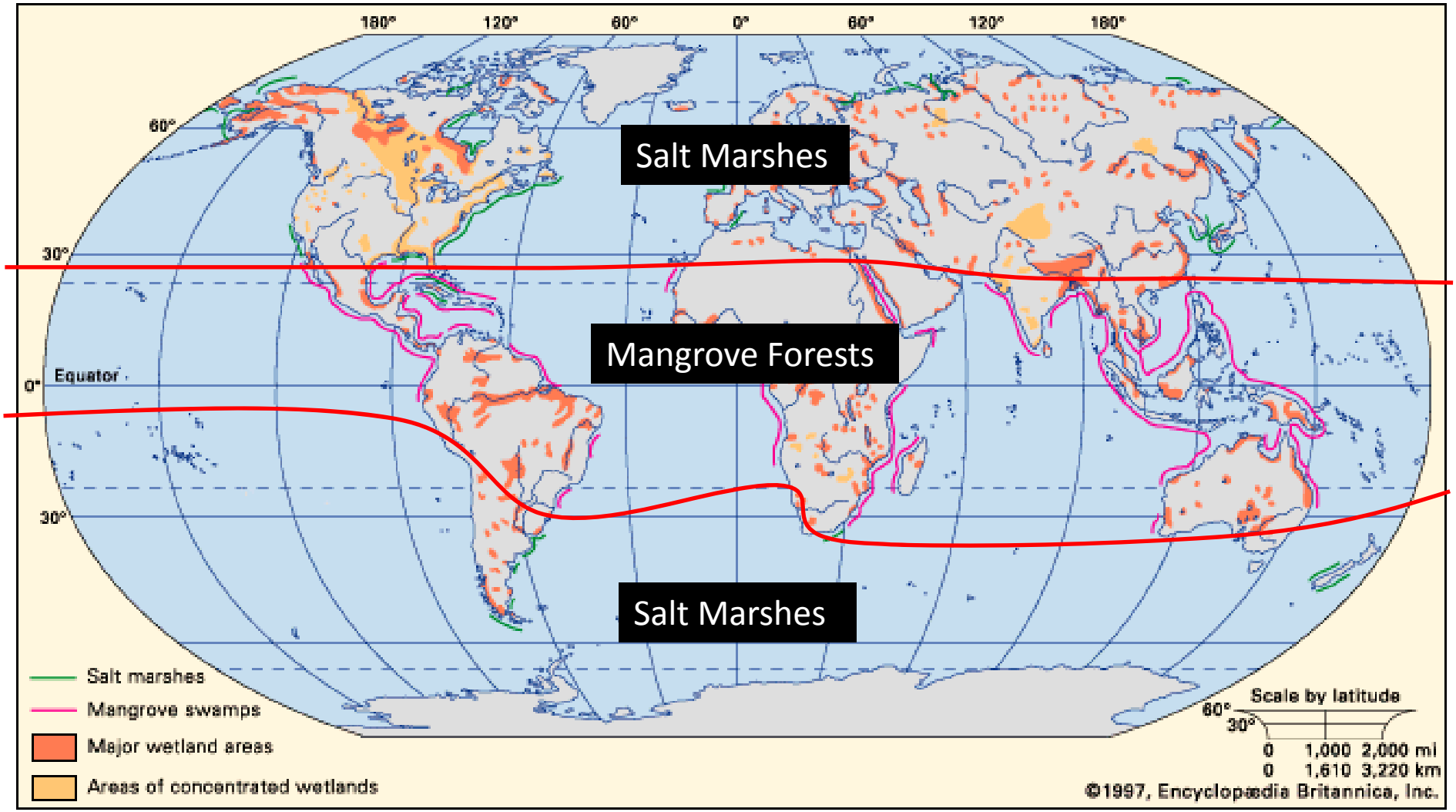
U.S. Department of Interior
U.S. Geological Survey

Global distribution of mangrove forests and salt marshes



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Salt Marsh

Mangrove Forest

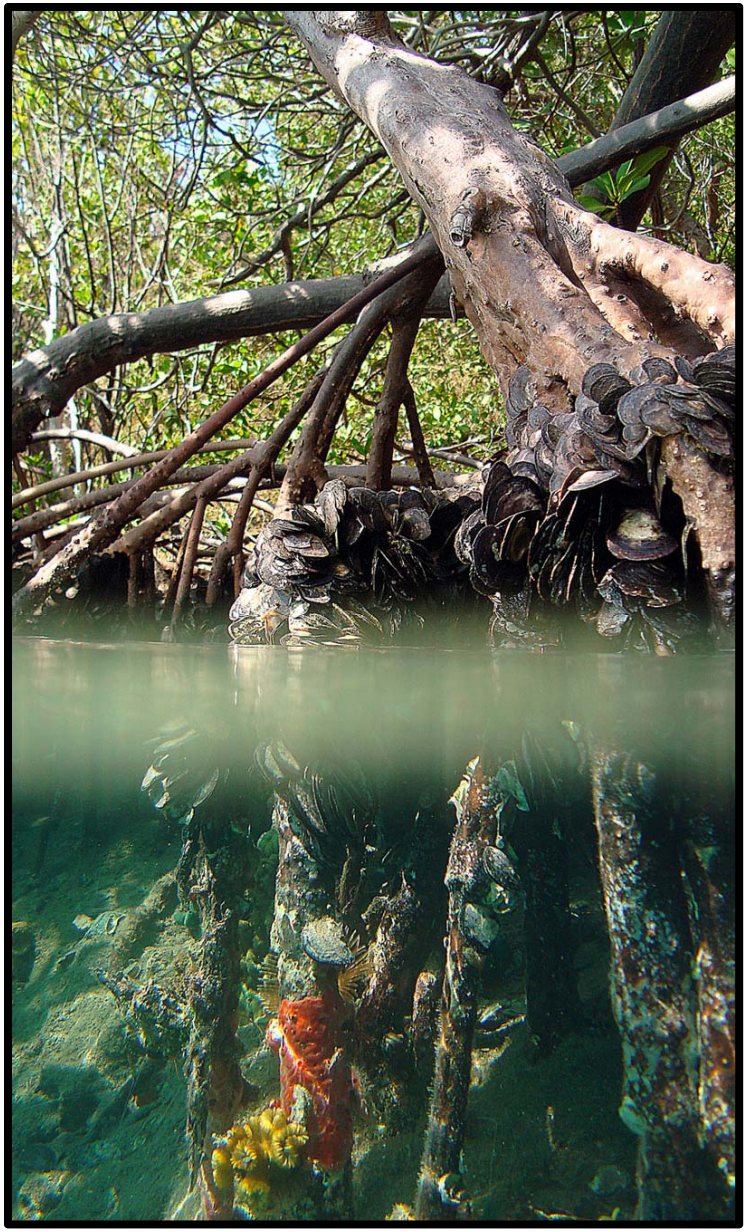

Photo: nps.gov- Rogers

Photo: nps.gov-Pringle

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Important points

- In areas with mild winters, mangrove forests outcompete salt marshes

- In areas with cold winters, salt marshes are dominant (mangrove forests are sensitive to extreme winter events)

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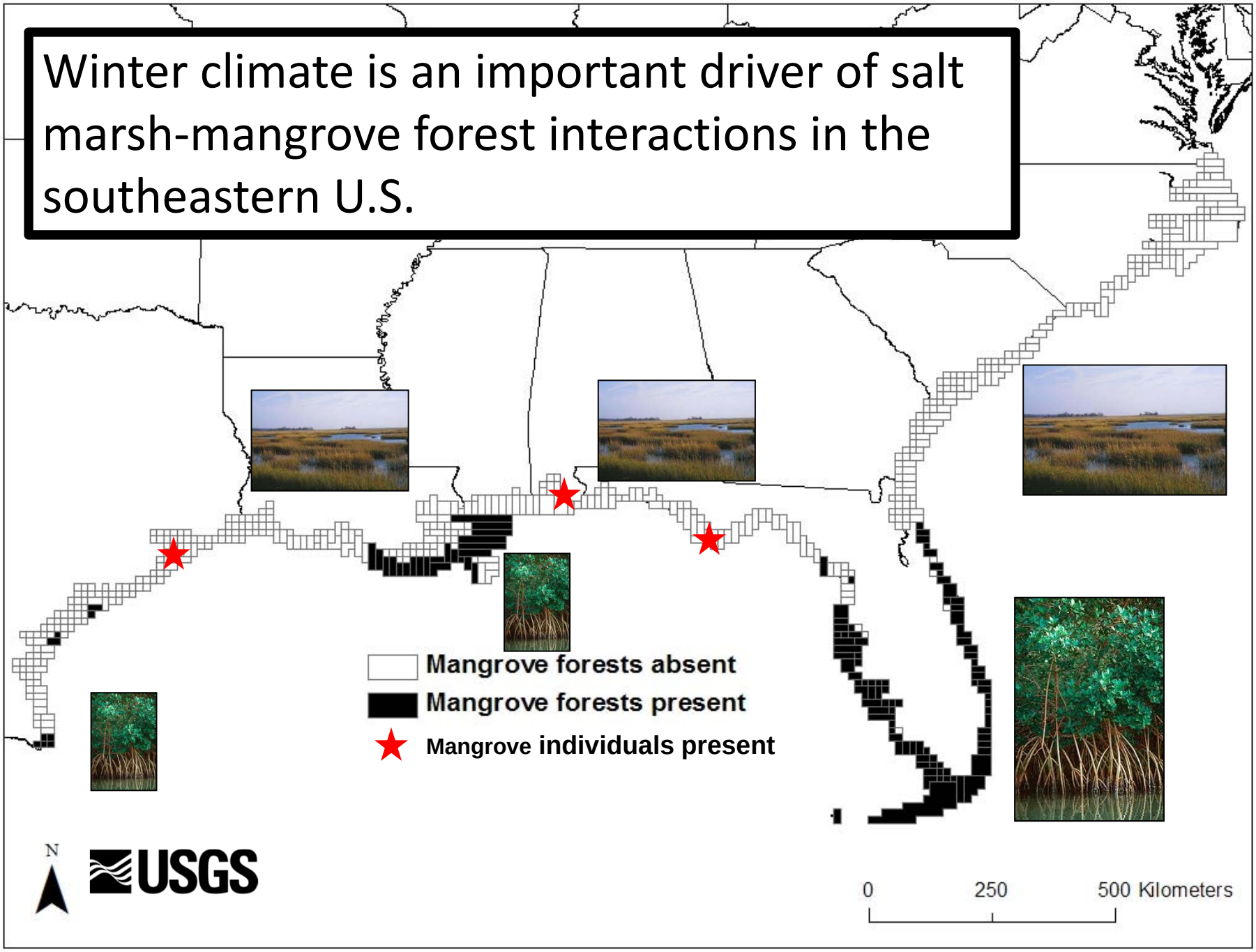
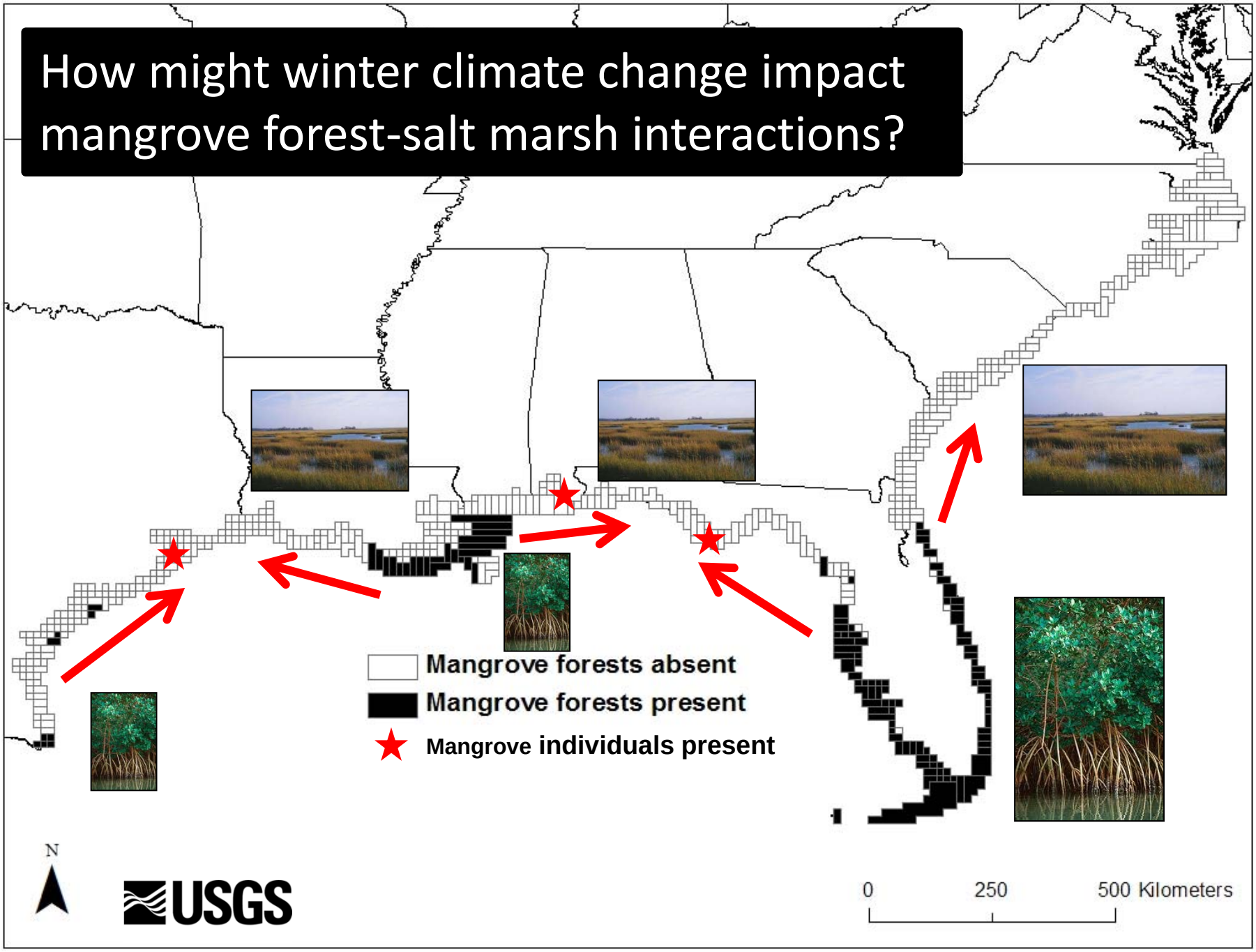
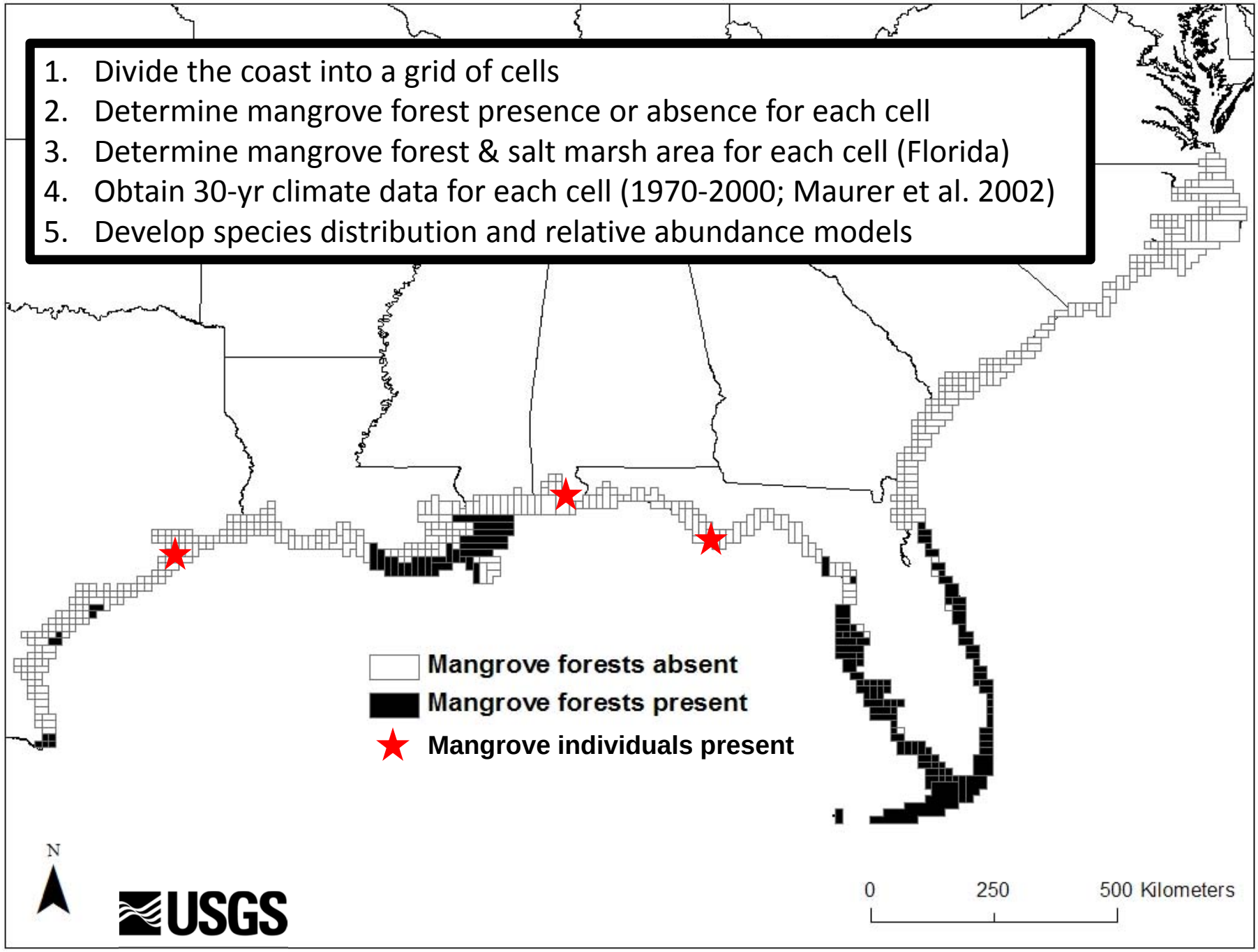

Winter climate is an important driver of salt marsh-mangrove forest interactions in the southeastern U.S.
Mangrove forests absent
Mangrove forests present
Mangrove individuals present
N
USGS
0
250
500 Kilometers


How might winter climate change impact mangrove forest-salt marsh interactions?
Mangrove forests absent
Mangrove forests present
Mangrove individuals present
N
USGS
0
250
500 Kilometers


1. Divide the coast into a grid of cells
2. Determine mangrove forest presence or absence for each cell
3. Determine mangrove forest & salt marsh area for each cell (Florida)
4. Obtain 30-yr climate data for each cell (1970-2000; Maurer et al. 2002)
5. Develop species distribution and relative abundance models
Mangrove forests absent
Mangrove forests present
Mangrove individuals present
N
USGS
0
250
500 Kilometers

Thresholds; species distribution and relative abundance models for 8 winter severity variables

Distribution models

Relative abundance models

Variable	Mangrove forest presence					Mangrove forest abundance			
	AIC	a	b	a Wald χ^2	b Wald χ^2	R^2	a	b	c
Mean annual minimum temperature	181.1	4.46	1.37	34	58	‡0.85***	75***	0.18**	-1.75***
Minimum temperature	190.5	8.99	0.91	41	54	‡0.82***	74***	0.50**	-6.97***
Mean annual maximum number of consecutive days with minimum temperature < 0°C	197.0	4.73	-2.14	49	72	‡0.85***	75***	-0.07*	1.51***
Mean annual minimum monthly mean temperature	200.5	-13.42	1.04	80	67	‡0.84***	74***	0.26**	14.76***
Mean annual maximum number of consecutive days with minimum temperature < -6.7°C	208.3	2.45	-9.14	37	75	†0.79***	70***	10.04***	NA
Mean annual number of days with minimum temperature < 0°C	225.4	2.23	-0.45	38	71	‡0.85***	75***	-0.11**	2.25***
Maximum number of consecutive days with minimum temperature < 0°C	228.4	6.53	-1.26	41	55	†0.63***	167***	0.37***	NA
Maximum number of consecutive days with minimum temperature < -6.7°C	247.0	2.52	-1.38	34	83	†0.78***	71***	1.23***	NA

Thresholds for predicting mangrove forest presence

Variable	Presence	Dominance
Mean annual minimum temperature	-3.0 (0.63)	-1.7 (0.84)
Minimum temperature	-8.9 (0.64)	-7.0 (0.81)
Mean annual maximum number of consecutive days with minimum temperature < 0°C	2.2 (0.60)	1.5 (0.85)
Mean annual minimum monthly mean temperature	13.6 (0.64)	14.9 (0.83)
Mean annual maximum number of consecutive days with minimum temperature < -6.7°C	0.2 (0.60)	0.0 (0.76)
Mean annual number of days with minimum temperature < 0°C	3.7 (0.59)	2.2 (0.85)
Maximum number of consecutive days with minimum temperature < 0°C	4.5 (0.48)	4.5 (0.80)
Maximum number of consecutive days with minimum temperature < -6.7°C	1.5 (0.57)	0.5 (0.76)

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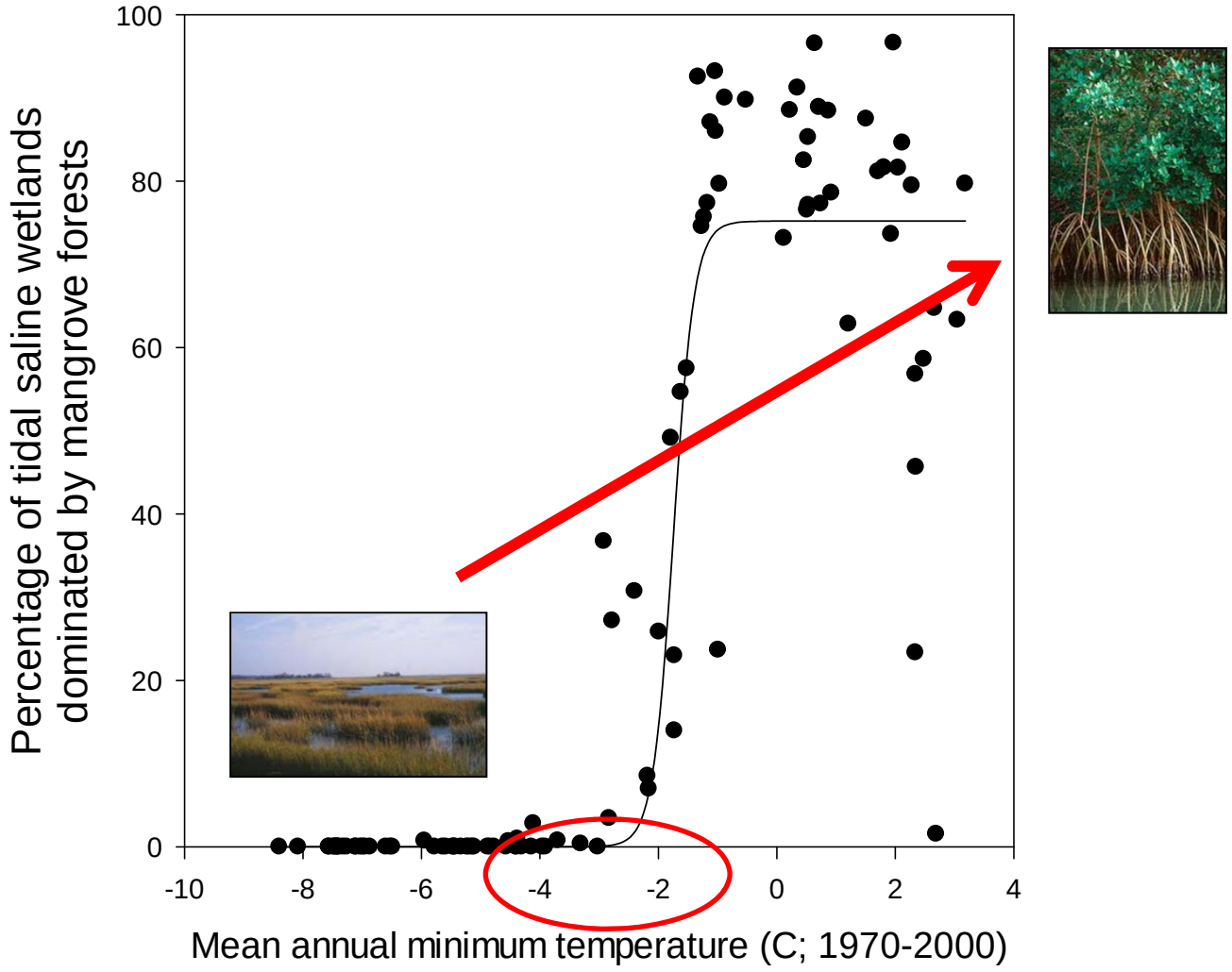
Thresholds for predicting mangrove forest dominance

The relationship between winter severity and mangrove forest dominance



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Alternative future winter climate scenarios

Two approaches:

1. Warming scenarios (0-8°C)

2. Future climate projections (2070-2100)

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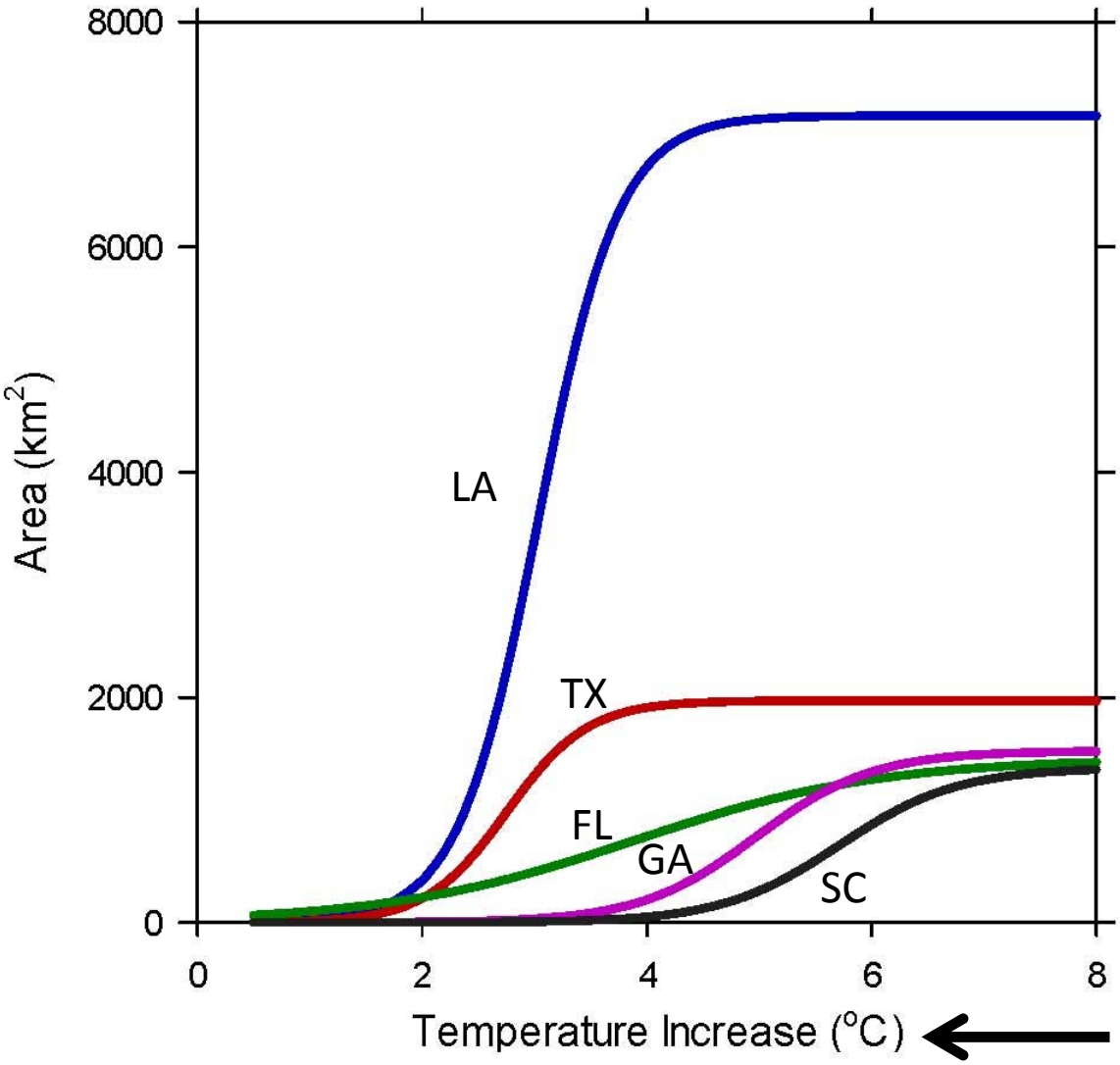
Salt marsh sensitivity to winter climate change-induced mangrove forest range expansion

Amount of salt marsh area within each state that could be replaced by mangrove forest



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

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Alternative future climate scenarios

Two approaches:

~~1. Warming scenarios (0-8°C)~~

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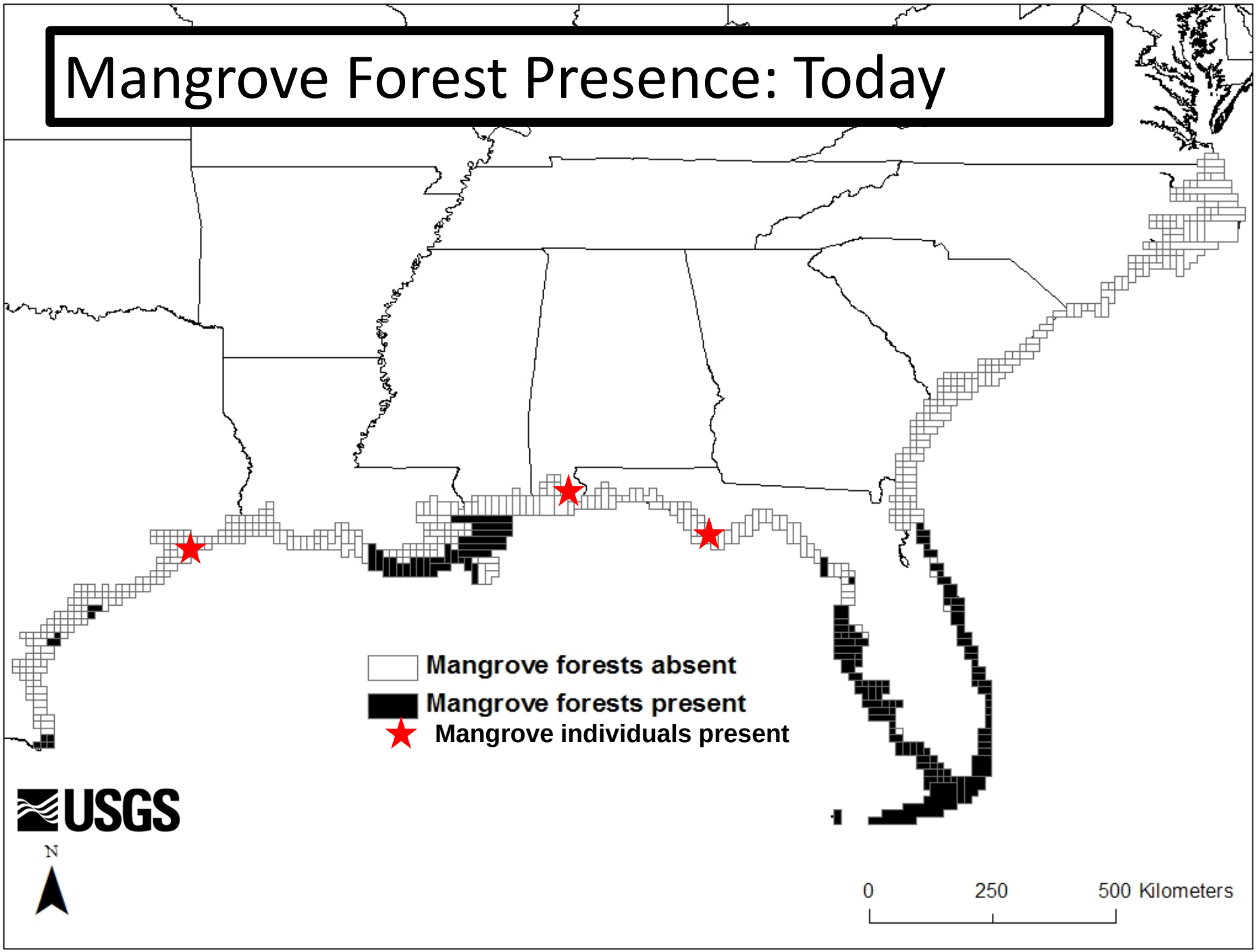
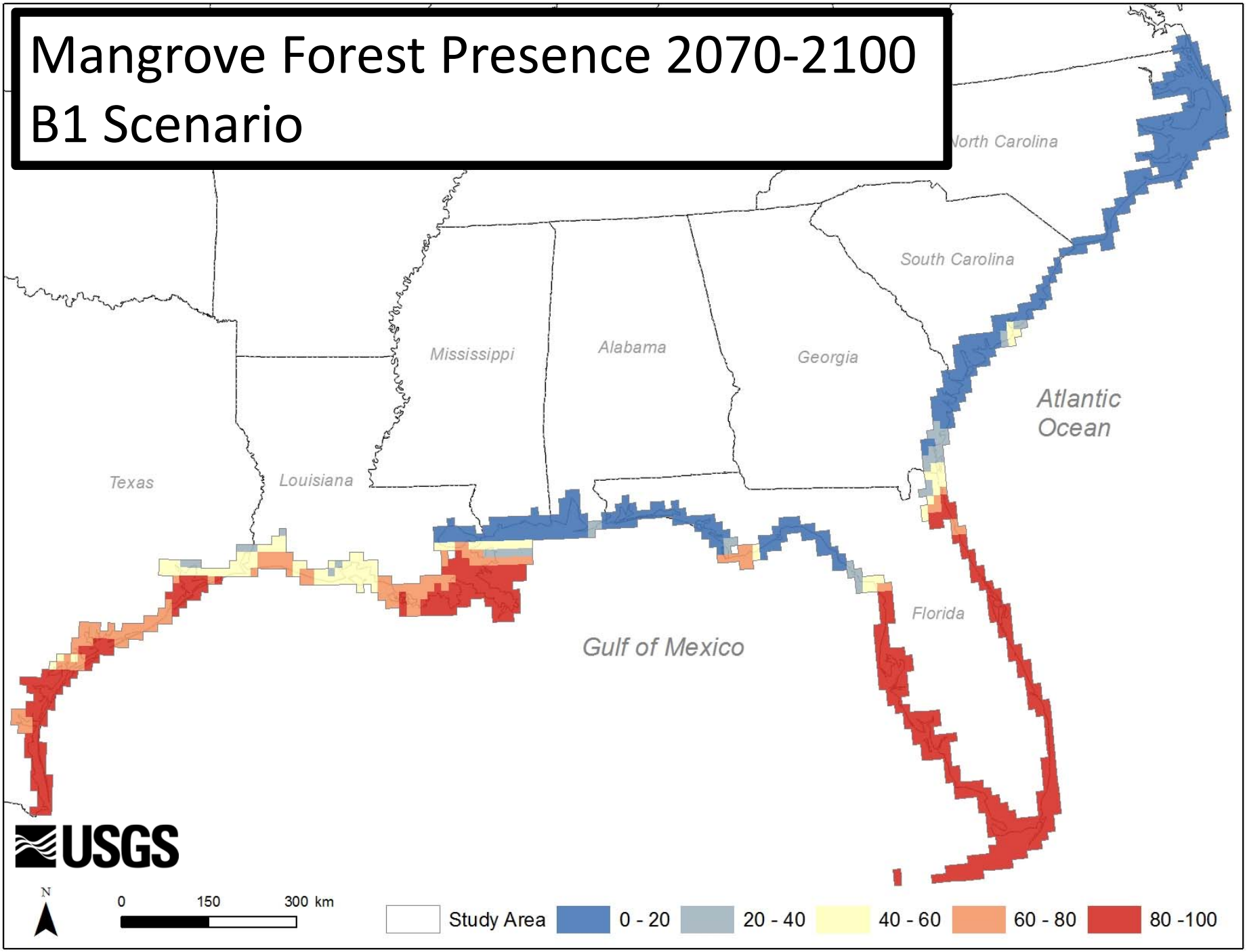
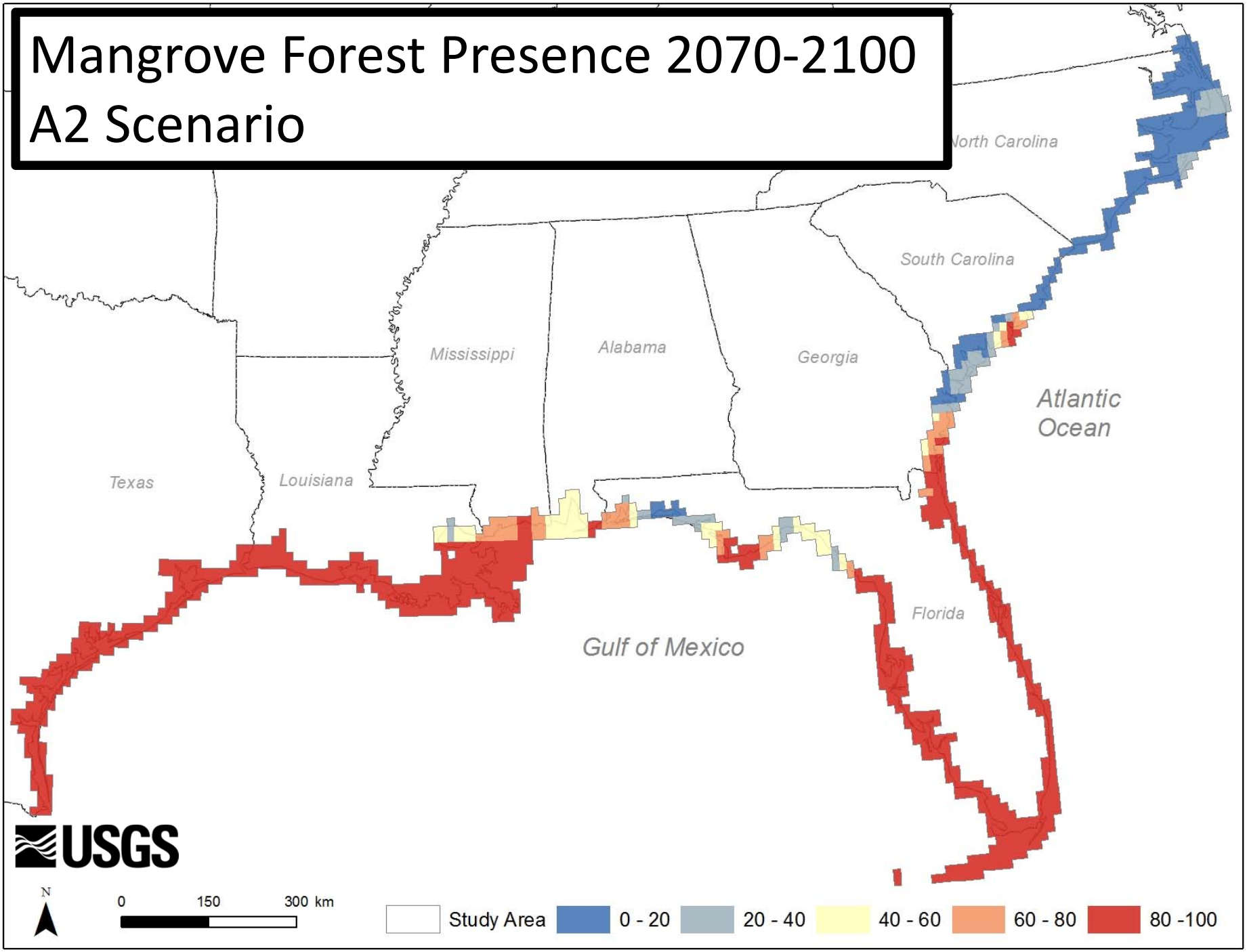
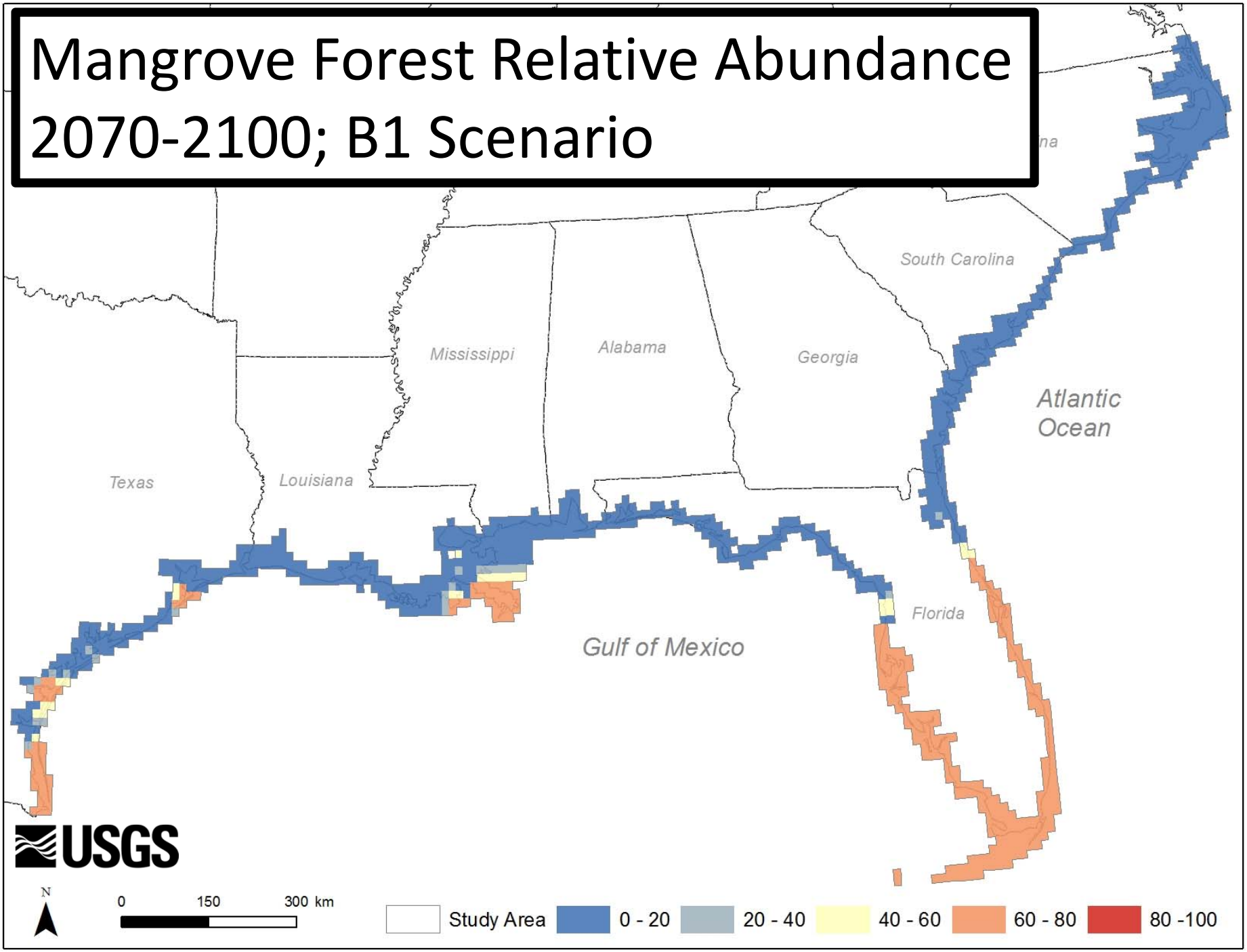

Mangrove Forest Presence: Today
Mangrove forests absent
Mangrove forests present
Mangrove individuals present
USGS
N
0
250
500 Kilometers

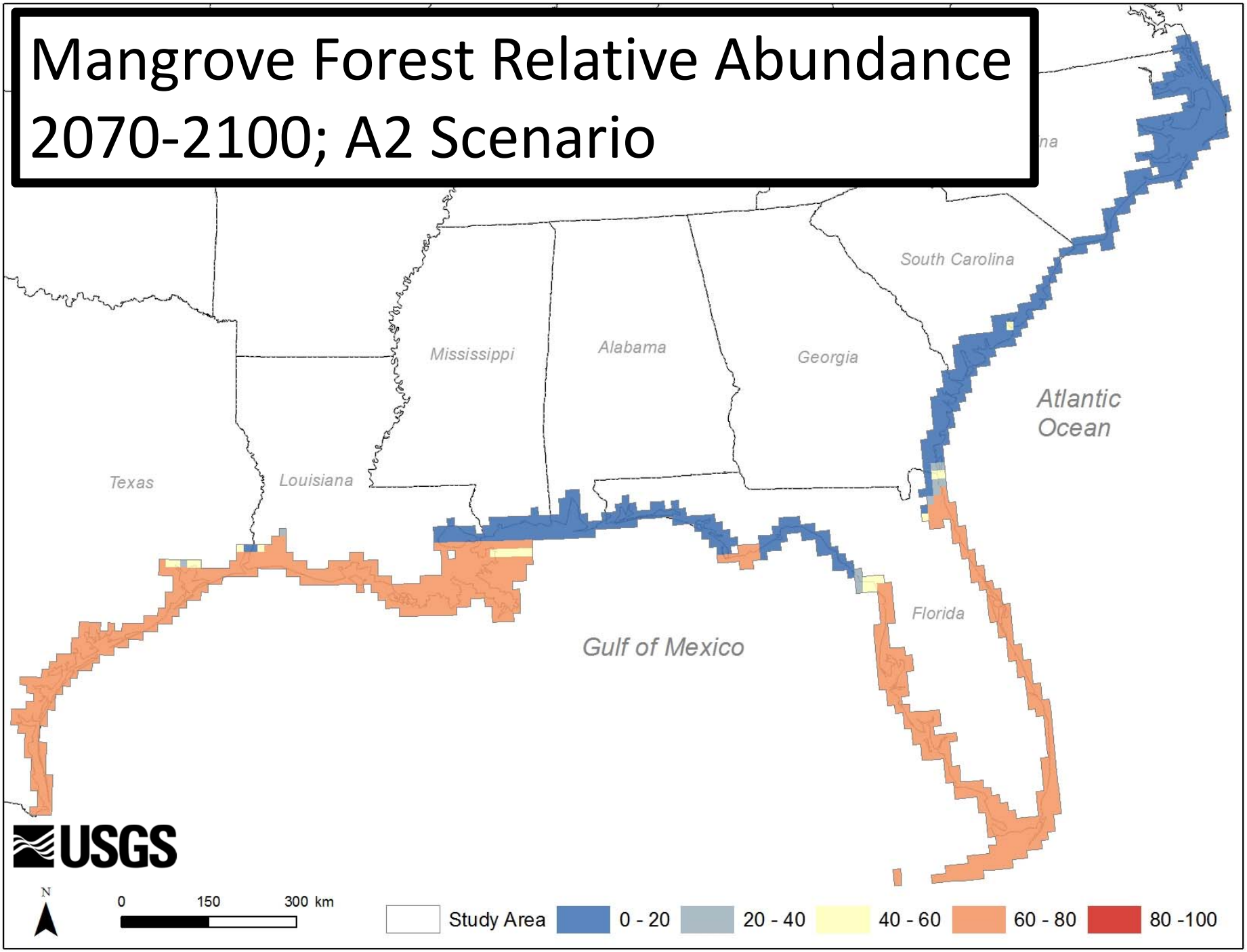

Mangrove Forest Presence 2070-2100
B1 Scenario
North Carolina
South Carolina
Georgia
Alabama
Mississippi
Louisiana
Texas
Atlantic Ocean
Gulf of Mexico
Florida
USGS
N
0
150
300 km
Study Area
0 - 20
20 - 40
40 - 60
60 - 80
80 -100

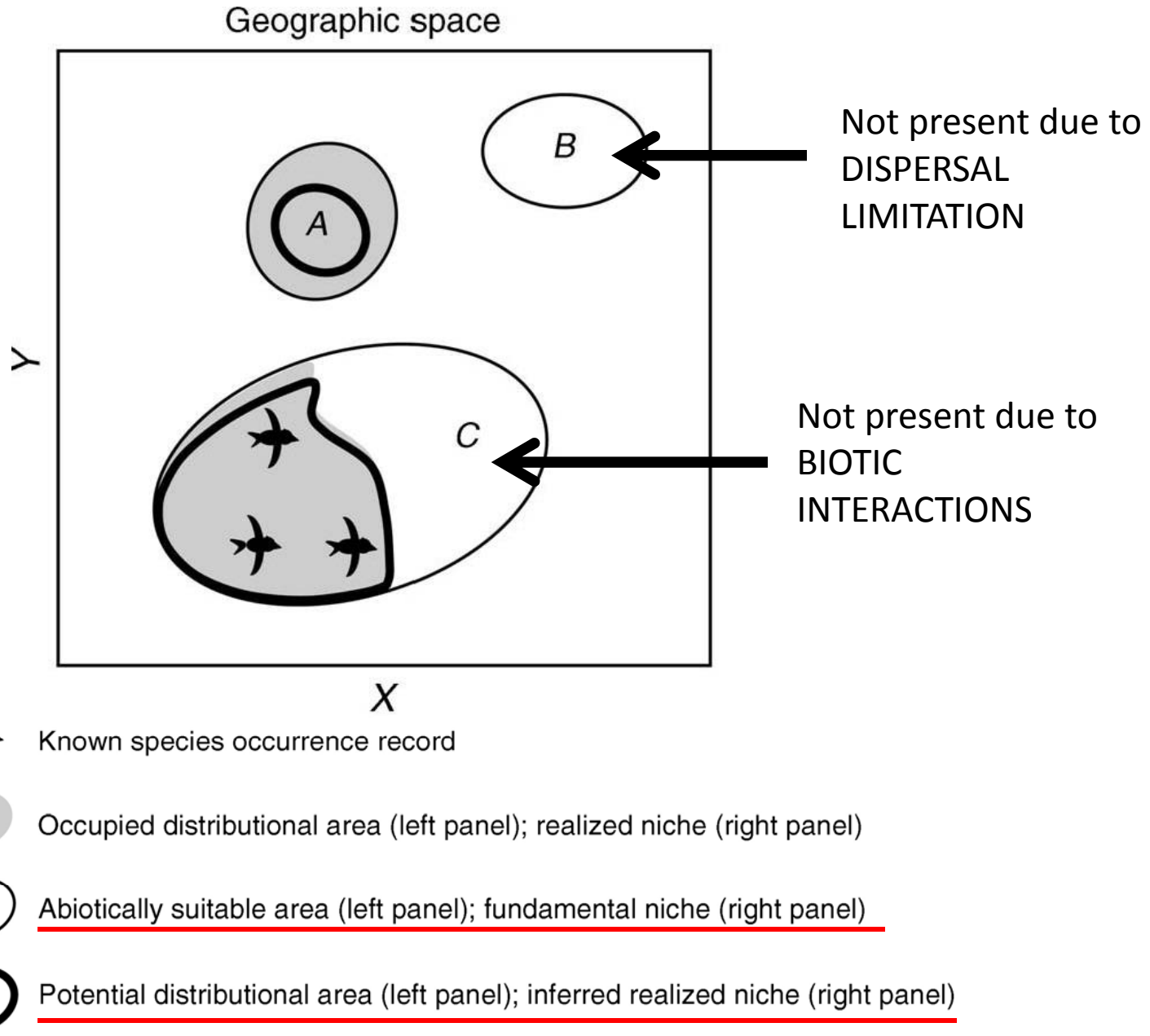

Mangrove Forest Presence 2070-2100
A2 Scenario
North Carolina
South Carolina
Georgia
Alabama
Mississippi
Louisiana
Texas
Atlantic Ocean
Gulf of Mexico
Florida
USGS
N
0
150
300 km
Study Area
0 - 20
20 - 40
40 - 60
60 - 80
80 -100

Mangrove Forest Relative Abundance 2070-2100; B1 Scenario



Mangrove Forest Relative Abundance 2070-2100; A2 Scenario





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From: Araujo and Peterson (2012); redrawn from Pearson (2007

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)

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