University of Mississippi
Graduate Student Council
9th Annual Research Symposium
March 26, 2019

Ecological Drivers of Subterranean Termite Distributions

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&

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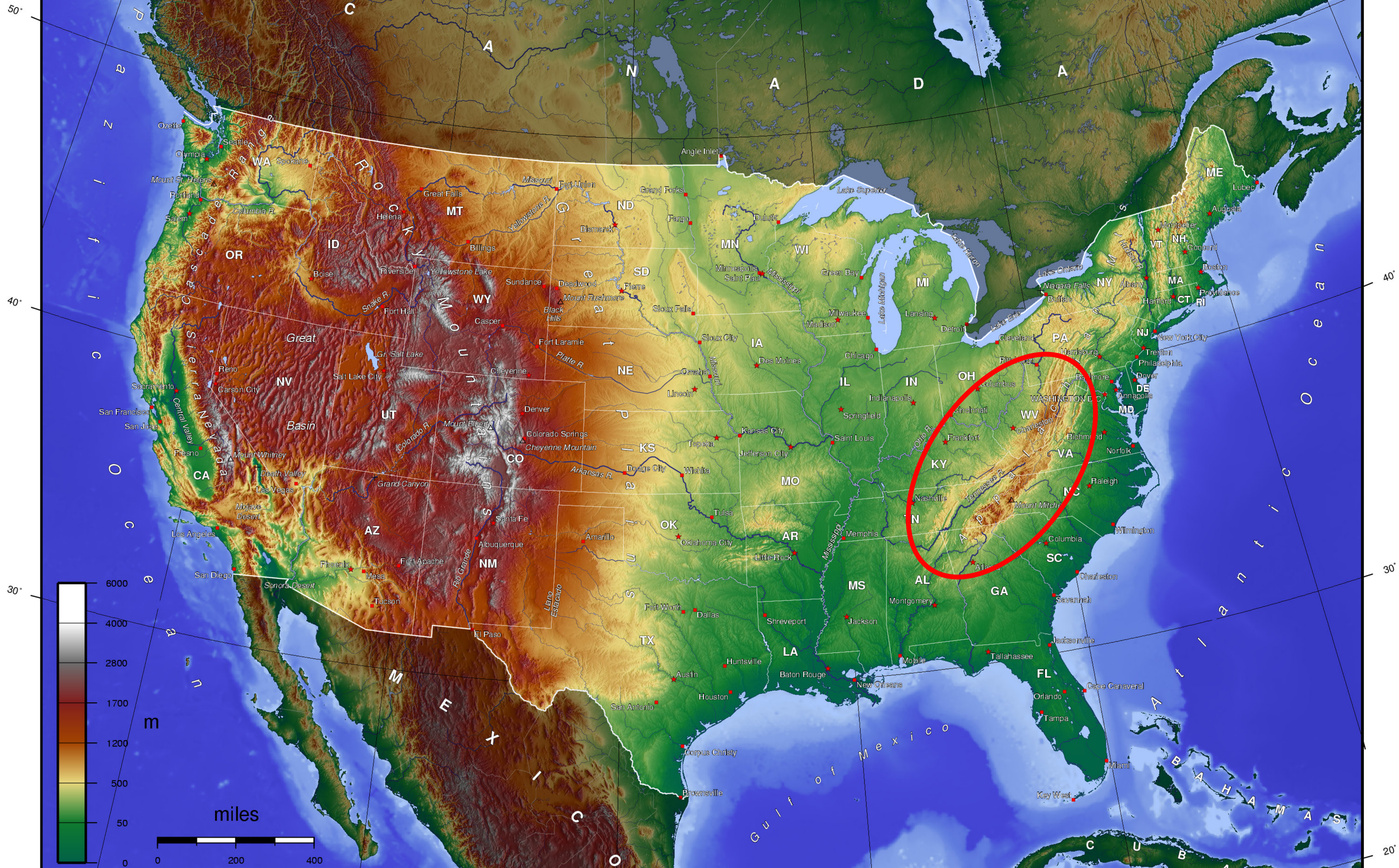
Distribution/niche modeling: occurrence data and environmental variables



C A N A D A
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
MEXICO
BAHAMAS
CUBA
Cascade Range
Sierra Nevada
Rocky Mountains
Great Plains
Great Basin
Appalachian Mountains
Central Valley
Mojave Desert
Sonora Desert
Death Valley
Grand Canyon
Llano Estacado
Black Hills
Mount Rushmore
Mount St. Helens
Mount Whitney
Mount Elbert
Mount Mitchell
Cheyenne Mountain
Yellowstone Lake
Gr. Salt Lake
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Niagara Falls
Columbia R.
Snake R.
Missouri
Yellowstone R.
Platte R.
Arkansas R.
Colorado R.
Rio Grande
Mississippi
Ohio R.
Tennessee R.
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WASHINGTON D.C.
Seattle
Olympia
Spokane
Portland
Salem
Boise
Helena
Great Falls
Billings
Riverside
Fort Hall
Casper
Cheyenne
Fort Laramie
Sundance
Deadwood
Reno
Carson City
Sacramento
San Francisco
San Jose
Fresno
Las Vegas
Los Angeles
San Diego
Salt Lake City
Phoenix
Mesa
Tucson
Fort Apache
Denver
Colorado Springs
Santa Fe
Albuquerque
El Paso
Amarillo
Fort Union
Bismarck
Pierre
Sioux Falls
Grand Forks
Fargo
Angle Inlet
Duluth
Minneapolis
Saint Paul
Omaha
Lincoln
Sioux City
Des Moines
Topeka
Dodge City
Wichita
Kansas City
Jefferson City
Tulsa
Oklahoma City
Fort Worth
Dallas
Austin
San Antonio
Houston
Corpus Christi
Brownsville
Shreveport
Little Rock
Memphis
Jackson
Baton Rouge
New Orleans
Mobile
Montgomery
Huntsville
Nashville
Atlanta
Tallahassee
Jacksonville
Orlando
Tampa
Cape Canaveral
Miami
Key West
Savannah
Charleston
Columbia
Wilmington
Raleigh
Norfolk
Richmond
Charleston
Frankfort
Cincinnati
Columbus
Cleveland
Pittsburgh
Harrisburg
Baltimore
Annapolis
Dover
Philadelphia
Trenton
New York City
Hartford
Providence
Boston
Concord
Montpelier
Albany
Buffalo
Augusta
Lubec
Detroit
Lansing
Milwaukee
Madison
Green Bay
Chicago
Springfield
Saint Louis
Indianapolis
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6000
4000
2800
1700
1200
500
50
0
miles
0
200
400
50°
40°
30°
20°

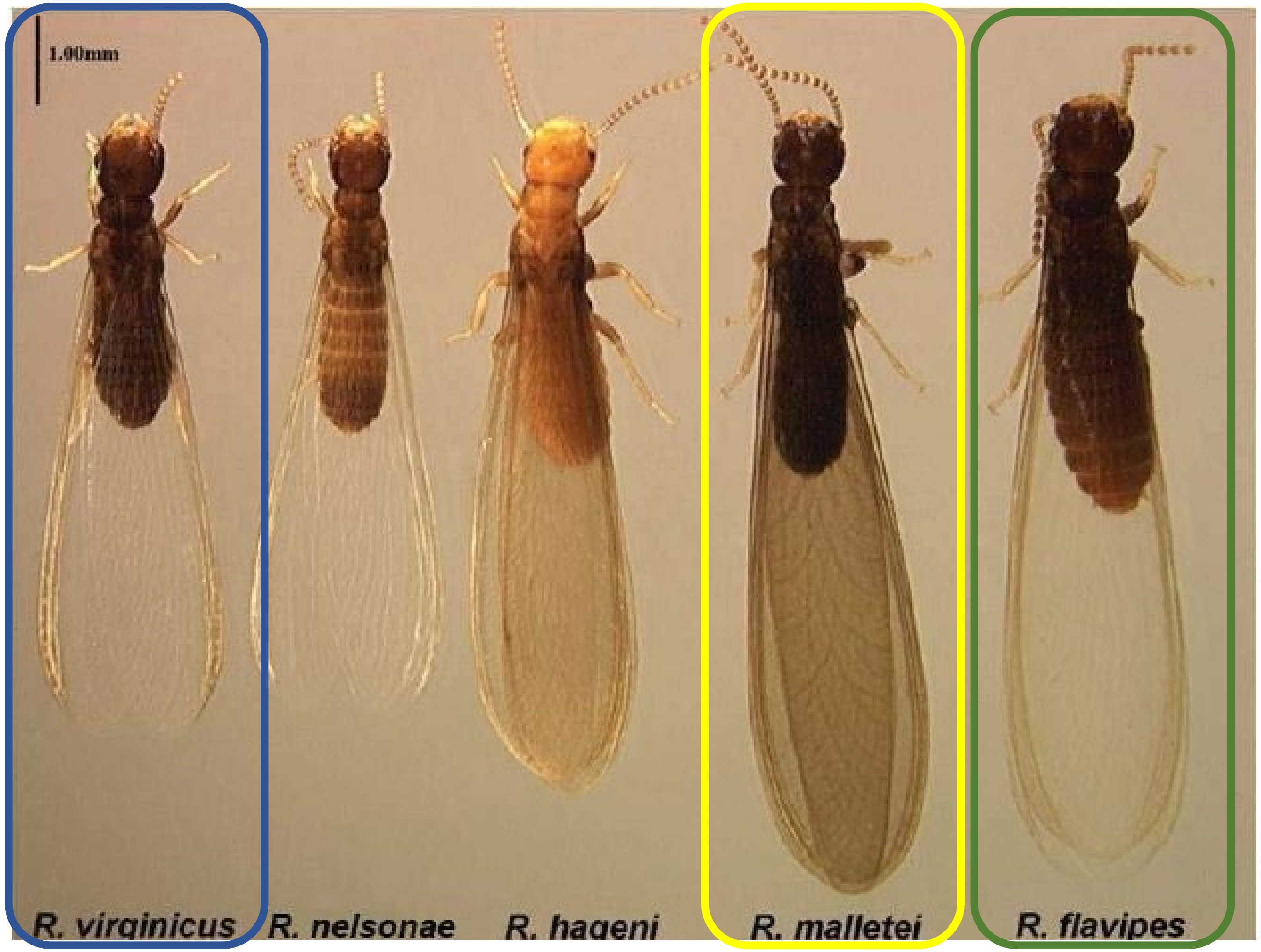
Why are some termite species ~~pests~~ more successful than others?

Niche divergence and competitive exclusion

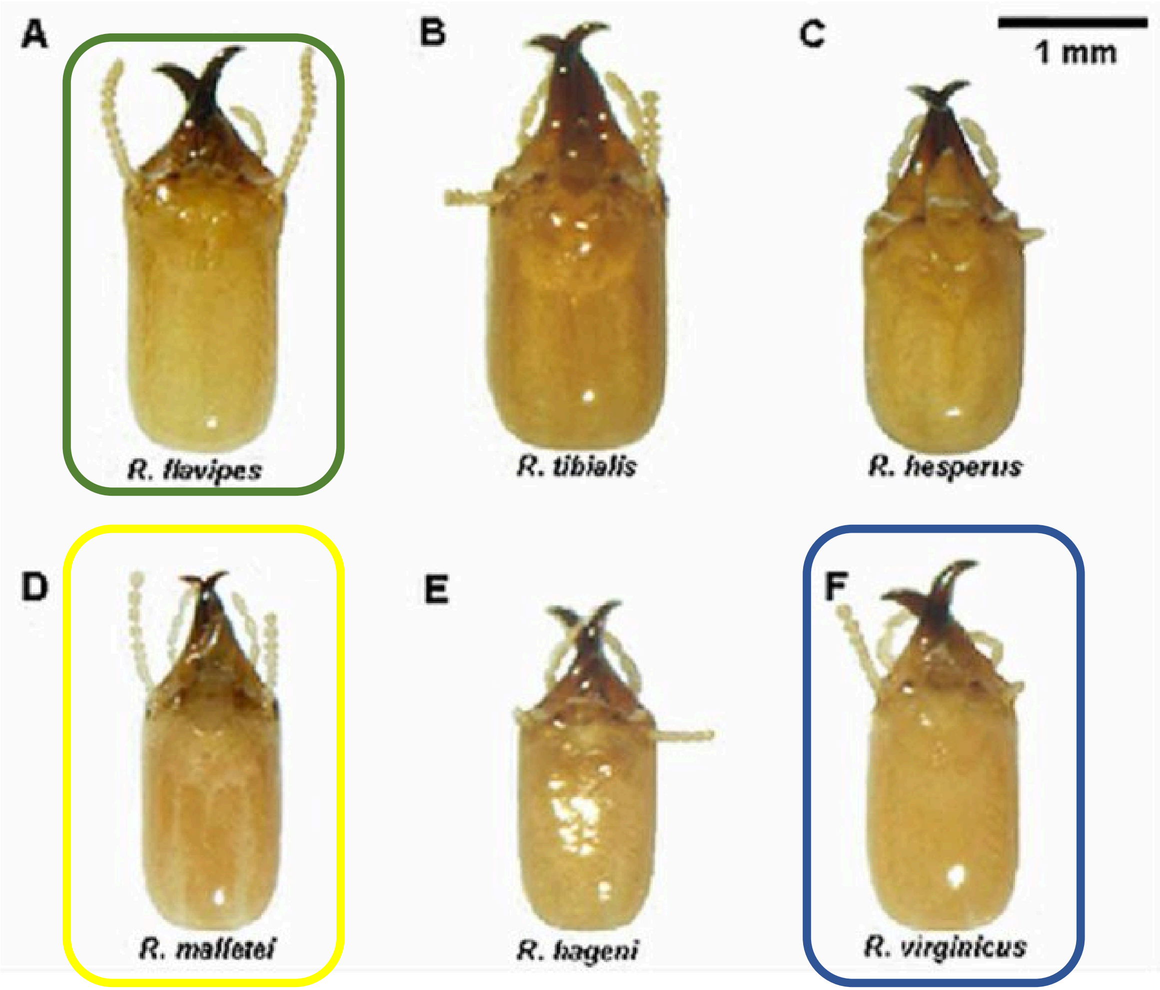
Is there niche divergence among species of subterranean termites?
Competition for resources: do species competitively exclude other species?

Geographic distribution and abundance

What environments do subterranean termites occur in?
What environmental conditions facilitate geographic and demographic expansions?

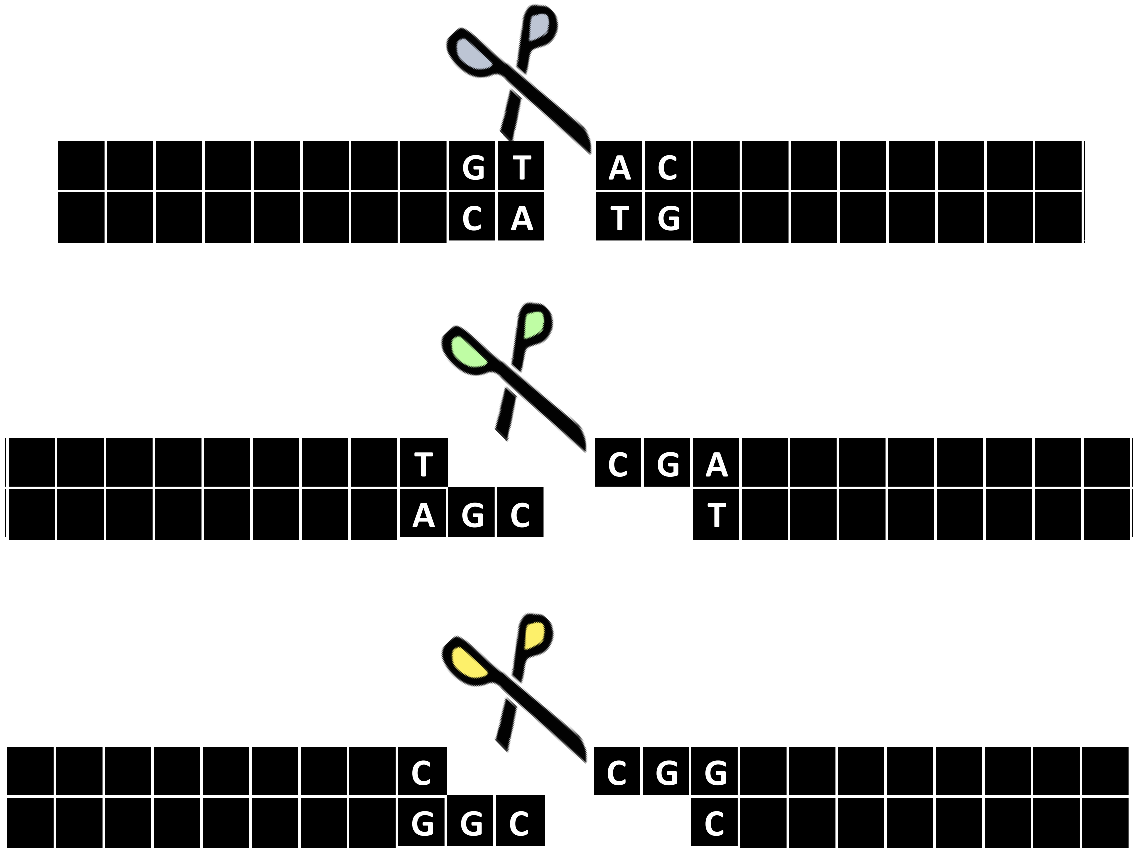


Lim SY, Forschler BT. Reticulitermes nelsonae, a New Species of Subterranean Termite (Rhinotermitidae) from the Southeastern United States. *Insects* 2012;3:62–90.



Austin JW, -G. Bagnères A, Szalanski AL, *et al.* Reticulitermes malletei (Isoptera: Rhinotermitidae): a valid Nearctic subterranean termite from Eastern North America. *Zootaxa* 2007;1554:1–26.

Restriction Digestion



Restriction Enzymes: RsaI TaqI MspI

Digestion of 376 bp fragment of mitochondrial DNA

Restriction Enzyme	Fragment Sizes (bp)	Species *R. flavipes*	*R. hageni*	*R. malletei*	*R. nelsonae*	*R. virginicus*
Rsa I	175, 201	✓	✗	✗	✓	✓
	48, 127, 201	✗	✗	✓	✓	✗
	86, 115, 175	✓	✓	✗	✗	✗
Taq I	376	✗	✓	✓	✓	✓
	153, 223	✗	✗	✗	✓	✗
	183, 193	✓	✗	✗	✗	✗
	67, 126, 183	✓	✗	✗	✗	✗
	30, 67, 126, 153	✓	✗	✗	✗	✗
Msp I	376	✓	✗	✗	✓	✓
	37, 339 *	✓	✗	✓	✗	✗
	77, 299	✗	✓	✗	✓	✗
	37, 40, 299	✗	✗	✓	✗	✗

Geographic Sampling

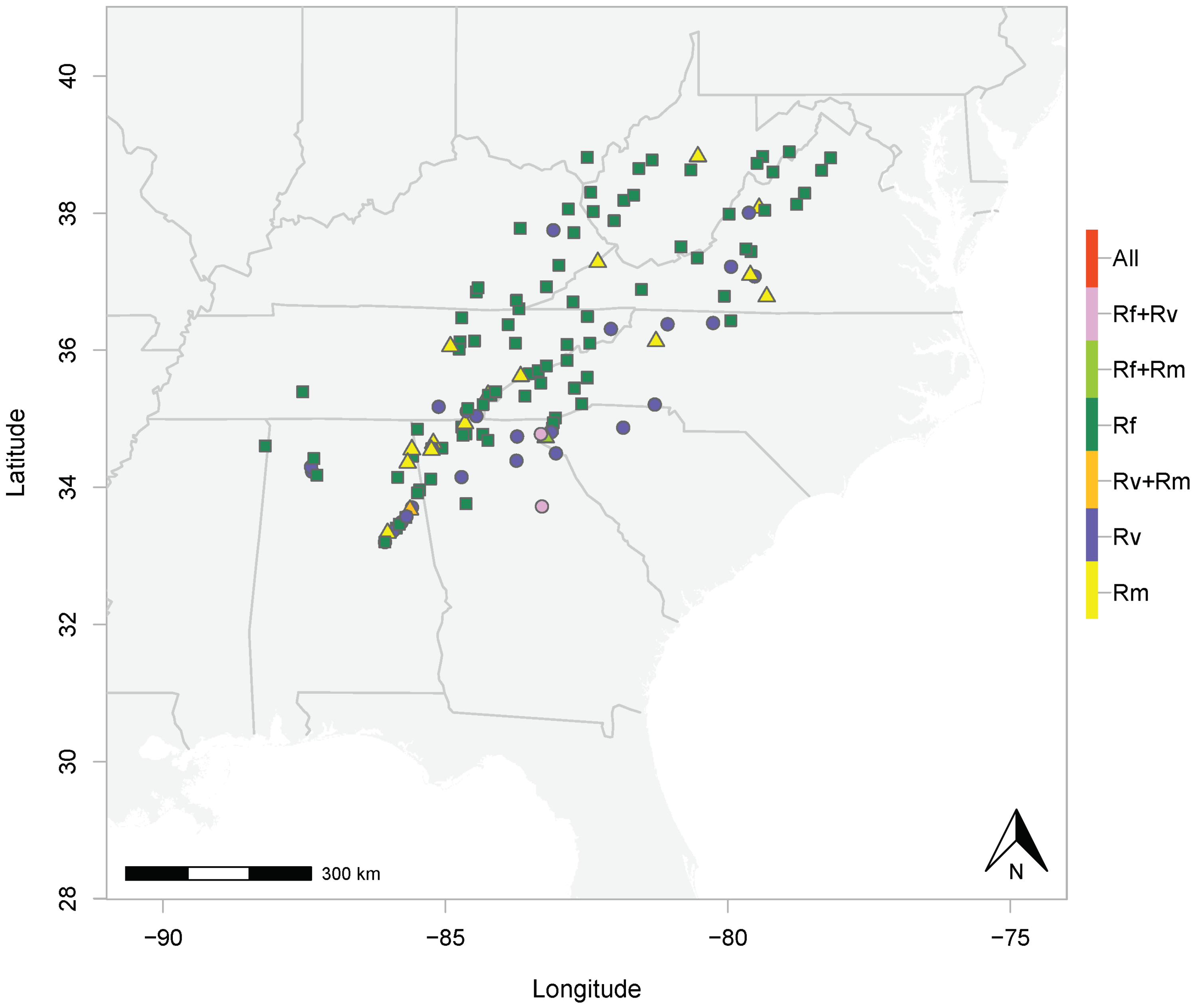
132 sampling sites:

122 sites: 1 rotting log each
10 sites: 2-4 rotting logs each

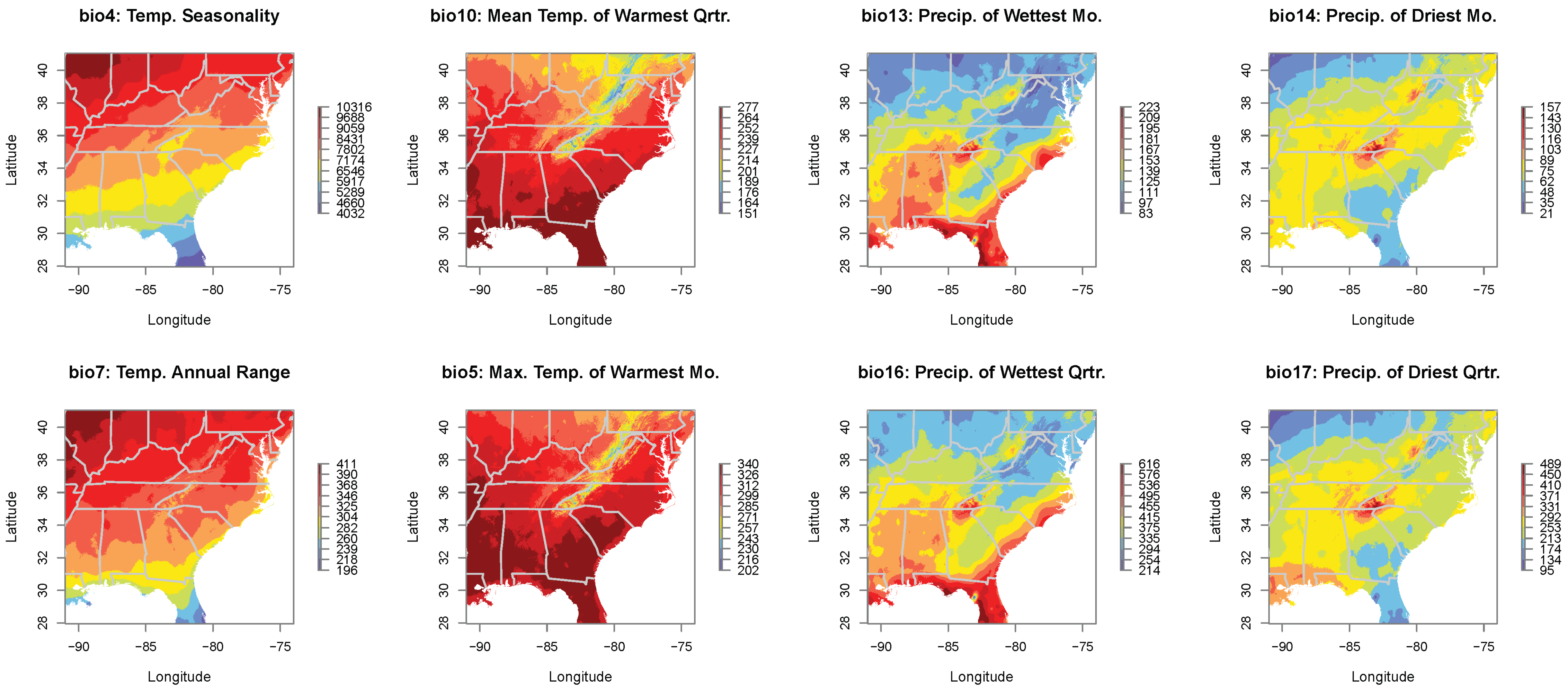
***Reticulitermes flavipes* = Rf (91)**

***Reticulitermes malletei* = Rm (17)**

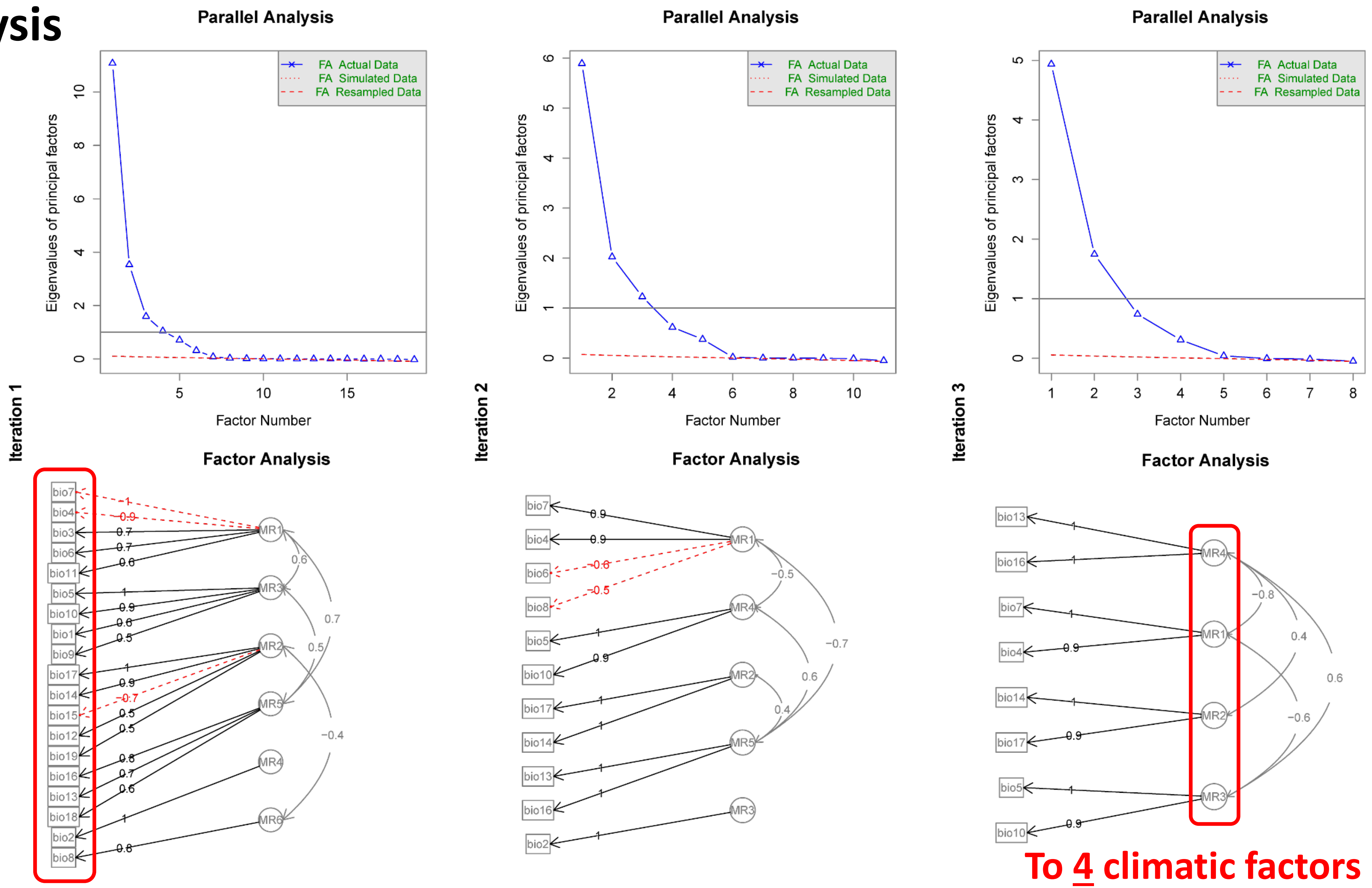
***Reticulitermes virginicus* = Rv (30)**



Bioclimatic (biologically-relevant climatic) variables



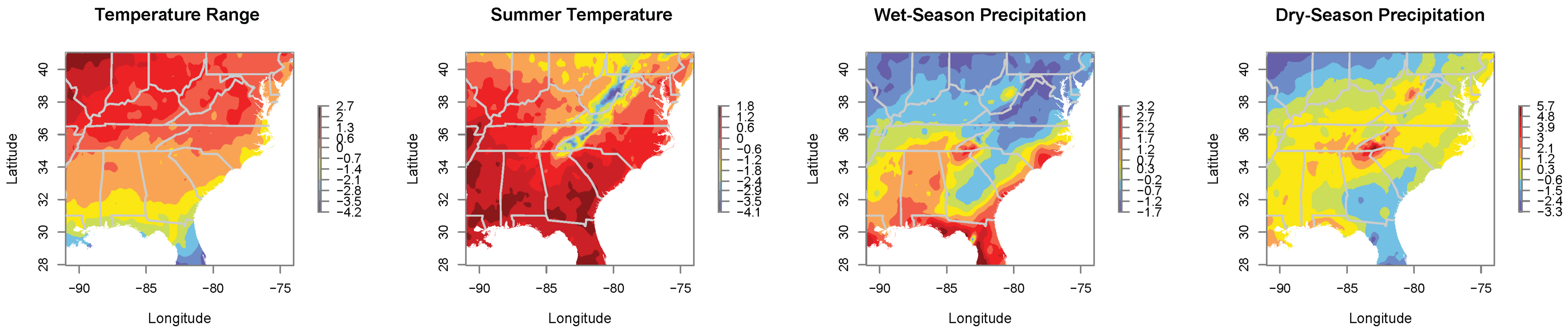
Factor analysis

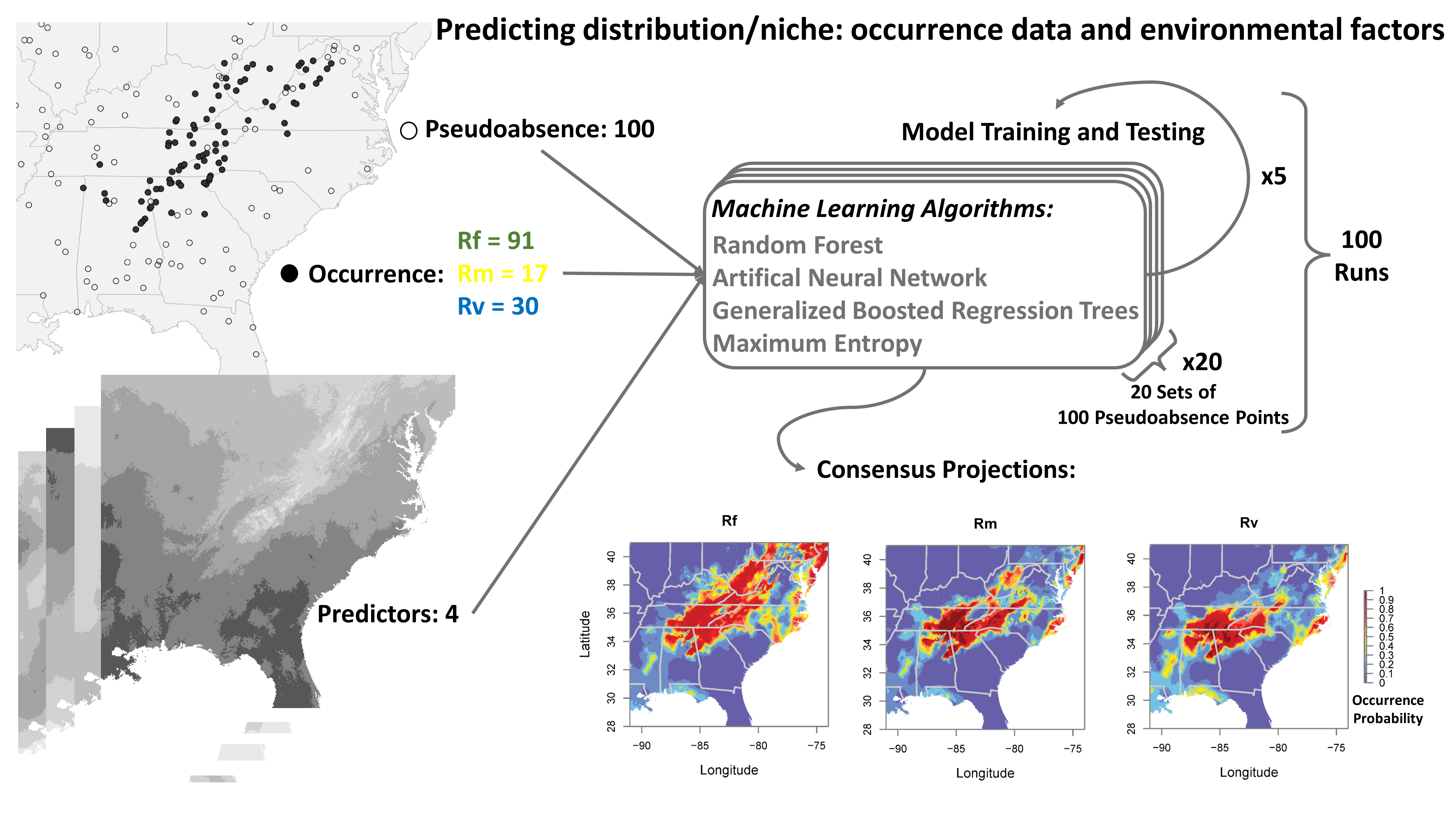


From 19 bioclimatic variables

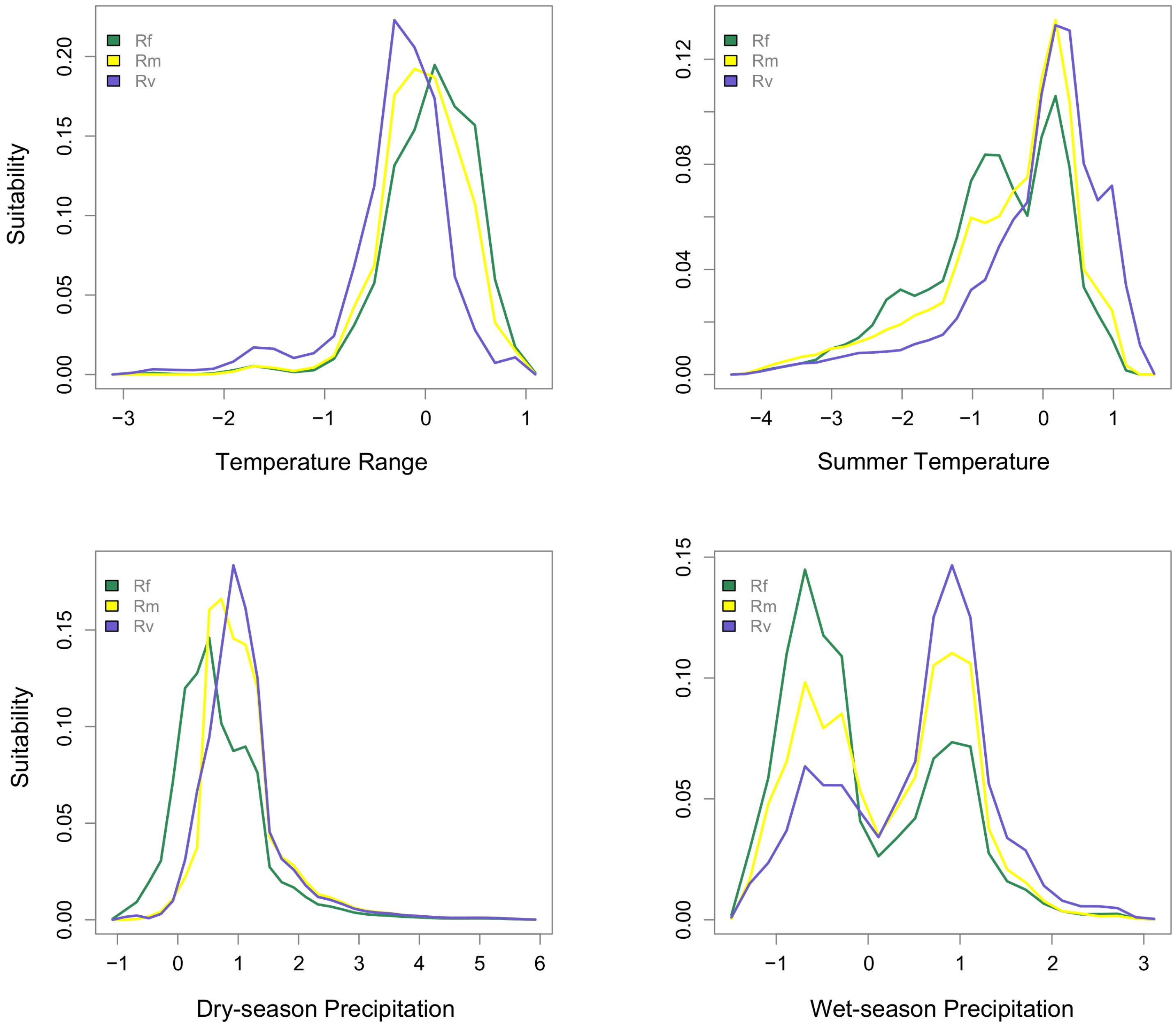
To 4 climatic factors

Environmental/climatic factors




Predicting distribution/niche: occurrence data and environmental factors
Pseudoabsence: 100
Occurrence:
Rf = 91
Rm = 17
Rv = 30
Predictors: 4
Model Training and Testing
x5
Machine Learning Algorithms:
Random Forest
Artifical Neural Network
Generalized Boosted Regression Trees
Maximum Entropy
x20
20 Sets of
100 Pseudoabsence Points
100
Runs
Consensus Projections:
Rf
Rm
Rv
Latitude
Longitude
Occurrence
Probability

Predicted niche occupancy



Niche overlap:
two different statistics: D and I

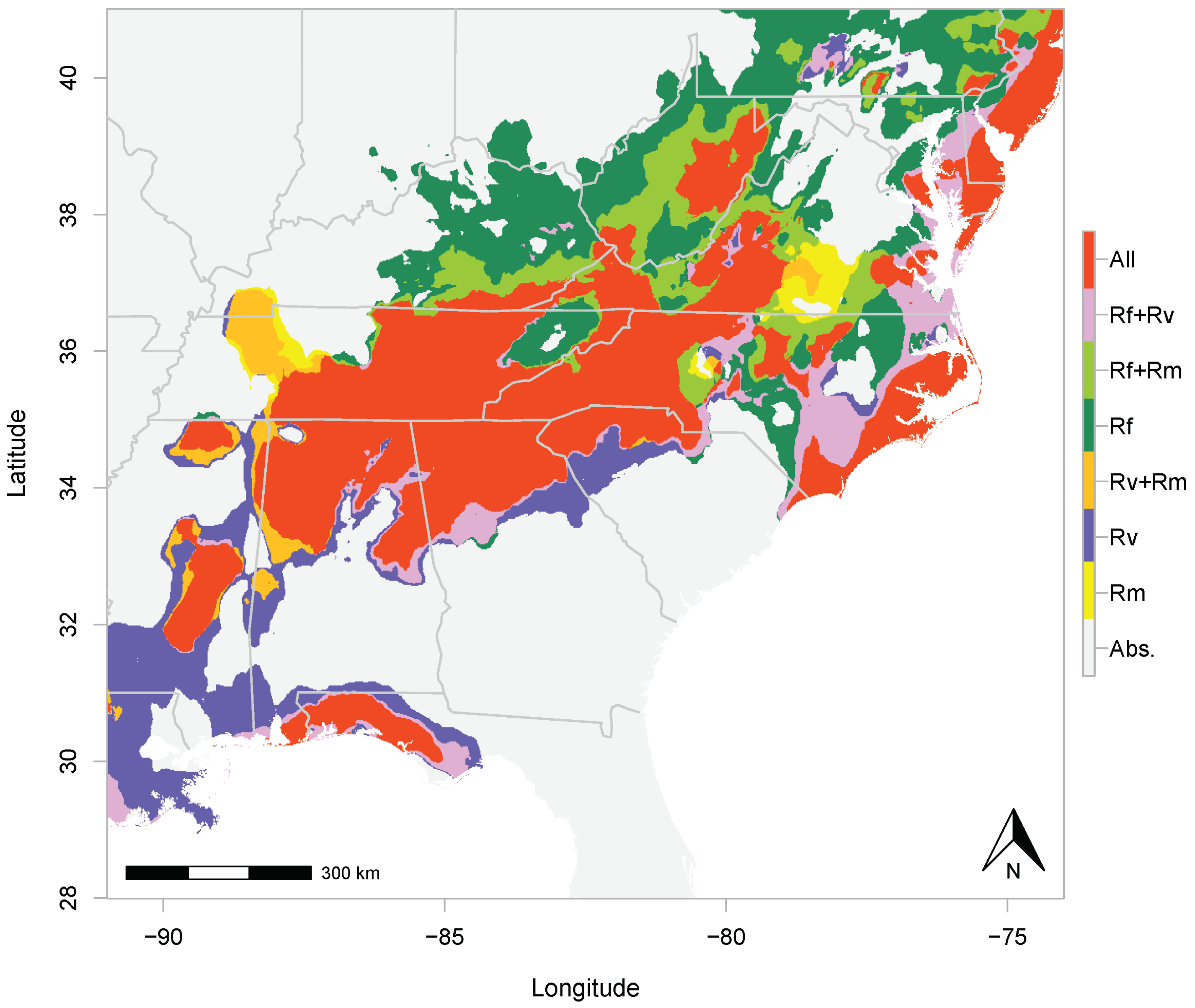
	Rf	Rm	Rv
Rf	-	D = 0.744 $p = 0.280$	**D = 0.582** $\boldsymbol{p < 0.001}$
Rm	I = 0.935 $p = 0.239$	-	D = 0.788 $p = 0.630$
Rv	**I = 0.843** $\boldsymbol{p < 0.001}$	I = 0.961 $p = 0.750$	-

Niche identity test:
p value < 0.05 = niche divergence

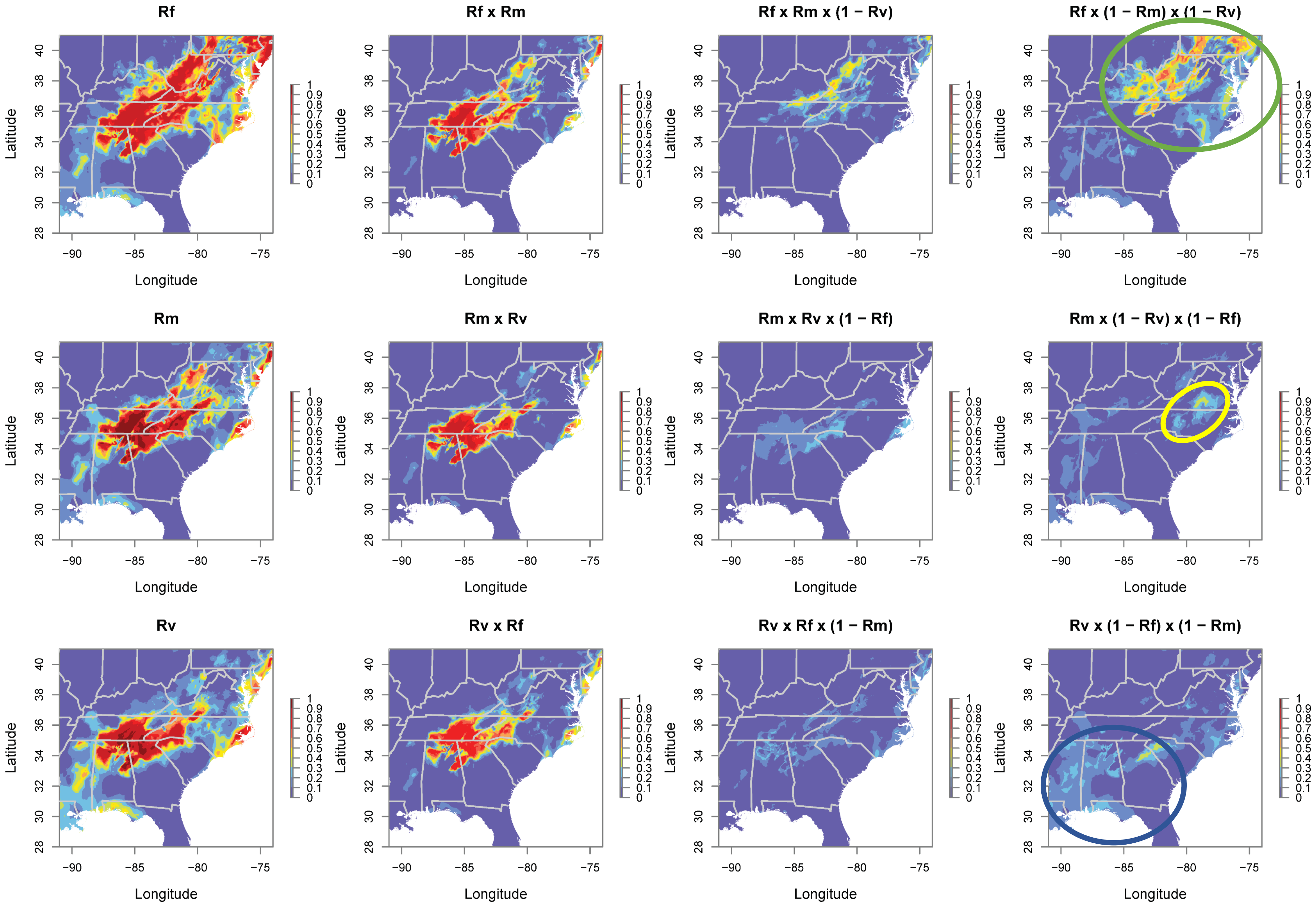
Niche overlap (for each environmental factor):
two different statistics: D and I

		TR	**ST**	**DP**	**WP**
D	Rf/Rm	0.889	0.872	0.693	0.820
	Rf/Rv	0.683	0.707	0.680	0.680
	Rm/Rv	0.791	0.809	0.894	0.848
I	Rf/Rm	0.991	0.990	0.919	0.982
	Rf/Rv	0.917	0.928	0.926	0.942
	Rm/Rv	0.952	0.961	0.990	0.984

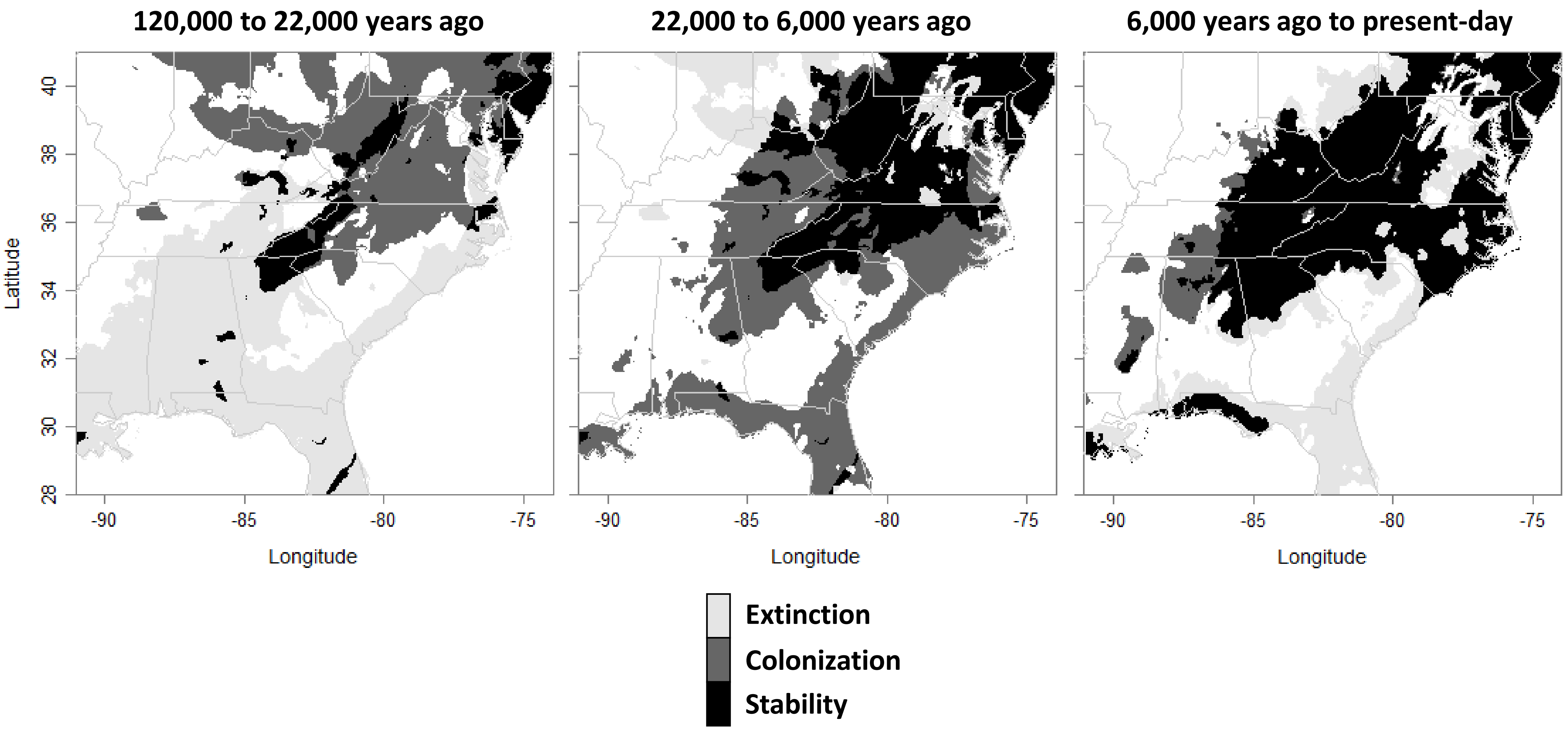
Co-occurrence of subterranean termite species



Competitive exclusion?

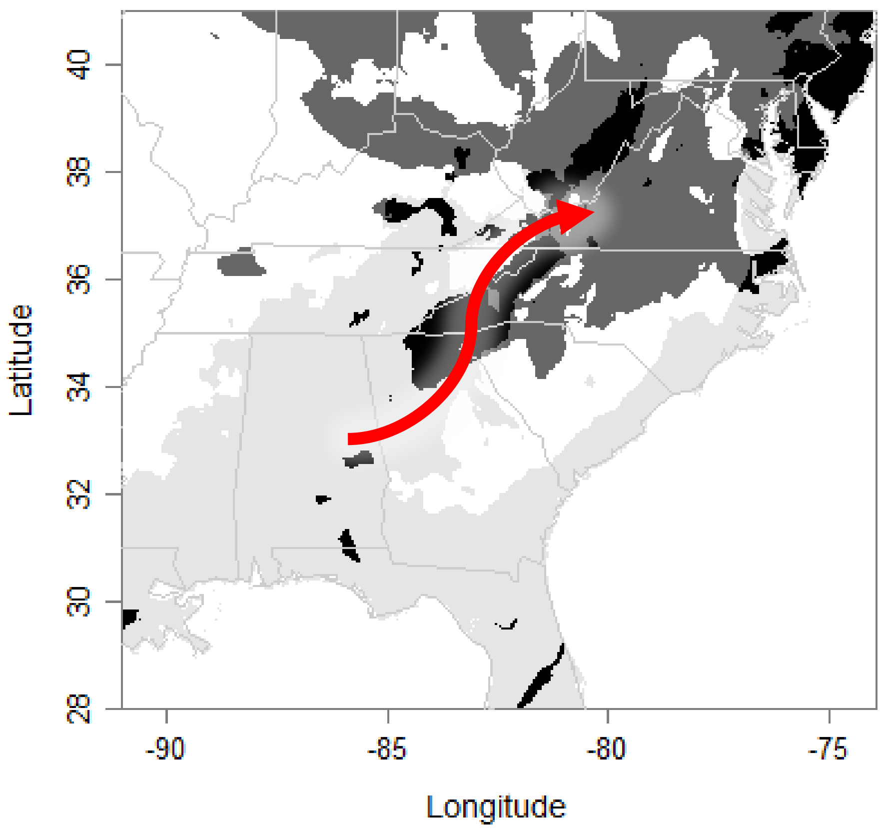


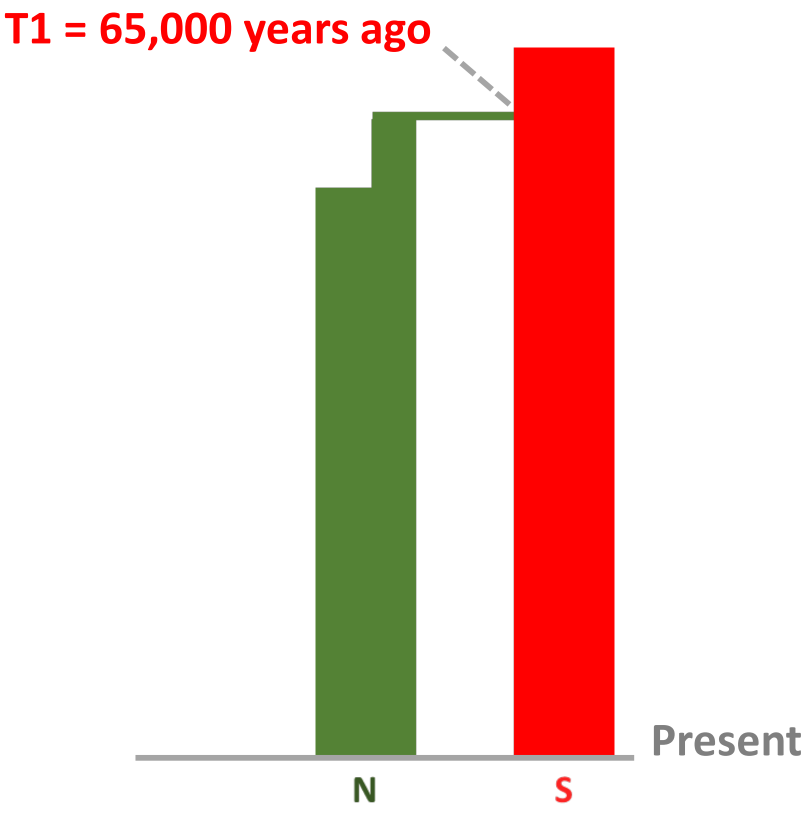
How/when did Rf spread northward?



Distributional Shift: South-to-North

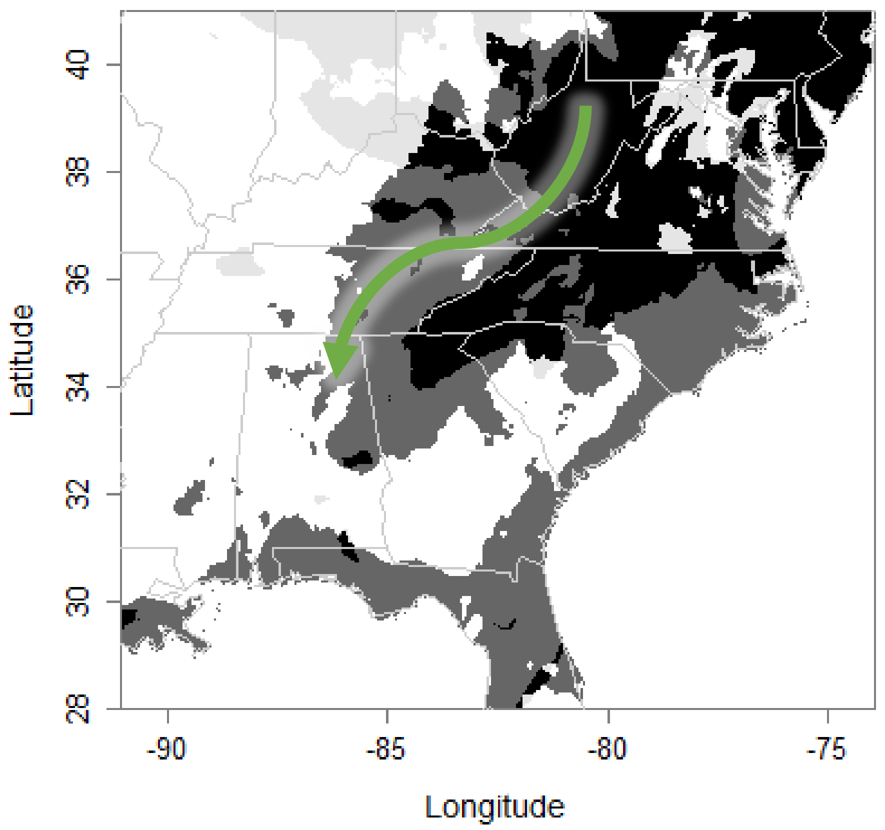
120,000 to 22,000

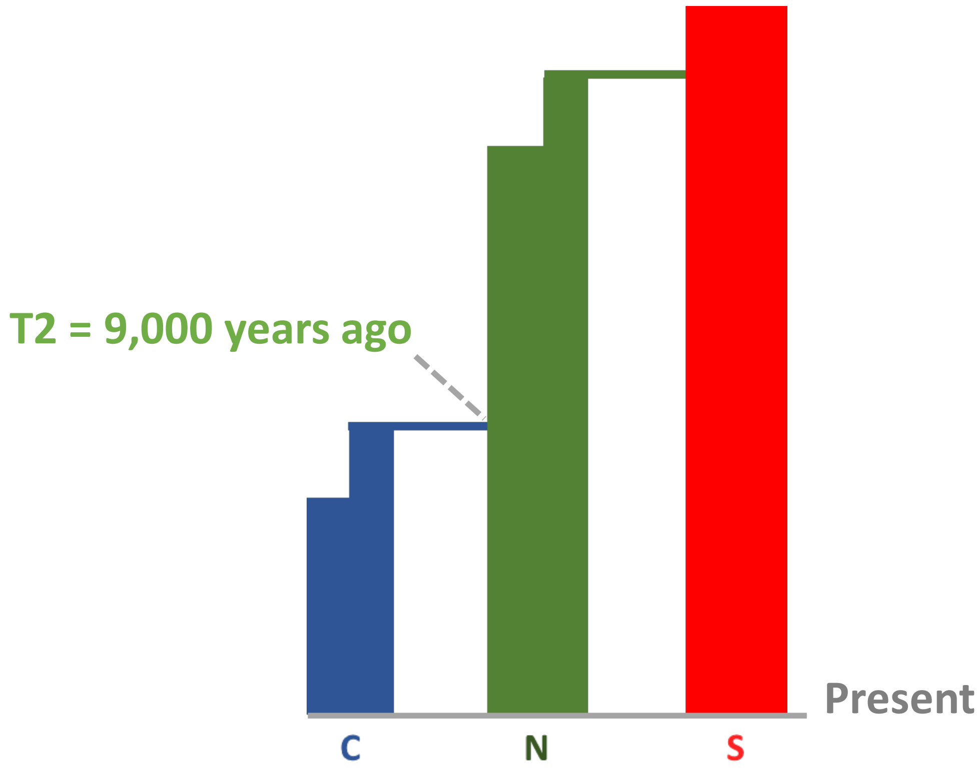




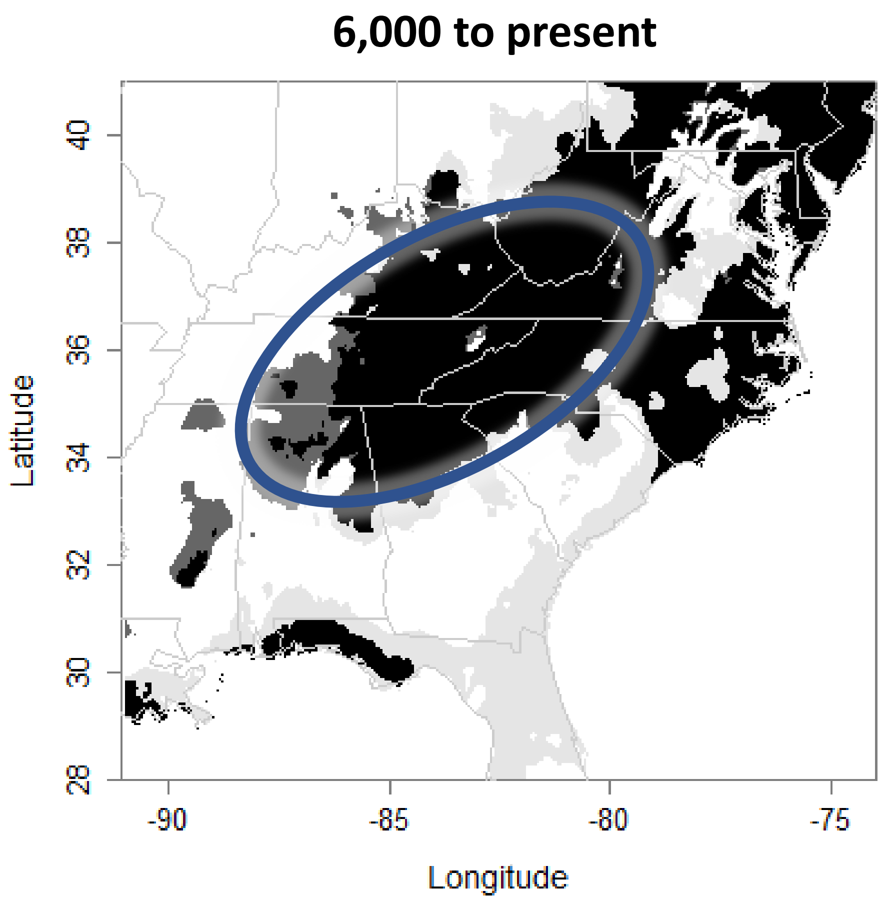
Distributional Shift: North-to-Center

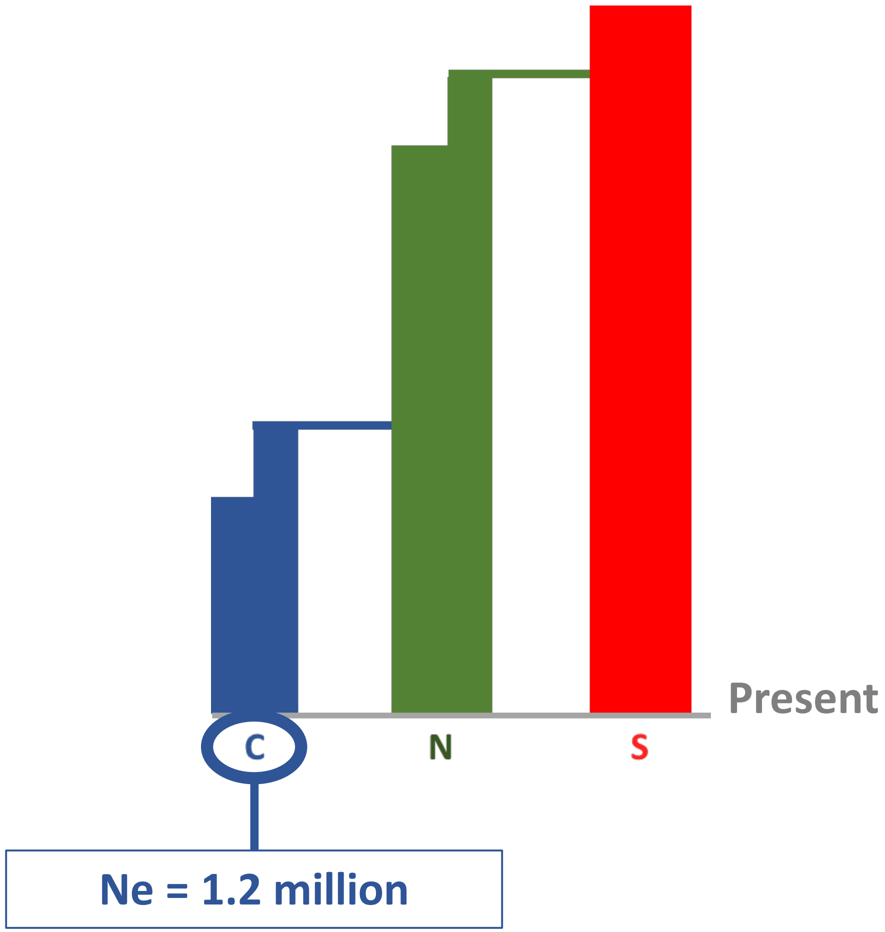
22,000 to 6,000





Central Expansion





Why is *R. flavipes* ~~a pest~~ more successful?

Niche divergence and competitive exclusion

- Significant niche divergence between *R. flavipes* and *R. virginicus*
- Competitive exclusion: *R. flavipes* occurs to the exclusion of other two species in the north

Geographic distribution and abundance

- All three *Reticulitermes* species co-occur in mid-latitudes of the southern Appalachians (high dry-season precipitation)
- Broad distribution: *R. flavipes* occurs farther north (low dry- and wet-season precipitation) than other two species
- Northward distributional shift followed by geographic/demographic expansion