Fall Armyworm: Management of a Genetically-Complicated Migratory Pest

Rob Meagher and Rod Nagoshi

Behavior and Biological Control Research Unit

Center for Medical, Agricultural & Veterinary Entomology

USDA-ARS, Gainesville, FL

Objectives

- species introduction
- population management in sweet corn
- genetic diversity - host strains
- biodiversity - migratory haplotypes
- how biodiversity affects pest management

Fall Armyworm

Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae)

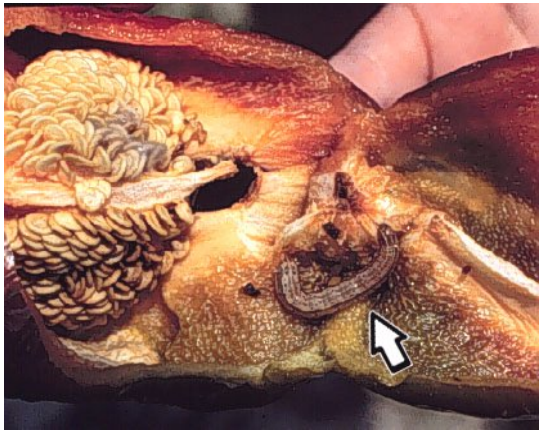
- **neotropical insect with no known diapause that migrates ea. spring from s. FL & s. TX to the NE & central U.S. & from s. AZ to central CA**
- **attacks several important field crops such as corn, sorghum, rice, forage grasses, cotton & peanut & vegetable crops such as sweet corn & pepper**
- **broad plant host range (> 60 plants)**
- **noted as serious pest in Venezuela in 1594; late 1700's in Georgia, described as species in 1797**

Injury

D. Keith & F. Baxendale, Univ. of Nebraska

R. H. Smith, Auburn

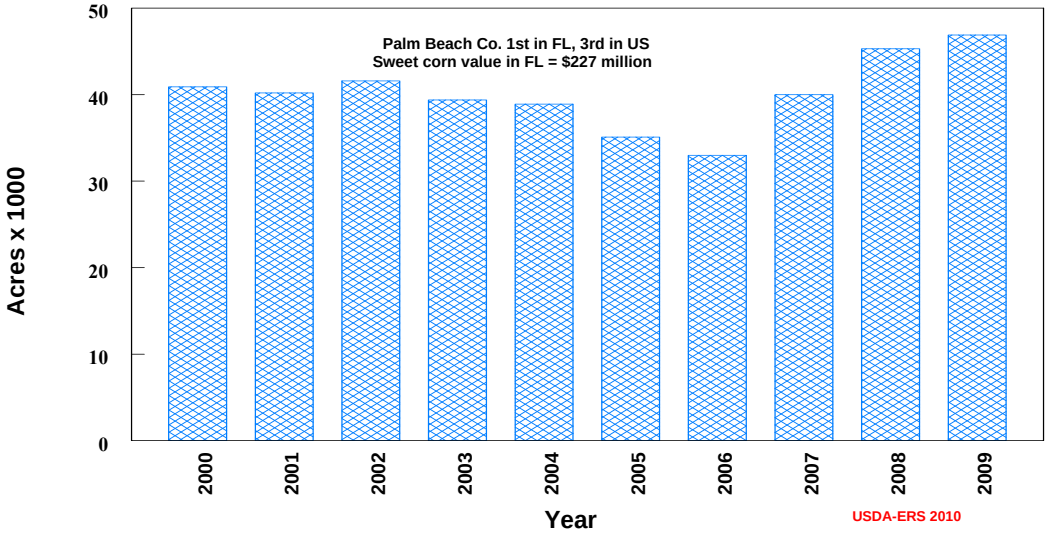
P. Cobb, J. French, K. Flanders, Auburn



NCSU

Sweet Corn Acreage Planted

Florida



Pest Management

- **chemical**
  - **treatment thresholds in s. FL avg. 5% infestation for all corn stages**
    - **some growers will go higher if whorl-stage corn and infestation is by younger stage larvae**
  - **30 products registered in FL for caterpillars, armyworms, or fall armyworm**
  - **growers spend ≈ 20% of production costs on pest management w/ 7.5% on insecticide costs**

Pest Management

- **plant resistance**
  - **endogenous sources**
    - **traditional breeding transferring genes (traits) from resistant land races into sweet corn lines ('Zapalote Chico *sh2*')**
    - **resistant characters include increased levels of cysteine proteinase, cuticular lipids, C-glycosyl flavones (maysin)**
  - **exogenous sources**
    - **Bt germplasm – almost exclusively in silage or forage corn systems**

Pest Management

- **biological**
  - **several parasitoid & predator species are active but are generally not considered in management decisions**
    - ***Cotesia marginiventris* over 40% parasitization of young larvae**

Cotesia marginiventris

Chelonus insularis

Meteorus autographae

Genetic / Biodiversity

- **host strains - morphologically identical & sympatric**
- overwintering populations involved in migration

Host Strains

- identify source locations of migrants in Louisiana
  - populations in PR, FL, GA, LA, TX, & MEX characterized using protein electrophoresis
  - populations collected from rice in PR was highly divergent from those collected from corn at all other locations
    - rice strain: rice, pasture, turf, millet
    - corn strain: maize, sorghum, cotton
  - host strains not caused by feeding on host plant
- physiological & behavioral differences
  - differential feeding on host plants (CS better on corn, RS on grass)
  - mating - time of females calling (CS early in evening, RS late)
  - oviposition (RS more selective to grasses)
  - pheromone blend production & male response
  - consistent results between labs have been difficult to achieve!

Host Strains

- **separated using genetic markers**
  - **polymorphisms in the Cytochrome Oxidase subunit I (*COI*) gene generate mitochondrial strain-specific haplotypes**
    - **>20 strain-specific polymorphic sites**
  - **genomic (tandem repeats) markers available (*FR*)**
  - **triose phosphate isomerase (*Tpi*) gene provides strain-specific polymorphisms**
    - **used to study interstrain hybridization since inherited from male parent**
- **geographic genetic variability found in "corn strain" populations from Mexico, Colombia, & Brazil**

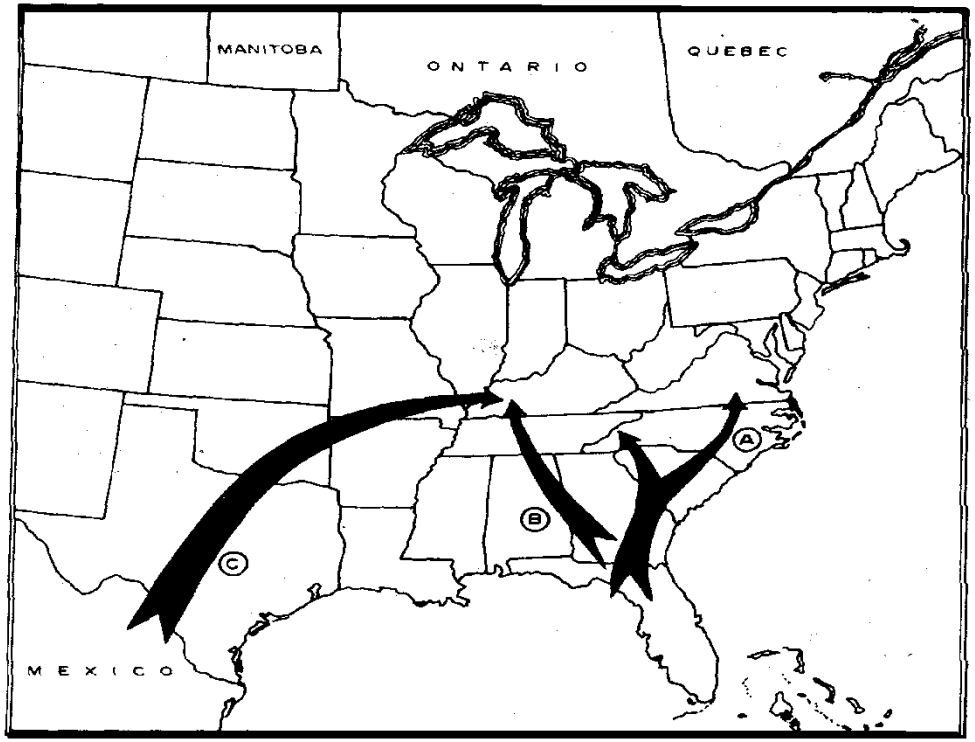
How Do Host Strains Affect Management?

- **chemical**
  - **differential susceptibility to insecticides between host strains**
- **plant resistance**
  - **little known about traditional germplasm differences in corn but large differences in pasture grasses w/ RS**
  - **differential host strain susceptibility to some Bt toxins**
- **biological**
  - **natural enemy profiles different among host plants but no evidence of host strain differences**




Biodiversity

- host strains - morphologically identical & sympatric
- **overwintering populations involved in migration**



Seasonal Distribution

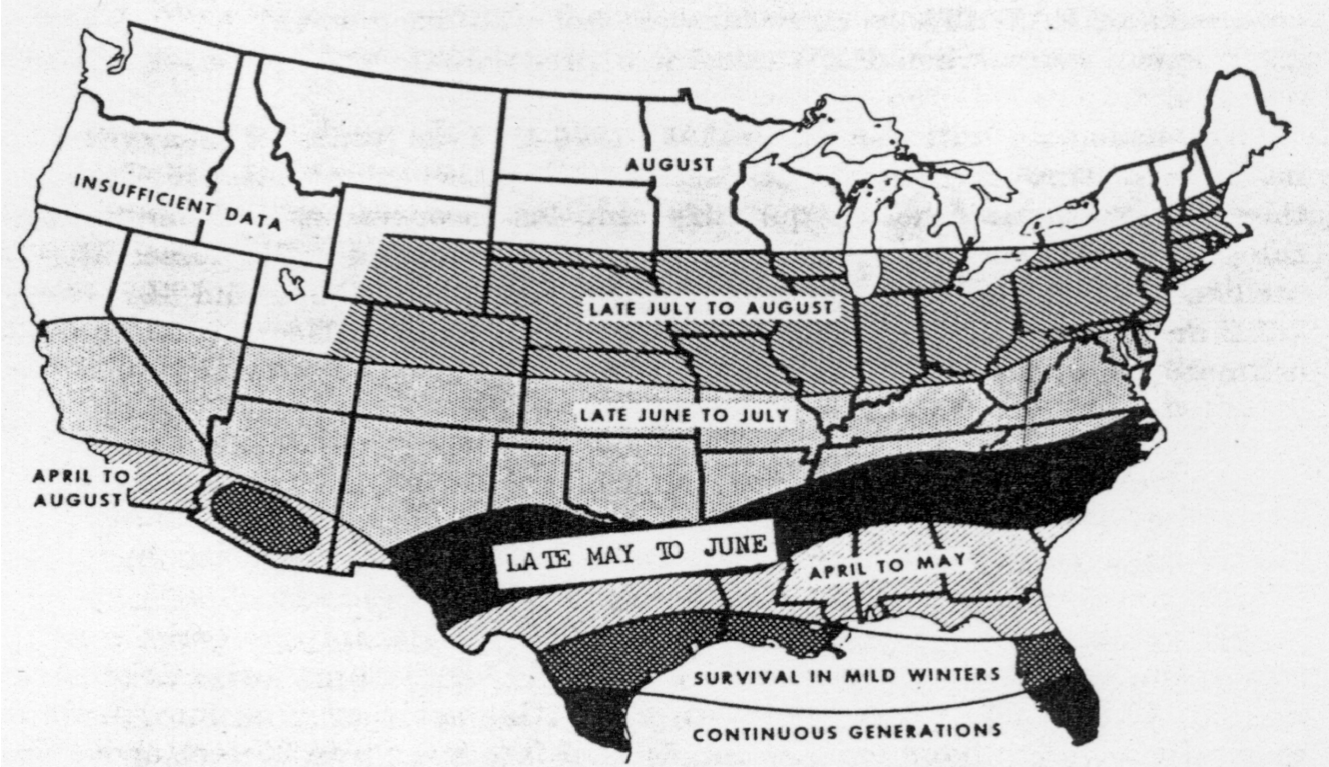
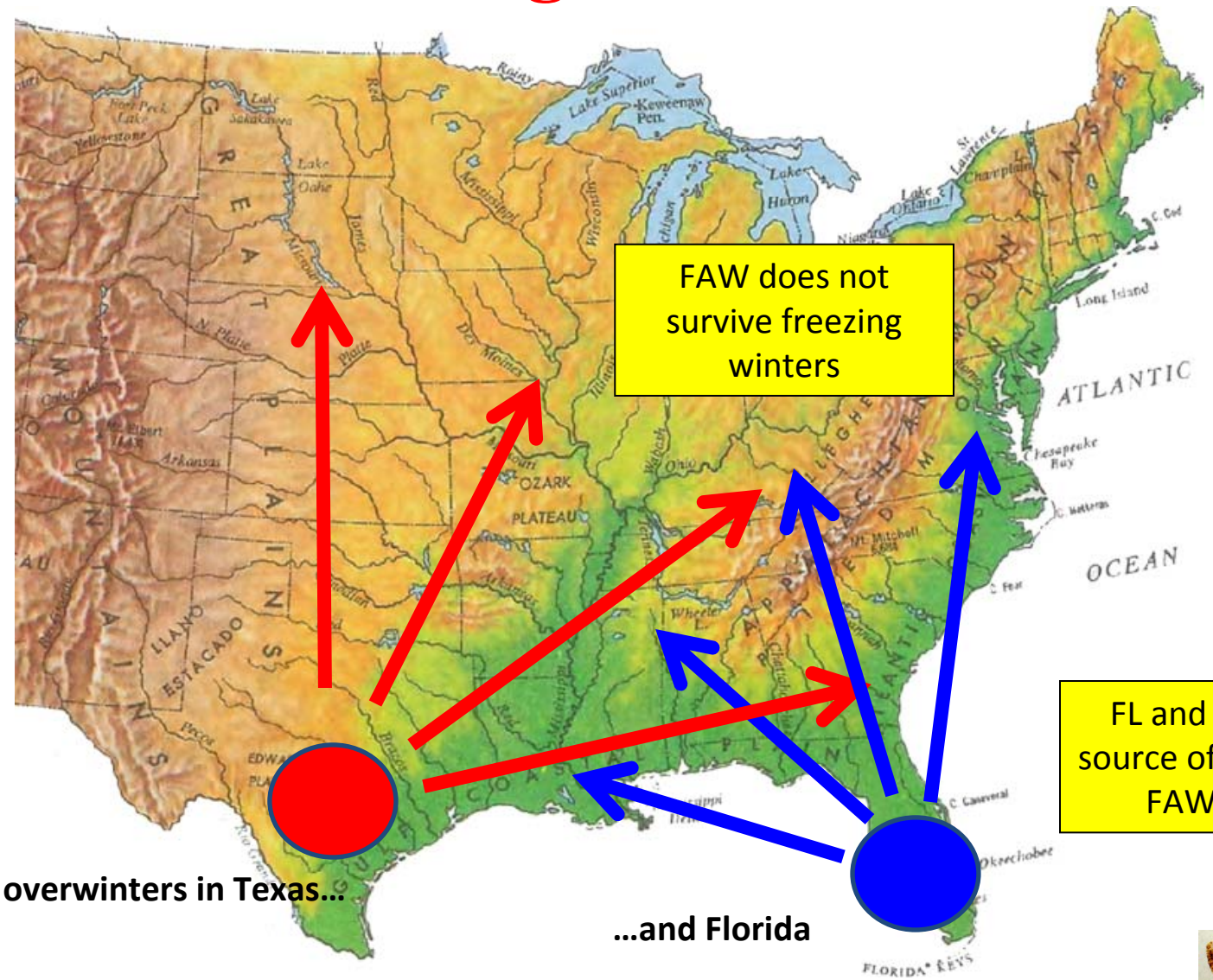


Fig. 1. Seasonal distribution of the fall armyworm in the United States.

Migration


FAW does not survive freezing winters
FL and TX source of U.S. FAW
FAW overwinters in Texas…
…and Florida
GREAT PLAINS
ATLANTIC
OCEAN
OZARK PLATEAU
ESTACADO
LLANO
Lake Superior
Lake Huron
Lake Ontario
Chesapeake Bay
Okeechobee
FLORIDA KEYS

Migration

Quebec

Tifton

Gainesville

Homestead

Puerto Rico

Virgin Is.

Guadeloupe

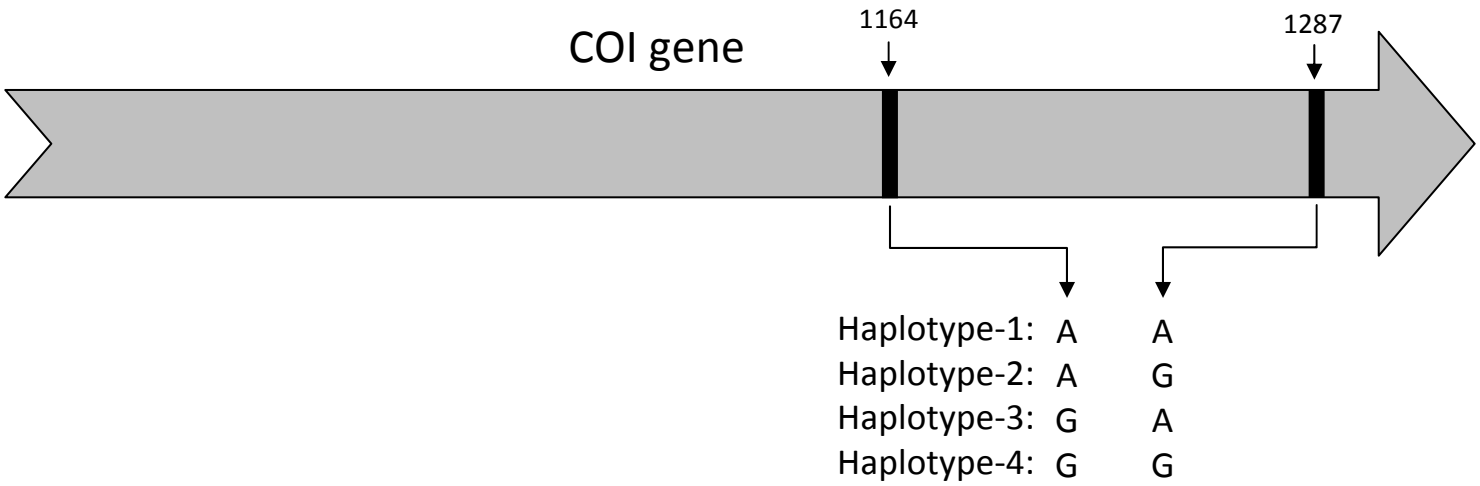
French Guiana

Migration

- seasonal migration from south to north in U.S.
- moth captures in traps plus analysis of wind currents provided circumstantial evidence of movement between the Antilles & continental U.S.
- however, no direct evidence that population reservoir in Caribbean contributes to temperate regions of North America
- meteorological evidence supports theory of southward migration in fall

Overwintering Populations

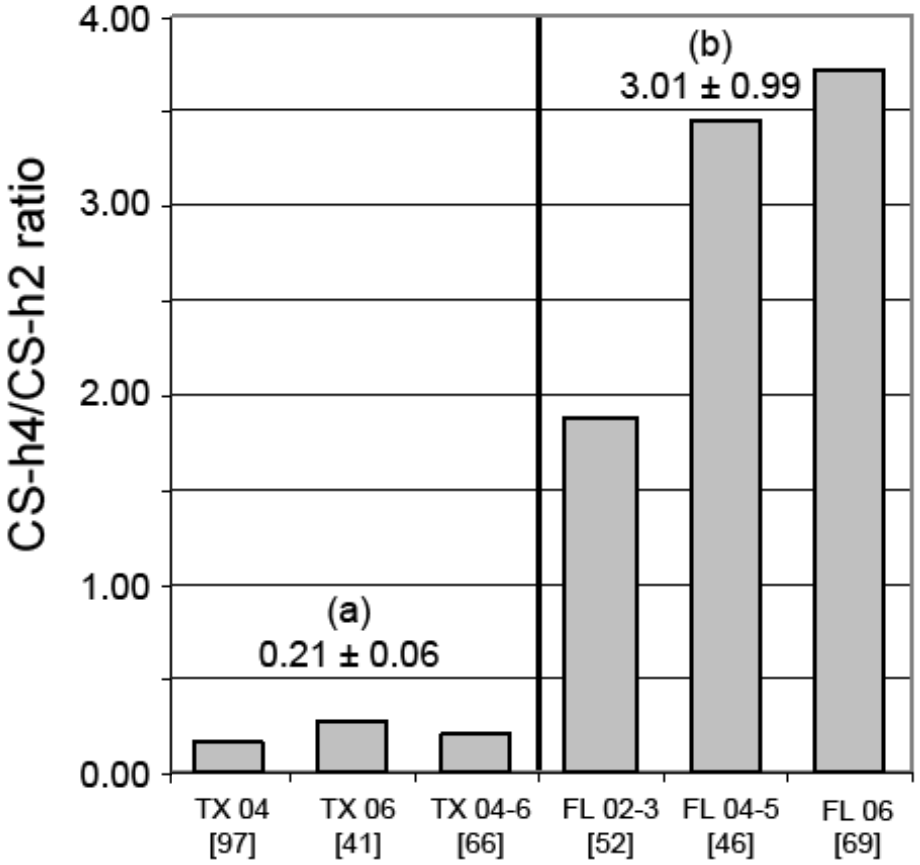
Portion of the Cytochrome Oxidase I Gene



- Four **corn-strain** haplotypes in all locations.
- Proportion of haplotypes 2 and 4 differ between TX and FL populations.

Overwintering Populations

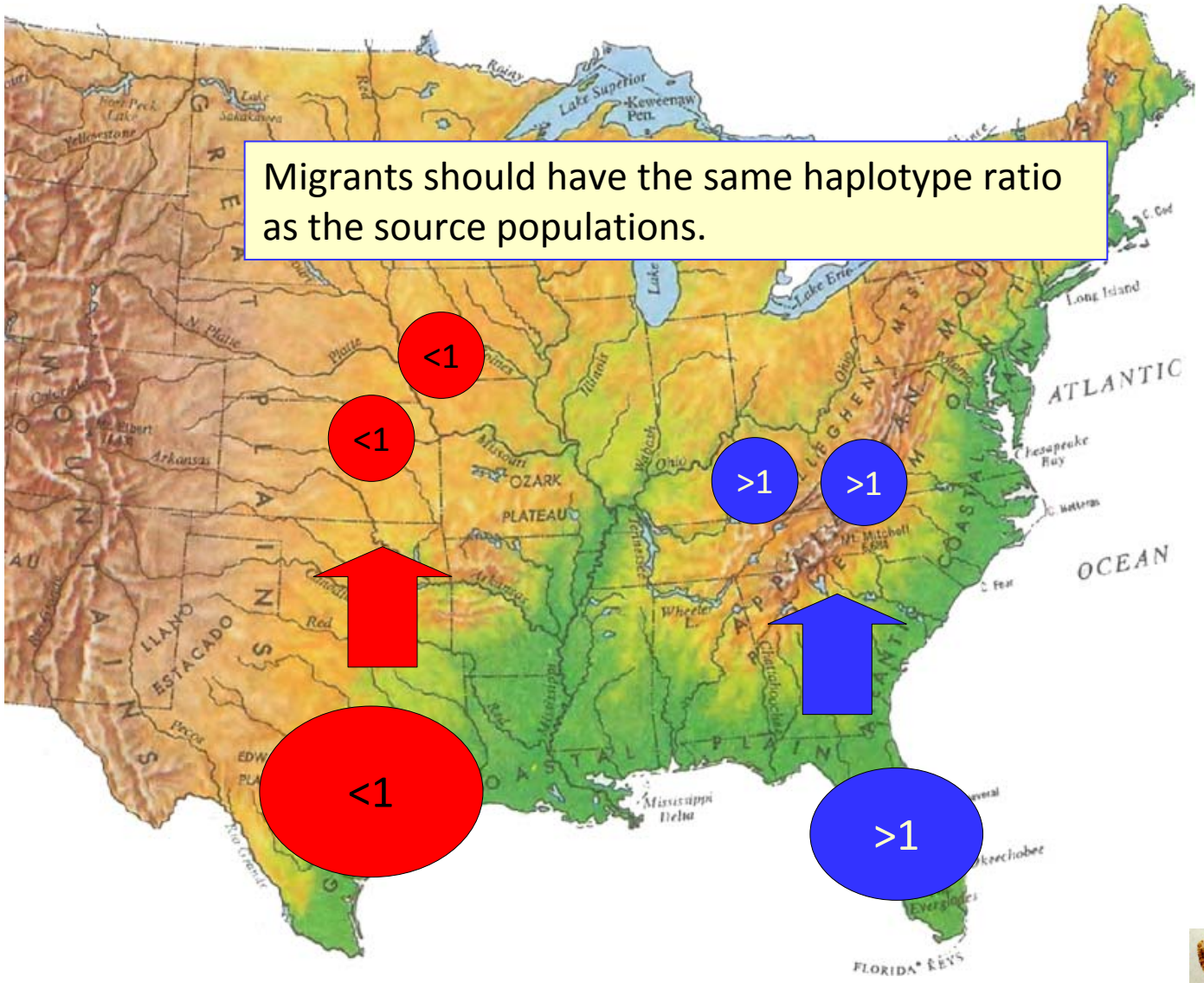
COI Haplotype Ratios: TX, FL



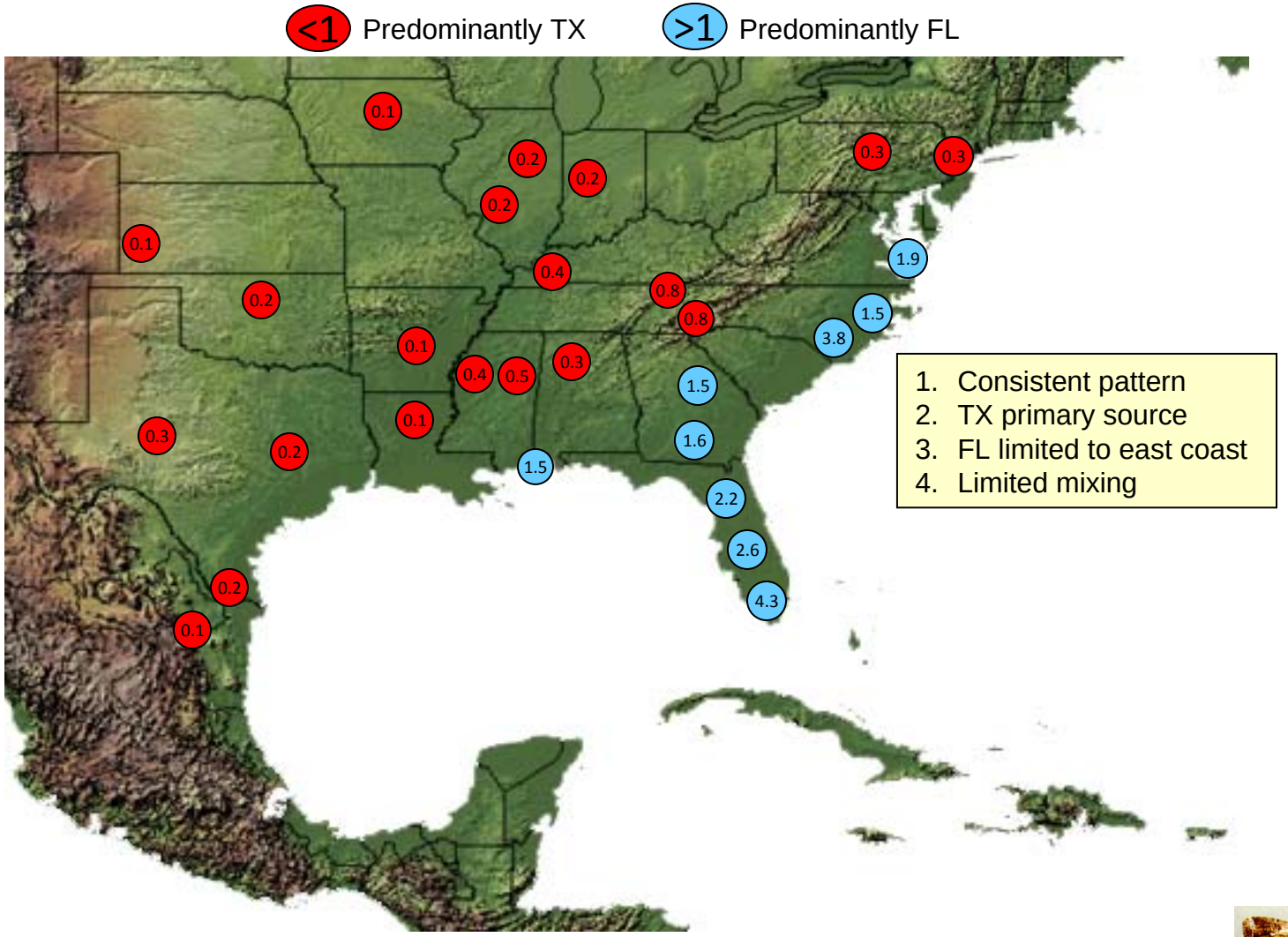
Ratios can discriminate FL and TX populations.

If all haplotypes migrate equally well, then can use these ratios to identify the origin of a migrating population.

Methodology for Mapping Migration



Cumulative Data 2007-2010

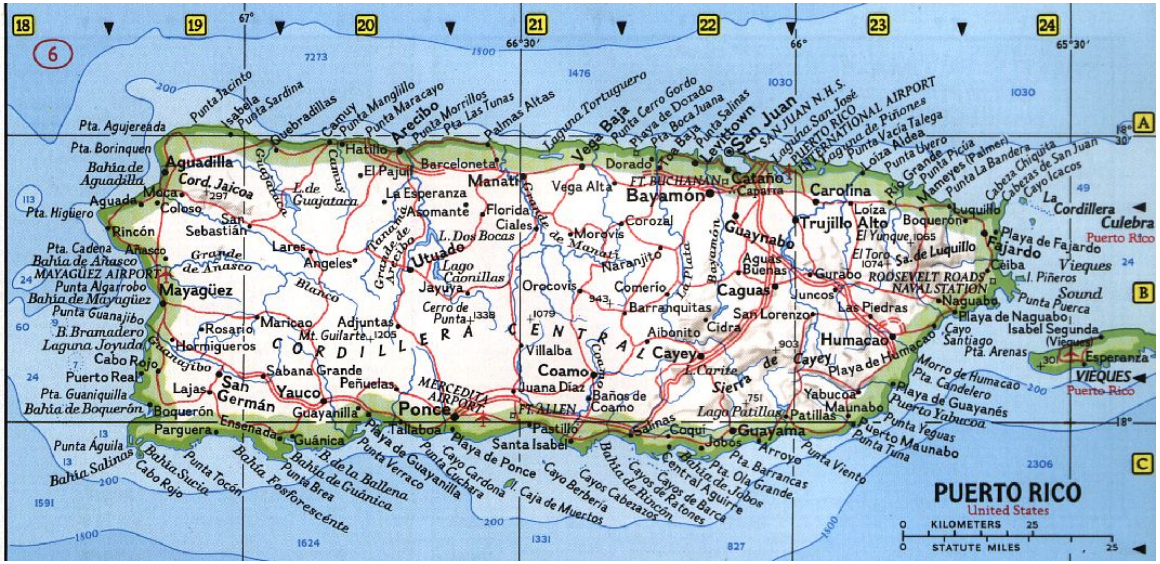


How Do Different Overwintering Populations Affect Management?

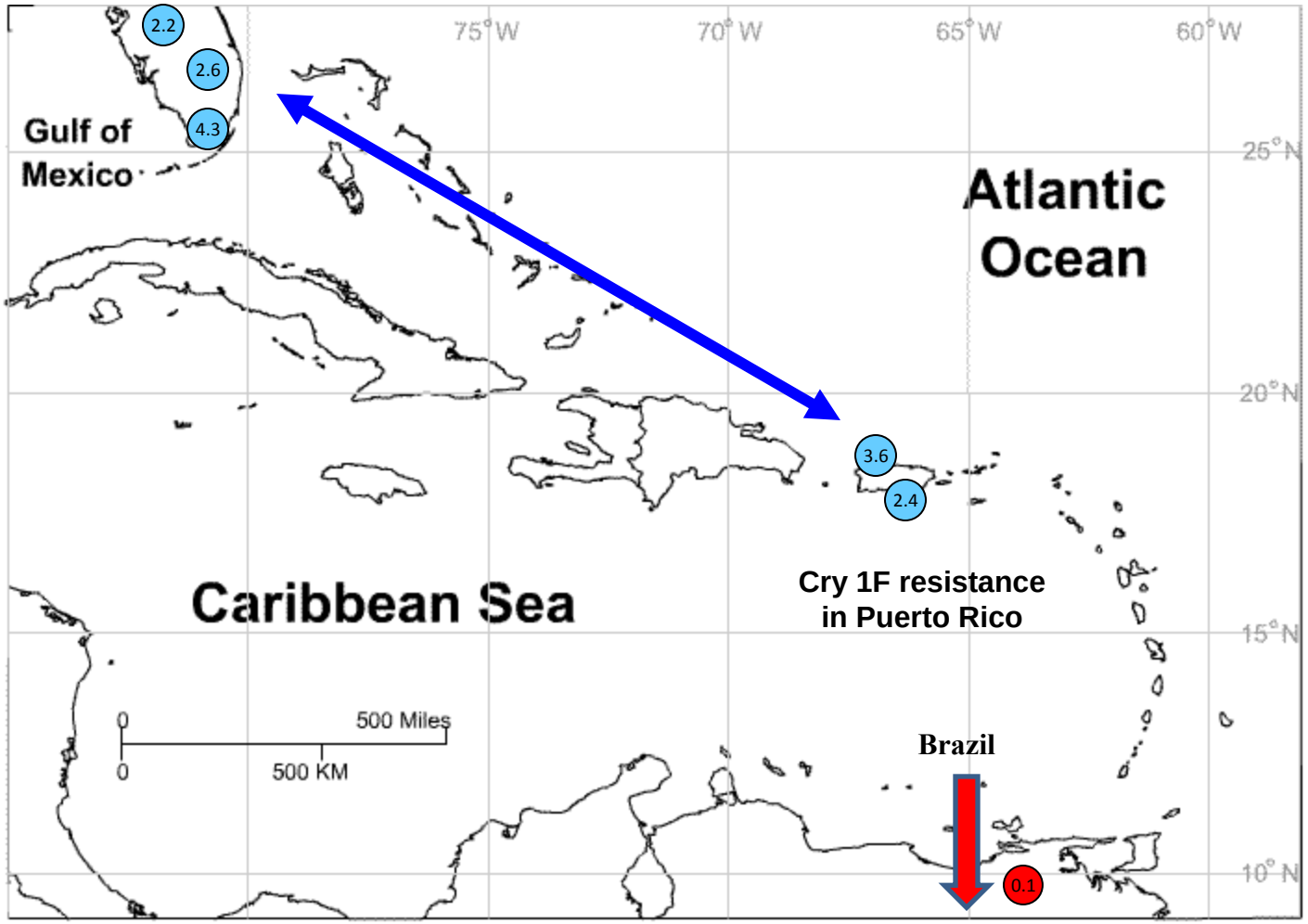
- **chemical**
  - **geographic differences in insecticide mortality**
- **biological**
  - **natural enemy profiles different among host plants but no evidence of overwintering population differences**
- **plant resistance**
  - **little known about traditional germplasm differences**
  - **Cry 1F field resistance in corn, southern Puerto Rico 2007 (Storer et al. 2010)**

What About Puerto Rico?

- **tropical corn production (year-round) with continual pest pressure**
- **insect migration & w/in island dispersal limited**
- **long history of insecticide/Bt use**



Florida & the Caribbean



How is Florida Different?

- **tropical corn production (year-round) with continual pest pressure**
  - **temperate/FL bred lines in production from October thru April**
  - **lower populations in winter when cold fronts move through though can concentrate populations in relatively small area (Homestead)**
  - **spring & summer w/ very susceptible cover crops (sorghum-sudangrass)**
- **insect migration & w/in island dispersal limited**
  - **much different – annual migration out of FL & amble opportunity for w/in state movement (no mountains!!)**
- **long history of insecticide/Bt use**
  - **many of the same products used in both areas**

Conclusions

- **by discovering & understanding w/in species diversity of FAW as described by genetic host strains and overwintering populations, we believe FAW management can be improved w/ future research**
- **more info ca. FAW pathways can be heard at Rod's talk 1463 (which I'm presenting) Wed. morning, 9:14 in Brittany**

Fall Armyworm Lab

Acknowledgements

- Florida
  - Gregg Nuessly
  - Jane Sharp
  - Charlie Dillard
  - Nancy Lowman
- Arkansas
  - Randy Luttrell
- Louisiana
  - Rogers Leonard
- Mississippi
  - Jeff Gore
  - Ryan Jackson
- Iowa
  - Tom Sappington
- Illinois
  - Robert Bellm
  - Kevin Steffey
- Indiana
  - John Obemeyer
- Kansas
  - Ankush Joshi
  - JP Michaud
  - Jeff Whitworth
- Kentucky
  - Doug Johnson
- Brazil
  - Pierre Silvie
  - Vilmar Machado
- Puerto Rico
  - David Jenkins
- Georgia
  - Kristine Braman
  - David Buntin
- Texas
  - John Adamczyk
  - Juan Lopez
  - Chris Sansone
  - Scott Armstrong
- Pennsylvania
  - Shelby Fleischer
- New Jersey
  - Joe Ingerson-Mahar
- Maryland
  - Kimberly Rice
- Delaware
  - Joanne Whalen
- Alabama
  - Kathy Flanders
- Oklahoma
  - Tom Royer
- North Carolina
  - Clyde Sorenson
  - Jim Walgenbach
- Tennessee
  - Frank Hale,
  - Bill Klingeman
  - Russ Patrick
- Virginia
  - Tom Kuhar