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Street palms and the potential impact of a palm pest on the USA mainland

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Introduction

- Urban forests are gateways for alien forest pests
  - Not well characterized
  - Relatively few are inventoried
- Koch et al. 2018:
  - Modeled urban distributions of 3 tree genera: ash, maple, oak
  - For ≈24000 communities in eastern and central USA
  - From limited sample of existing urban forest inventories (n=842)

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Look! Just three steps!

Modeling urban distributions of host trees for invasive forest insects in the eastern and central USA: A three-step approach using field inventory data

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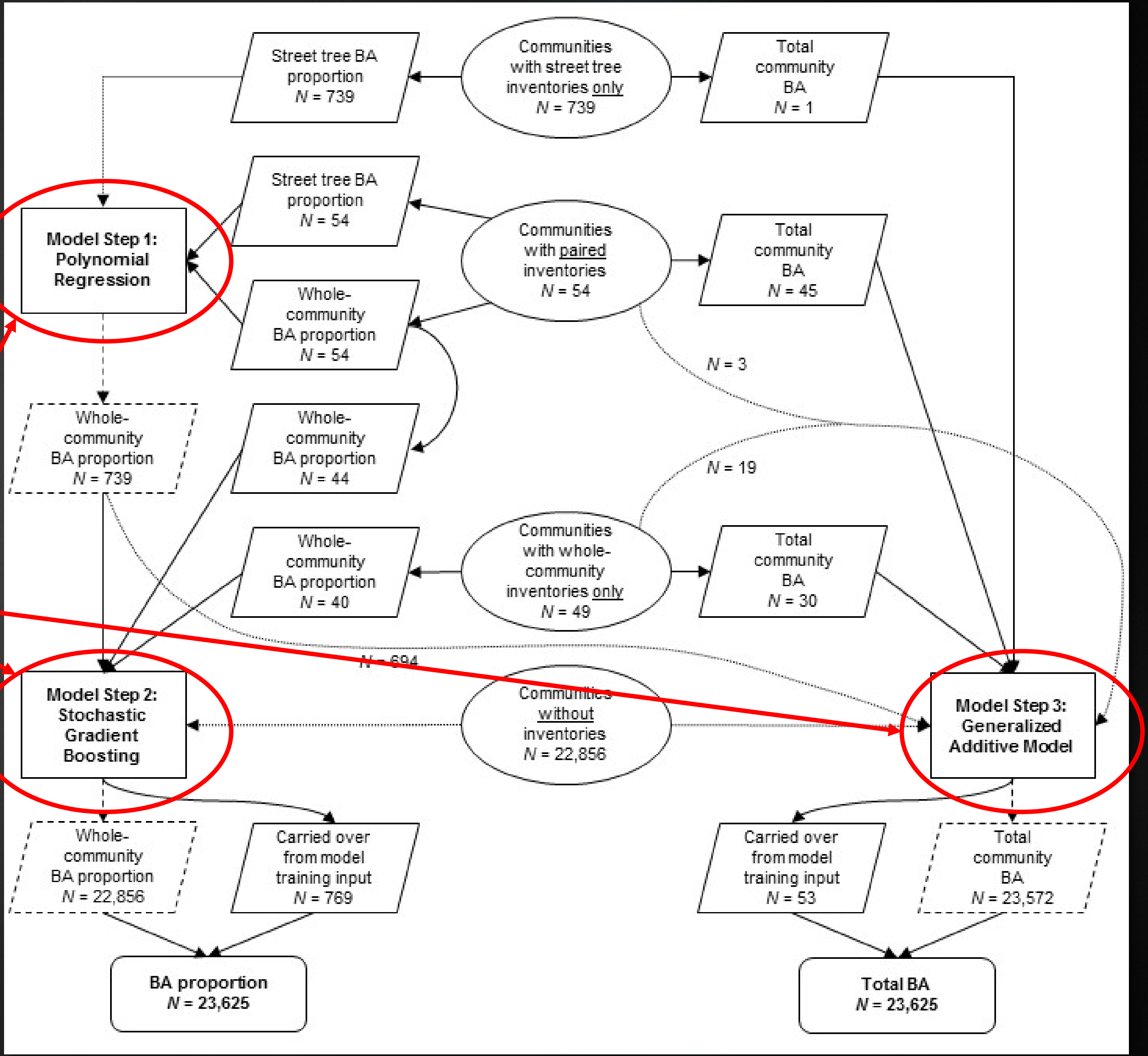
ABSTRACT

Despite serving as invasion gateways for non-native forest pests, urban forests are less well understood than natural forests. For example, only a fraction of communities in the USA and Canada have completed urban forest inventories, and most have been limited to street trees; sample-based inventories that provide valid community-wide estimates of urban forest composition are much rarer. As a proof of concept, we devised a three-step approach to model urban tree distributions regionally using available street tree and whole-community inventory data. We illustrate the approach for three tree genera – ash (*Fraxinus* spp.), maple (*Acer* spp.), and oak (*Quercus* spp.) – that are hosts for high-profile insect pests. The objective of the first step was to estimate, for communities with only street tree inventories, the proportion of the community's total basal area (BA) in each host genus. Utilizing data from communities with paired street tree and whole-community inventories, we applied polynomial regression to estimate whole-community BA proportion per genus as a function of a community's street tree BA proportion and its geographic location. The objective of the second step was to estimate per-genus BA proportions for communities in our prediction region (eastern and central USA) with no urban forest inventory. We used stochastic gradient boosting to predict these proportions as a function of environmental and other variables. In the third step, we developed a generalized additive model for estimating the total BA of a community as a function of its canopy cover, geographic location, and area. We then combined the outputs from the second and third steps to estimate ash, maple, and oak BA for the nearly 24,000 communities in our prediction region. By merging these estimates with similar information on natural forests, we can provide more complete representations of host distributions for pest risk modeling, spread modeling, and other applications.

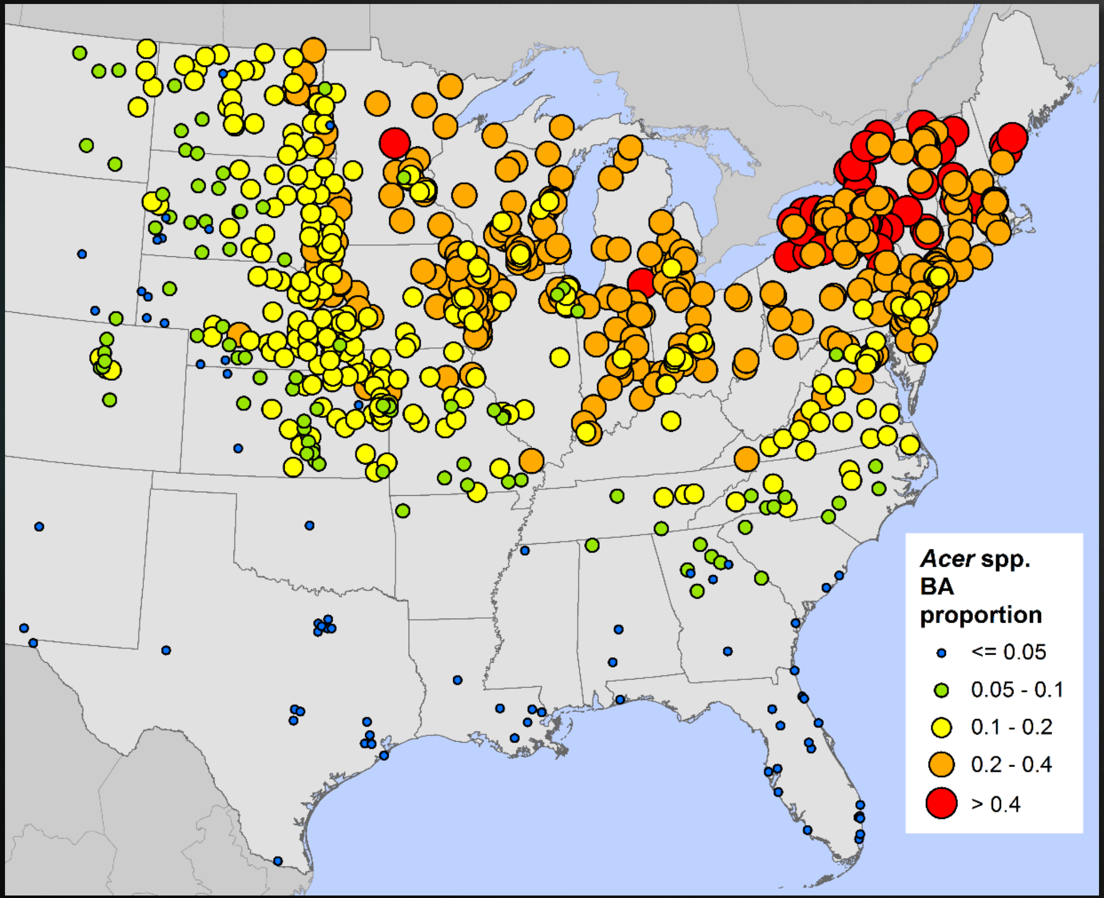
Conceptual diagram of the three-step modeling approach applied to each genus

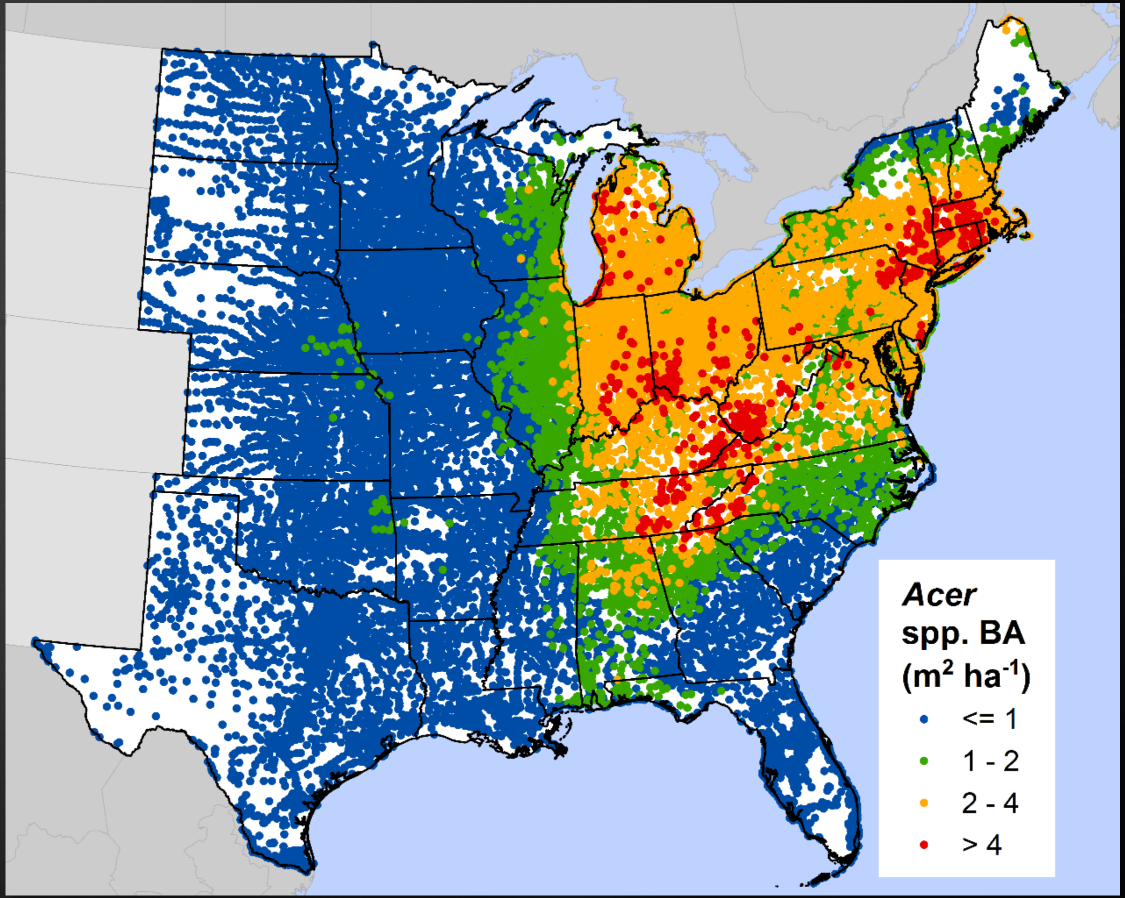
See, there they are!



Example: Maple (*Acer*)

Estimated proportion of community's urban basal area that is maple ✖ Community's estimated total basal area, all trees = Community's estimated maple basal area





Modeling Street Palm Distributions in the Continental USA

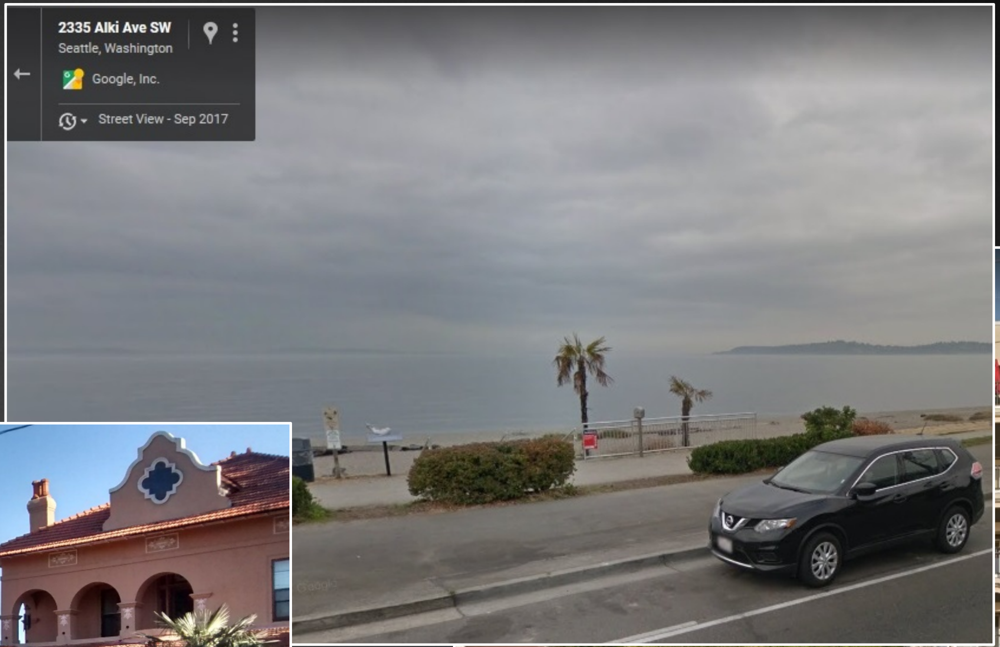
- Building on Koch et al. 2018
- Objective: estimate potential losses if a major palm pest were to invade mainland USA
- Little agricultural palm production in mainland USA
  - ≈3000 ha of date palms in California and Arizona
- But widely used in urban areas for landscaping
  - Largest palms are usually street “trees”

Urban Street Palms: Examples

Palm Beach, Florida

Beverly Hills, California

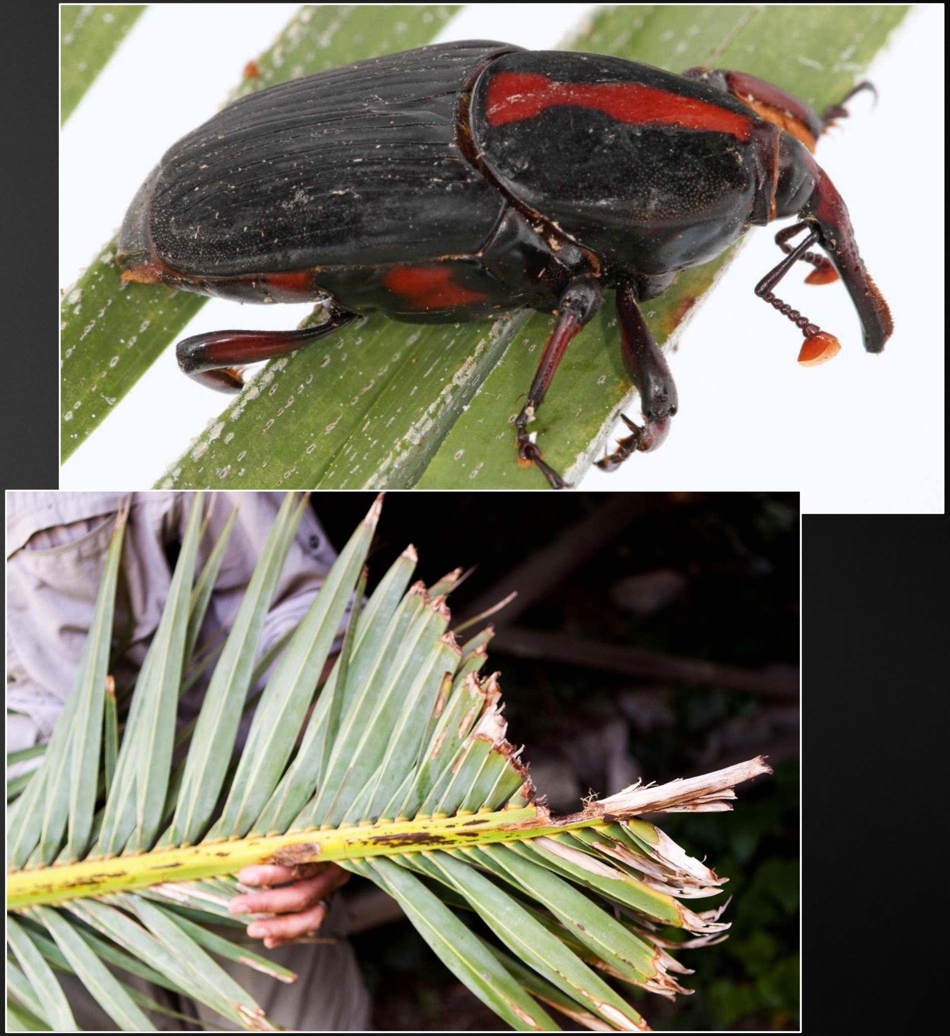
Urban Street Palms: Examples



Palm Pests of Concern: Examples

Coconut rhinoceros beetle,
Orycytes rhinoceros

Red palm weevil,
Rhynchophorus ferrugineus

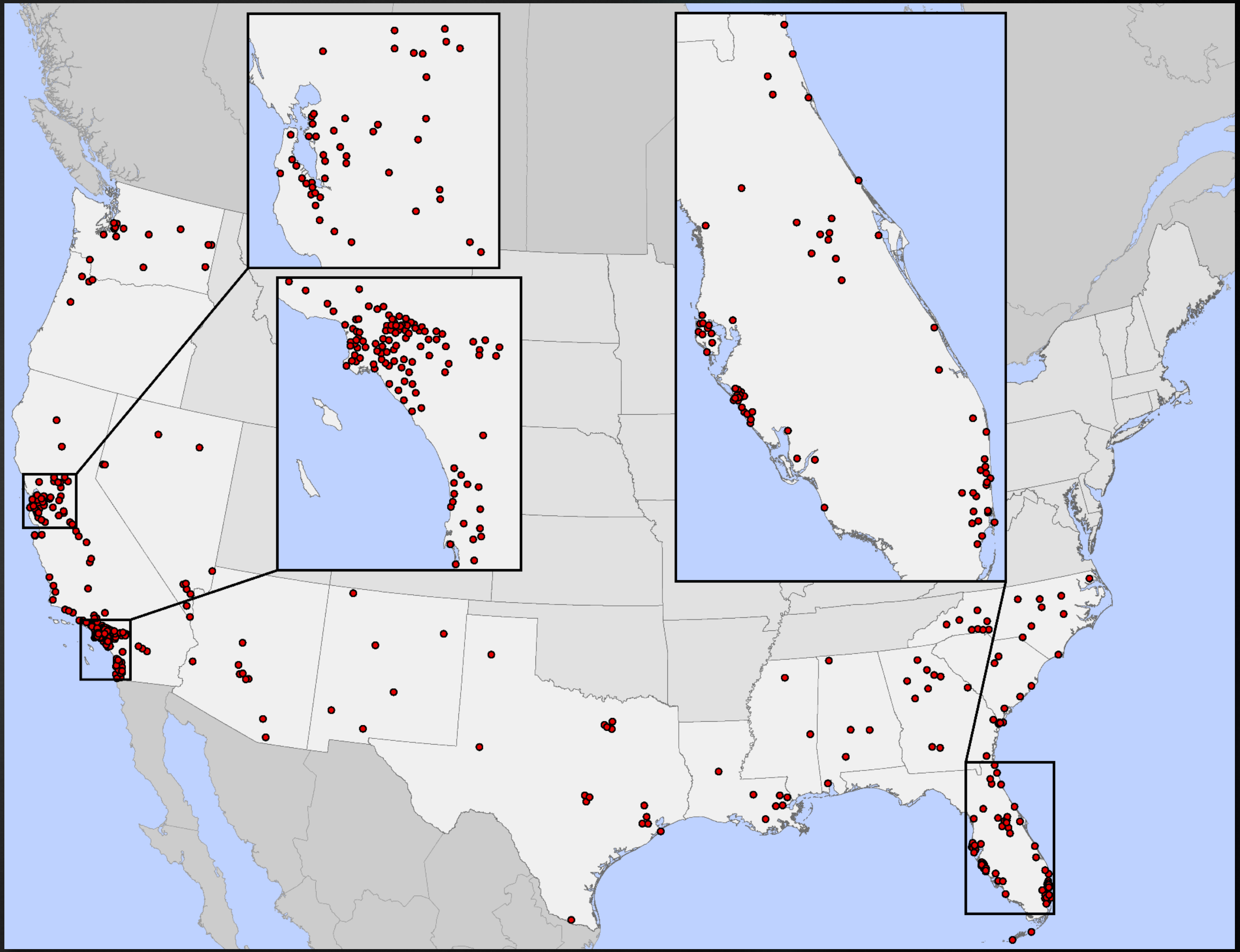


General Approach

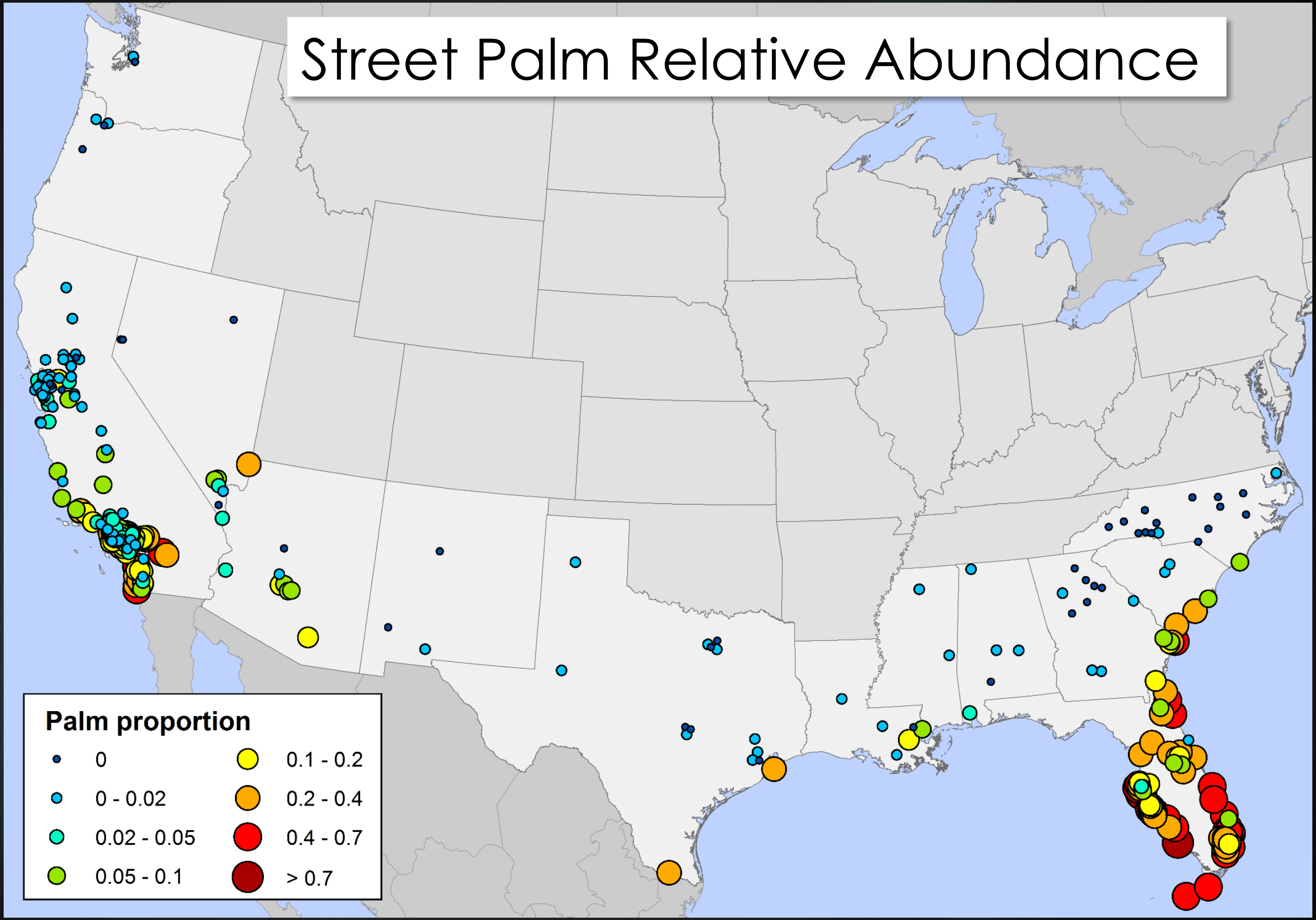
- Based on sample of street tree inventories:
  - Model to estimate palm proportion of a community's street trees
  - Predicted average street tree density (trees / km)
- Measure of the community's total street length
- With these, can estimate total number of palms in communities without inventories

Street Tree Inventory Data

- 368 inventories
- 14 states
  - Effective range of palms in continental USA
- Best represented states are California and Florida

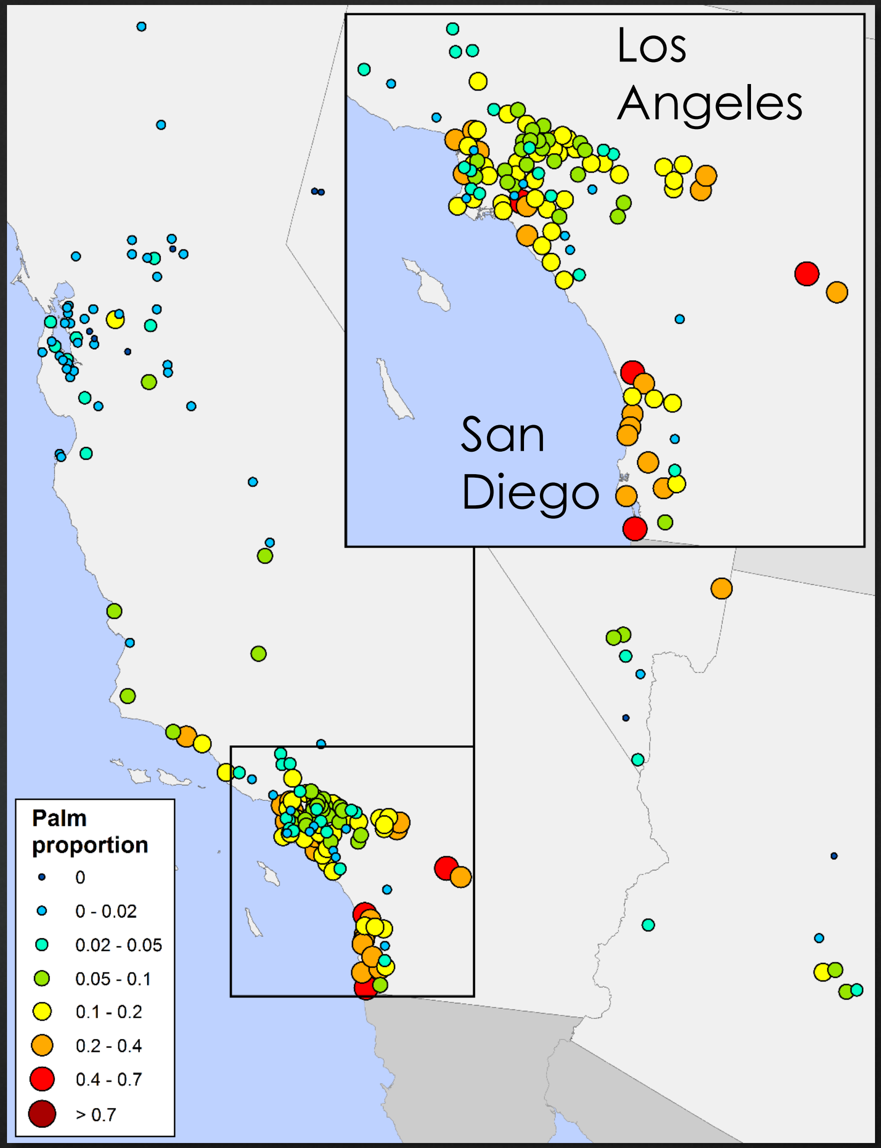


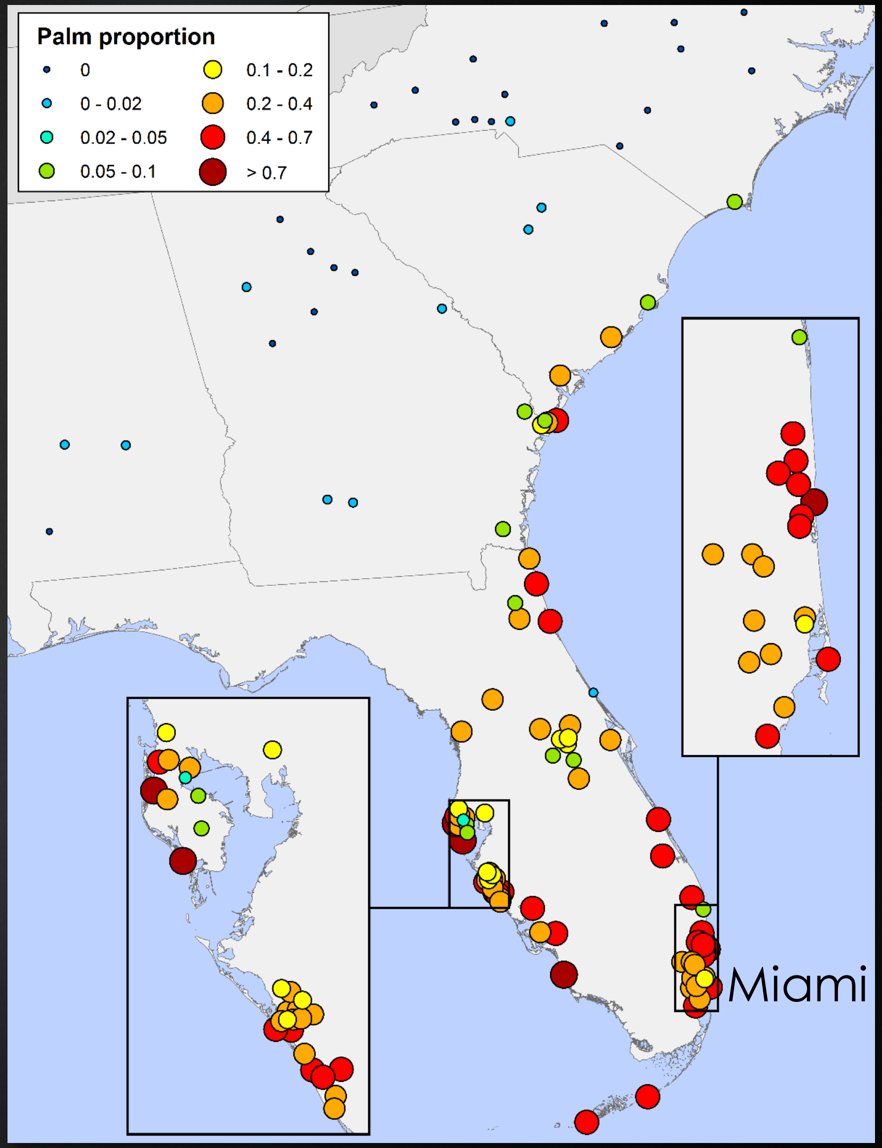
Model Input Data



Street Palm Relative Abundance

- Data clustered
- South-north gradient
- Coastal proximity
- Barrier island communities have higher abundance



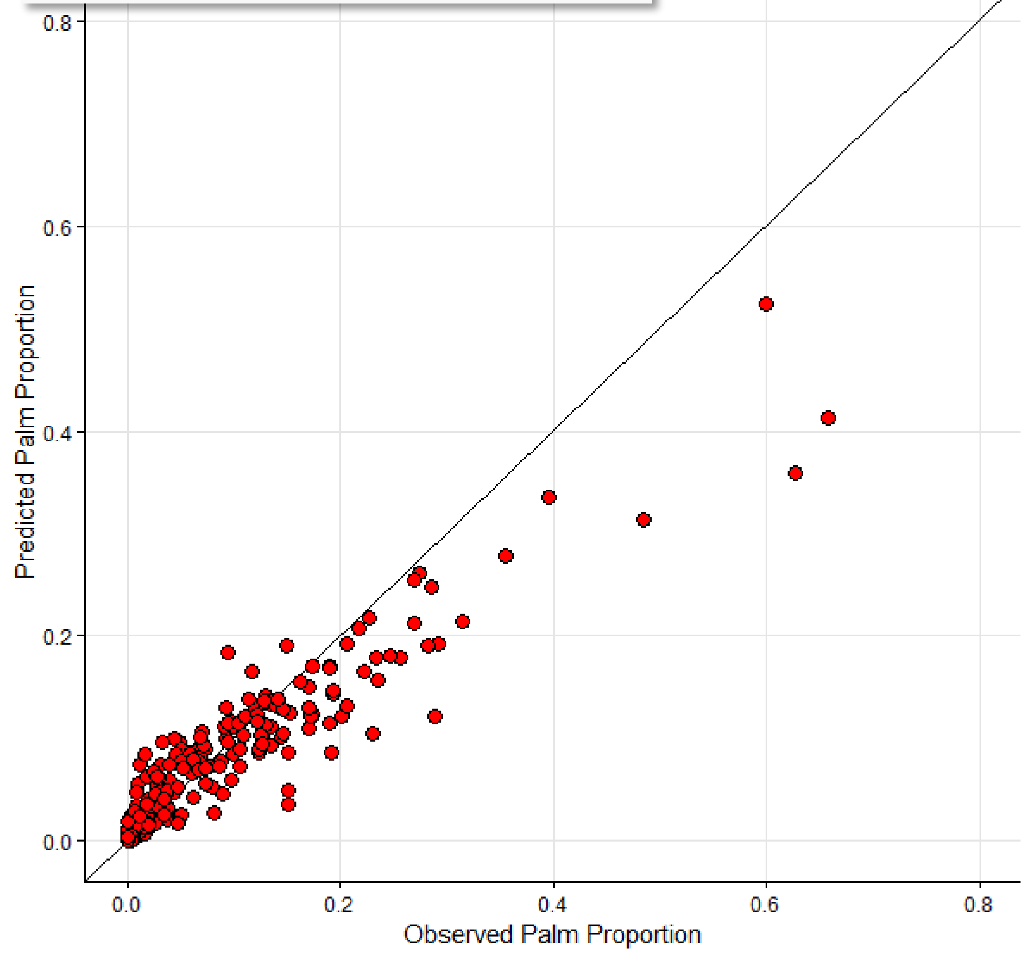


Step 1: Modeling Street Palm Proportion

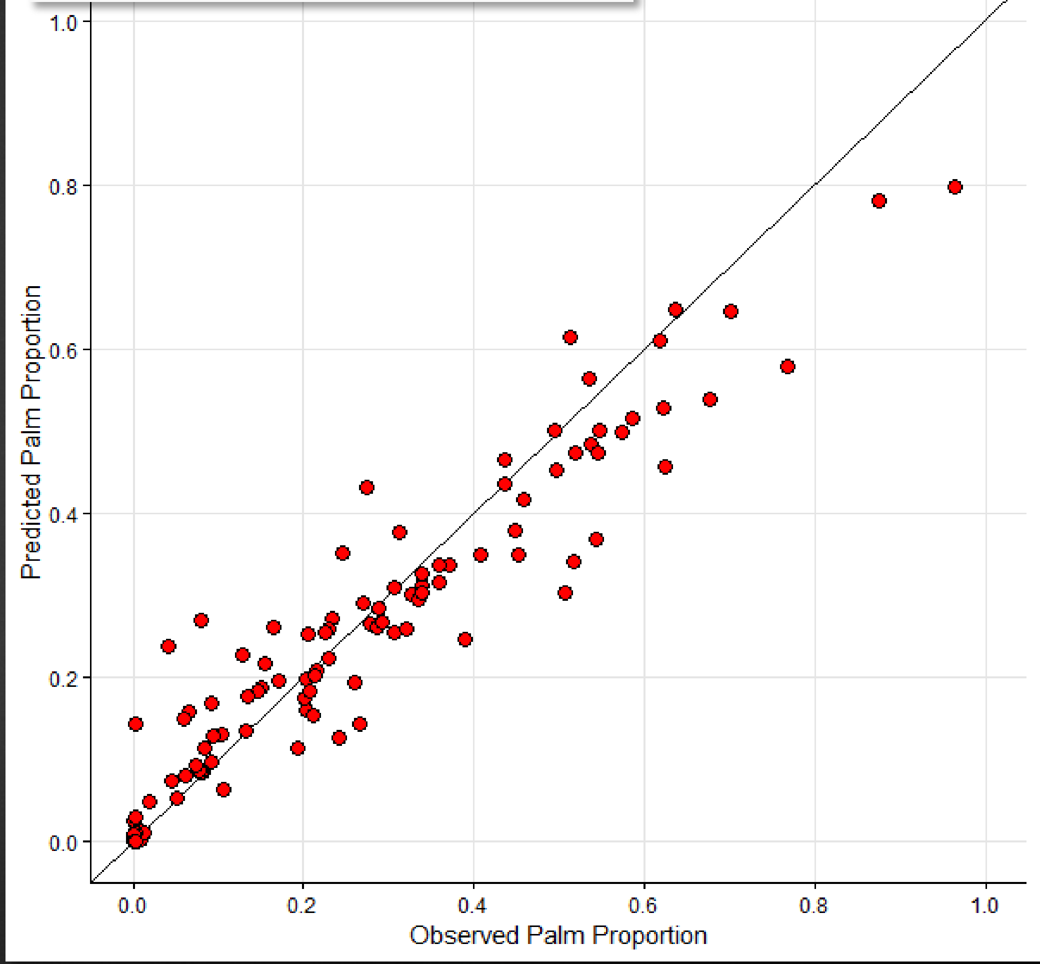
- R package *xgboost* (eXtreme Gradient BOOSTing)
- Separate models for eastern US (n = 139) and western US (n = 229)
- Candidate predictor variables
  - Categories: geographic, environmental, socioeconomic, land cover / land use
- Model tuning, 5-fold cross validation

Results: Predicted vs. Observed

West: $R^2 = 0.869$



East: $R^2 = 0.932$

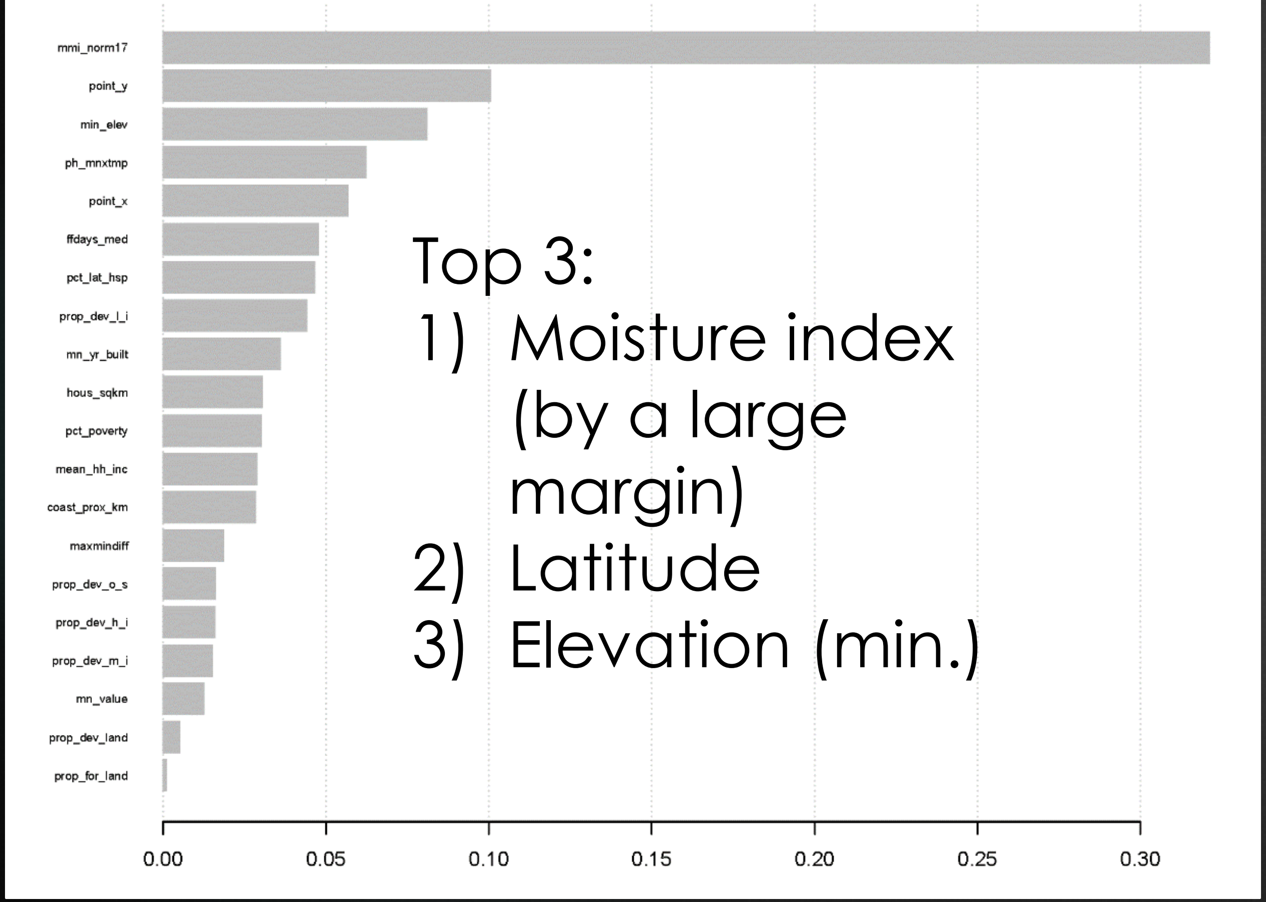


Predicted

Observed

Important Explanatory Variables

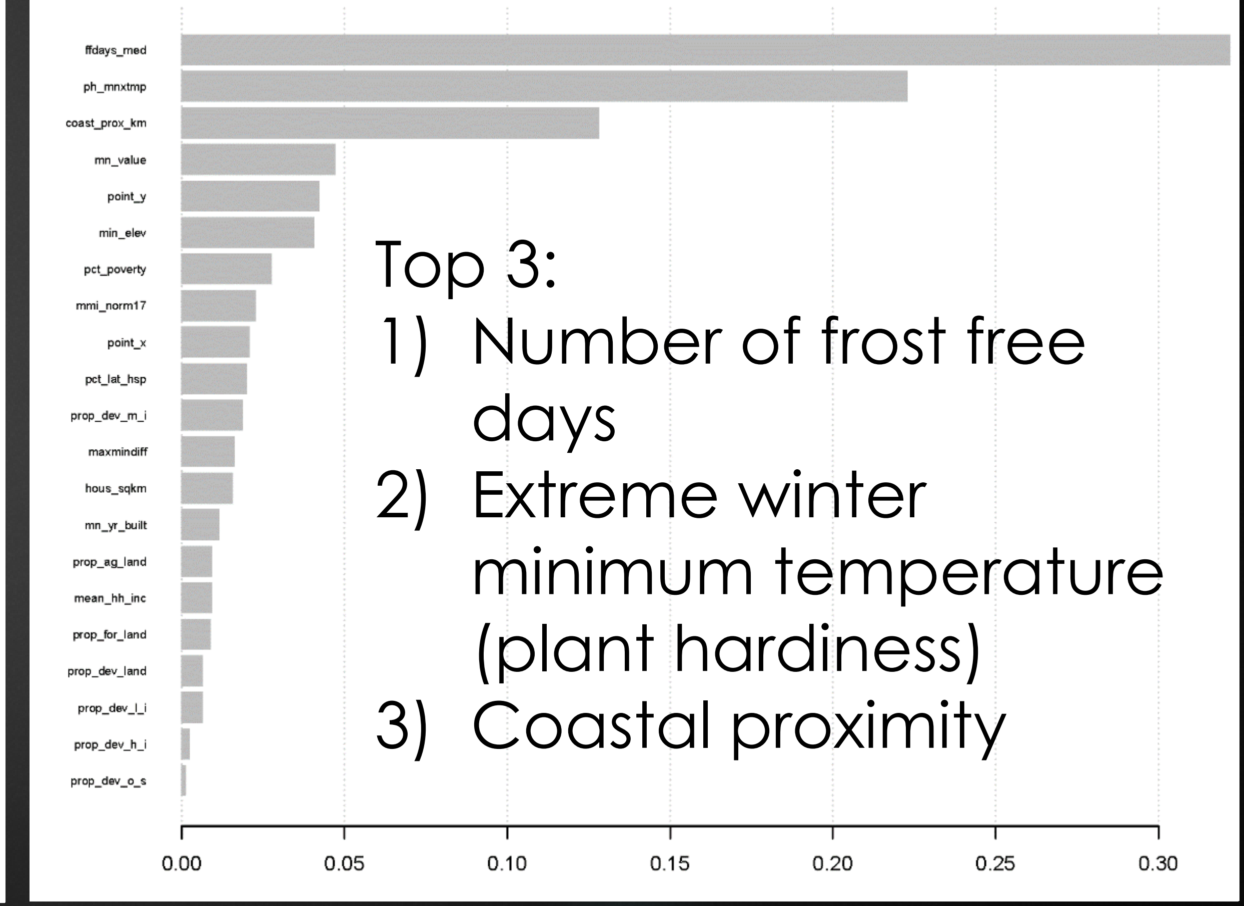
Variable Importance, West



Top 3:

1) Moisture index (by a large margin)
2) Latitude
3) Elevation (min.)

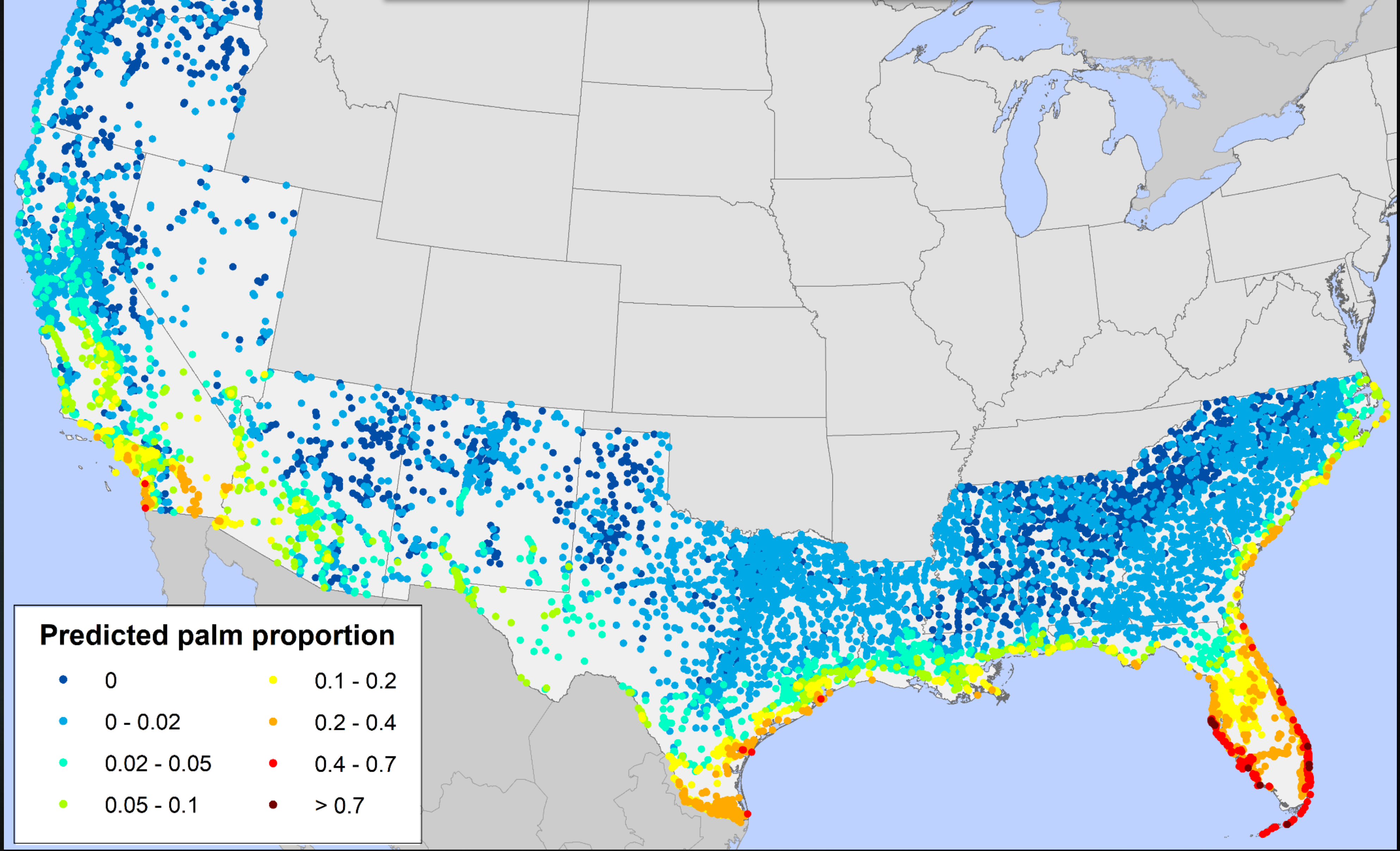
Variable Importance, East



Top 3:

1) Number of frost free days
2) Extreme winter minimum temperature (plant hardiness)
3) Coastal proximity

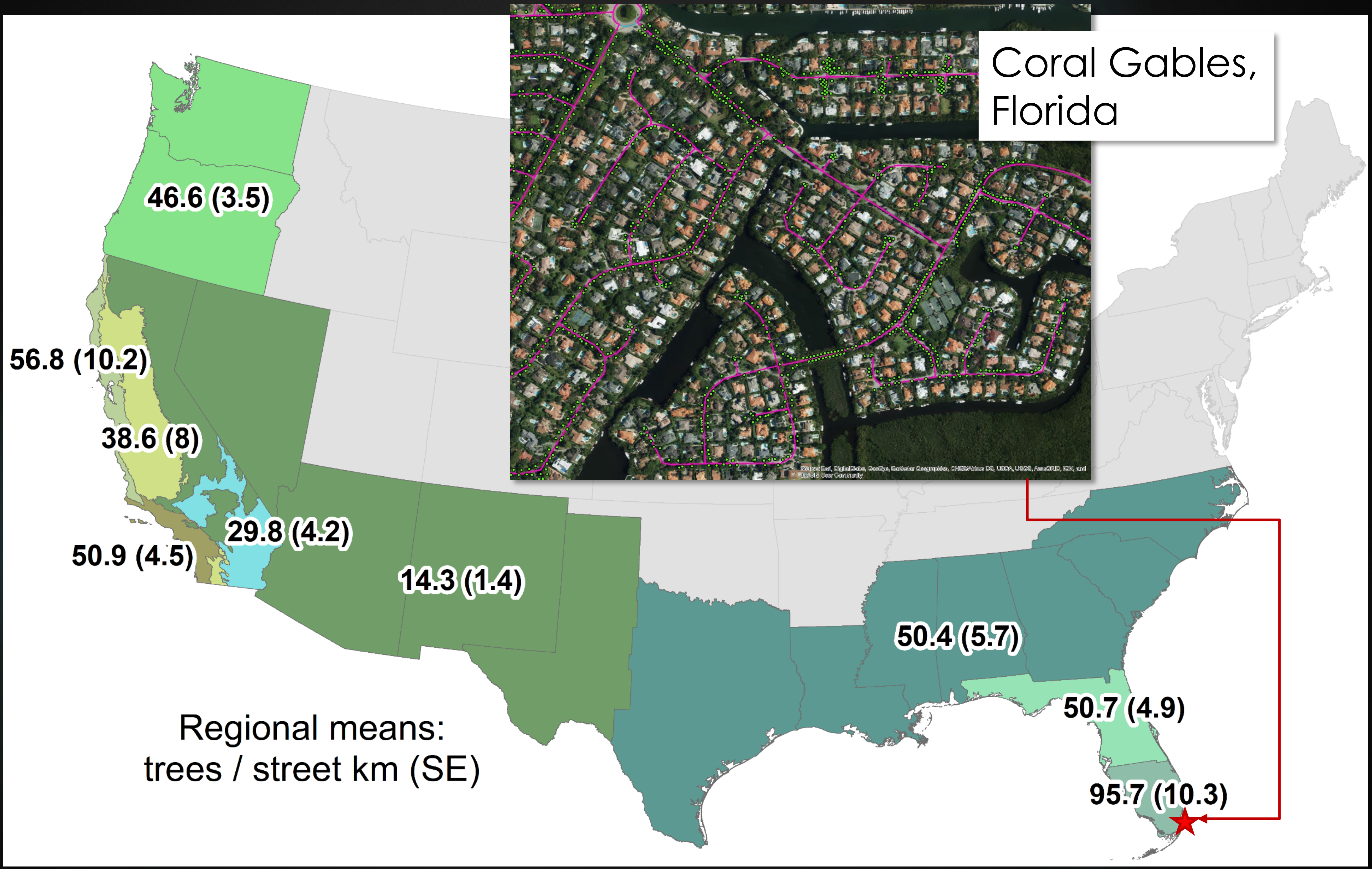
Predicted Palm Proportion



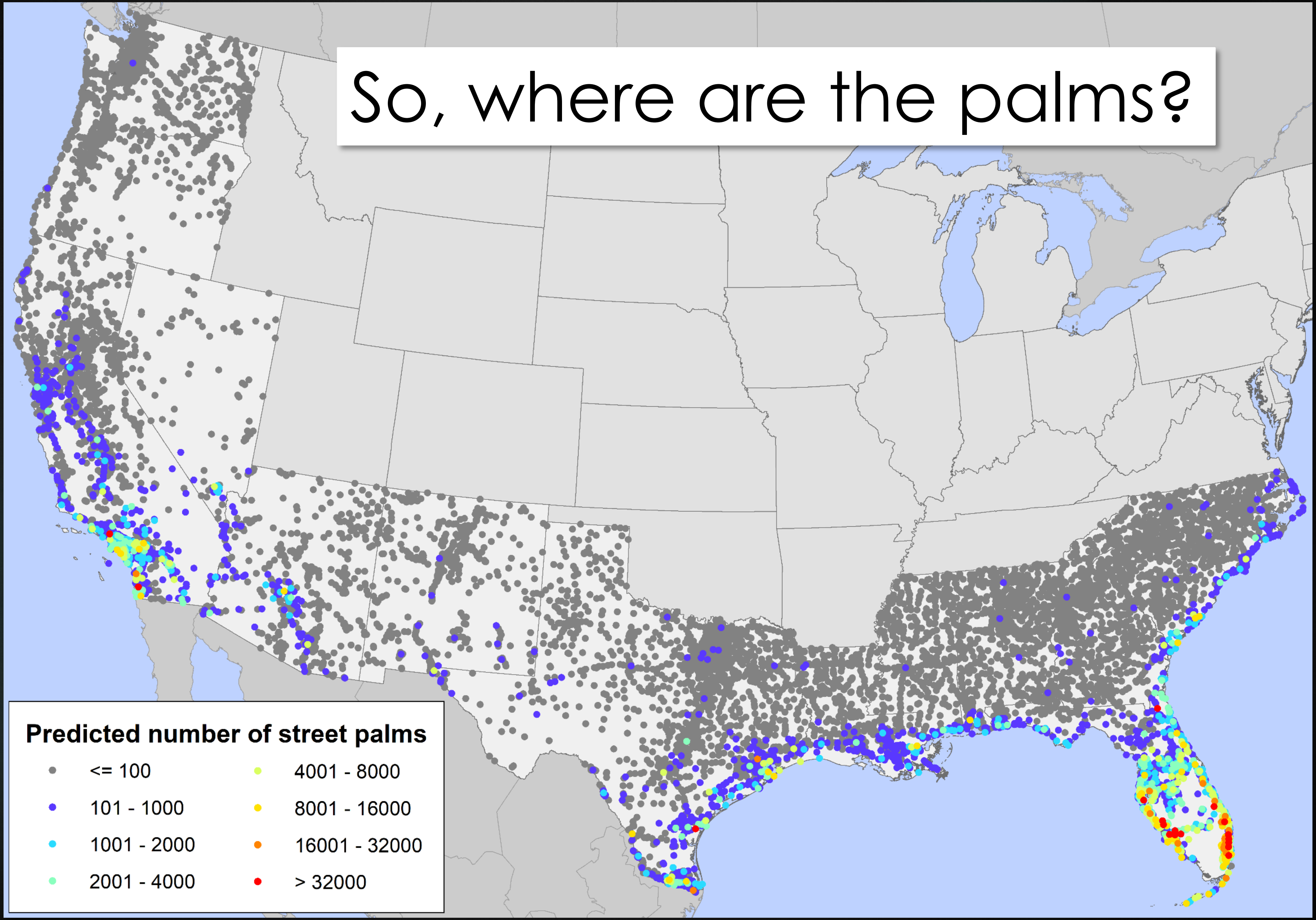
Step 2: Estimating Street Tree Density

- Across USA, street trees usually 40-55 trees / street km
- Some communities have tighter spacing
  - City of Miami Beach, Florida = 144 trees / km (!)
  - Very high street palm proportion

- Street tree density data are difficult to acquire
- Ultimately, decided to use regional mean street tree densities
  - From existing literature or calculated from inventories using GIS and aerial imagery


Coral Gables, Florida
46.6 (3.5)
56.8 (10.2)
38.6 (8)
29.8 (4.2)
50.9 (4.5)
14.3 (1.4)
50.4 (5.7)
50.7 (4.9)
95.7 (10.3)
Regional means:
trees / street km (SE)

So, where are the palms?



Predicted Number of Street Palms by State

Palms estimated using selected road classes

- Case 1: local roads only
- Case 2: local and secondary roads (e.g., state routes)

State	# Palms, Case 1	# Palms, Case 2
Alabama	20,258 ± 4,470	24,297 ± 5,361
Arizona	57,949 ± 11,109	59,687 ± 11,449
California	655,566 ± 137,309	691,480 ± 145,373
Florida	2,424,763 ± 496,249	2,816,307 ± 576,325
Georgia	26,265 ± 5,800	31,221 ± 6,896
Louisiana	68,916 ± 15,259	89,260 ± 19,777
Mississippi	16,602 ± 3,658	18,893 ± 4,172
Nevada	13,216 ± 2,534	14,302 ± 2,739
New Mexico	3,960 ± 737	4,753 ± 892
North Carolina	33,346 ± 7,387	40,056 ± 8,856
Oregon	1,024 ± 135	1,176 ± 155
South Carolina	65,754 ± 14,569	76,809 ± 17,019
Texas	380,686 ± 84,095	422,347 ± 93,288
Washington	1,073 ± 141	1,188 ± 158
Total	**3,769,378 ± 783,452**	**4,291,776 ± 892,460**

Final Points

- Model results seem reasonable at a state or county level
- Rough estimate of potential economic impact of a palm pest: up to US$8-9 billion to remove and replant
- Data quantity & quality are major limitations
- Ecological impact of a palm pest?

Acknowledgements

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Questions?

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