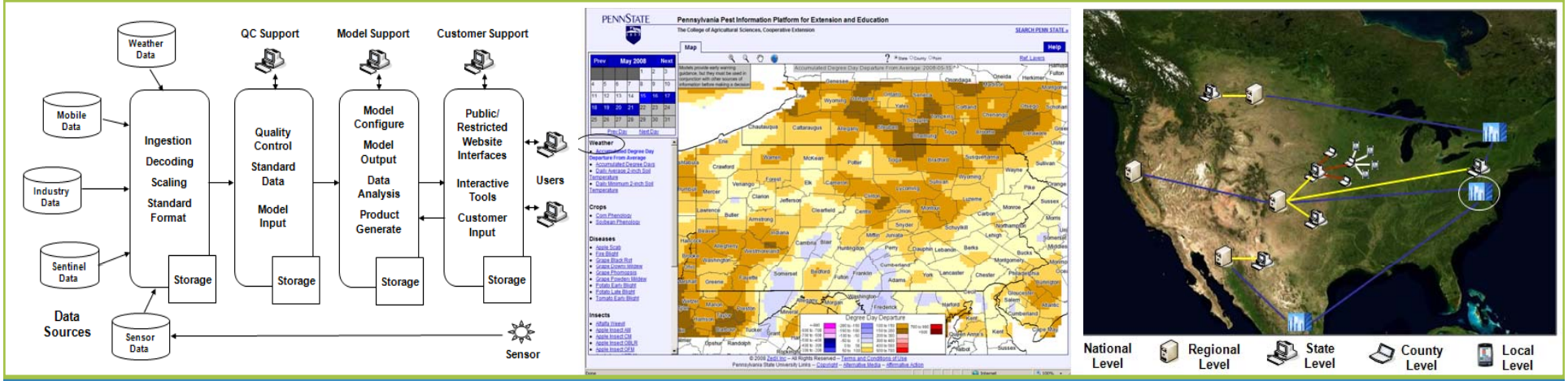
Challenges for modelling and predicting establishment and spread of new plant pests and pathogens



Roger Magarey

NCSU and Cooperator with USDA-APHIS-PPQ-CPHST PERAL

NC STATE UNIVERSITY

Challenges for prediction of emerging pests

Challenge	Modelling tool
Which pests?	Self Organizing Maps
What hosts?	Phylogenetics
Where?	Freight analysis
	NAPPFAST Integrated Atmospheric Modeling System

Challenges for prediction of emerging pests

Challenge	Modelling tool
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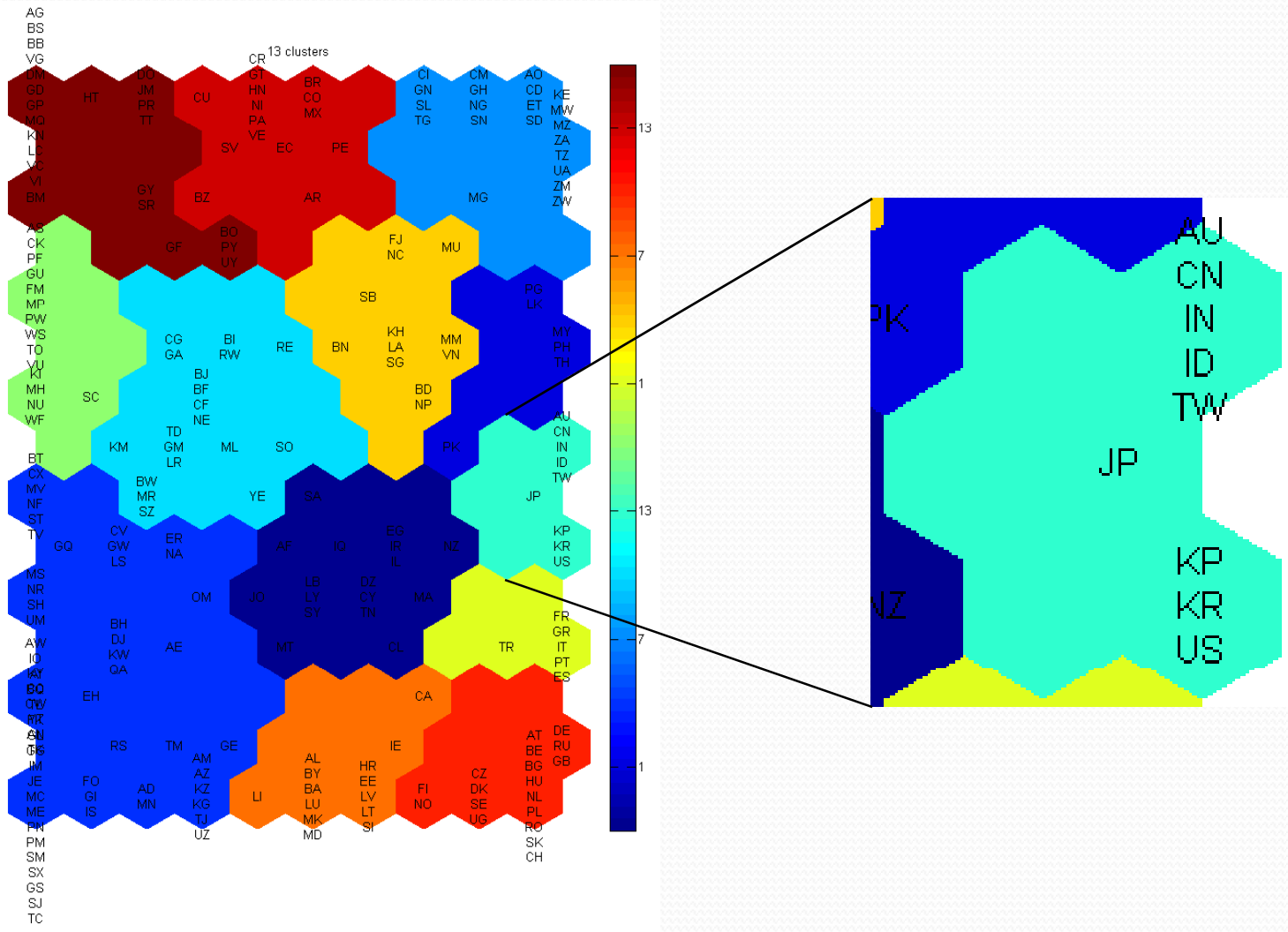
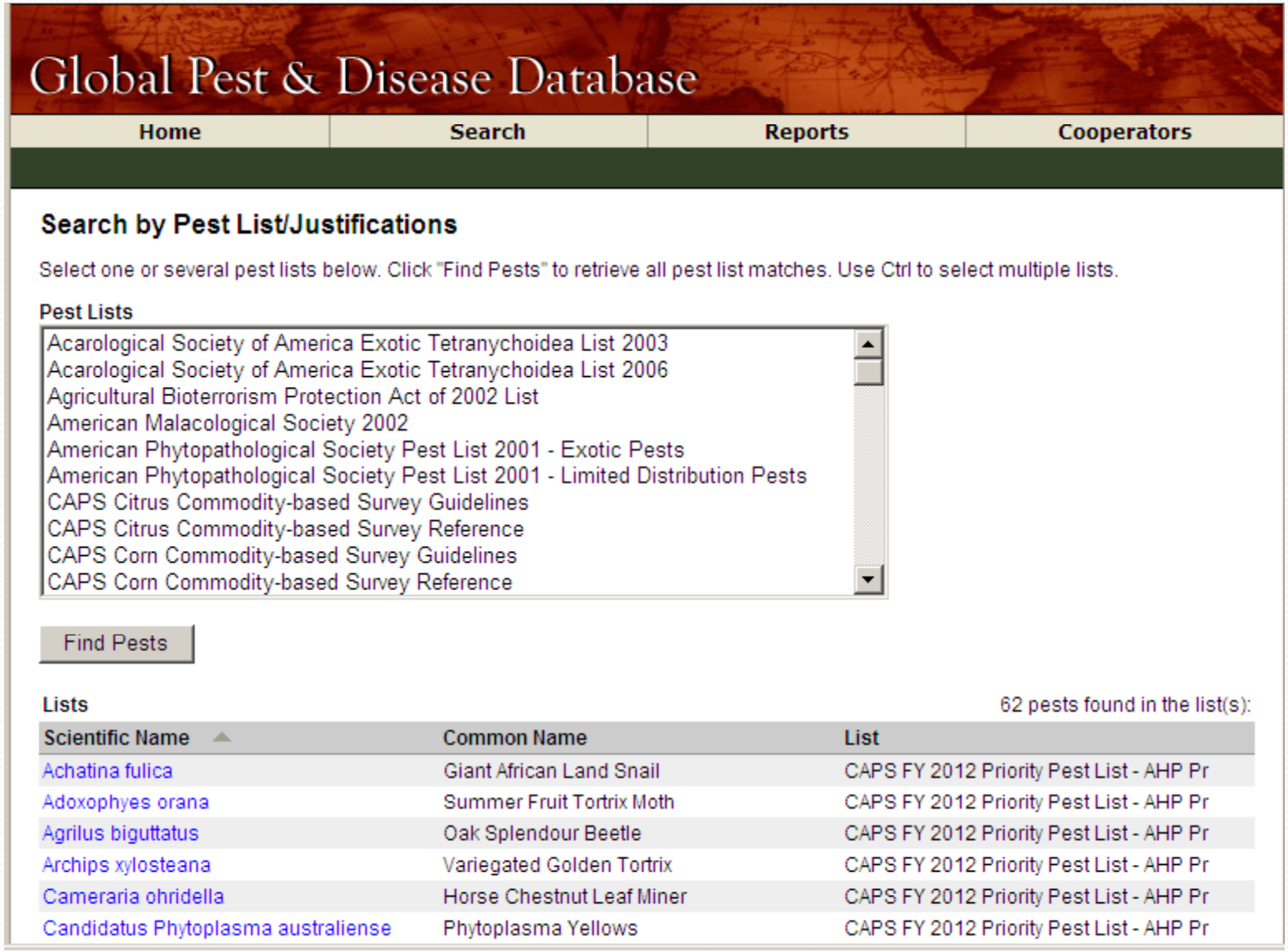
Self Organizing Maps (SOMS)

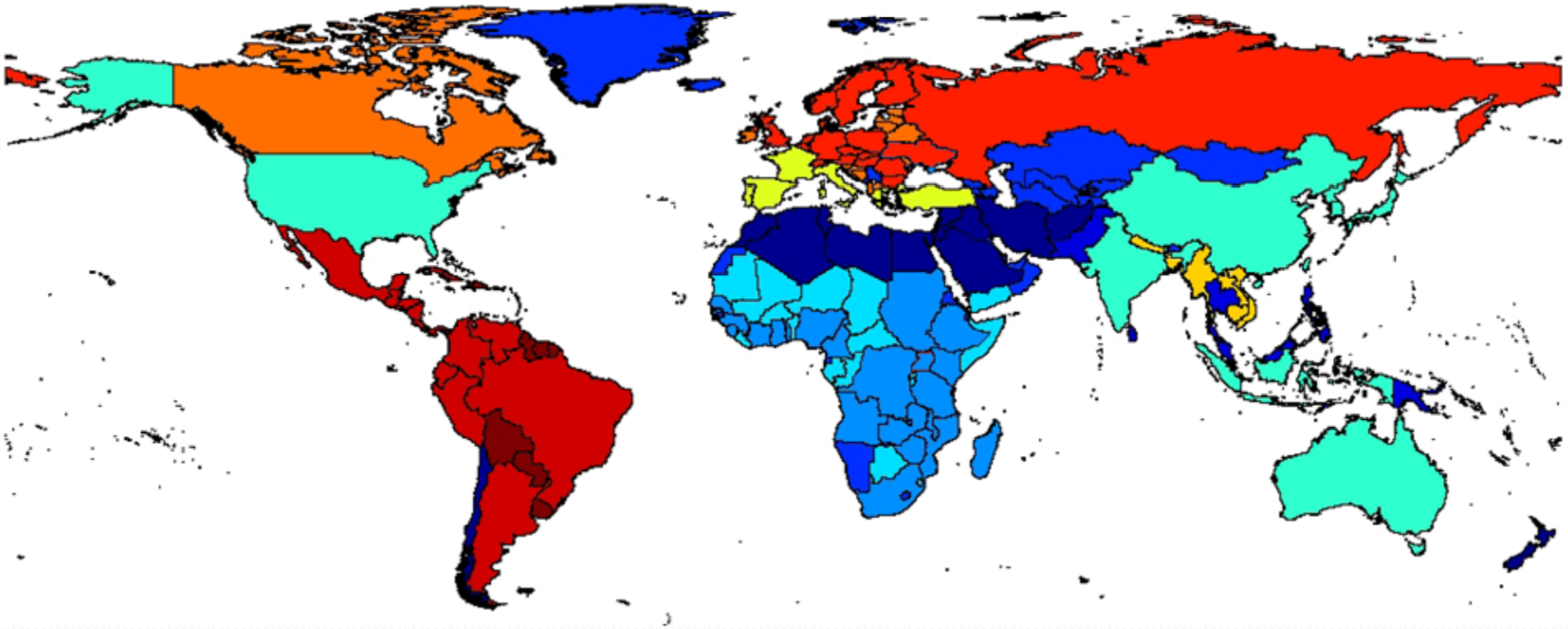


Karl Suiter, CIPM-NCSU

Identification of threats



Countries with Similar Pest Grouping (GPDD)



K. Suiter, CIPM-NCSU

United States - Top 25 Potential Invasive Species (GPDD)

Weight	Pest	Type
0.83887	Helicoverpa armigera (Old World Bollworm)**	I
0.83798	Hippotion celerio (Taro Hawkmoth)	I
0.78131	Agrotis segetum (Turnip Moth)	I
0.78040	Chromatomyia horticola (Pea Leaf Miner)	I
0.77556	Mamestra brassicae (Cabbage Moth)	I
0.77401	Pycreus globosus (Rumput Toyan)	W
0.75170	Laodelphax striatellus (Small Brown Planthopper)	I
0.73861	Autographa gamma (Silver Y Moth)	I
0.71439	Hylastes ater (Black Pine Bark Beetle)	I
0.69867	Amphitetranychus viennensis (Fruit Tree Spider Mite)	I
0.69676	Empoasca vitis (Smaller Green Leafhopper)	I
0.68901	Ascochyta fabae (Spot on Broad Bean)	P
0.68046	Bemisia afer (Sycamore Whitefly)	I
0.67555	Unaspis yanonensis (Arrowhead Scale) **	I
0.66543	Aporia crataegi (Black-veined White)	I
0.66341	Cydia funebrana (Plum Fruit Moth)	I
0.65628	Lymantria monacha (Nun Moth)	I
0.65624	Inachis io (European Peacock Butterfly)	I
0.63452	Athalia rosae (Cabbage Leaf Sawfly)	I
0.62611	Juncus prismatocarpus (Jointed Rush)	W
0.62547	Anomis sabulifera (Jute Semi-looper)	I
0.62016	Phytoplasma SPLL (Sweet potato little leaf phytoplasma)	P
0.62000	Calyptra thalictri (Fruit-piercing Moth)	I
0.60558	Ascotis selenaria (Cotton Geometrid)	I

I = Insect	0.84
W = Weed	0.08
P = Pathogen	0.08
M = Mollusk	0.00
V = Virus	0.00
N = Nematode	0.00

** CAPS 2011 Pest

K. Suiter, CIPM-NCSU

United States - Top 25 Potential Invasive Species (CABI)

Weight	Pest	Type
0.83341	Venturia pyrina (black spot of pear)	P
0.76005	Ralstonia solanacearum race 3 (brown rot of potato) **	P
0.72679	Cortaderia selloana (pampas grass)	W
0.68390	Erysiphe cruciferarum (powdery mildew of crucifers)	P
0.64553	Pantoea ananatis (fruitlet rot of pineapple)	P
0.64161	Colletotrichum musae (tip rot of banana)	P
0.62277	Macrosiphum rosae (rose aphid)	I
0.57686	Citrus leprosis virus (leprosis of citrus)	P
0.56933	Conyza sumatrensis (tall fleabane)	W
0.54120	Hemileia vastatrix (coffee leaf rust)	P
0.54002	Xanthomonas axonopodis pv. manihotis (cassava bacterial blight)	P
0.53139	Pseudomonas fuscovaginae (sheath brown rot)	P
0.53074	Colletotrichum boninense ()	P
0.52954	Parapoynx stagnalis (rice case bearer)	I
0.52345	Aphidius colemani ()	I
0.47582	Antigastra catalaunalis (sesame webworm)	I
0.47239	Oxalis latifolia (sorrel)	W
0.46386	Liriomyza huidobrensis (serpentine leafminer)	I
0.46312	Senecio inaequidens (South African ragwort)	W
0.46312	Apple ringspot disease (Granny Smith ring spot)	P
0.46298	Xylosandrus morigerus (brown twig beetle)	I
0.45169	Helicoverpa armigera (cotton bollworm) **	I
0.45167	Hippotion celerio (taro hawkmoth)	I
0.45133	Locusta migratoria (migratory locust)	I

I = Insect	0.36
W = Weed	0.16
P = Pathogen	0.44
M = Mollusk	0.00
V = Virus	0.00
N = Nematode	0.00

** CAPS 2011 Pest

K. Suiter, CIPM-NCSU

Challenges for prediction of emerging pests

Challenge	Modelling tool
Which pests?	Self Organizing Maps
What hosts?	Phylogenetics
Where?	Freight analysis
	NAPPFAST Integrated Atmospheric Modeling System

Identify future host range expansions

Global Pest & Disease Database

Home | Search | Reports | Cooperators

GPDD Pest ID 3154 - Last Full Review May 5, 2008 | Pest Tools | View Pest Data

Scientific Name

Phytophthora captiosa M.A. Dick & Dobbie 2006

Taxonomic Position

Chromista : Oomycota : Oomycetes : Pythiales : Pythiaceae

Preferred Common Name

Eucalyptus Crown Disease

Justification for Inclusion in GPDD

- PPQ Phytophthora - AHP Prioritized Pest List 2008

Cooperator's Database(s)

No data available

EPICA Articles

No data available

Hosts Show PPQ-researched Hosts

Eucalyptus botryoides Sm. (Bangalay) : (2, 3, 4, 6, 7)
Eucalyptus saligna Sm. (Gum, Sydney Blue) : (1, 2, 3, 4, 6, 7)
Eucalyptus spp. L'Hér. (Eucalyptus) : (6)

Distribution Show PPQ-researched Distribution

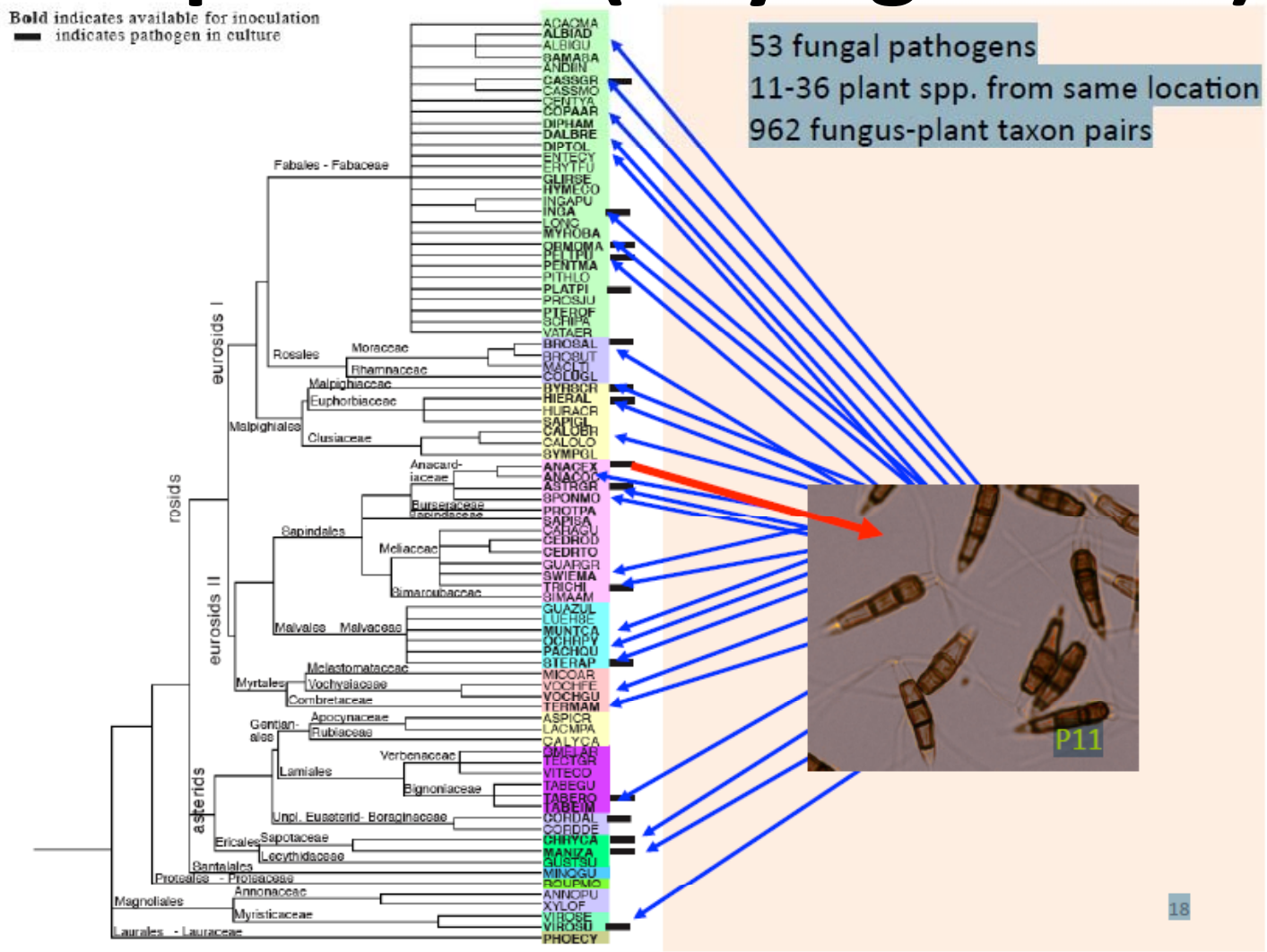
PPQ-researched Distribution

These distribution references have been researched by PPQ.

New Zealand : (2, 3, 6)

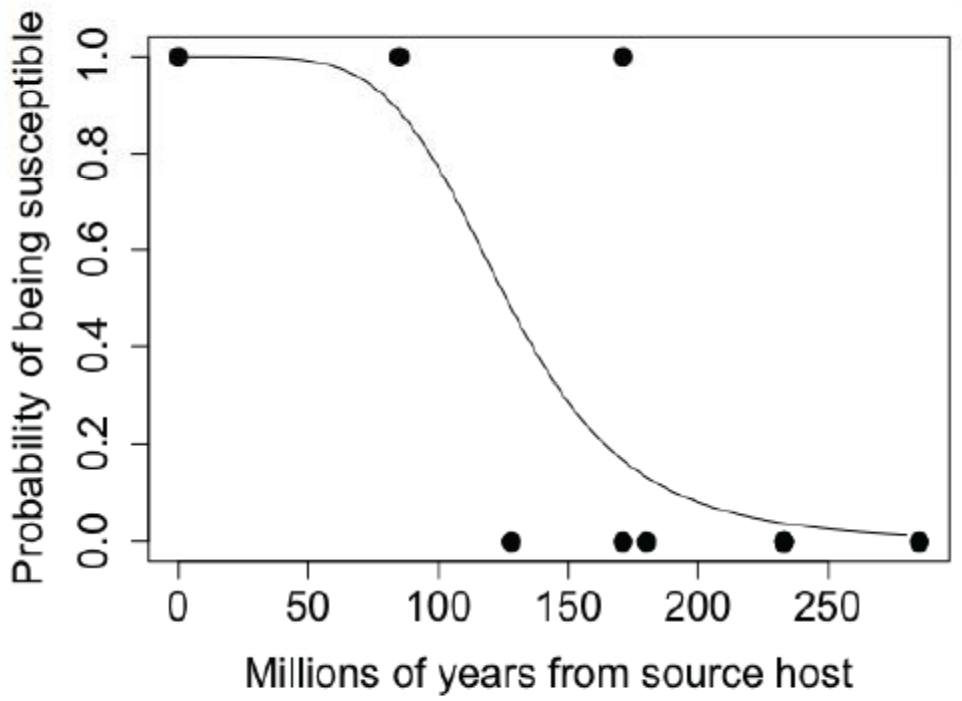
New Zealand : (1, 2, 3, 4, 6). Exotic (5). Bay of Plenty (7)

Identify future host range expansions (Phylogenetics)



Gregory Gilbert, (UCSC)

Target Host	My from Lithocarpus	Susceptible?
lonicera	233	no
ilex	233	no
arbutus	233	no
arctostaphylos	233	no
corylus	128	no
lithocarpus	0	yes
quercus	85	yes
rhamnus	171	yes
pyracantha	171	no
acacia	180	no
umbellularia	285	no



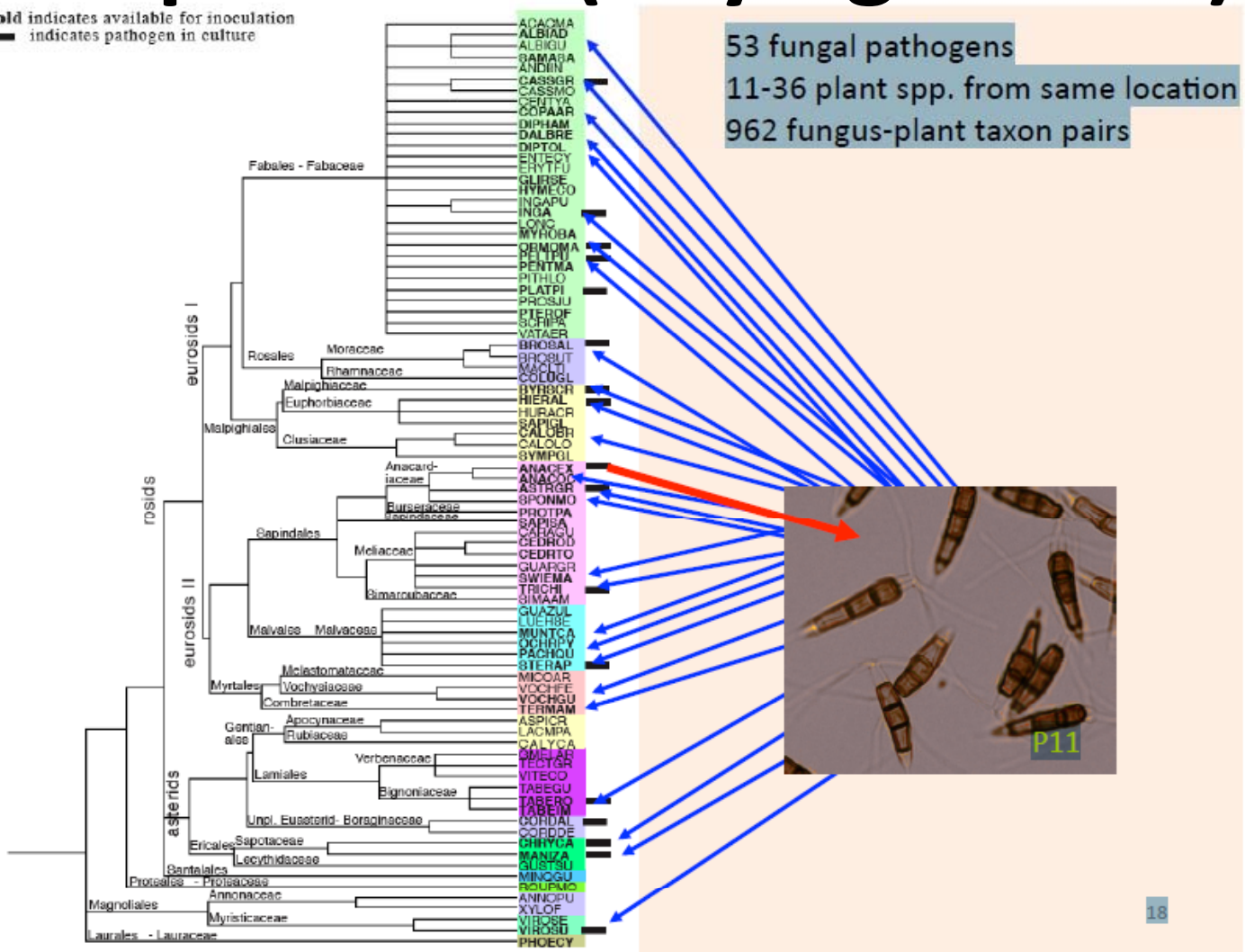
$$\text{logit}(\text{suscept}) = 25.67 - 12.20 \log_{10}(\text{My}+1)$$

$$\text{prob}(\text{suscept}) = \exp(\text{logit}(S) / (1 + \exp(\text{logit}(S))))$$

p.s., logit=$ln(p)$-$ln(1\text{-}p)$

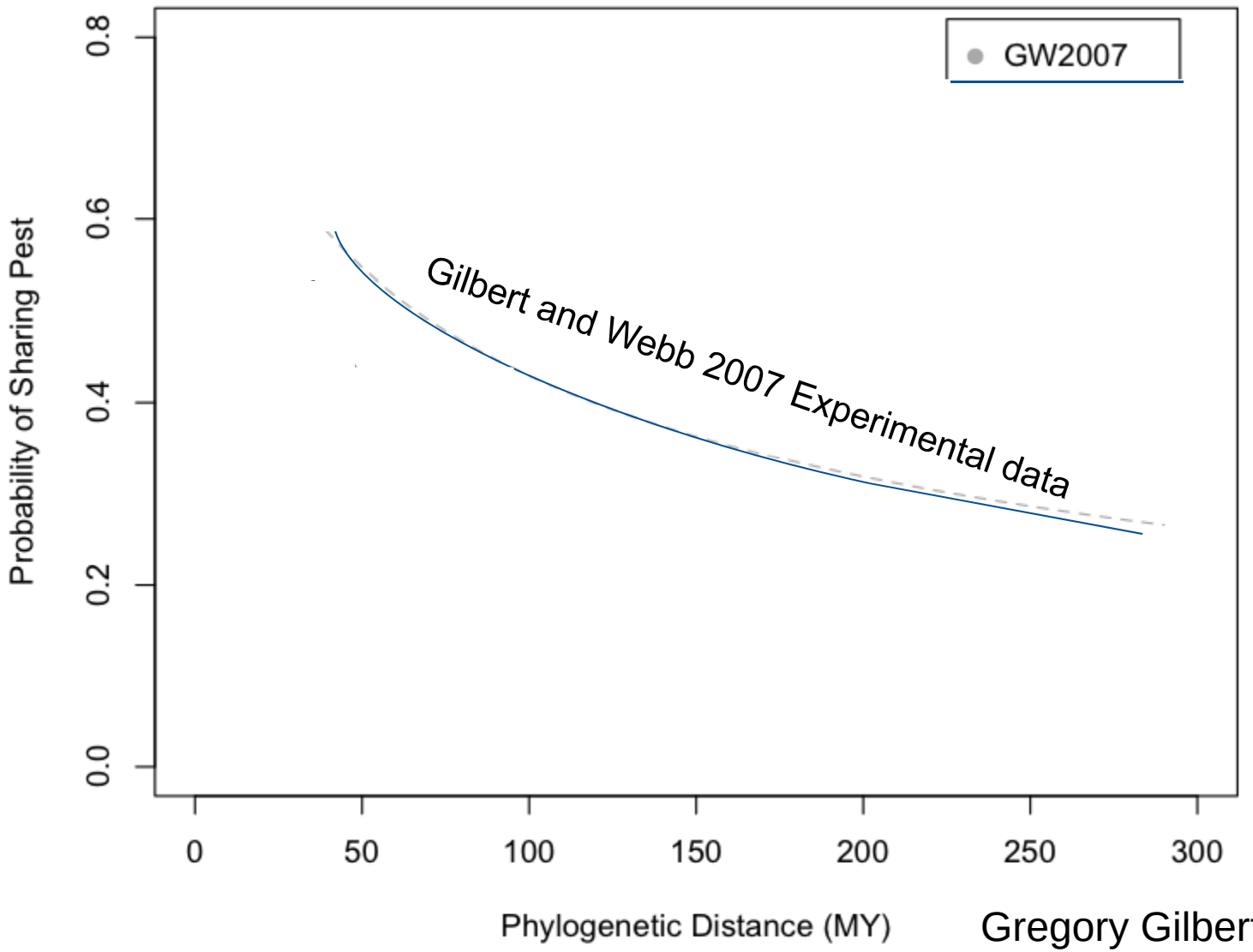
Gregory Gilbert, (UCSC)

Identify future host range expansions (Phylogenetics)



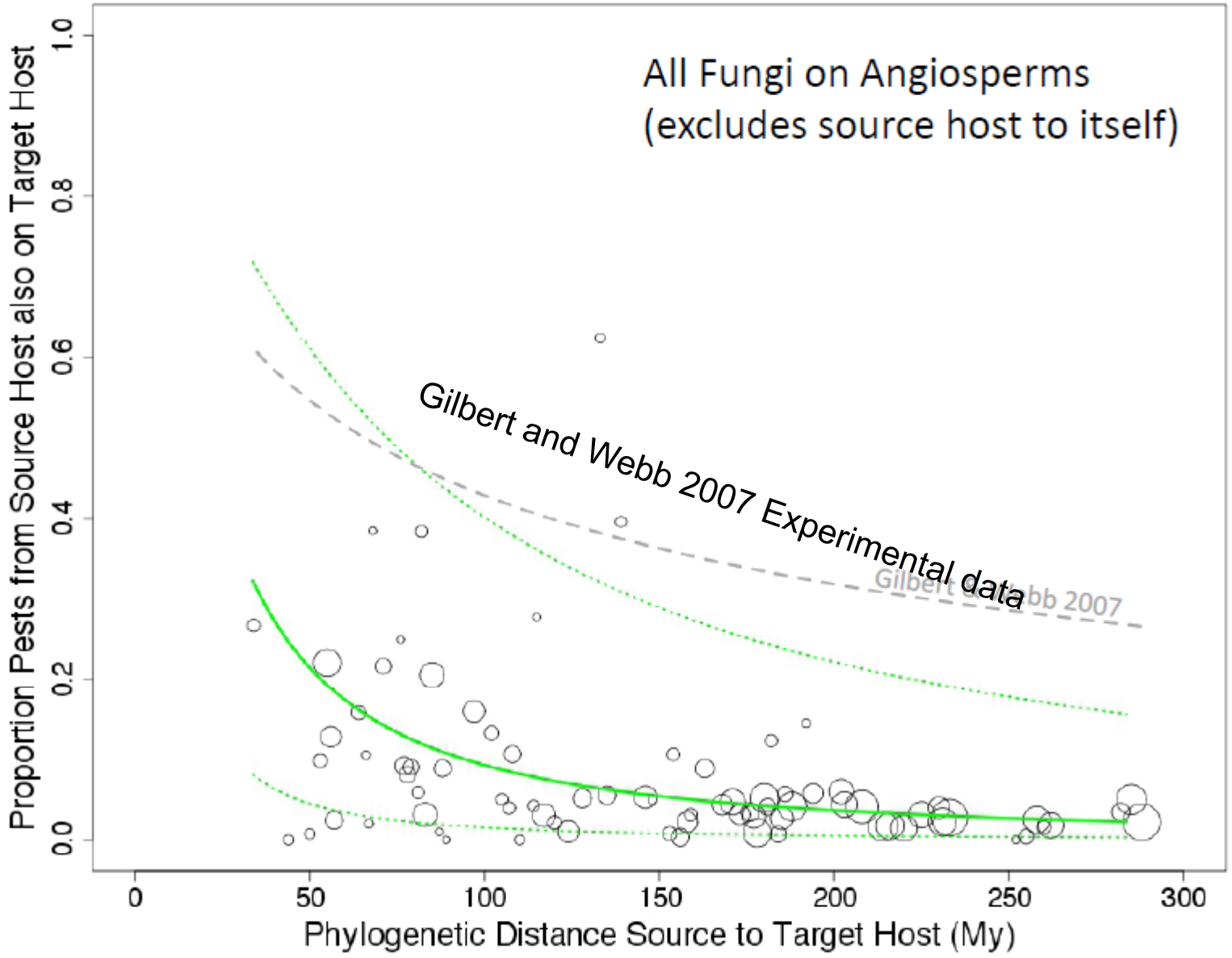
Gilbert and Webb 2007

Identify host range expansions



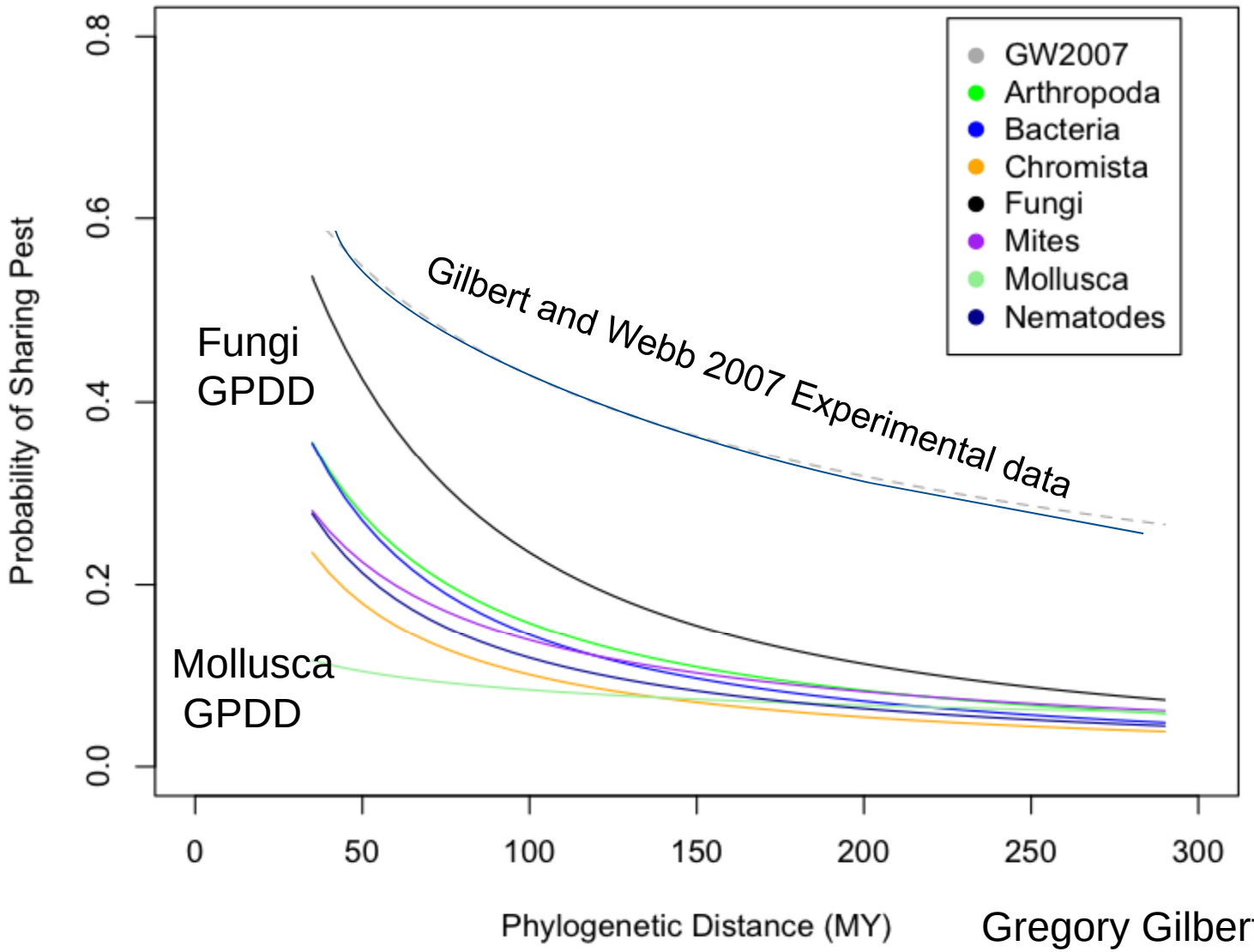
Gregory Gilbert,(UCSC)

Identify host range expansions



Gregory Gilbert,(UCSC)

Identify host range expansions



Gregory Gilbert,(UCSC)

Challenges for prediction of emerging pests

Challenge	Modelling tool
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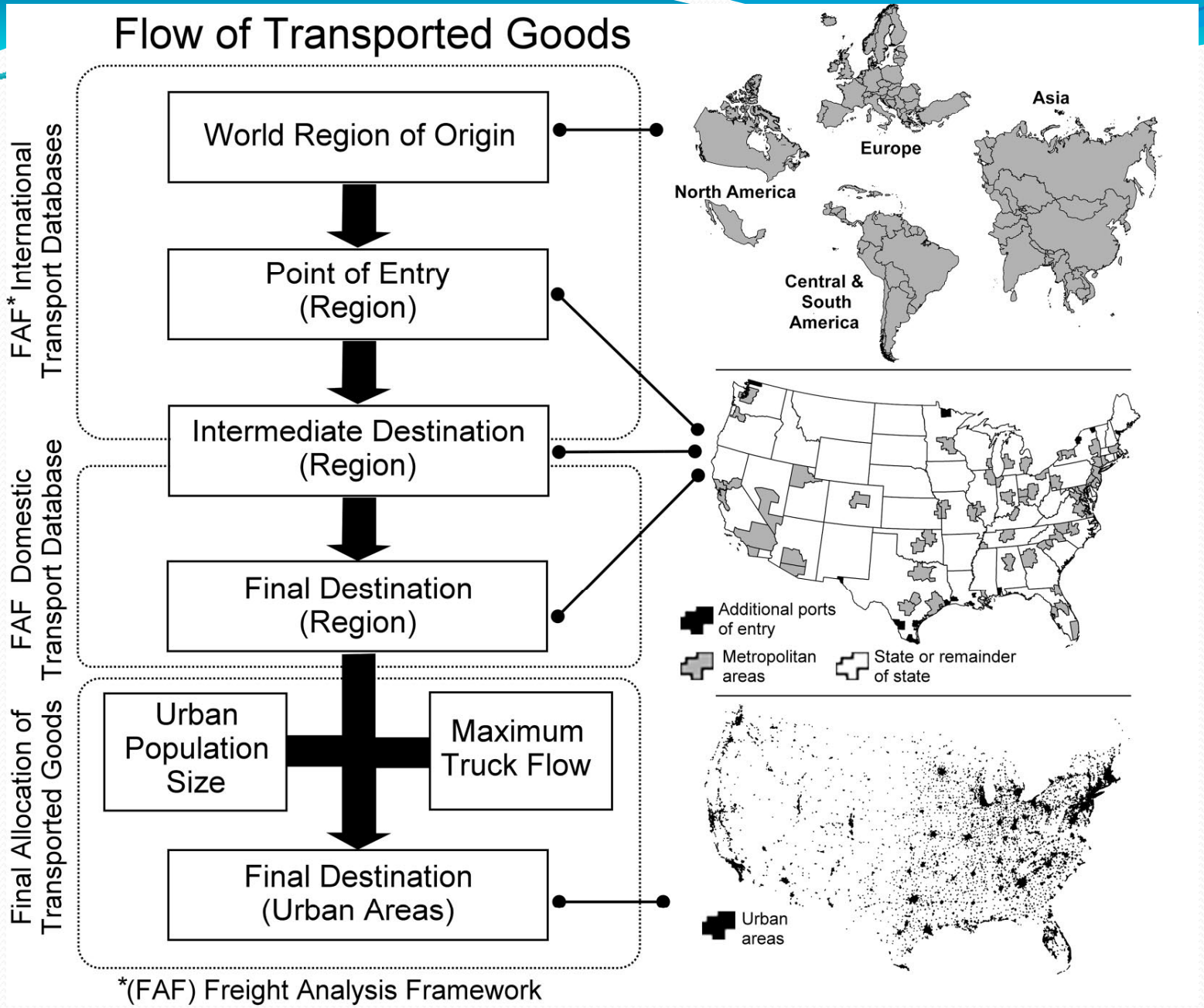
	NAPPFAST Integrated Atmospheric Modeling System

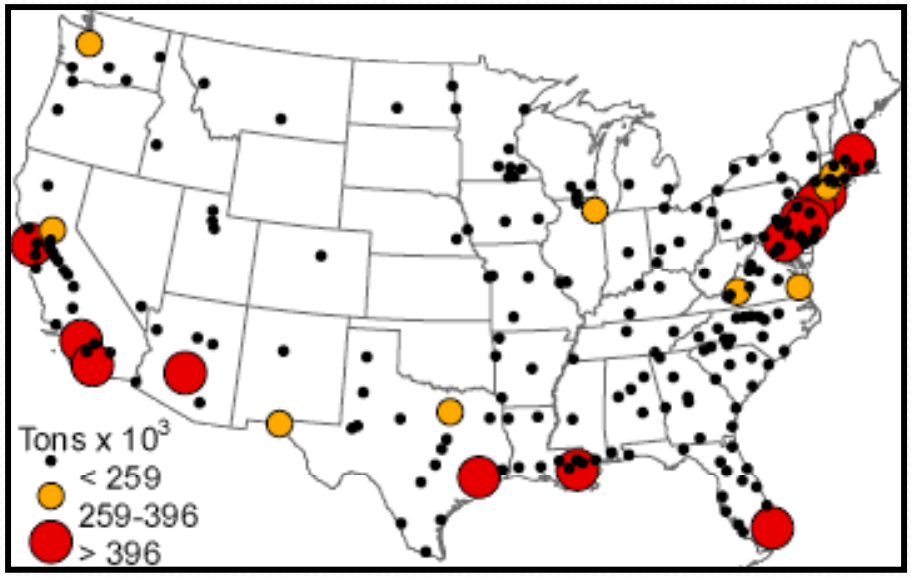


Manuel Colunga-Garcia (MSU)

Predict high risk areas for pest

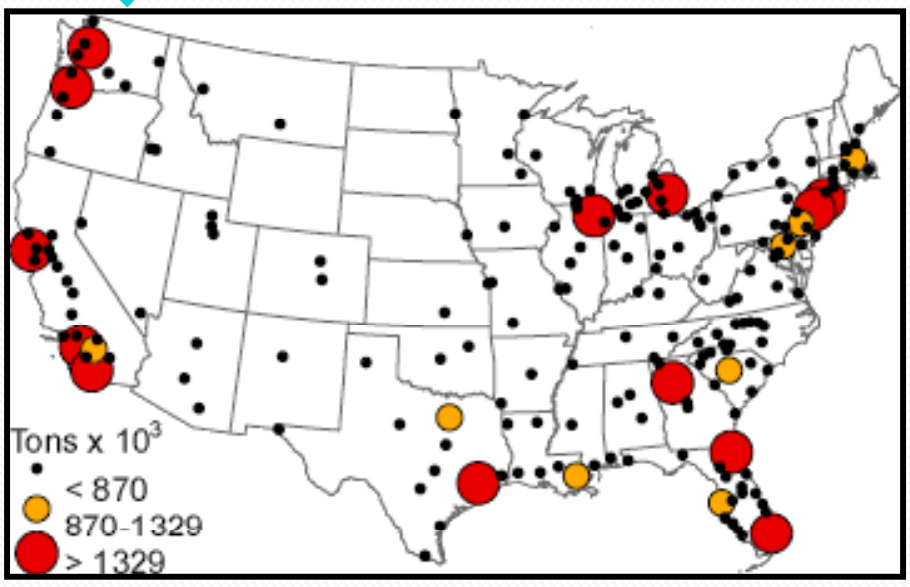
Agric.

- Cereal grains
- Other agricultural products



Forest

- Wood products
- Non-metallic mineral products
- Machinery



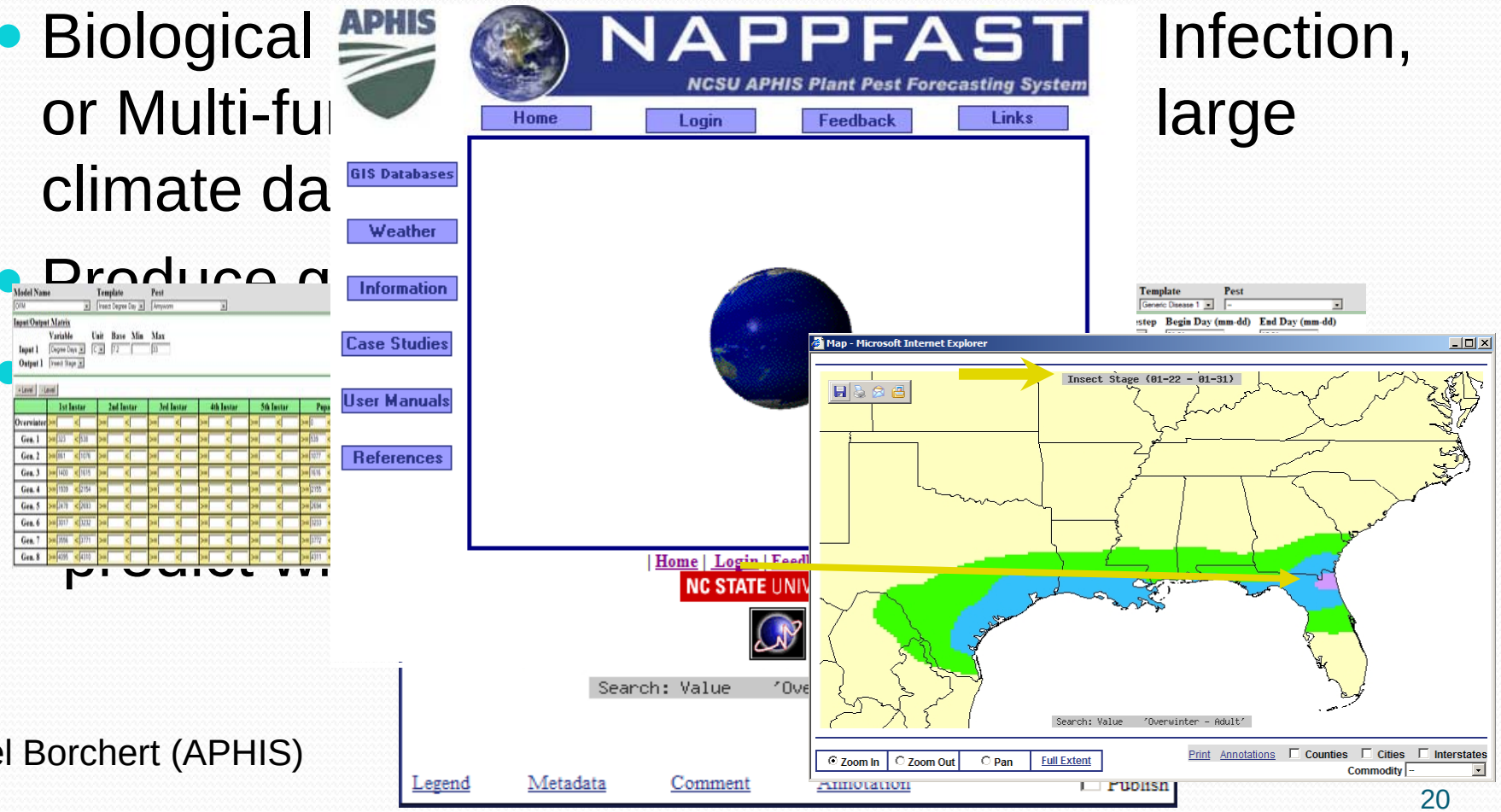
Manuel Colunga-Garcia (MSU)

Photo source: JOC

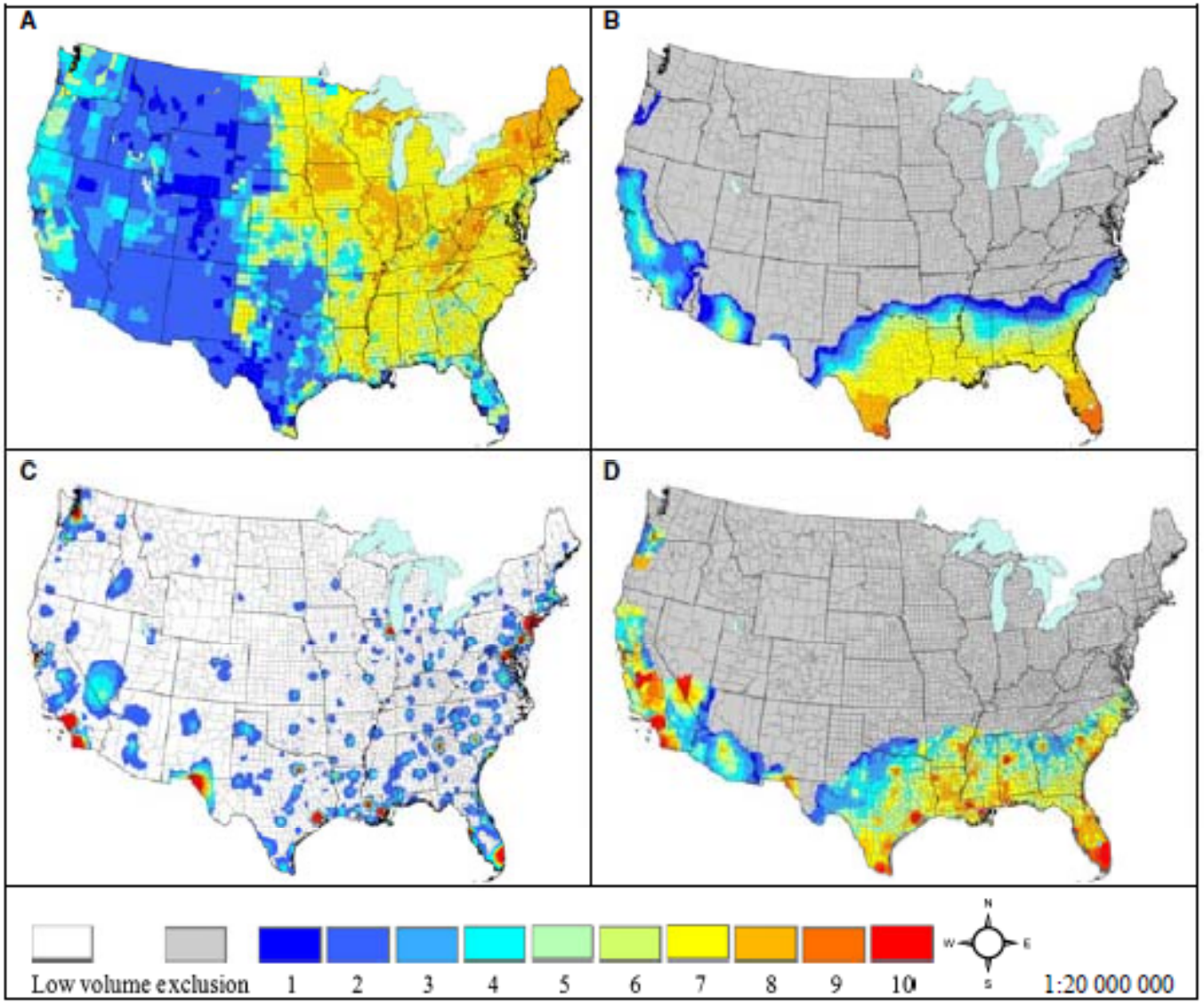
Predict high risk areas for pest establishment (NAPPFAST)

- Internet-based Pest Prediction System
- Biological
  or Multi-fu
  climate da
- Produce g
  predict w

Infection,
large

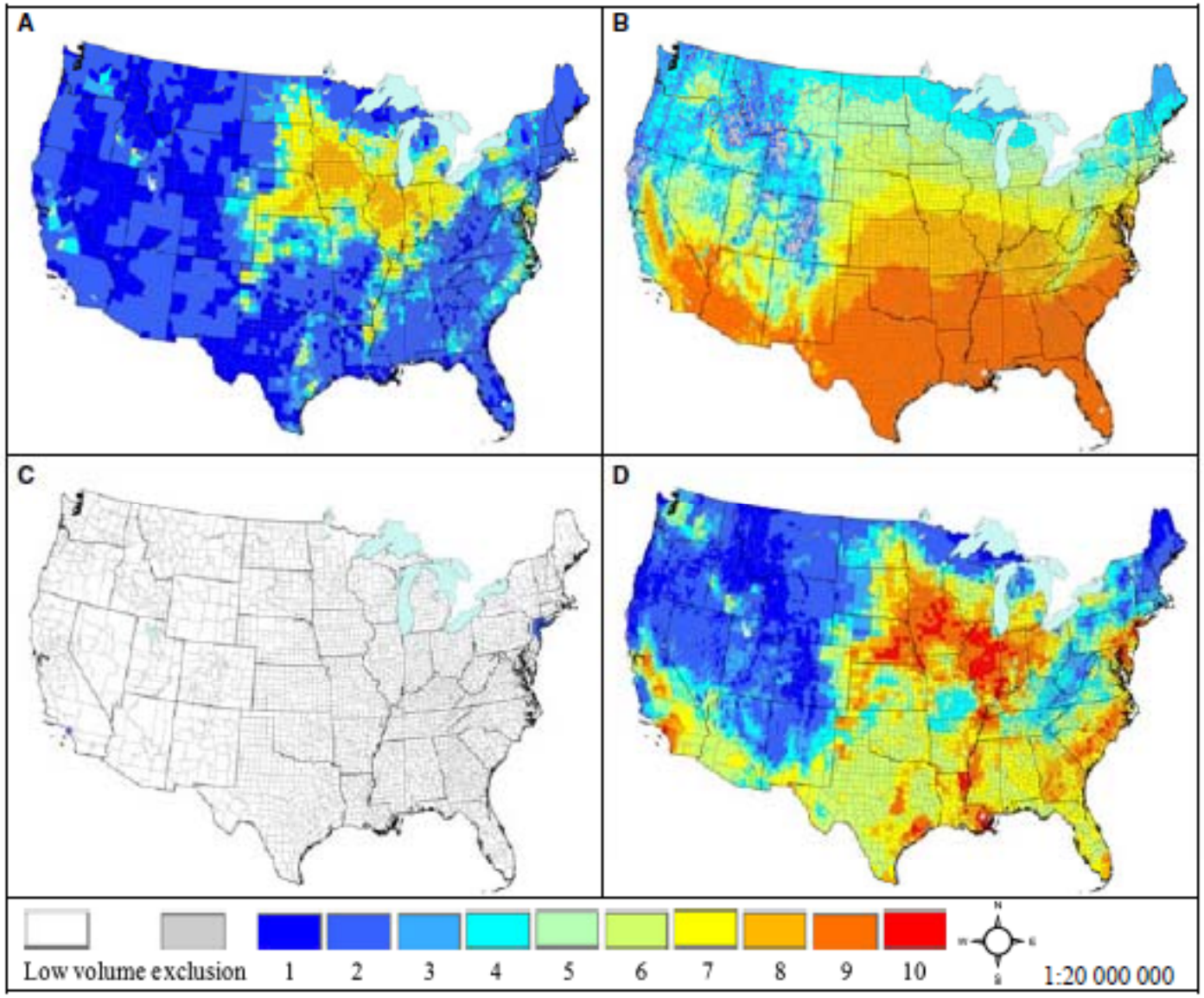


Daniel Borchert (APHIS)



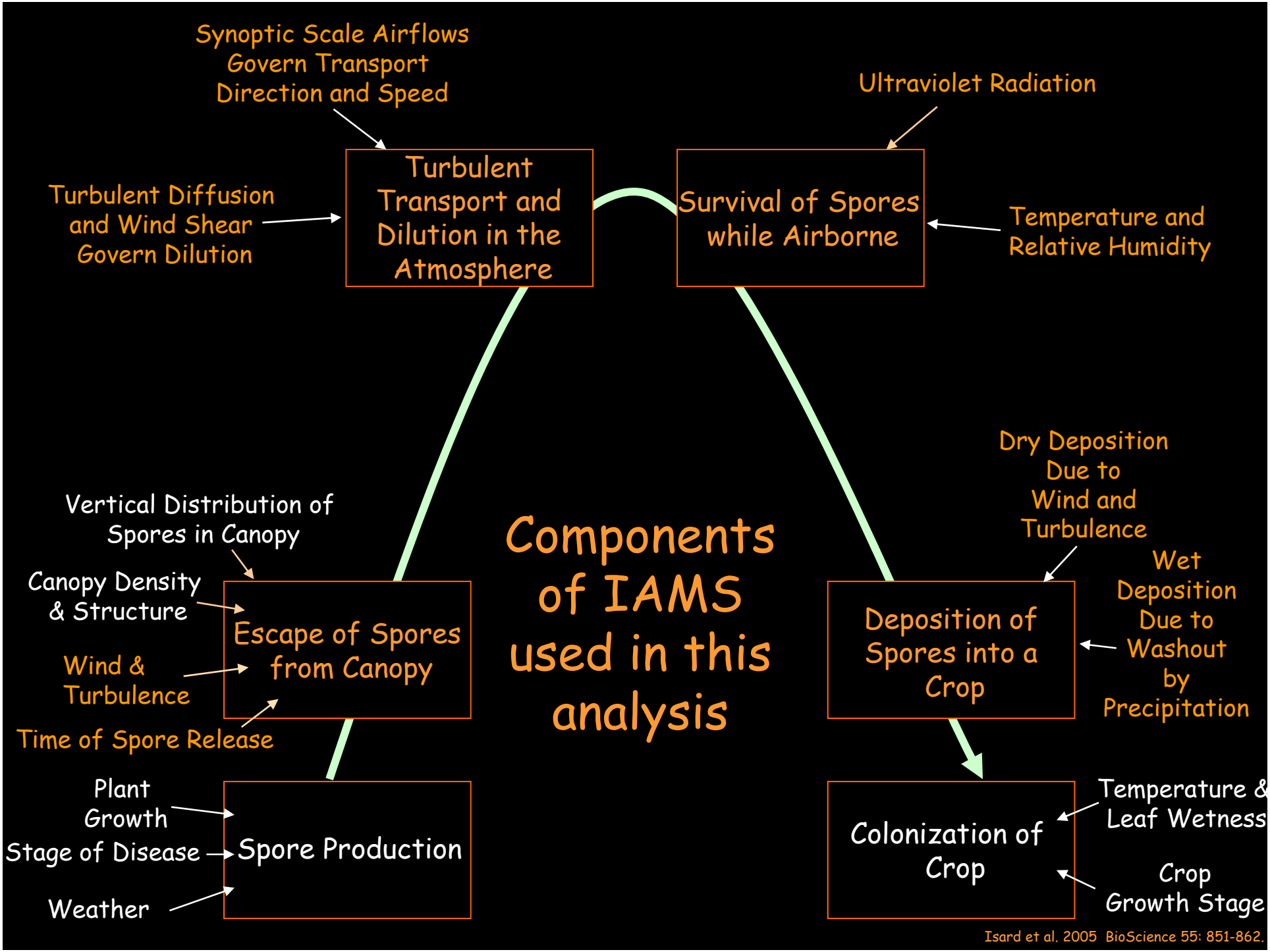
Risk maps for the giant African land snail, *Achatina fulica*: (A) susceptible host density; (B) climatic suitability (NAPPFAST map); (C) introduction potential; (D) integrated Pareto risk map.

Pareto from Denys Yemshanov CFS



Risk maps for the Corn late wilt, *Harpophora maydis*: (A) susceptible host density; (B) climatic suitability (NAPPFAST map); (C) introduction potential; (D) integrated Pareto risk map.

Pareto from Denys Yemshanov CFS


Components of IAMS used in this analysis
Synoptic Scale Airflows Govern Transport Direction and Speed
Turbulent Diffusion and Wind Shear Govern Dilution
Turbulent Transport and Dilution in the Atmosphere
Ultraviolet Radiation
Temperature and Relative Humidity
Survival of Spores while Airborne
Vertical Distribution of Spores in Canopy
Canopy Density & Structure
Wind & Turbulence
Time of Spore Release
Escape of Spores from Canopy
Dry Deposition Due to Wind and Turbulence
Wet Deposition Due to Washout by Precipitation
Deposition of Spores into a Crop
Plant Growth Stage of Disease
Weather
Spore Production
Temperature & Leaf Wetness
Crop Growth Stage
Colonization of Crop
Isard et al. 2005 BioScience 55: 851-862.

APHIS

ZedX, Inc.

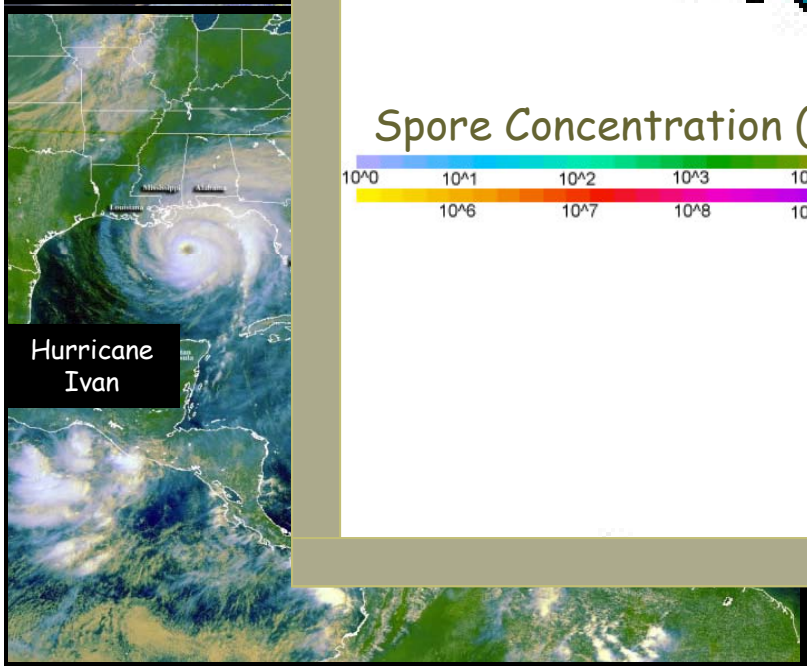
Aerobiological Risk Analysis for Soybean Rust

A project funded by APHIS to examine the risk of the aerial incursion of soybean rust into North America.

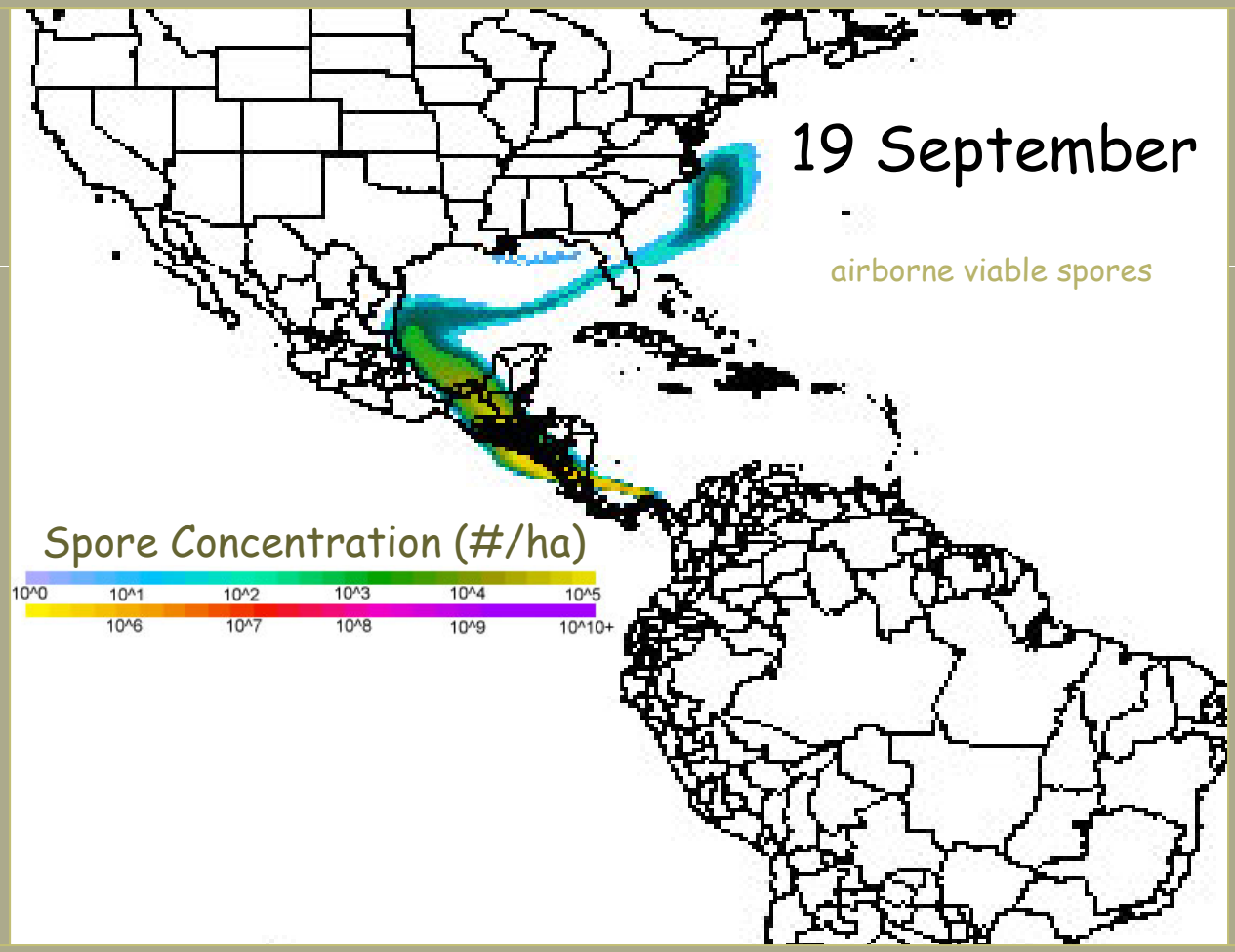
PENNSTATE

ILLINOIS

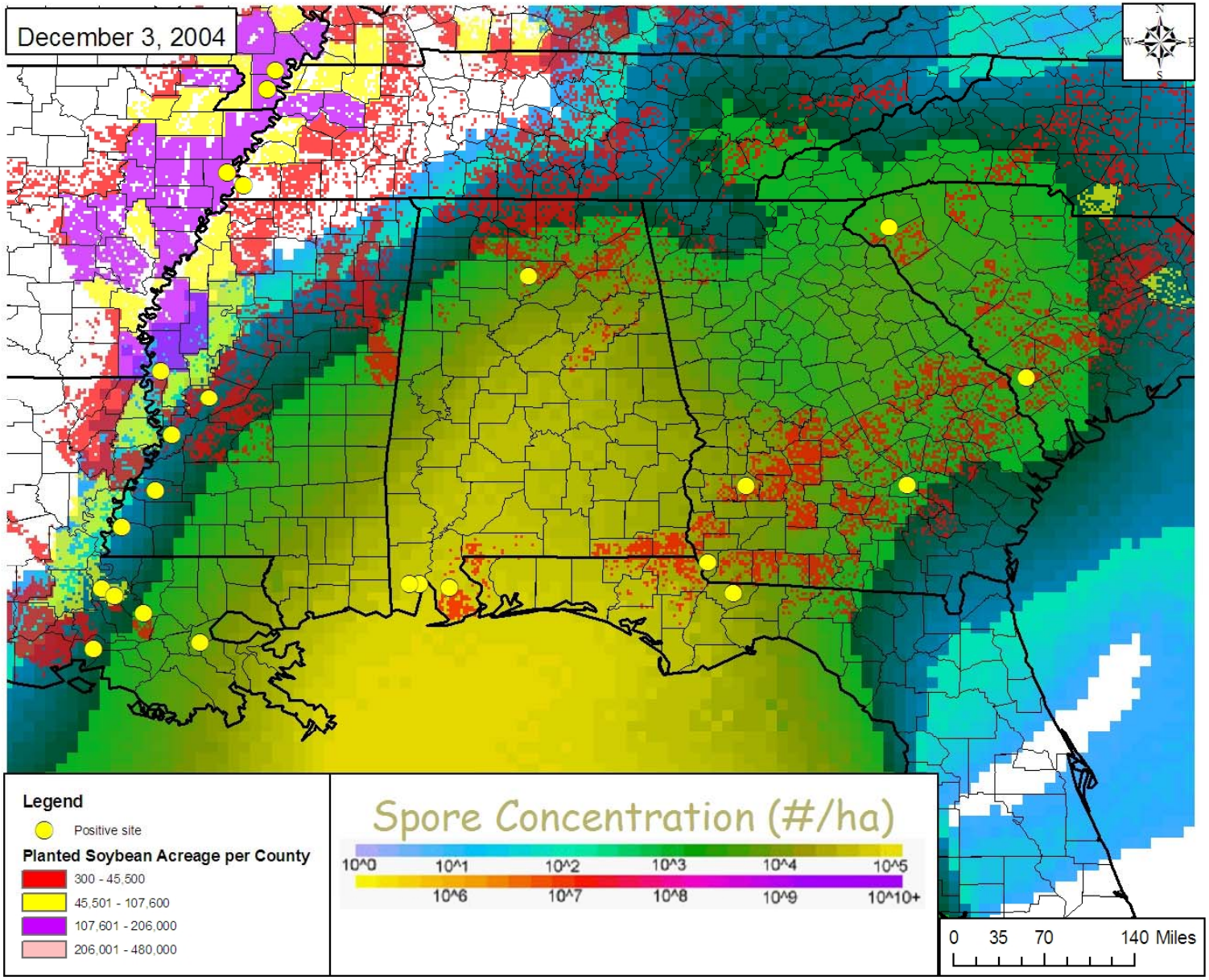
NC STATE UNIVERSITY



Hurricane Ivan



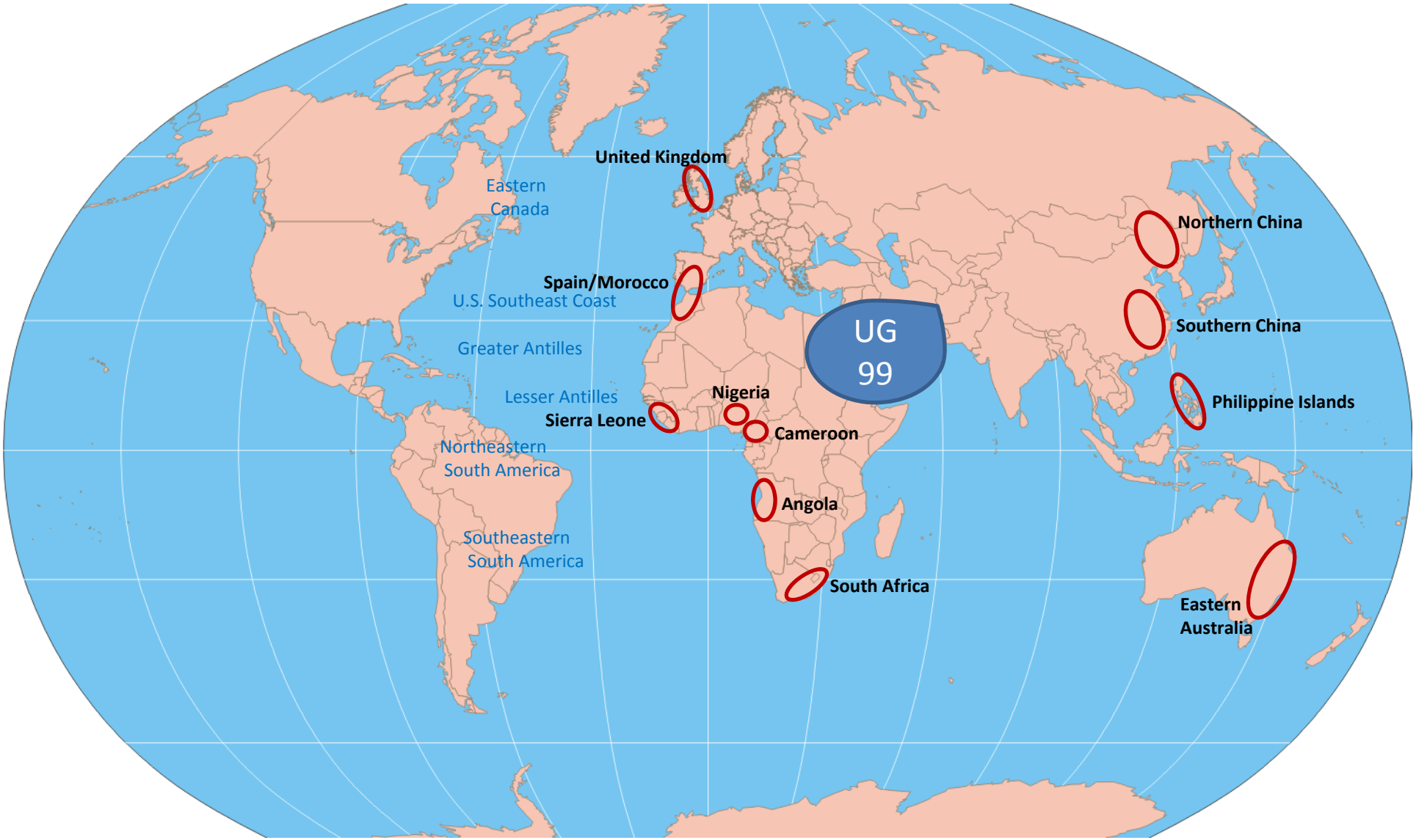
Scott Isard, PSU



Scott Isard, PSU

Atmospheric Transport (IAMS)

Potential Source Regions used in Analysis



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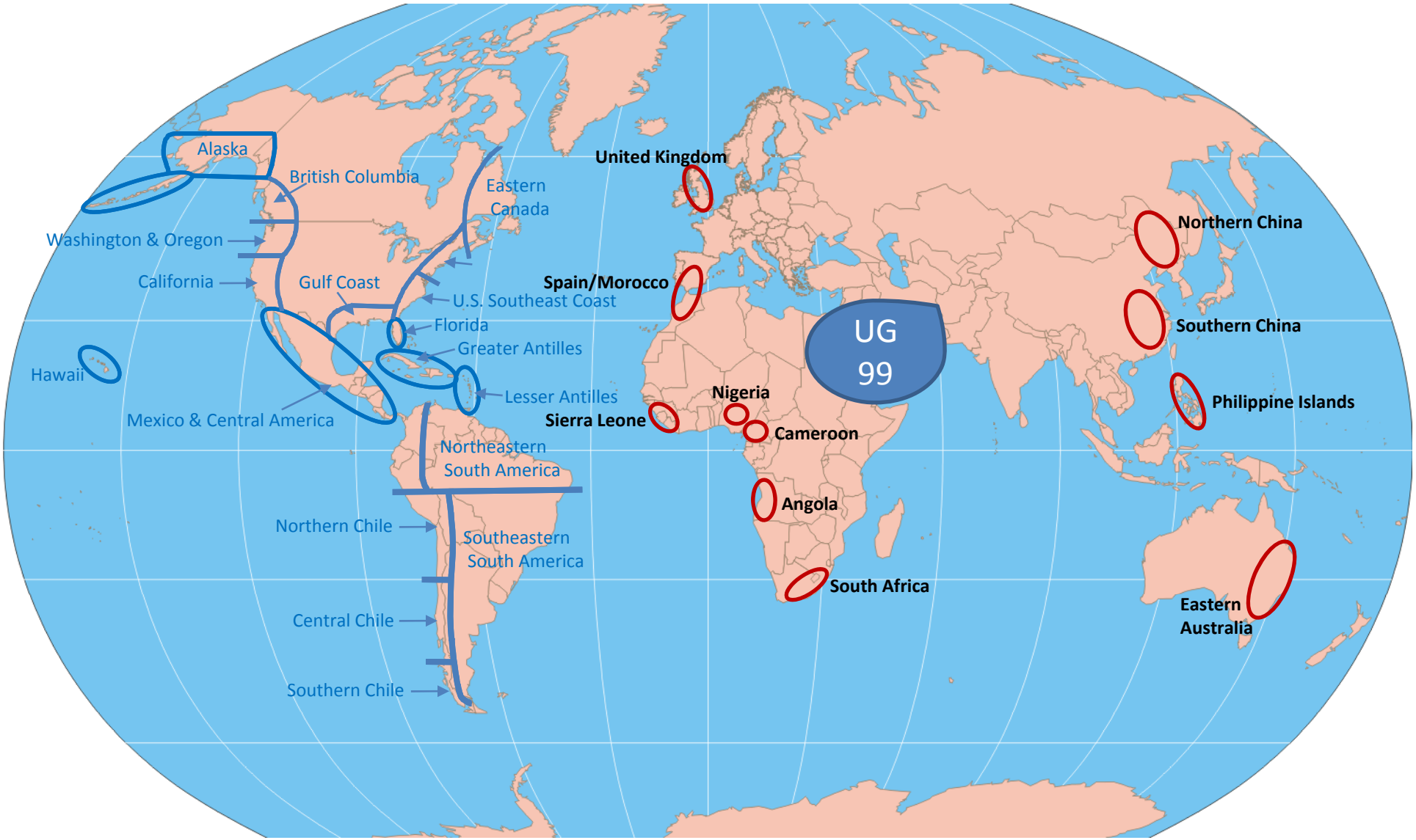
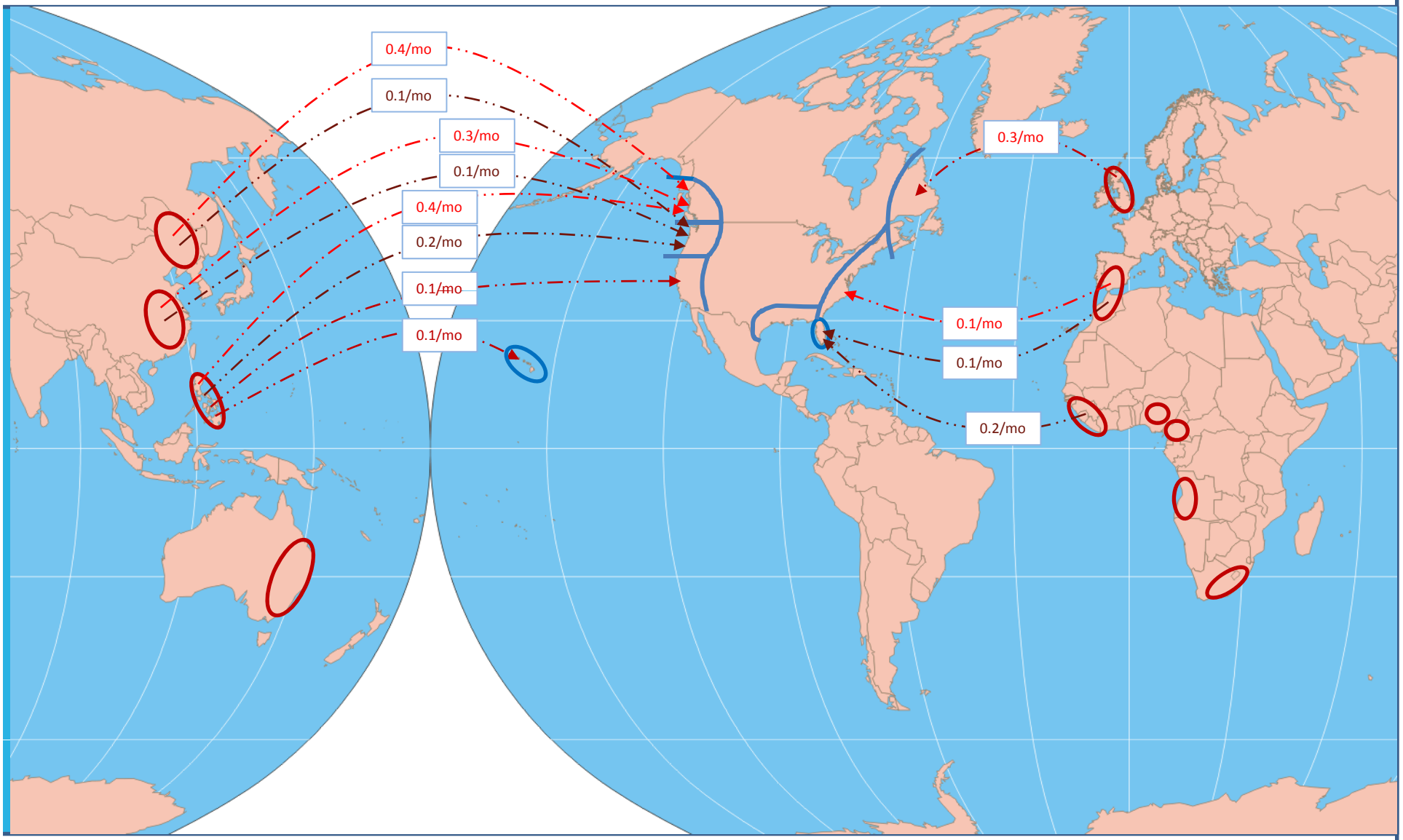


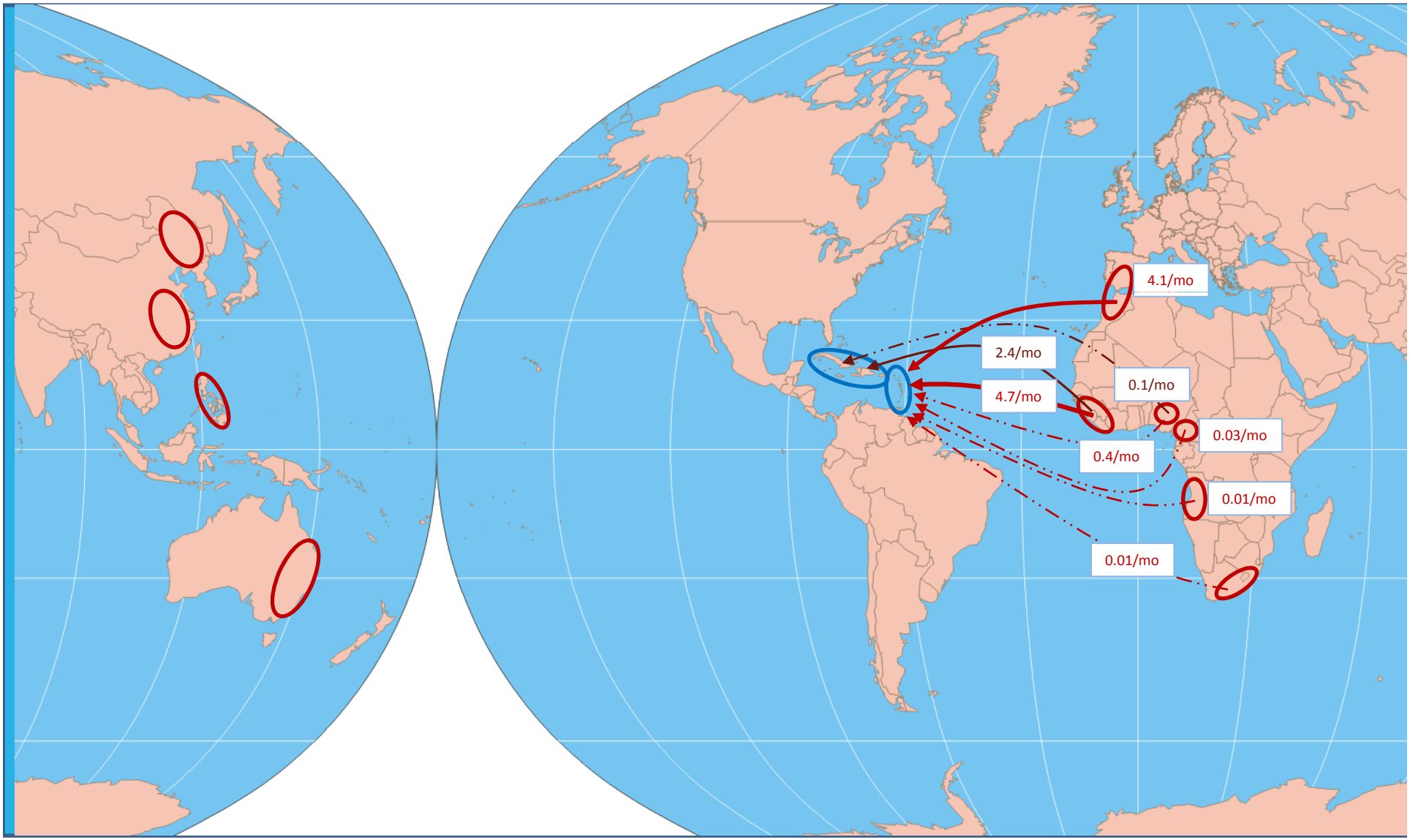
Scott Isard, PSU

Number of Days with Deposition of Viable Rust Spores from Eastern Hemisphere Source Regions in U.S. Destination Regions as Simulated by IAMS for 1998-2007 Averaged for Year



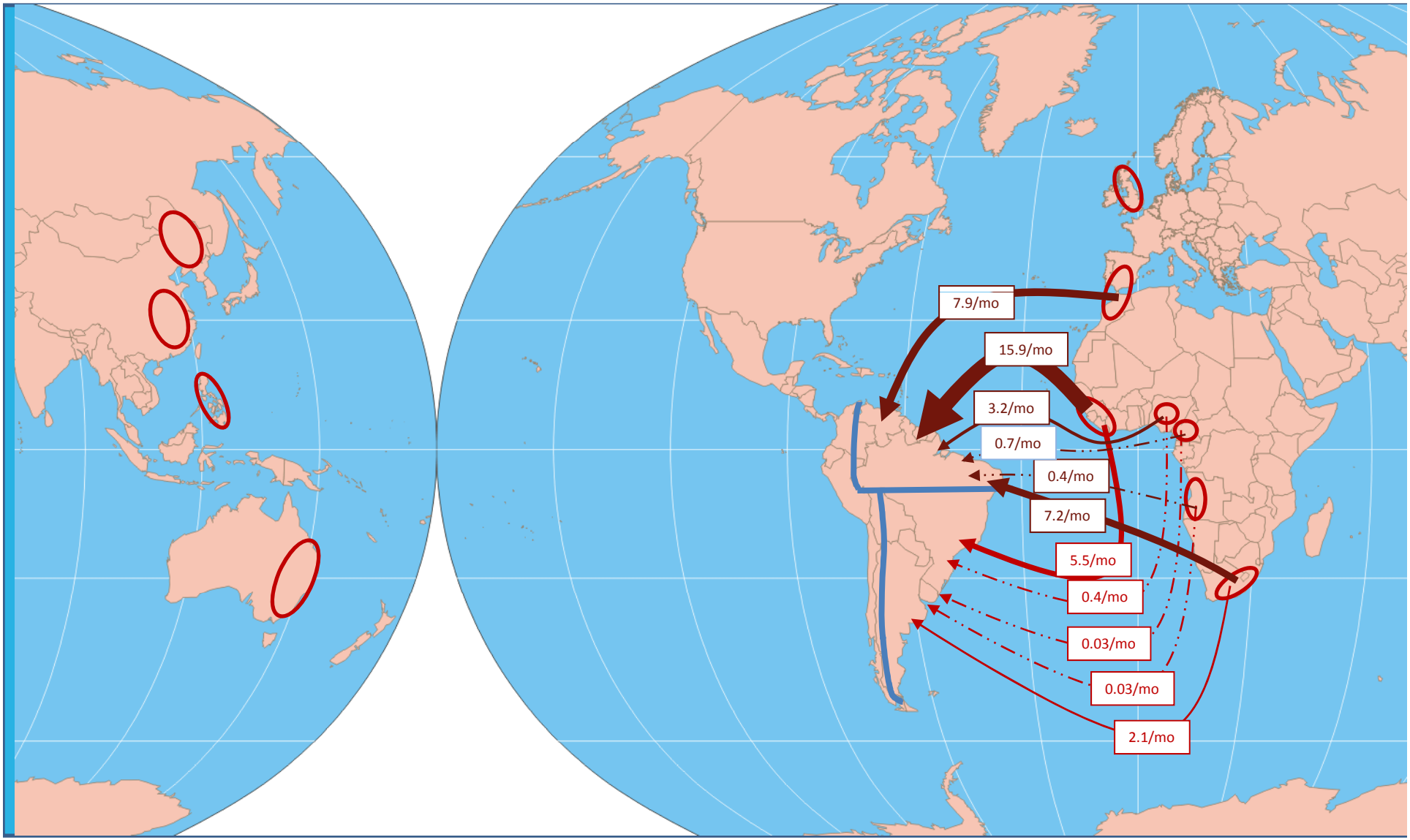
Scott Isard, PSU

Number of Days with Deposition of Viable Rust Spores from African Source Regions in the Caribbean Islands as Simulated by IAMS for 1998-2007
Averaged for Year



Scott Isard, PSU

Number of Days with Deposition of Viable Rust Spores from African Source Regions in Eastern South America as Simulated by IAMS for 1998-2007
Averaged for Year



Scott Isard, PSU

Challenges for prediction of emerging pests

Question	Modelling tool	Strengths/weakness
Which pests?	Self Organizing Maps	+ Data driven - Data dependent
What hosts?	Phylogenetics	+ Simple model - Only genera resolution
Where?	Freight analysis	+ Map pest entry points - Poor commodity and spatial resolution
	NAPPFAST	+ Simple parameters - Poor global spatial resolution - Simple models
	Integrated Atmospheric	+ Powerful tool - Complex parameters
	Modeling System	

Acknowledgements

Contribution	Who
Self Organizing Maps	Dr. Karl Suiter, CIPM-NCSU
Phylogenetics	Dr. Gregory Gilbert UCSC
Freight analysis NAPPFAST	Dr. Manuel Colunga-Garcia, MSU; Dr. Frank Koch US FS; Dr. Denys Yemshanov, CFS Dr. Daniel Borchert, APHIS-PPQ
Atmospheric Modeling	Dr. Scott Isard, PSU Dr. Joe Russo, ZedX
Funding	APHIS-PPQ-CPHST & PPQ-EDP
Review	Dr. Marina Zlotina, Dr. John Brightwell, CPHST

Parameters and Input Data for IAMS Simulations

- Grid spatial resolution was 0.083 degrees (~ 14 km),
- Vertical resolution was defined by the standard pressure levels (1000, 950, 900, 850, 800, 700, 600, 500 hPa)
- One hr time step.

- National Center for Environmental Prediction–Department of Energy Reanalysis 2 data set (Kalnay et al. 1996; Kanamitsu et al. 2002) for the 1998-2007 period

- Each simulation was initiated for 1 January 1998 with the daily spore production held constant for the duration of the 10-yr run.

- Nine grid cells (equivalent to about 125,000 ha at the Equator), distributed throughout a source area, were assumed to have a healthy crop and rust infection severity of 50%.

- Parameters for the spore release and escape, dispersion, mortality and deposition modules were those used in a previous soybean rust study (Isard et al 2007)

Scott Isard, PSU