A Comprehensive Threat Management Framework for a Crop Biosecurity National Architecture

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Conceptual Framework

DHS	NRC Study	APHIS
Anticipation	Deterrence	Protection
Prevention	Prevention	
Detection	Detection	Detection
Response	Response	Response
Recovery	Recovery	Recovery

A comparison of the conceptual framework of the DHS requisite national architecture with that proposed by NRC and USDA/APHIS.

Applying the Framework to Agriculture

- *Anticipation* primarily involves surveillance and modeling. Surveillance will be the monitoring of foreign pests in *offshore* locales using a variety of assets (e.g., human, remote sensing).
- *Prevention* involves improving our scientific understanding of the offshore pest so various strategies can be developed and assessed for their efficacy in preventing entry of the pest by either accidental or intentional means.
- *Detection* is the *onshore* monitoring for the foreign pest. Detection and Prevention are closely related. For example, genomic information for a pathogen might be the basis of a ground monitoring system used in a port of entry to scan for the presence of the pathogen.
- *Response* is the action that U.S. authorities and producers will take in the current growing season. For example, this pest management response may include an interdiction to destroy the infected crop or to apply a chemical treatment.
- *Recovery* is the action that U.S. authorities and producers principally take in future growing years. These might include alternate crops, development of resistant varieties, etc.

Anticipate/Awareness Perspective of Framework

1. Anticipate/Awareness
    1.1. Reference scenario
    1.2. Information gathering
        1.2.1. Conferences
        1.2.2. Partnerships
        1.2.3. Reports
        1.2.4. Archives
    1.3. Surveillance
        1.3.1. Space based remote sensing
        1.3.2. Human assets (e.g., USDA FAS)
    1.4. Modeling
        1.4.1. Pest
            1.4.1.1. Arrival times in US territory
            1.4.1.2. Environmental conditions (suitability of regions for establishment of pest)
                1.4.1.2.1. Weather & climatic conditions
                1.4.1.2.2. Soil conditions
                1.4.1.2.3. Water conditions
            1.4.1.3. Virulence or invasiveness of pest
            1.4.1.4. Propagation
        1.4.2. Economic
            1.4.2.1. Market projections
            1.4.2.2. Yield impacts
    1.5. Assets inventory
        1.5.1. Equipment
        1.5.2. Pesticides
            1.5.2.1. Section 18 needs assessment

Prevention Perspective of Framework

2. Prevention
   2.1. Historical analysis and case studies
      2.1.1. Lessons learned
      2.1.2. Gaps
      2.1.3. Points of entry
      2.1.4. Production area assessment
      2.1.5. Pathway protection
      2.1.6. First responders' actions
      2.1.7. Alternate hosts
      2.1.8. Pest propagation
         2.1.8.1. Spatial
         2.1.8.2. Temporal
      2.1.9. Conditions and characterizations
         2.1.9.1. Climatic
         2.1.9.2. Cultural management practices
      2.1.10. Mechanisms of introduction
         2.1.10.1. Anthropogenic
            2.1.10.1.1. Accidental
               2.1.10.1.1.1. Tourist
               2.1.10.1.1.2. Imported products
            2.1.10.1.2. Intentional
               2.1.10.1.2.1. Contaminated contraband (inadvertent)
               2.1.10.1.2.2. Terrorist
         2.1.10.2. Natural
            2.1.10.2.1. Weather systems
            2.1.10.2.2. Oceans
            2.1.10.2.3. Animal
            2.1.10.2.4. Land bridge

Prevention Perspective of Framework

- 2.2. Analysis of current Government programs and policies
  - 2.2.1. Gaps
  - 2.2.2. Recommendations and updates to programs and policies
- 2.3. Strategies to prevent or delay entry
  - 2.3.1. Continuous surveillance
  - 2.3.2. Delaying tactics
- 2.4. Modeling
  - 2.4.1. Pest
    - 2.4.1.1. Arrival times in US territory
    - 2.4.1.2. Environmental conditions (suitability of regions for establishment of pest)
      - 2.4.1.2.1. Weather & climatic conditions
      - 2.4.1.2.2. Soil conditions
      - 2.4.1.2.3. Water conditions
    - 2.4.1.3. Virulence or invasiveness of pest
    - 2.4.1.4. Propagation
  - 2.4.2. Economic
    - 2.4.2.1. Market projections
    - 2.4.2.2. Yield impacts
- 2.5. Technology gaps and research requirements
  - 2.5.1. In situ detection systems
  - 2.5.2. Remote sensing systems
  - 2.5.3. Models
  - 2.5.4. Integrated system (end-to-end control system)
- 2.6. Socio-economic & psychological gaps
- 2.7. Education and outreach
  - 2.7.1. Awareness of threat
  - 2.7.2. Awareness of plan

Detection Perspective of Framework

3. Detection
    - 3.1. Detection systems
        - 3.1.1. Ground based infrastructure
            - 3.1.1.1. PCR
                - 3.1.1.1.1. Genomic
            - 3.1.1.2. Sentinel plots
            - 3.1.1.3. Traps
                - 3.1.1.3.1. Insect
                - 3.1.1.3.2. Spore
                    - 3.1.1.3.2.1. Air (filters)
                    - 3.1.1.3.2.2. Water (deposition in rainfall)
                - 3.1.1.3.3. Other
            - 3.1.1.4. Handheld instruments
                - 3.1.1.4.1. Spectroradiometers
                - 3.1.1.4.2. Specialized instruments
        - 3.1.2. Remote sensing systems
            - 3.1.2.1. Space based remote sensing
            - 3.1.2.2. Aircraft based remote sensing
        - 3.1.3. Human assets
            - 3.1.3.1. Field scouts and consultants
            - 3.1.3.2. Producer
            - 3.1.3.3. Regulatory (e.g., APHIS, state)
            - 3.1.3.4. CSREES National Plant Diagnostics Network
            - 3.1.3.5 Rapid Pathogen Identification to the Delivery of Cures Act (RAPID Cures Act) Bill (sponsored by U.S. House of Representatives)

Detection Perspective of Framework

3.2. Validation of detection systems
- 3.2.1. Identification and control guidelines
- 3.2.2. Procedures for collection, analysis, verification, and actions

3.3. Technology gaps, research gaps, and updates to detection guidelines (national strategic plans)

3.4. Socio-economic & psychological gaps

3.5. Education and outreach
- 3.5.1. Identification of threat
- 3.5.2. Detection plan

Response Perspective of Framework

4. Response - current growing season
   - 4.1. Communications
     - 4.1.1. Post-detection information dissemination network
       - 4.1.1.1. Pest specific
   - 4.2. Implement pest specific response plan
     - 4.2.1. Forecasting impact
       - 4.2.1.1. Regional
       - 4.2.1.2. National
     - 4.2.2. Acquire assets for mitigation
       - 4.2.2.1. Equipment
       - 4.2.2.2. Chemicals
   - 4.3. Incident response
     - 4.3.1. Initiate appropriate action plan
       - 4.3.1.1. Pest specific
       - 4.3.1.2. APHIS guidelines
     - 4.3.2. Pest management response
       - 4.3.2.1. Sanitation
       - 4.3.2.2. Chemical response
         - 4.3.2.2.1. Preventive treatment
         - 4.3.2.2.2. Curative treatment
       - 4.3.2.3. Replacement crops
       - 4.3.2.4. Alternative crops
       - 4.3.2.5. No response alternative
         - 4.3.2.5.1. Policy and regulatory impacts

Response Perspective of Framework

- 4.3.3. Technical support
  - 4.3.3.1. Assemble team of experts
  - 4.3.3.2. Communications
- 4.3.4. Monitoring and assessments
  - 4.3.4.1. Determine efficacy of response actions
  - 4.3.4.2. Adjust response actions as needed
- 4.4. Technical gaps and research requirements
- 4.5. Socio-economic & psychological gaps
- 4.6. Education and outreach
  - 4.6.1. Educating public about the threat
  - 4.6.2. Actions required to minimize spread of event

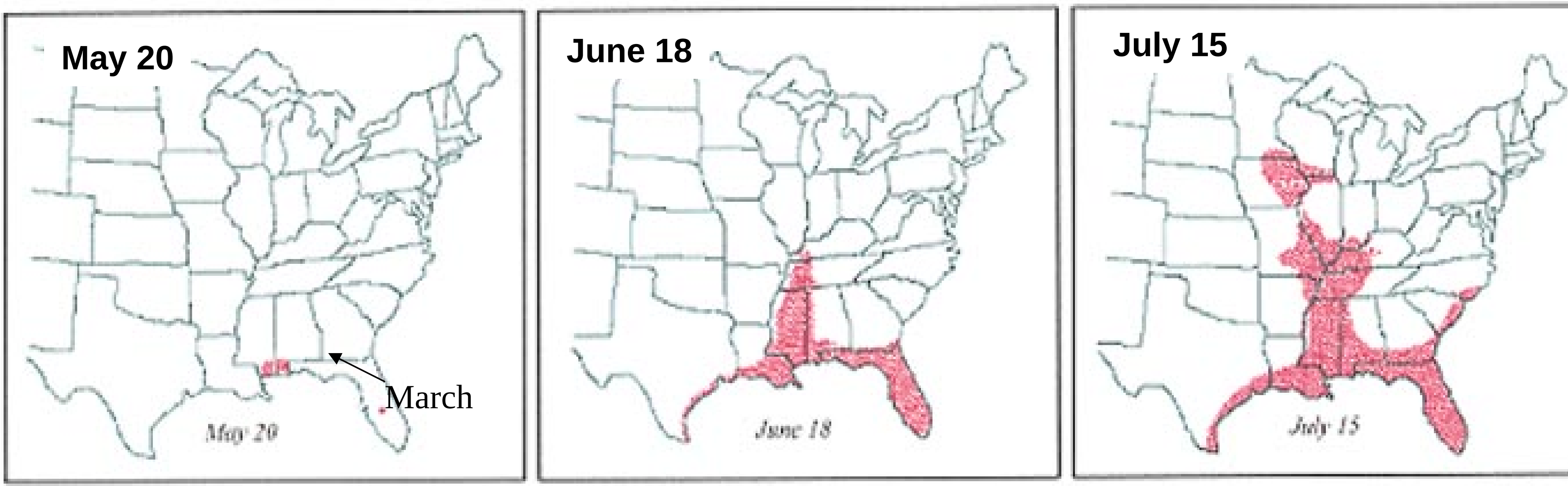
Recovery Perspective of Framework

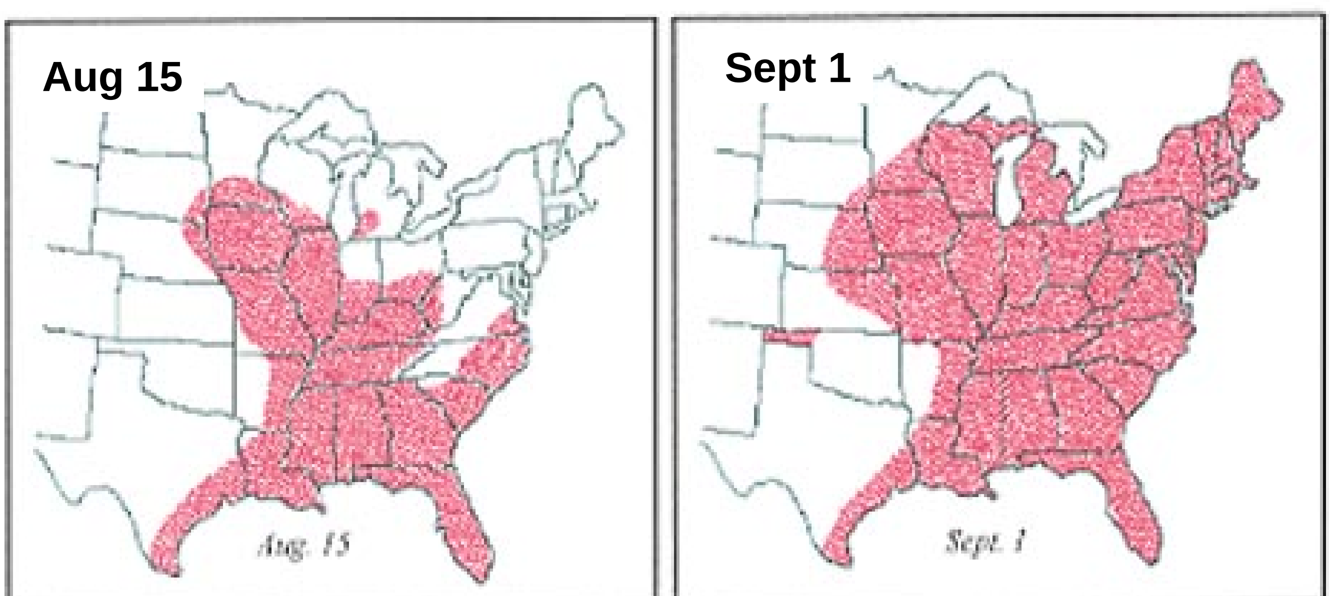
5. Recovery – future crops/growing seasons
    - 5.1. Update end-to-end system (new specifications for component systems)
        - 5.1.1. Technology insertion
        - 5.1.2. Government programs and policies
    - 5.2. Monitor recovery
    - 5.3. Communication
    - 5.4. Validate recovery
    - 5.5. Forecast future incidents
        - 5.5.1. Identify sources of inoculant
        - 5.5.2. Identify relationship between disease parameters and climate
    - 5.6. Update mitigation procedures
        - 5.6.1. Resistant variety
        - 5.6.2. Cultural practice
            - 5.6.2.1. Crop residue management
            - 5.6.2.2. Sanitation
        - 5.6.3. Chemical response
            - 5.6.3.1. Preventive treatment
            - 5.6.3.2. Curative treatment
            - 5.6.3.3. Section 18 needs assessment
        - 5.6.4. Alternative crop strategies
    - 5.7. Socio-economic & psychological gaps
    - 5.8. Education and outreach

Entry Pathways and Modeling

- Rust spores are disseminated efficiently by wind over large distances, and can survive in the environment and establish reservoir infections in other plant species (e.g., other leguminous crops, as well as wild species such as kudzu).
- Delivery on crop debris via imports.
- Inadvertent delivery via tourists returning from infested areas.
- Bioterrorism.

Worst case scenario - southern leaf blight of corn in 1970 (*Moore, Plant Disease:1970*).





Quick spread was due to favorable weather and no resistance in corn belt in that year

Understanding of Environmental Conditions on Pathogen

- Development of Phakopsora pachyrhizi at different temperatures, relative humidities and leaf wetness durations using potted specimens.

Understanding of Environmental Conditions on Pathogen

- 15, 19, 21, 24, 26, 28 and 30°C
- 6, 9, 12, 14 and 16hr
- 75, 85 and 95%RH
- Number of pustules/lesion and lesion size on abaxial and adaxial leaf surface calculated

Results

- Infection did not occur on plants incubated at 15°C and 30°C at 85% or 95%RH
- Infection did not occur on plants incubated at 15°C, 19°C and 30°C at 75%RH
- Number of pustules/lesion and lesion size increased with increasing leaf wetness duration
- With correct environmental conditions SBR can infect plant at any stage.
- This is RSA research. What may happen as US researchers begin to conduct research on SBR spores? What impact is there that there is limited US research?
- What is lacking for US researchers? The most obvious example is the lack of containment facilities to work with listed agents.

US Soybean Rust Detection and Aerobiological Modeling November, 2004

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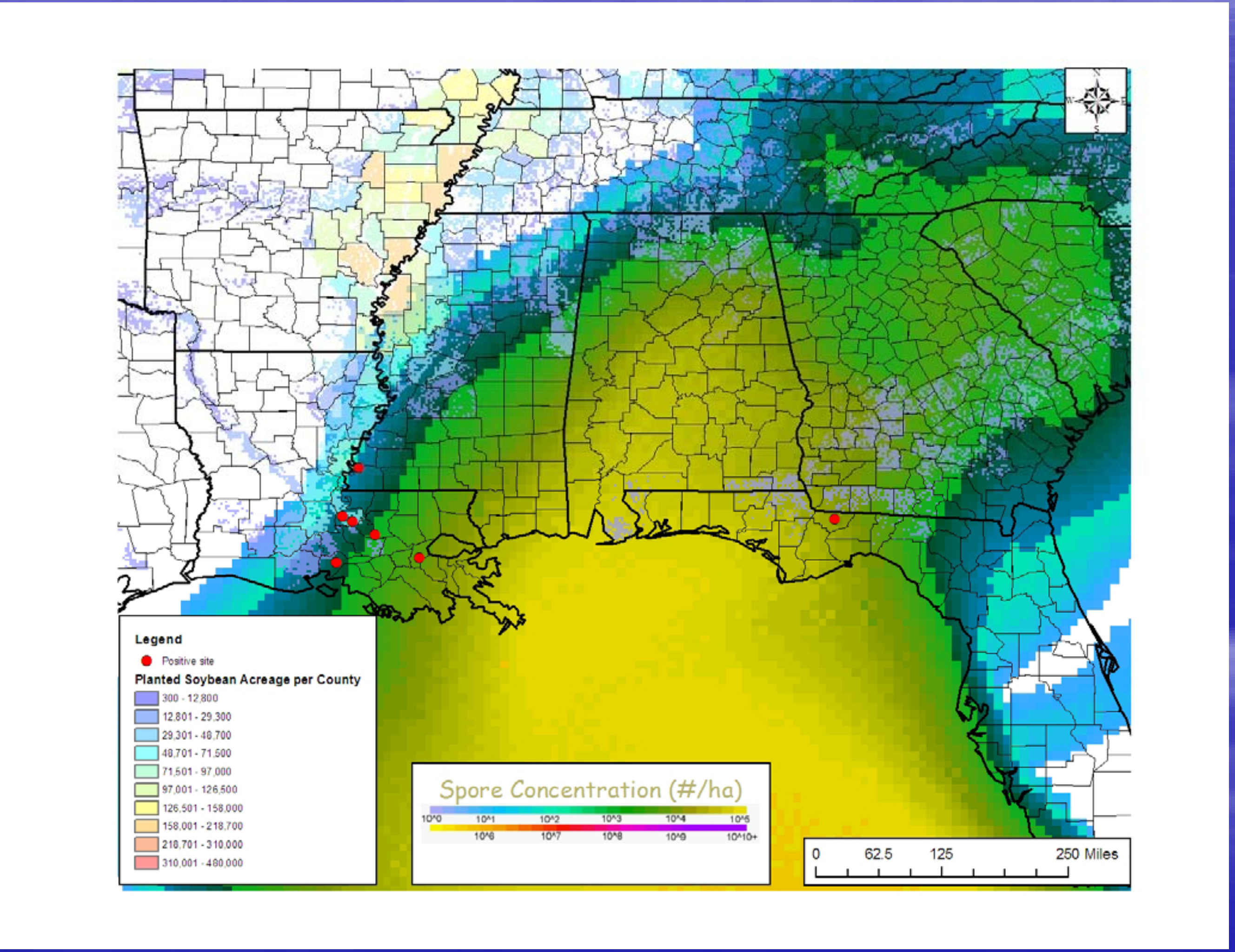
Soybean Rust Spore Deposition and Planted Soybean Acreage per County



Overwintering of Spores

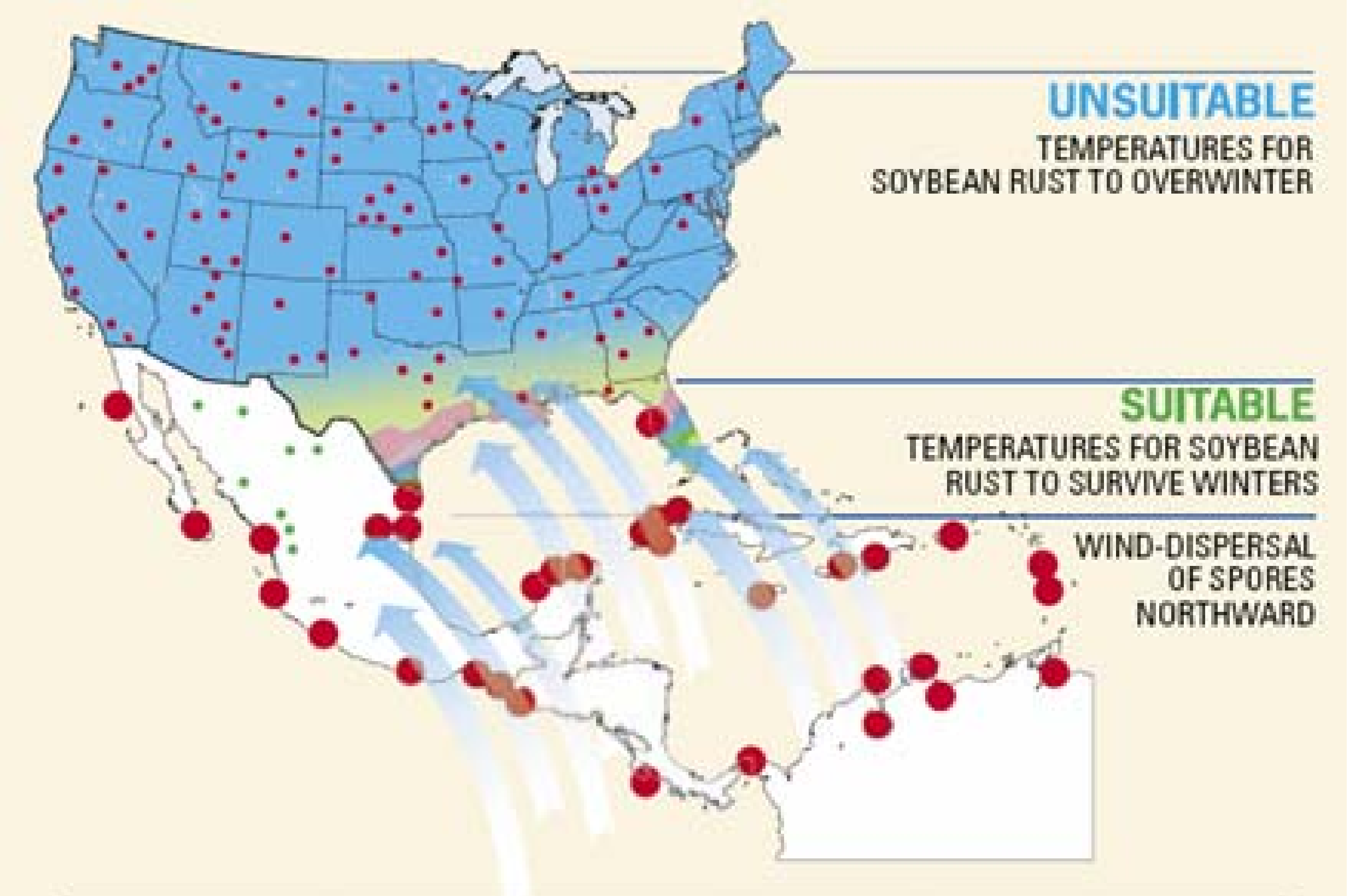
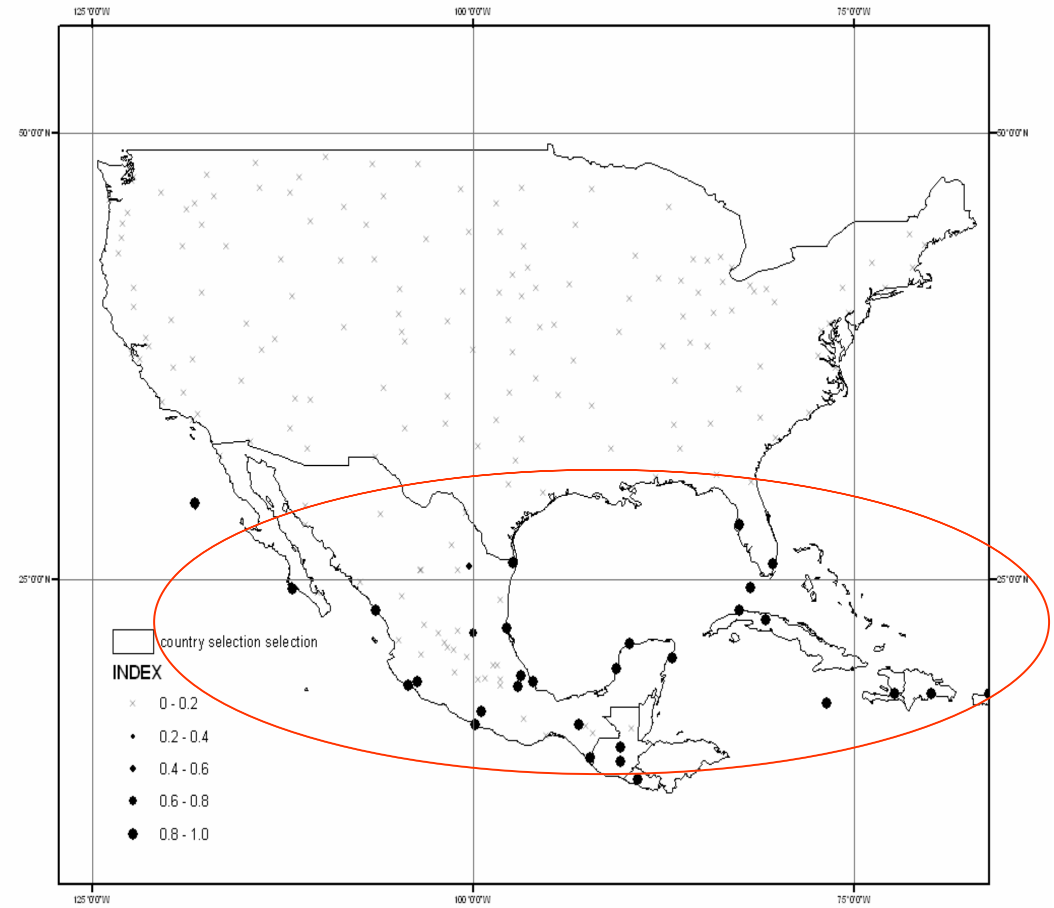


Figure 7. Potential sites in North America, Caribbean, Central America, and South America where soybean rust may overwinter. (Yang et al., 2004)

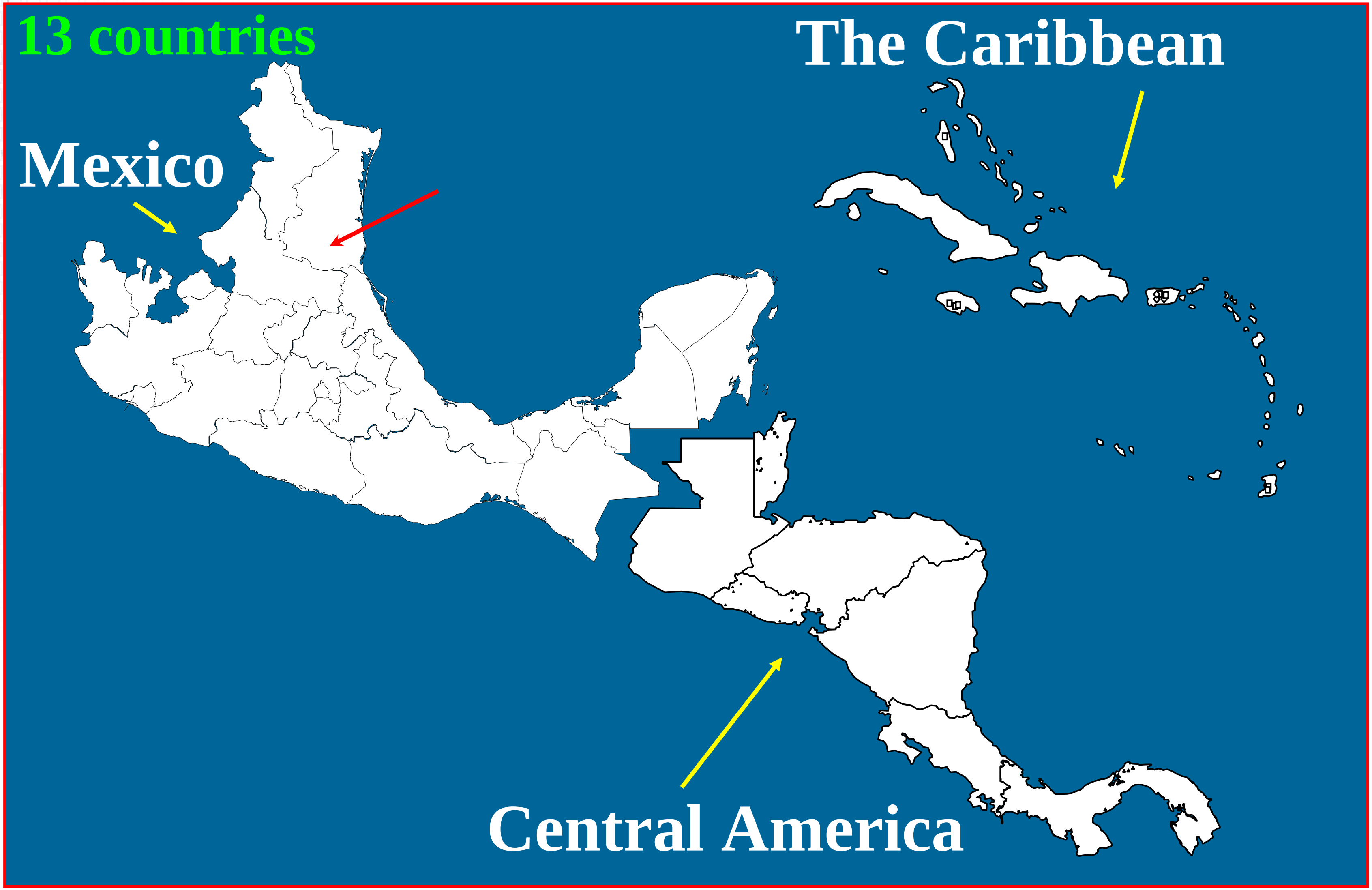
Understand the Viability of Non-South American Spore Sources

Determine the distribution of alternative hosts of *P. pachyrhizi* in Central America, the Caribbean and Mexico.



Analyze the host availability periods in these regions and their potential for spore production and dispersal of *P. pachyrhizi* to the continental USA.

Regions Investigated



Hosts Selected

Fabaceae:

Papilionoideae

Soybean (*Glycine max*)

Kudzu (*Pueraria lobata*)

Yam bean (*Pachyrhizus erosus*)

Cowpea (*Vigna unguiculata*)

Pigeon pea (*Cajanus cajan*)

Hyacinth bean (*Lablab purpureus*)

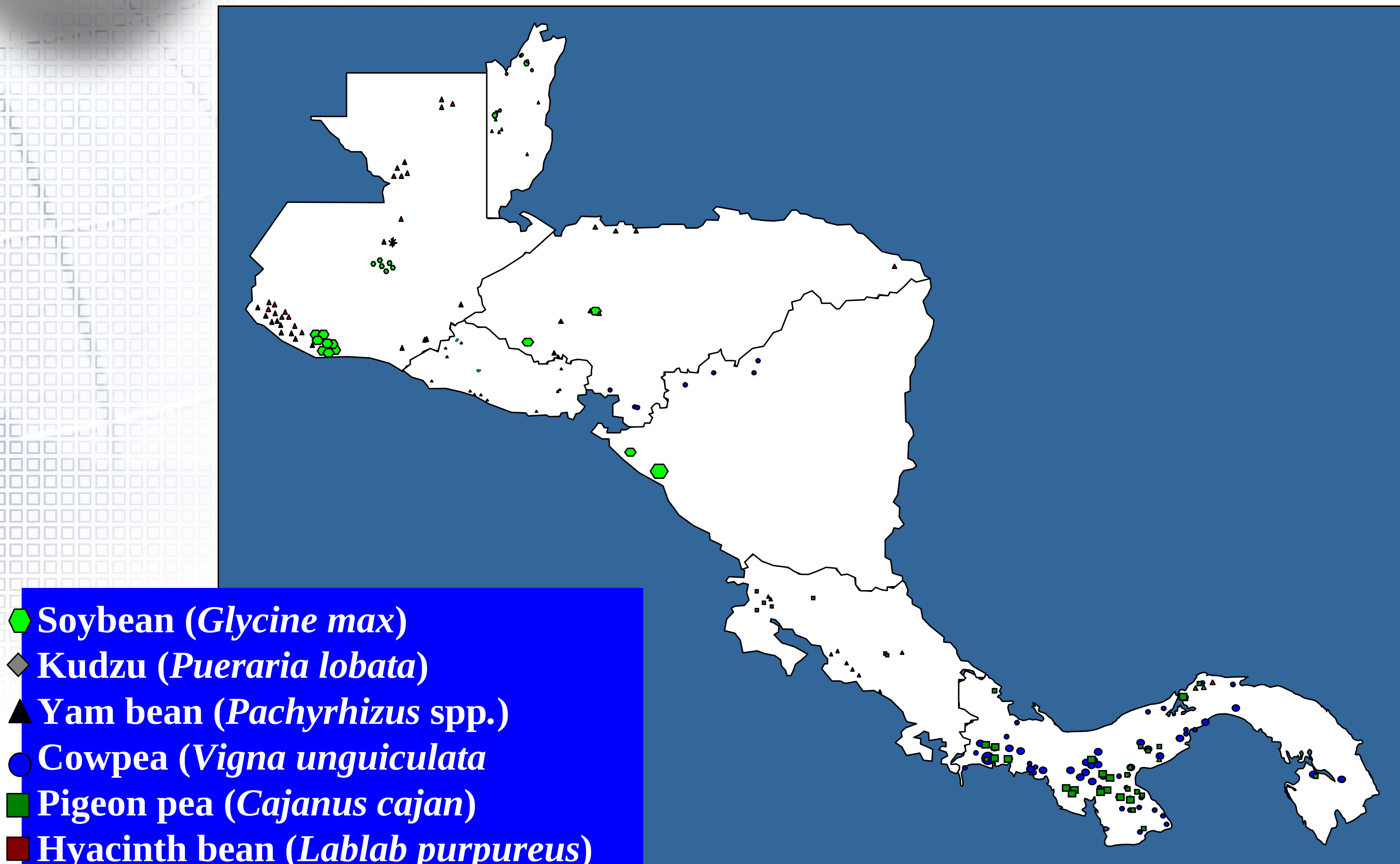
Why we selected these hosts?

- Most of them are cultivated species in the countries investigated in this study.
- Reported as functional hosts in areas where specific pathotypes of the fungus and specific strains of legumes coexist.

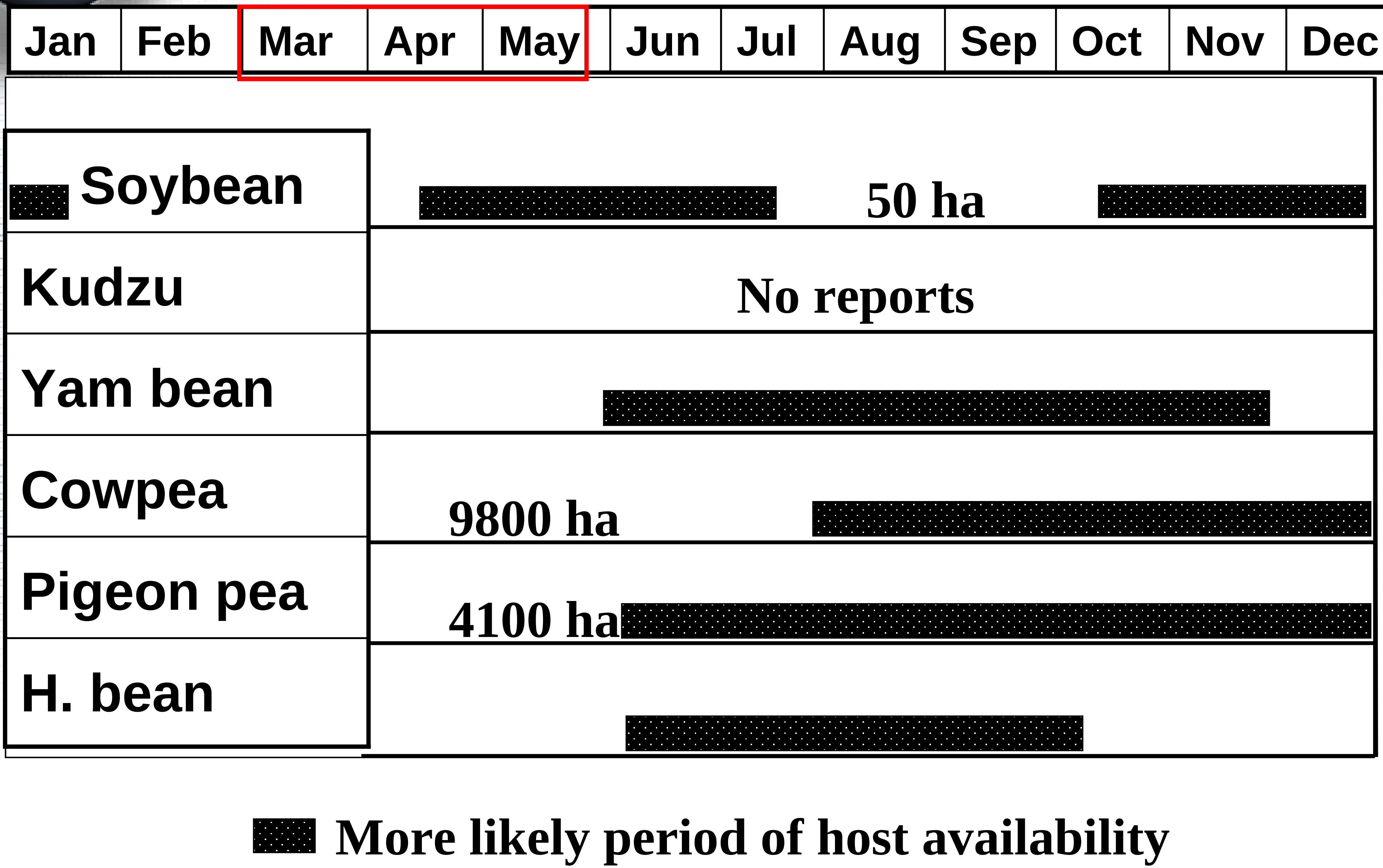
Data Collection

- Information of interest
  - Reports of the presence of each host in each region (at least in the last 5 years).
  - Planting and harvesting dates of each species (annual occurrence).
  - Total area grown of each host.

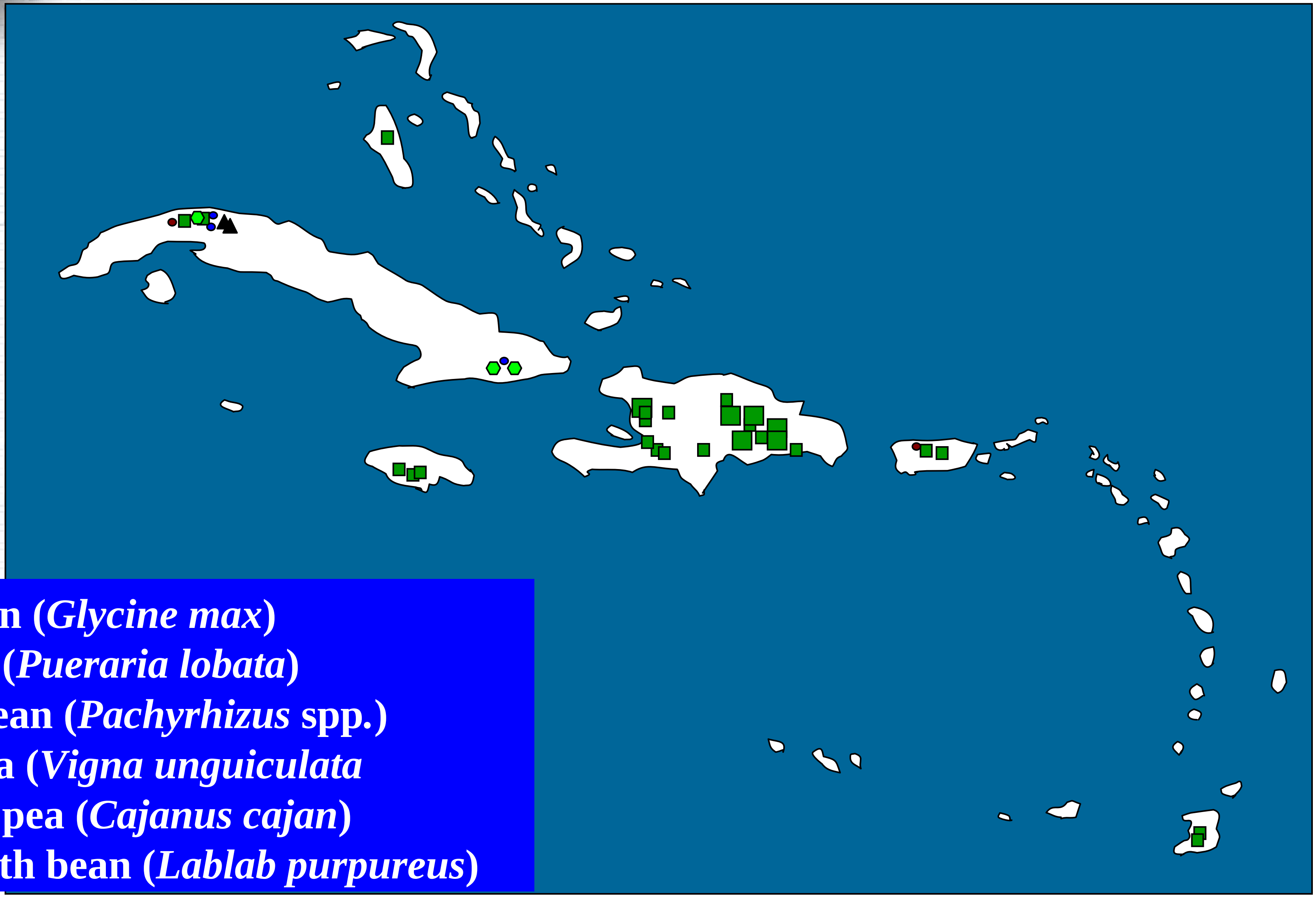
Distribution of SBR hosts in Central America



Host Availability Periods in Central America

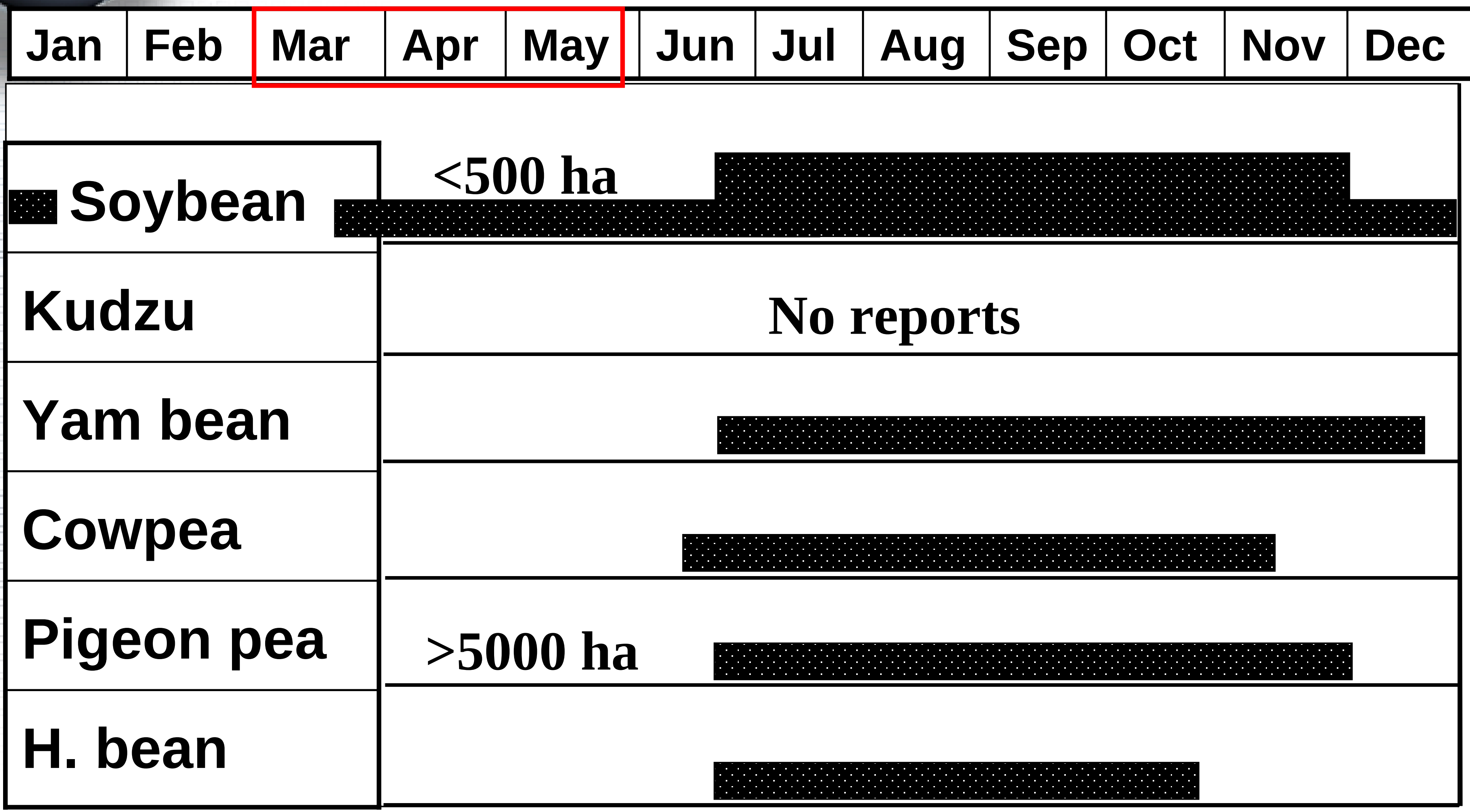


Map of Hosts Distribution in the Caribbean



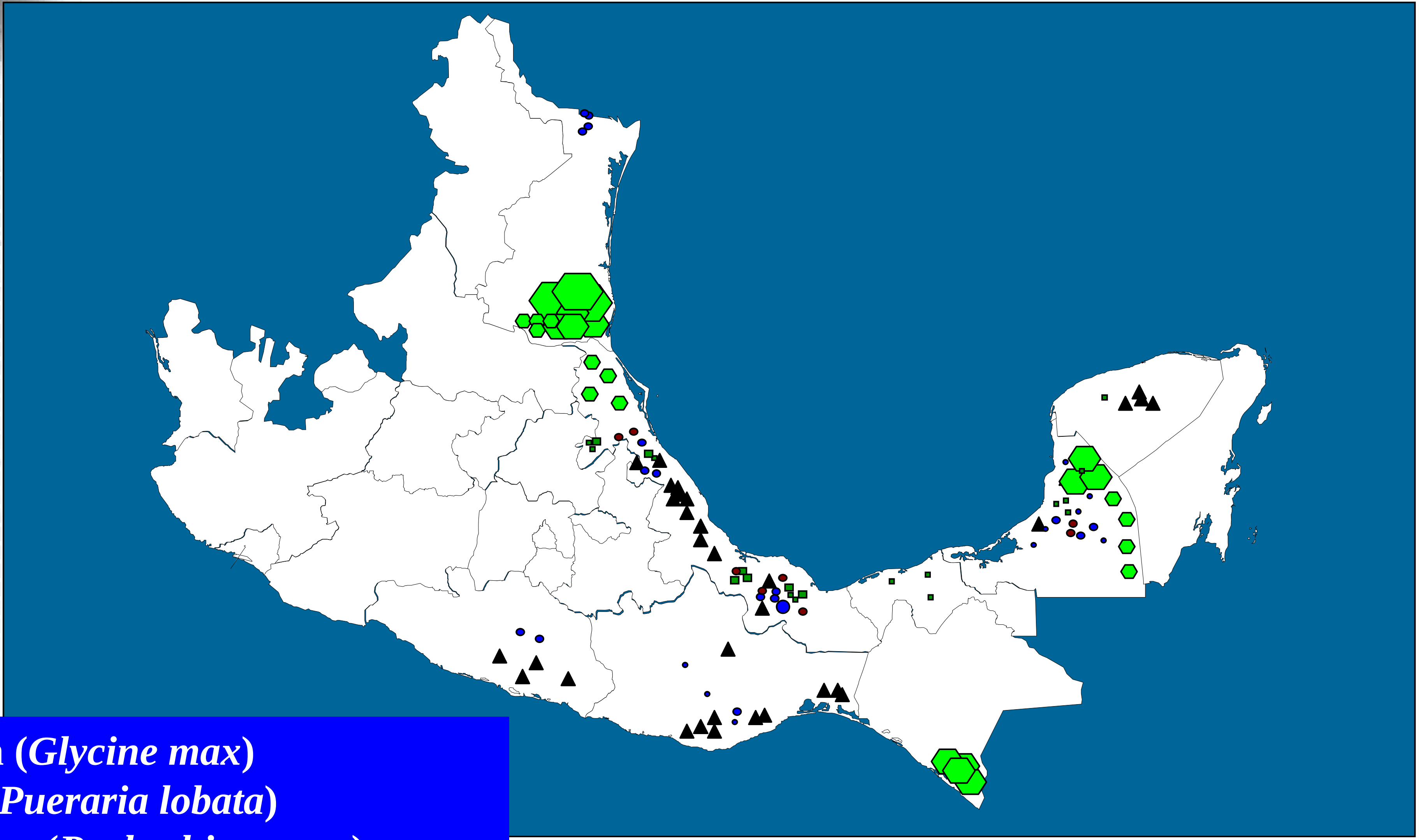
Soybean (*Glycine max*)
Kudzu (*Pueraria lobata*)
Yam bean (*Pachyrhizus* spp.)
Cowpea (*Vigna unguiculata*
Pigeon pea (*Cajanus cajan*)
Hyacinth bean (*Lablab purpureus*)

Host Availability Periods in the Caribbean



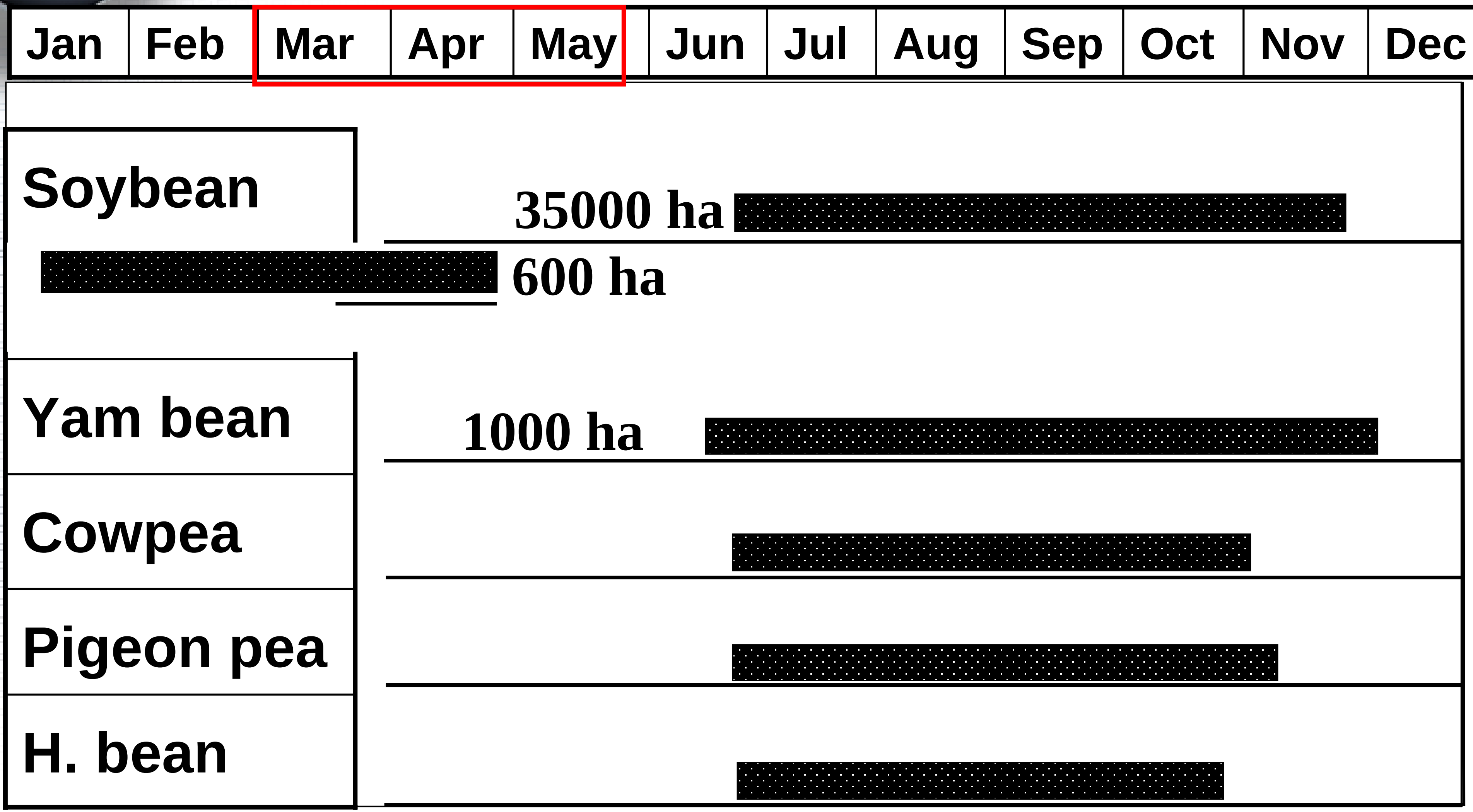
More likely period of host availability

Hosts Distribution in Mexico



Soybean (*Glycine max*)
Kudzu (*Pueraria lobata*)
Yam bean (*Pachyrhizus* spp.)
Cowpea (*Vigna unguiculata*
Pigeon pea (*Cajanus cajan*)
Hyacinth bean (*Lablab purpureus*)

Host Availability Periods in Mexico



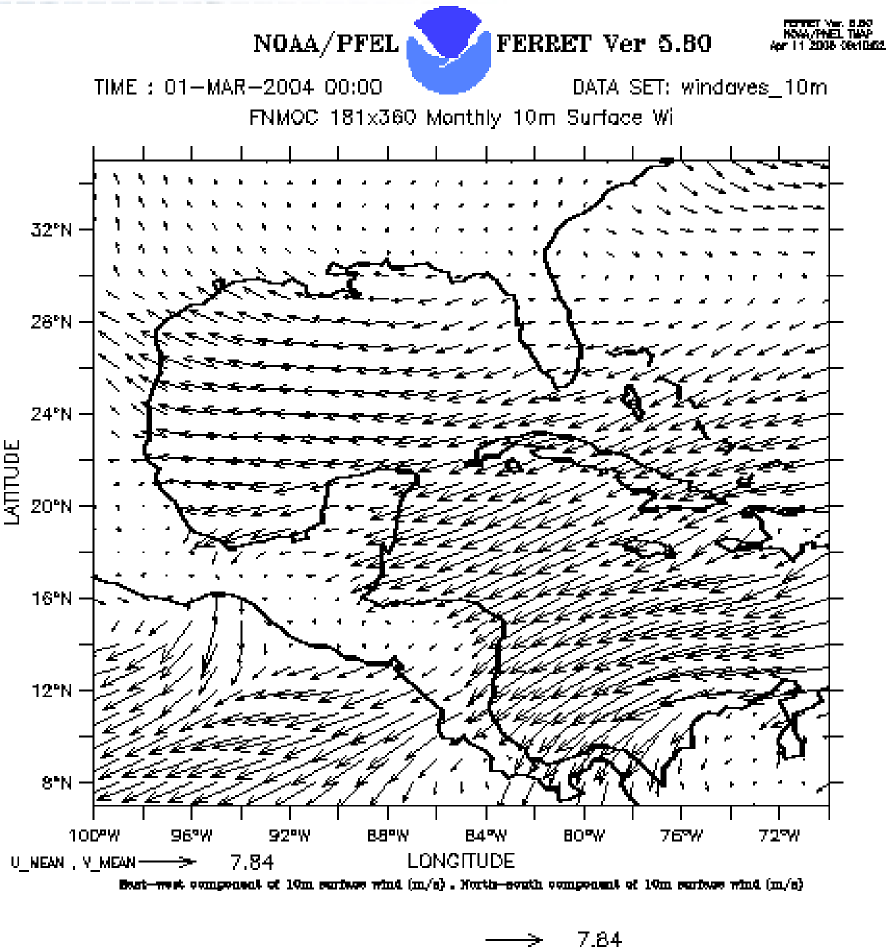
More likely period of host availability

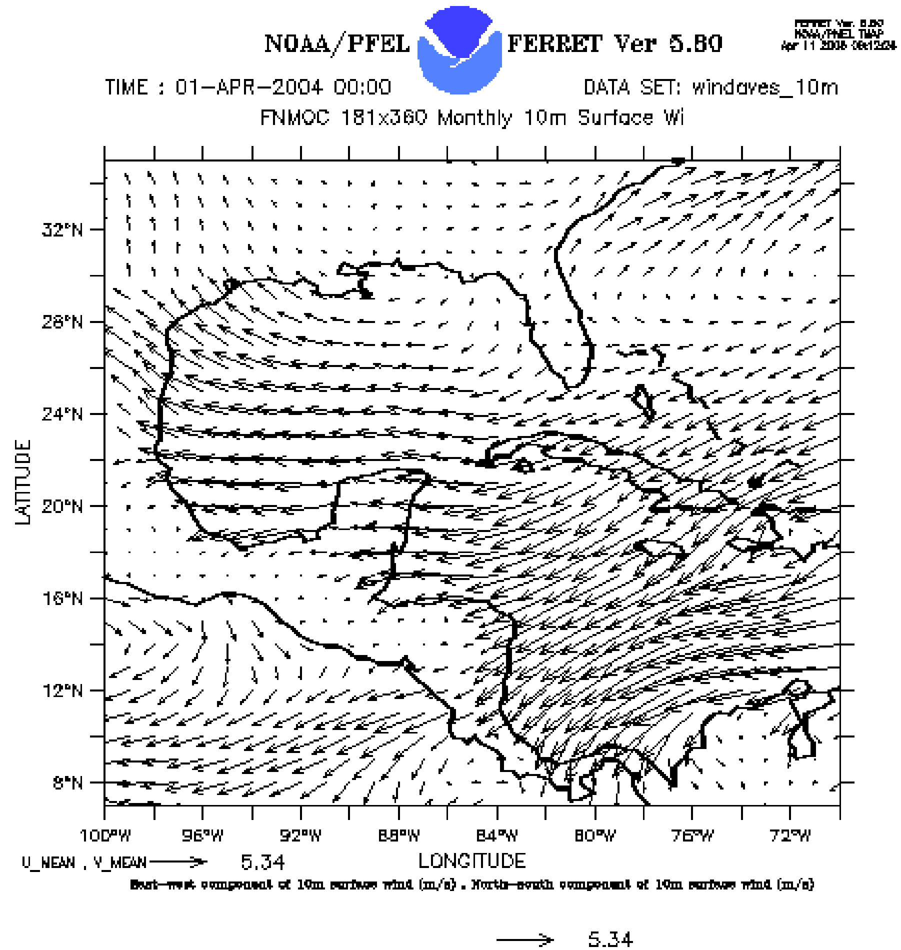
Kudzu (*Pueraria lobata*) is not present in Mexico

Rainy and Dry Season in the Regions Studied

	Rainy Season	Dry season
Panama	May-December	January-April
Honduras	May-November	December-April
Guatemala	May-October	November-April
Cuba	May-October	November-April
Dom. Rep.	May-November	December-April
Puerto Rico	June-November	December-May
Mexico	June-December	January-May

Prevailing Winds (surface winds) During the Critical Months of the Year





Summary

- Potential alternative hosts of the pathogen are present in Central America, the Caribbean and Mexico.
- Central America and Caribbean are unlikely the source regions of soybean rust to the US because host availability is minimum in early spring.
- In Mexico, south Tamaulipas is the only area with potential as source region.

Crop Surveillance System Requirements

- System must detect subtle changes in plant health and environmental conditions in their earliest stages, before the effects of a disease outbreak or environmental conditions can become widespread and devastating.
- Spatial resolution
  - Sufficient to detect significant changes to crop health
  - Coarse enough to be practical.
- Temporal resolution
  - Sufficient to detect unexpected changes in crop health within days.
- Affordable

Field on Right is Infected with SBR

Have field boundaries, but unable to find any high resolution imagery of area during time period of interest.

Crop Surveillance Methods – Insitu Methods

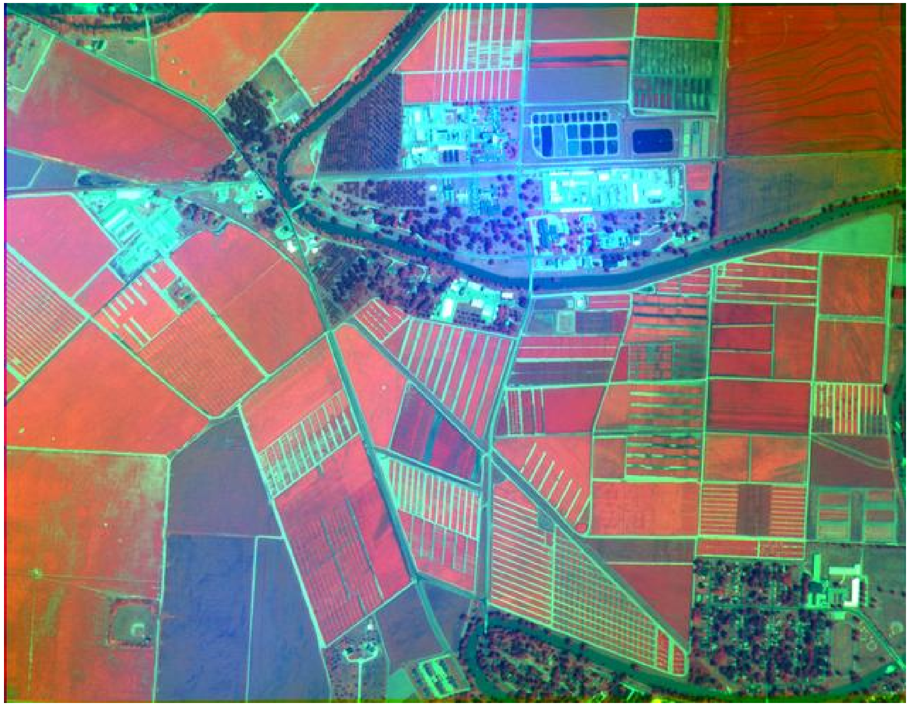
- ❑ Small number of data points
- ❑ Limited coverage
- ❑ Labor intensive
- ❑ Expensive
- ❑ Vulnerable to politics
- ❑ Accurate
- ❑ Not limited to surface
- ❑ Day/night all-weather

Results

- In 2005 spore traps were established in many states.
- However, they were of limited value because collected test urediniospores could not be identified as to the type of rust.
- Information released on finding the unidentified spores in traps alarmed producers and promoted the unnecessary sales and application of fungicide.
- Spore trapping has merit because it could potentially represent the earliest detection method.
- However, guidelines about when to release findings based solely on visual identification need to be established.

Crop Surveillance Methods – Remote Sensing

- Large number of data points
- Large coverage
- Can be automated
- Relatively inexpensive
- Ignores politics
- Can be inaccurate
- ~Limited to surface
- Affected by atmosphere



Remote sensing is the only method that can be used today to monitor large areas.

Surveillance System Considerations

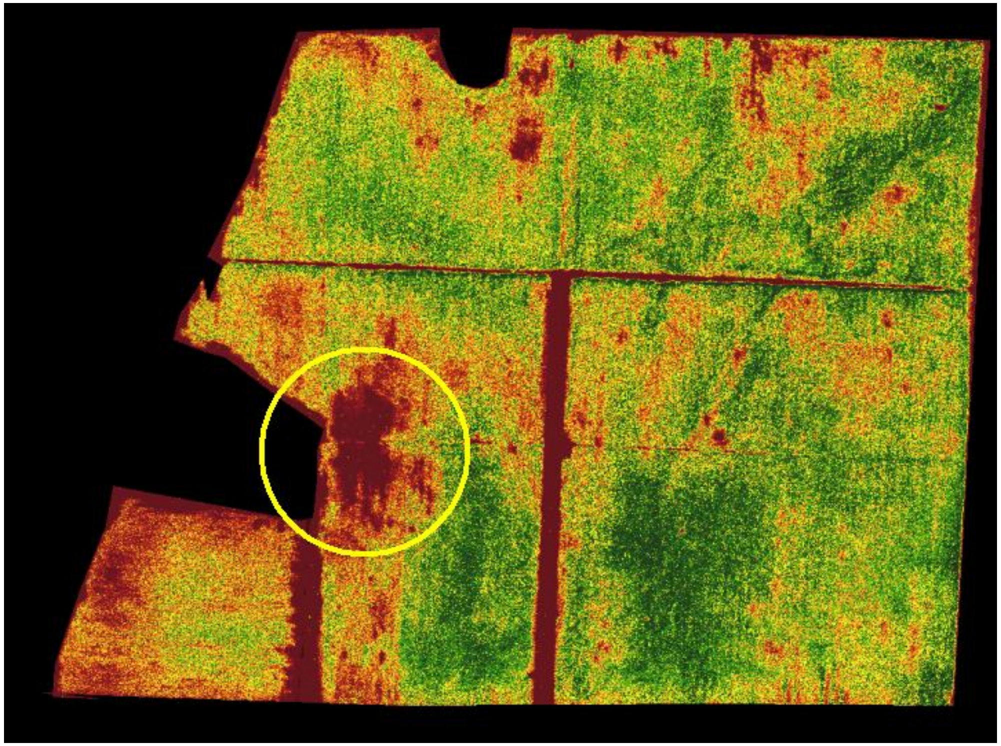
- Total system will require all source solution.
- Remote sensing will be dominant component.
- Cloud statistics and cost of launching future systems will require use of many systems including international ones.
  - Some places in the world could require active airborne solutions
- Problem can be cast as a detection/estimation problem.

Surveillance System Issues

- Interoperability of a variety systems
  - Spatial Scales
    - 1-1000 m range
  - Time Scales
  - Products
    - What should they be?
    - Radiometric calibrations
    - Spectral bandpasses
    - Solar and viewing geometry
- Detection
  - How do we set thresholds or detect anomalies?
  - What are the natural variations?

Prior Success with Remote Sensing

- Sudden Death Syndrome in soybeans detected in MSU fields two weeks prior to visual symptoms.
- This early detection of plant stress is possible due to the fact that a plant's cellular structure is the dominant factor in controlling leaf reflectance in the near infrared range. Often these cells become distressed (i.e., change reflectance) prior to any changes in the leaf in the visible portion of the spectrum.



Potential Crop Surveillance System Architecture I

Inexpensive Anomaly Surveillance

Large Swath Systems

Near-Daily Wide Area Surveillance
MODIS/AVHRR

Coarse Resolution Spectral
Time Series Analysis

Agriculture Database

Crop Models &Geospatial Detection
(Time Series & Coarse Spatial/Spectra)

Meteorology &
In Situ Data

Targeted Moderate/High Spatial Resolution Systems (Expensive Acquisitions)

Moderate & Small Swath Systems

Moderate & High Spatial Resolution
Surveillance
Commercial Satellite Systems

High Spatial Resolution
Analysis

Scouts/Remediation

Potential Crop Surveillance System Architecture II

Inexpensive Anomaly Surveillance

Daily Wide Area Surveillance
Disaster Monitoring Constellation

Moderate Swath Systems

Moderate Resolution Spectral
Time Series Analysis

Agriculture Database

Crop Models &Geospatial Detection
(Time Series & Moderate Spatial/Spectra)

Meteorology &
In Situ Data

Targeted High Spatial Resolution Systems (Expensive Acquisitions)

High Spatial Resolution
Surveillance
Commercial Satellite Systems

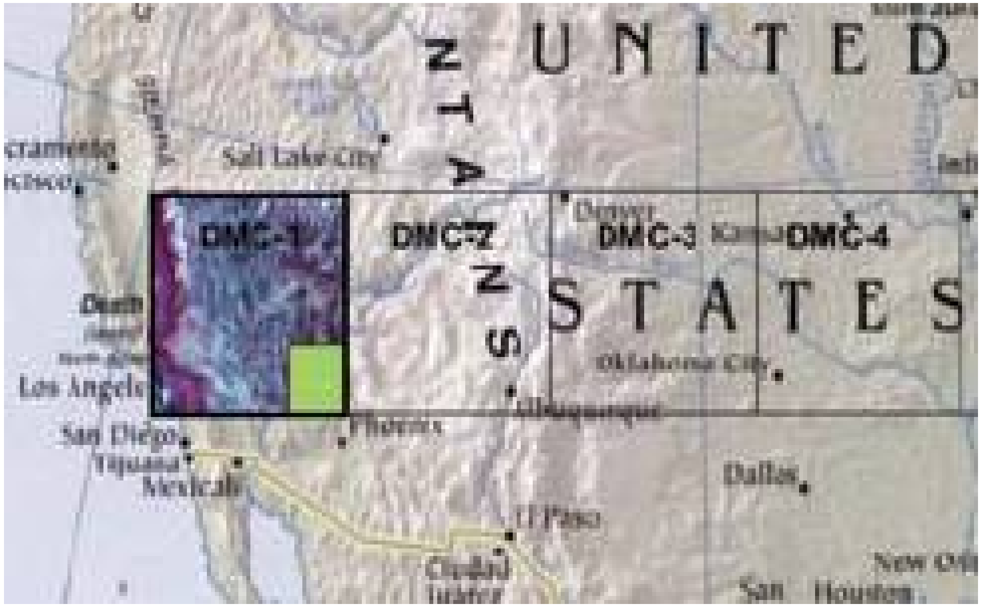
Small Swath Systems

High Spatial Resolution
Analysis

Scouts/Remediation

Disaster Monitoring Constellation International Imaging (www.dmcii.com)

- DMC Consortium members:
  - Centre National des Techniques Spatiales (CNTS), Algeria
  - National Remote Sensing Centre, Ministry of Science and Technology (MoST), China
  - National Space Research and Development Agency (NASRDA), Nigeria
  - TUBITAK BILTEN, Turkey
  - Surrey Satellite Technology Ltd, UK
- 32m GSD with 600 km swath
- Image data in 3 Landsat equivalent spectral bands - NIR, Red and Green
- How can USDA obtain access to this information?



Relevant Coarse Resolution Systems

Asset	Revisit Time	Spectral Bands/Spatial Resolution (GSD)	Swath/Image Size
Terra/Aqua MODIS	1-2 days	250 m R, NIR, 500 m Vis-SWIR 1 km Thermal	2200 km
SPOT 4 and 5 Vegetation	1 day	B,R,NIR,SWIR 1 km	2250 km
AVHRR NOAA	1-2 days	R, NIR, MWIR, 3 TIR 1.1 km	2940 km
ENVISAT-1 AATSR	3 days	G, R, NIR, SWIR, MIR, 2 TIR 1 km	500 km

MODIS is the highest resolution (250 m) large swath system

Relevant Moderate Resolution Systems

Asset	Revisit Time	Spectral Bands/Spatial Resolution (GSD)	Swath/Image Size
SPOT-4	1-2 days	G, R, NIR, SWIR, IR, Pan 20 m (multi) 10 m Pan	60 km
Landsat 7 ETM+	16 days	B, G, R, NIR, SWIR, 30 m 60 m TIR	180 km
IRS-P6 LISS3	5 days	G, R, NIR, SWIR 24 m	23.9 km, 70.3 km
IRS-P6 AWiFS	5 days	G, R, NIR, SWIR 56 m	740 km
Terra ASTER	4-16 days	30 m G, R, NIR, 60 m SWIR, 90 m LWIR	60 Km

Relevant High Spatial Resolution Systems

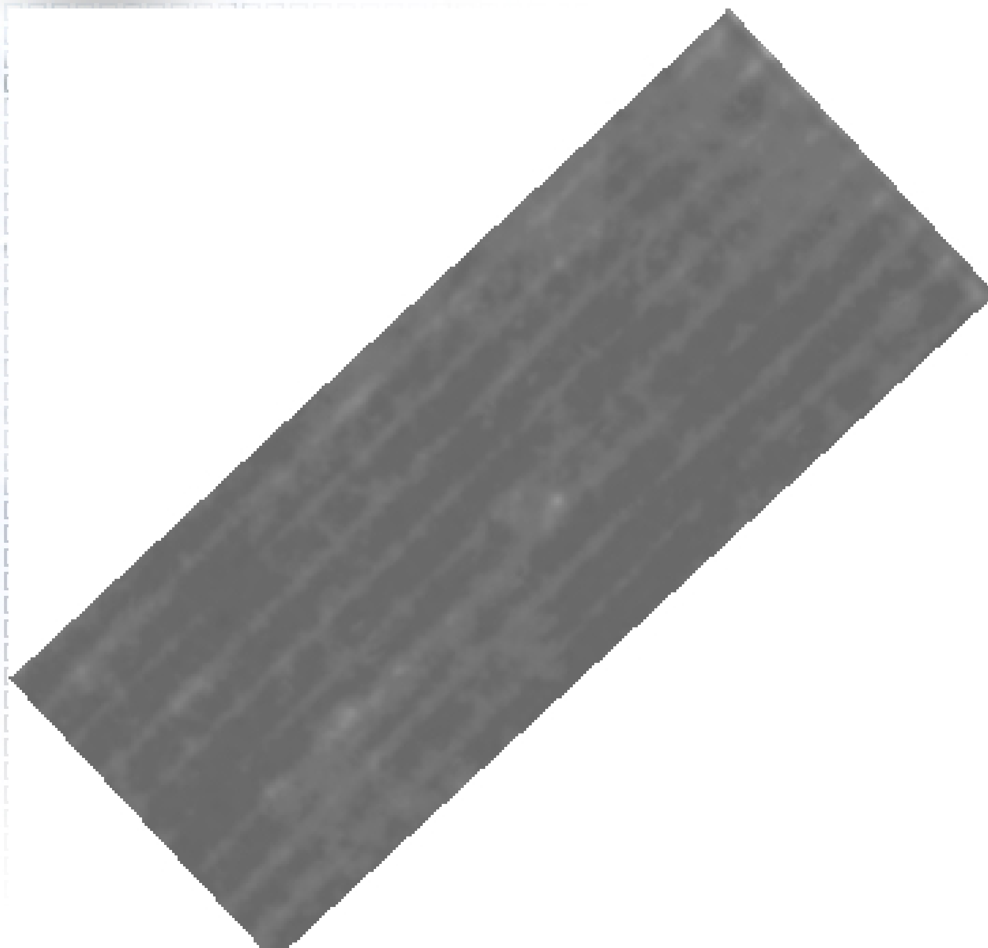
Asset	Revisit Time	Spectral Bands/Spatial Resolution (GSD)	Swath/Image Size
IKONOS	1-2 days	B, G, R, NIR, Pan 4 m (multi) 0.86 m (pan)	11 km
QuickBird 2	1- 5 days	B, G, R, NIR, Pan 2.44 (multi) 0.61 m (pan)	16.5 km
OrbView-3	< 3 days	B, G, R, NIR, Pan 4 m (multi) 1 m (pan)	8 km

Geolocated and radiometrically corrected products available.

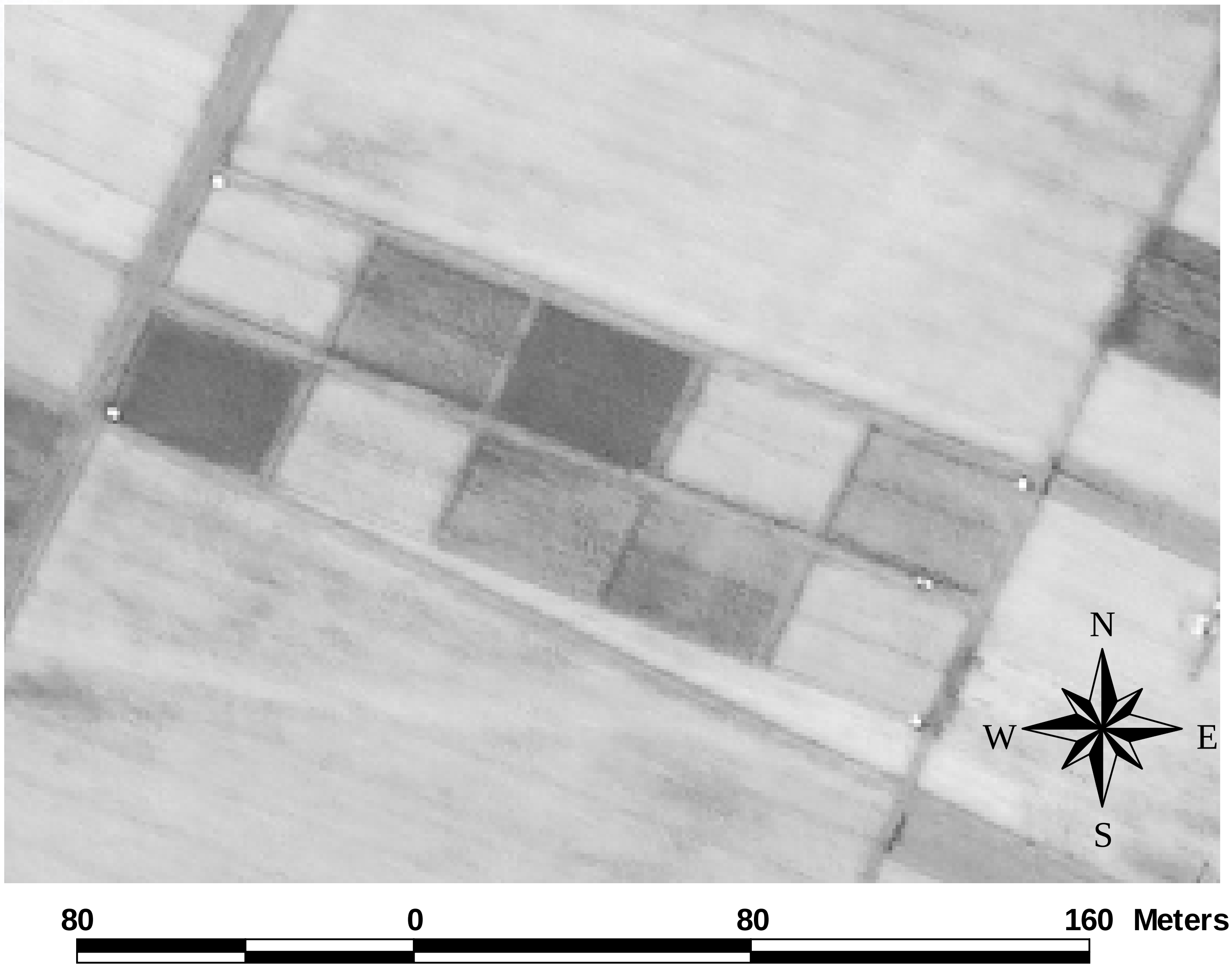
Satellite Remote Sensing Measurements in South America

- Field experiments were conducted at Mato Grosso and Londrina, Brazil.
- There were four fungicide treatments with two replications.
- Disease severity was estimated from the top, middle, and bottom of each plant.
- IKONOS satellite image with 1 m resolution was obtained one day after the disease assessments were conducted.

Satellite imagery from a SBR soybean field (800 by 400 m) in Itapua, Paraguay



Satellite imagery from experimental plots infested by SBR in Mato Grosso, Brazil



Satellite imagery from experimental plots infested by SBR in Londrina, Brazil

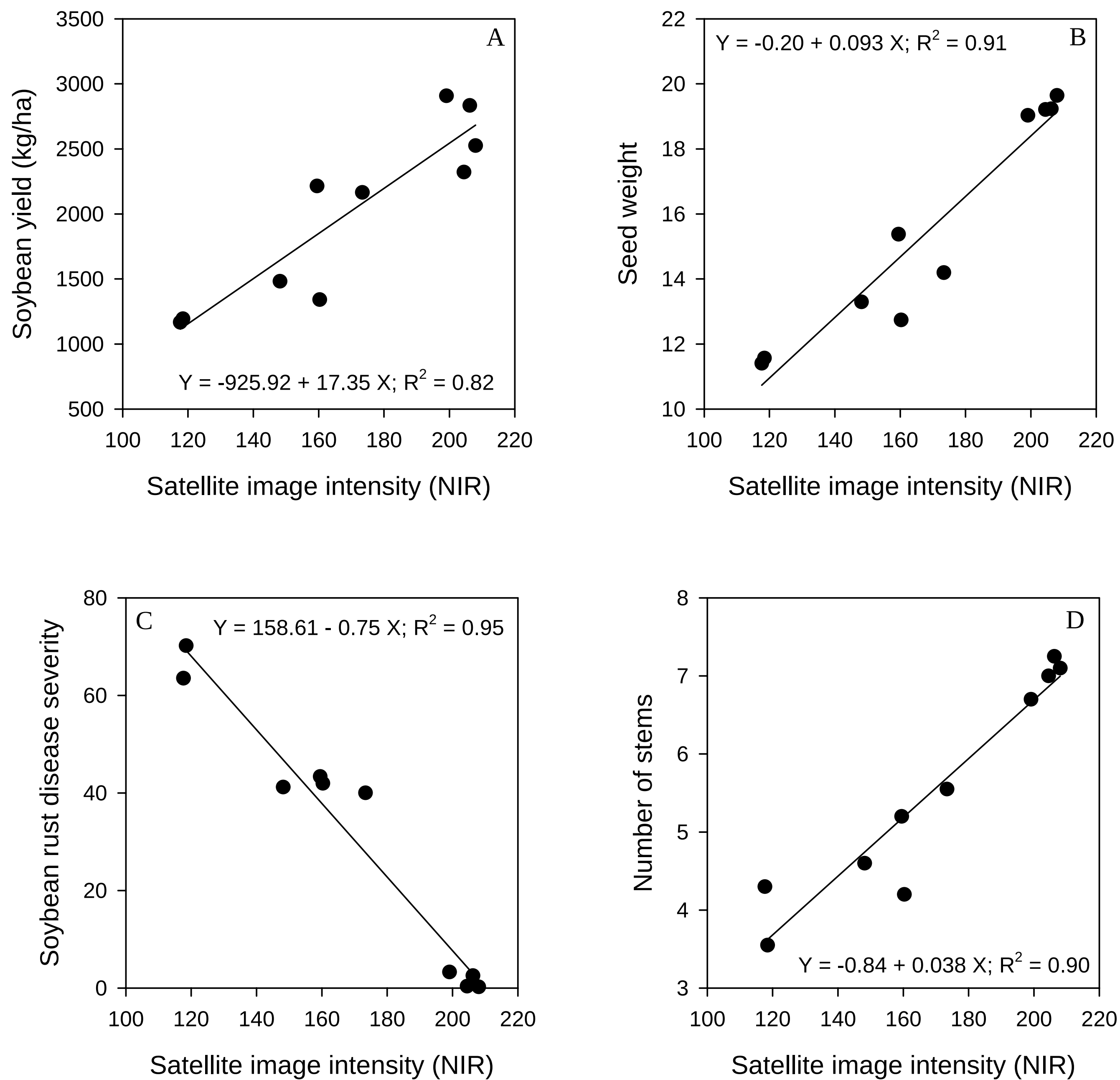
Relationship between satellite imagery & different ground crop measurements at Mato Grosso, Brazil,

A) soybean yield,

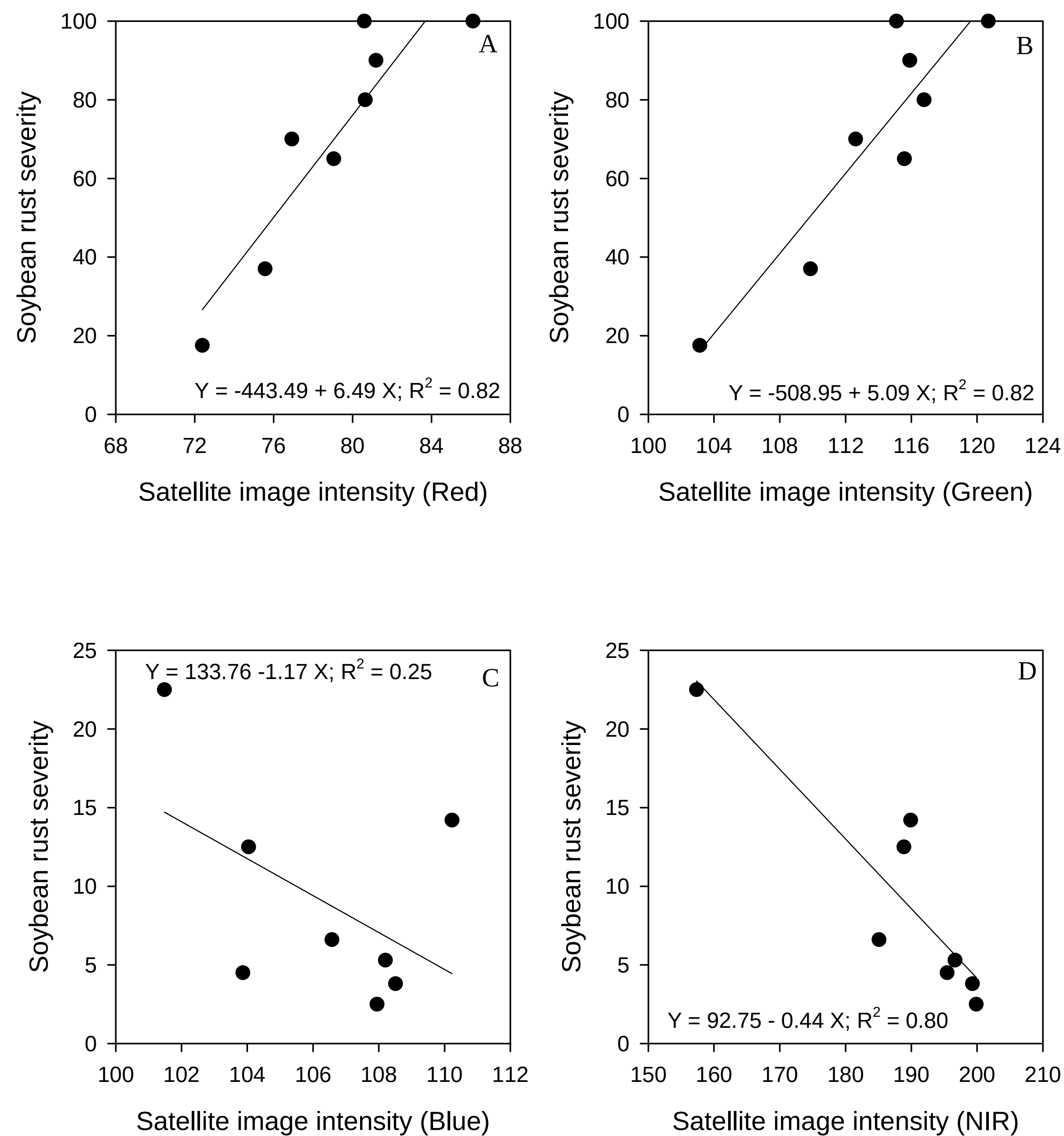
B) seed weight,

C) rust severity

D) number of stems



Relationship between satellite imagery to different ground rust measurements in plots at Londrina, Brazil.



A Red band with lower leaves severity

B Green band with lower leaves severity

C Blue bend with middle leaves severity

D NIR with from middle leaves severity

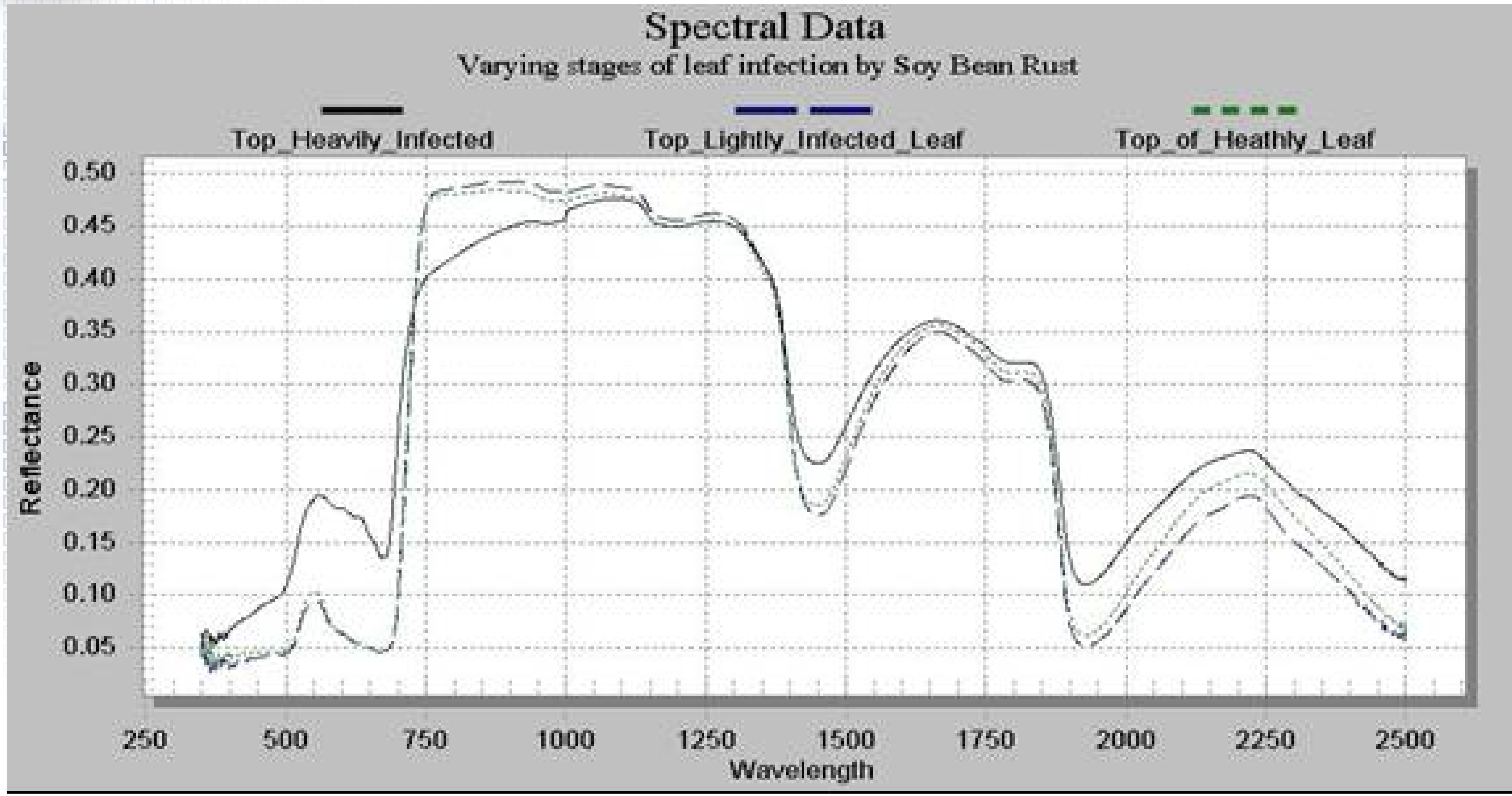
Results

- Relationships have been found between satellite image intensities and ground measurements of soybean rust.
- Satellite image measurements had significant relationship between soybean crop measurements.
- Early in a season, light disease intensity can not be detected effectively from satellite when other diseases are present.
- Satellite images may be used if identifications and differentiations of SBR from other foliar diseases can be made.

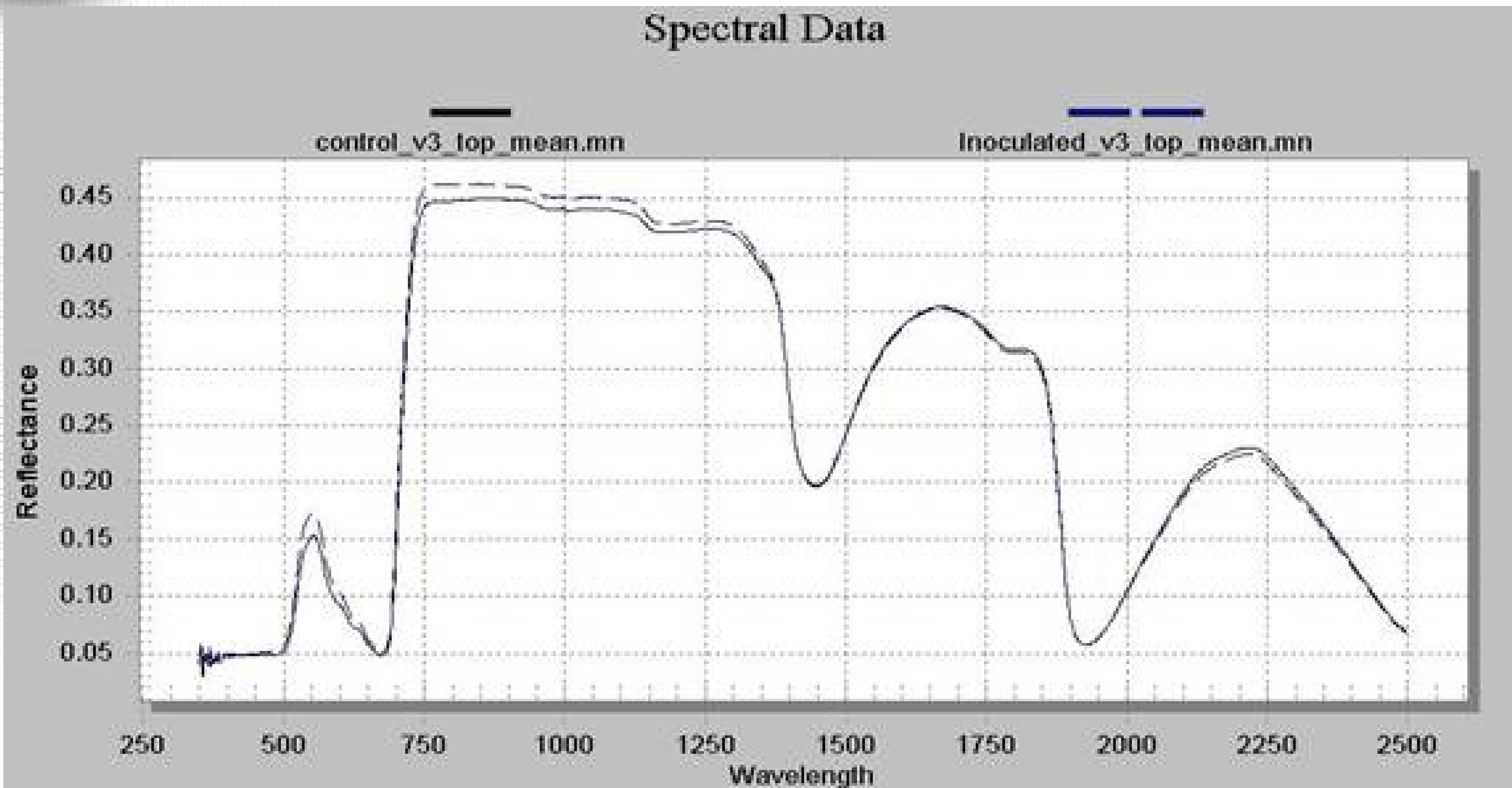
ASD in Paraguay

- Collection protocol developed with USDA.
- Measurements taken over 3 months.
- Data returned to MSU for weekly analysis.

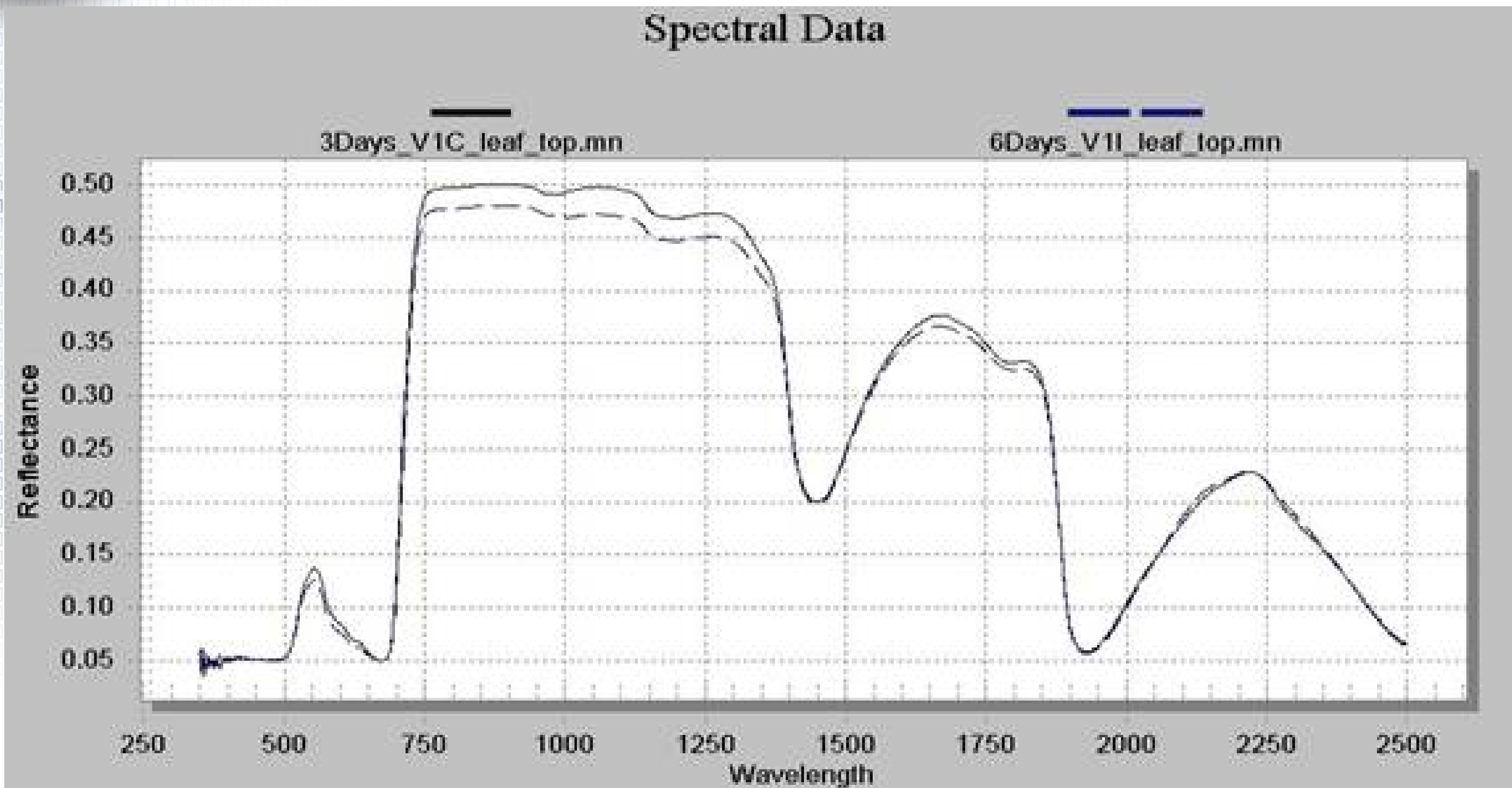
Spectral data of leaves collected from 3 soybean plants ranging from healthy to heavy infection.



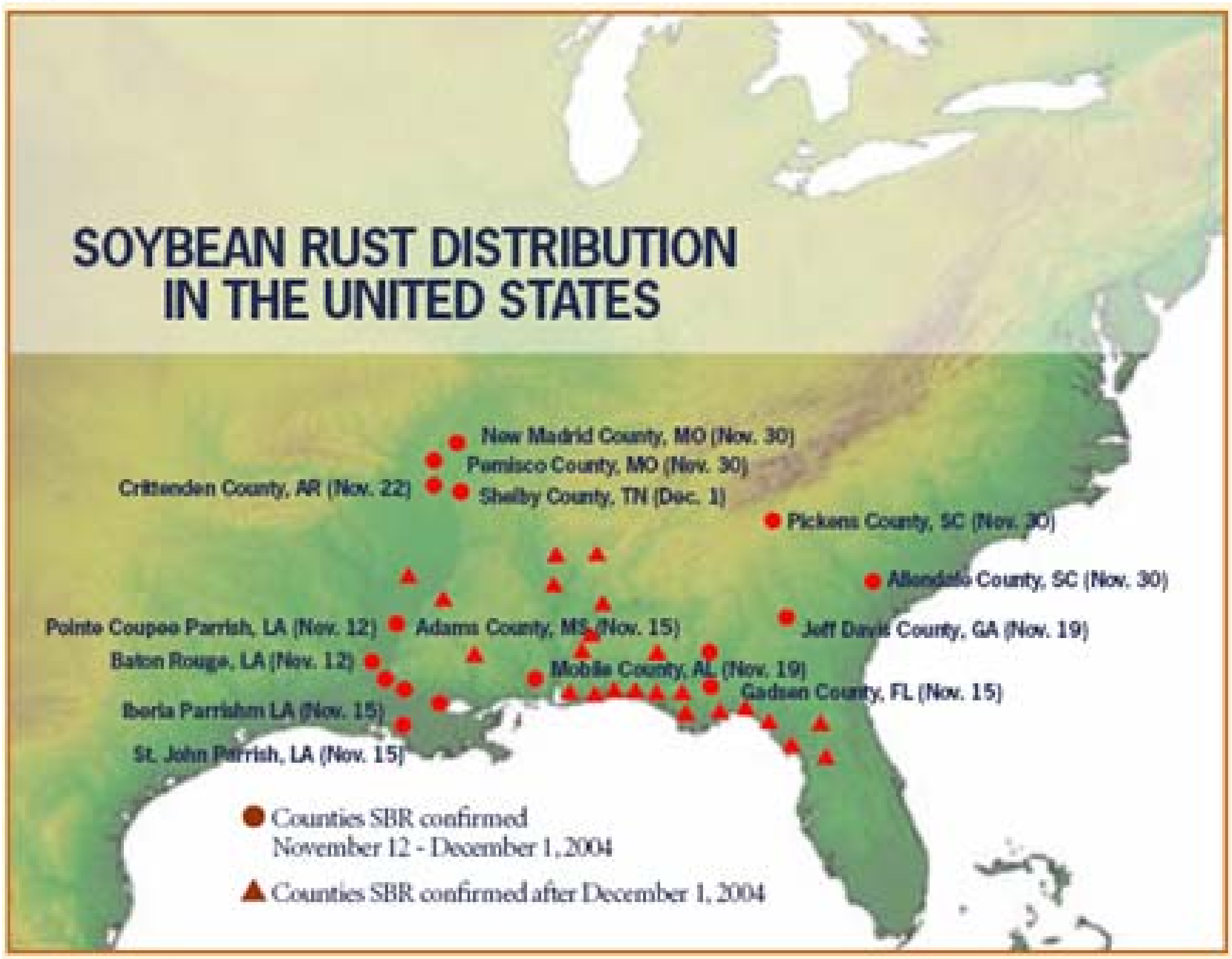
Top of Canopy Leaf Measurements



Lower Leaf Measurements Over Time



SBR Positive in Soybeans



(Dorrance et. al., 2005)

Retrospective with US Incident

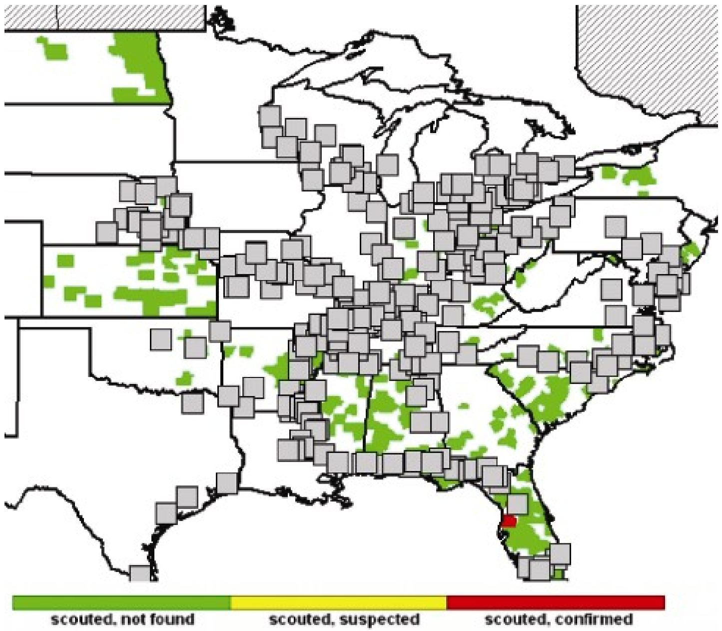
- Acquire Landsat &, MODIS, ASTER imagery for dates prior to and subsequent to Hurricane Ivan.
- Using known locations of infection to conduct retrospective.
- Problem was that fields were not delineated and a total lack of high resolution imagery.

Problems with U.S. Incident Data Collection: Lessons Learned

- Lack of definition of field boundaries
- Often location was the center of a county
- Description was SBR – Yes or No
- SBR generally was on volunteer soybeans
- Multitude of other diseases present which made a unique signature for SBR from the satellite imagery problematic

Sentinel Fields

- Plant late February to early March in the Southeast
- Weekly monitoring starting R-1 stage
- Detection protocol – alert southeast producers & other soybean production areas of U.S.



Trap Plot planted October 4, 2004. SBR detected January 3, 2005. Epidemic level by January 31, 2005.

USDA-APHIS Guidelines for Obtaining Survey Data

- Sentinel plots should be sampled once a week
- When model predictions or observations indicate that SBR is imminent surveys should be conducted every three days.
- Samples should be taken from different sites and should not be in a straight line.
- Initial information recorded should include GPS location, cultivar name and description, planting dates, row spacing, stand counts and size of the plot.
- The date, GPS location and number, plant height, percent canopy closure, the vegetative and reproductive growth stages and name of who is monitoring the plot.
- Suspected positive samples should be placed in a zip-lock plastic bag, marked with plot information and forwarded to the Plant Diagnostic laboratory for a diagnosis.
- Disease severity should by assessed as absent, low, medium, or high.

Disease Progression

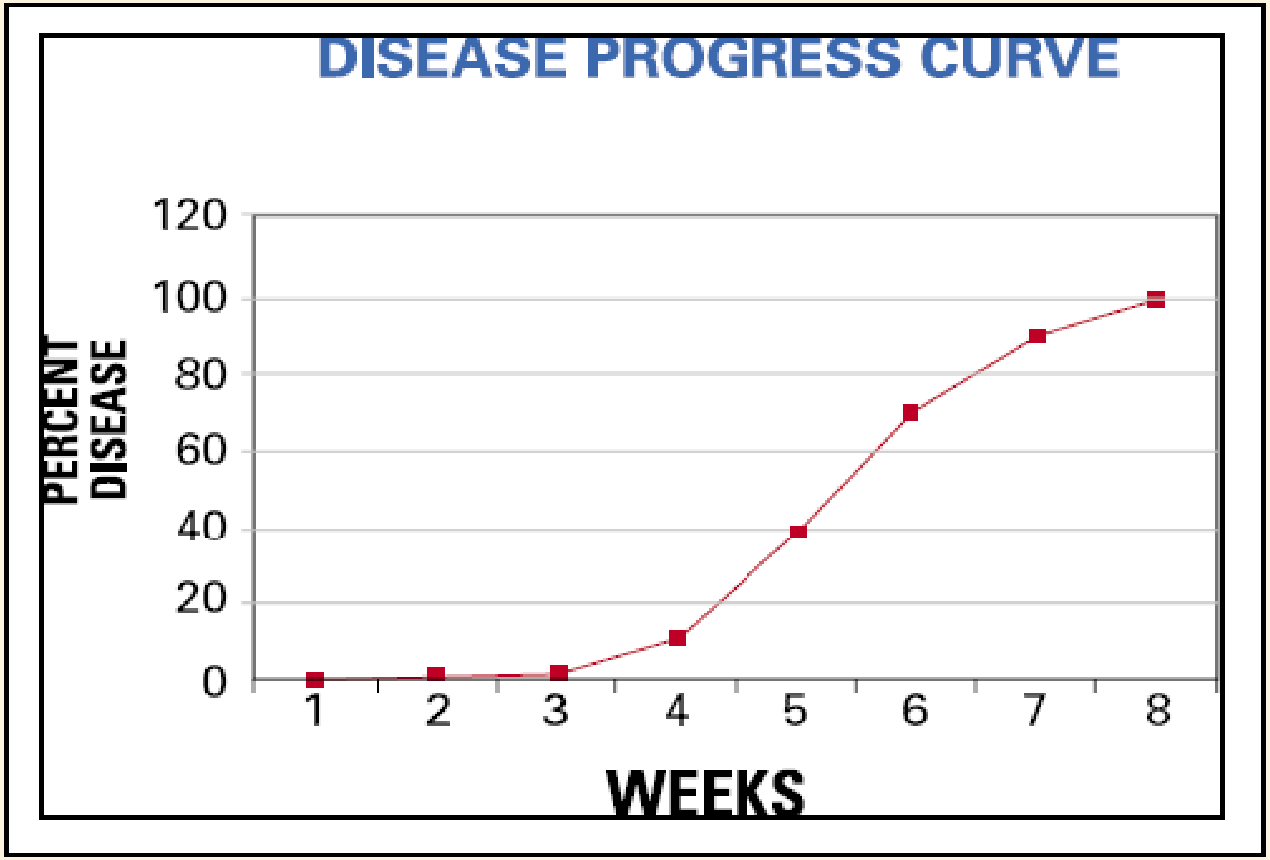
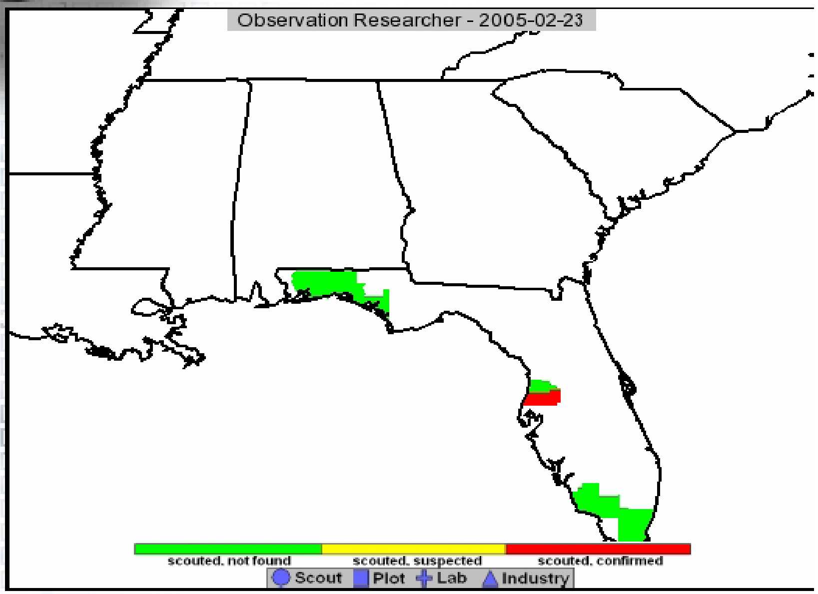
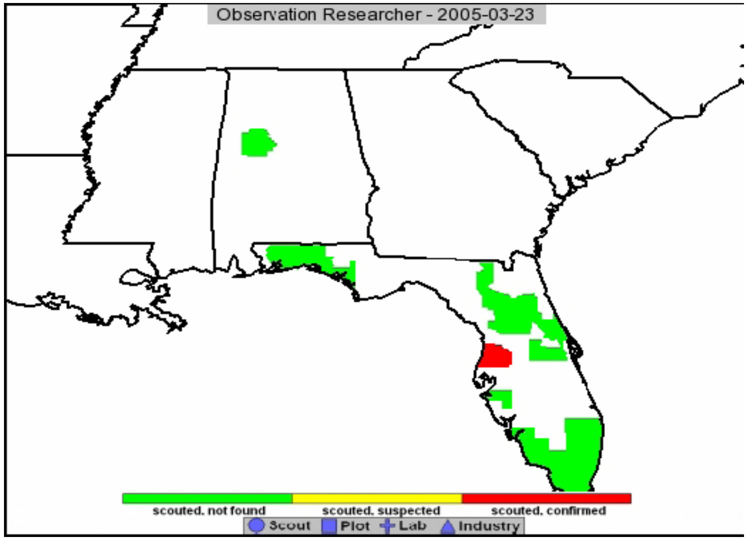


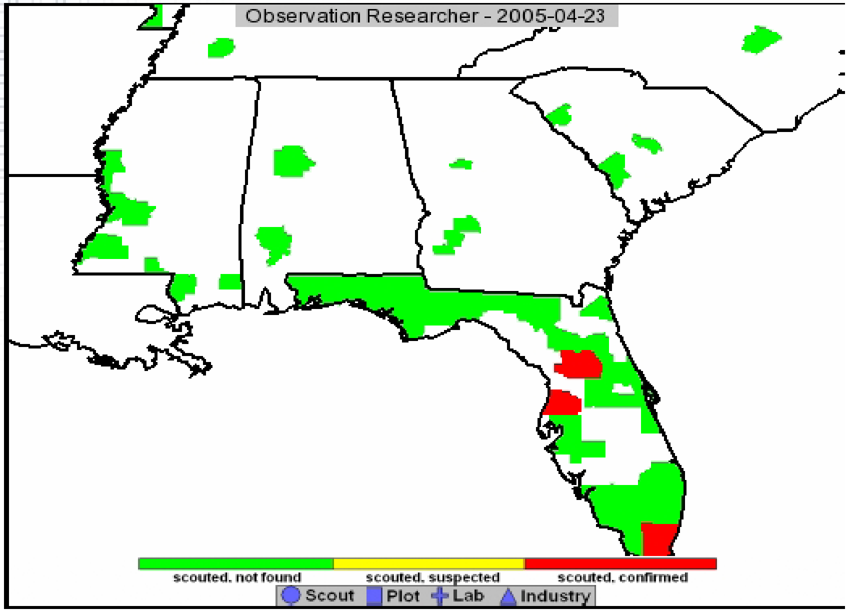
Figure 6. A typical rust disease progress curve. Since rusts produce more spores capable of reinfecting the host plant disease severity starts slowly, but increases logarithmically until the food source, leaves, becomes limiting or the environment becomes less favorable for growth and reproduction.

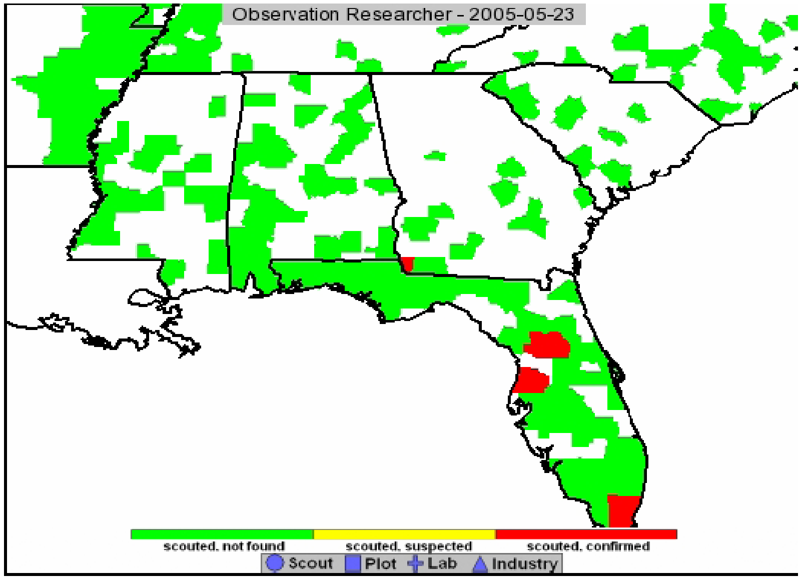
(Dorrance et. al., 2005)

Progression of SBR Throughout the 2005 Season: February - May

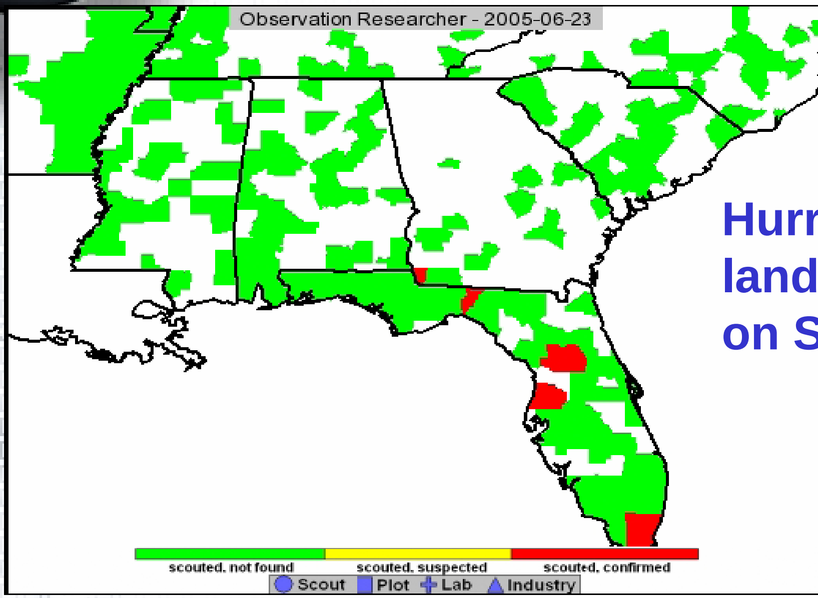




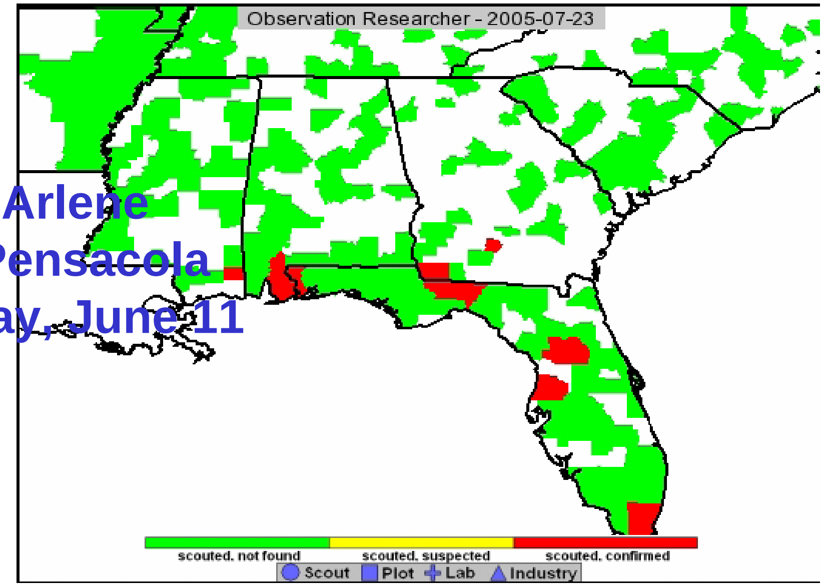


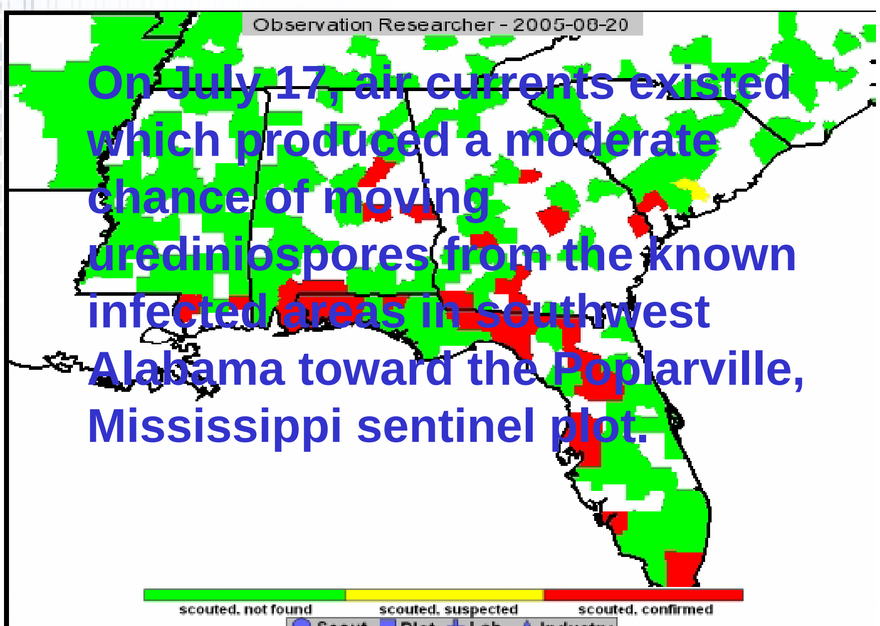


Progression of SBR Throughout the 2005 Season: June - September

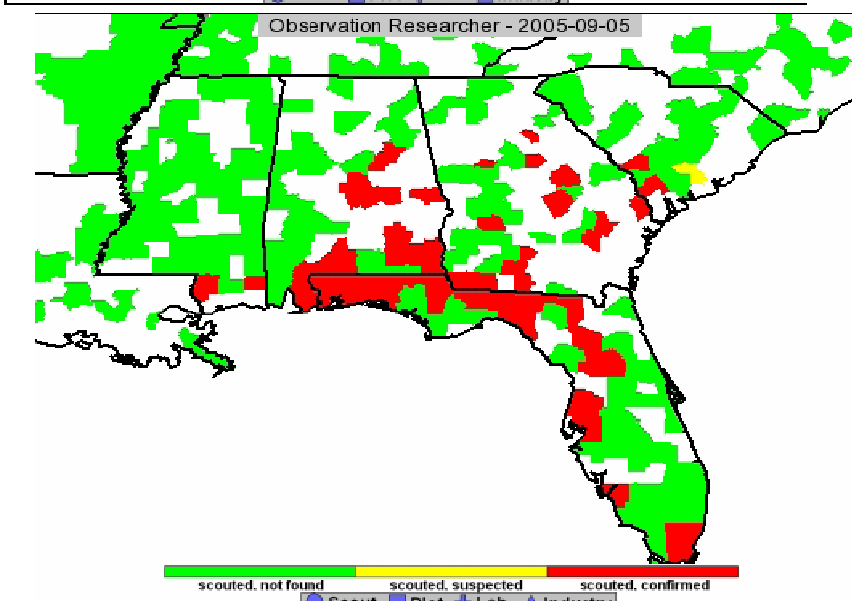


Hurricane Arlene landfall - Pensacola on Saturday, June 11





On July 17, air currents existed which produced a moderate chance of moving urediniospores from the known infected areas in southwest Alabama toward the Poplarville, Mississippi sentinel plot.



SBR in the U.S. in 2005

- It appears that SBR failed to overwinter in the southern part of the Gulf coastal states north of Florida.
- By June 12, SBR had been found near Tampa, Florida in 4 patches of Kudzu and in one county in southwest Georgia on volunteer soybeans. It is unknown if SBR overwintered in the Georgia location or if the resulting infection was the result of wind-blown urediniospores.
- Two new cases of Asian soybean rust were confirmed June 29 in sentinel plots in Baldwin County, Alabama and Marion County, Florida.
- It is very likely that SBR will overwinter in Florida and the Caribbean area each year, but will overwinter in Gulf States only in very mild winters that may occur in approximately one in three years (Dorrance et al, 2005).
- This means that for rust to become a problem in Northern areas, the urediniospores will be blown northward from the more southern overwintering areas.
- Found in sentinel fields in R3-R7 stages in 2005.

Need for Information Technology in Agricultural Industry

- Ability to assimilate data from sensors and other data streams (e.g., human assets, laboratories, archives) and to use the information derived from these data sources to reduce the uncertainty in identifying agricultural threats.
- This integrated observing web includes a variety of data types and vantage points (e.g., space, ports of entry, sentinel plots, production fields) and can stream from archived data and/or simultaneous, incremental or real time or near-real time sources.
- Key issue identified in USDA Soybean Rust Integrated Research Strategy meeting was need for ability to share research results and data.

Next Steps for USDA/DHS?

- Take a more proactive approach at points of entry for plant materials and pathogens. This will require interaction with APHIS and people will have to be up to date on current issues and how to screen for pathogens.
- Oversee/develop, staff, and provide funding for a national spore trapping/air and water monitoring network that can be used as a component of an early warning system for multiple plant pathogens and other airborne or water borne chemicals or agents.
- Investigate alleged intentional introductions of plant pathogens.
- Establish/fund a larger network of containment research facilities for listed agents.