Refining the Generic Model for Disease Recovery Plans for the National Plant Disease Recovery System (or) Are We Finally Getting Closer to Generic Plans?

5th National Plant Disease Recovery System Workshop
Apr 14-16, 2013, Falls Church, VA

Ray Martyn, Purdue University
Neil McRoberts, UC Davis
Carla Thomas, UC Davis
Judy Brown, University of Arizona
Forrest Nutter, Iowa State University
Jim Stack, Kansas State University

Refining the Generic Model for Disease Recovery Plans

1. Ray Martyn – Background and how we got to where we are now – the generic plan concept and the cluster analysis model.
2. Neil M^{c}Roberts – Defining and validating the model.
3. Carla Thomas – How can we use this to build generic recovery plans?
4. Breakout session – Where do we go from here, if anywhere?

Prioritizing Plant Diseases for the NPDRS

- 1st NPDRS Workshop – April 2006 (Memphis, TN)
  - What is a recovery plan and how to select pathogens for a recovery plan
  - (Old McDonald's farm – your list, my list, here a list, there a list, everybody's list list - pathogen du jour)

Historical Background

Criteria for prioritization

- USDA Select agents and toxins list ✔
- Economic value of host crop
- Risk assessment criteria
- Type of pathogen (Taxa)
- Type of host (crop)
- Type of host x type of pathogen matrix

Host x Pathogen Taxa

Host

Pathogen Taxa

	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Land-scape	Veggies	Orna-mentals
Viruses	X	X					
Bacteria							
Fungi (Rusts)			X		X		
Fungi (Other)							
Downy mild. (Oomycota)					X		
Phytophthora (Oomycota)				X			
Nematodes			X				

	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Land-scape	Veggies	Orna-mentals
Viruses	X	X	X	X	X	X	X
Bacteria	X	X	X	X	X	X	X
Fungi (Rusts)	X	X	X	X	X	X	X
Fungi (Other)	X	X	X	X	X	X	X
Downy mild. (Oomycota)	X	X	X	X	X	X	X
Phytophthora (Oomycota)	X	X	X	X	X	X	X
Nematodes	X	X	X	X	X	X	X

	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Land-scape	Veggies	Orna-mentals

Viruses		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals
Bacteria								
Fungi (Rusts)	Foliar		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals
Fungi (Other)	Root rots	Wind dispersed		Hay	Alfalfa	Corn	Wheat	Rice	Soybean	Pulse crops
Downy mild (Oomycota)	Vascular wilts	Wind / rain dispersed	Viruses		Ornament.	Green-house	Citrus	Fruits & Nuts	Forest & Land-scape	Veggies	Berries
Phytophthora (Oomycota)	Seed rots	Seed-borne	Bacteria	Viruses							
Nematodes	Fruit rots	Vector-borne	Fungi (Rusts)	Bacteria							
	Rusts	Soilborne	Fungi (Other)	Fungi (Rusts)							
	Mildews	Over-seasoning	Downy mild. (Oomycota)	Fungi (Other)							
			Phytophthora (Oomycota)	Downy mild. (Oomycota)							
			Nematodes	Phytophthora (Oomycota)							
				Nematodes							

Prioritizing Plant Diseases for the NPDRS

- 1st NPDRS Workshop – April 2006 (Memphis, TN)
  - Selecting pathogens for recovery plans (Here a list, there a list, pathogen du jour)

- 2nd NPDRS Workshop – April 2007 (St. Louis, MO)

  - How to prioritize plant diseases for the NPDRS (The concept of generic plans – 'the Martyn Method')

http://www.ars.usda.gov/research/docs.htm?docid=14271

Research

Office of Pest Management Policy National Plant Disease Recovery System

Office of Pest Management Policy National Plant Disease Recovery System

Plant Diseases That Threaten U.S. Agriculture

Identified and Prepared For Under the

National Plant Disease Recovery System

The National Plant Disease Recovery System

http://www.ars.usda.gov/research/docs.htm?docid=14271

"Two overriding concerns of the program discussed at our annual workshops are how to deal with the thousands of documented exotic diseases that may enter the United States and how to prepare for diseases that are yet unknown? We believe that the solution is the Martyn Method. Simply put, the Martyn Method prepares for all diseases by developing a core group of recovery plans that represent every type of pathogen that could arrive or develop. When an unexpected pathogen does arrive or emerge, one of the representative plans is used as a model to quickly assemble a new recovery plan for the unexpected pathogen."

Prioritizing Plant Diseases for the NPDRS

- 1st NPDRS Workshop – April 2006 (Memphis, TN)
  - Selecting pathogens for recovery plans (My list, your list, pathogen du jour)
- 2nd NPDRS Workshop – April 2007 (St. Louis, MO)
  - How to prioritize plant diseases for the NPDRS (The Martyn Method!)

- 3rd NPDRS Workshop – October 2008 (San Antonio, TX)
  - Prioritizing high risk pathogens for the NPDRS (So many pathogens; so little time)

Prioritizing Plant Diseases for the NPDRS

- 1st NPDRS Workshop – April 2006 (Memphis, TN)
  - Selecting pathogens for recovery plans (My list, your list, pathogen du jour)
- 2nd NPDRS Workshop – April 2007 (St. Louis, MO)
  - How to prioritize plant diseases for the NPDRS (The Martyn Method!)
- 3rd NPDRS Workshop – October 2008 (San Antonio, TX)
  - Prioritizing high risk pathogens for the NPDRS (So many pathogens; so little time)
- 4th NPDRS Workshop – March 2011 (Dallas, TX)
  - Developing methods for selection of recovery plans for the NPDRS (Are generic plans feasible and appropriate?)

Criteria for prioritization

- USDA Select agent and toxins list ✔
- Economic value of host crop
- Type of pathogen (Taxa)
- Type of host (crop)
- Type of host x type of pathogen matrix
- Pathogen epidemiology (dissemination / survival)
- Risk or threat factor
- Management strategy and epidemiology (Principles of disease management)

The Generic Cluster Concept

- Do plant diseases cluster around a set of epidemiological parameters that dictate similar response and management strategies?

Detection → Response → Mitigation & Mgt. → Recovery

Response and Recovery

– How does it spread, survive, infect, reproduce, etc.

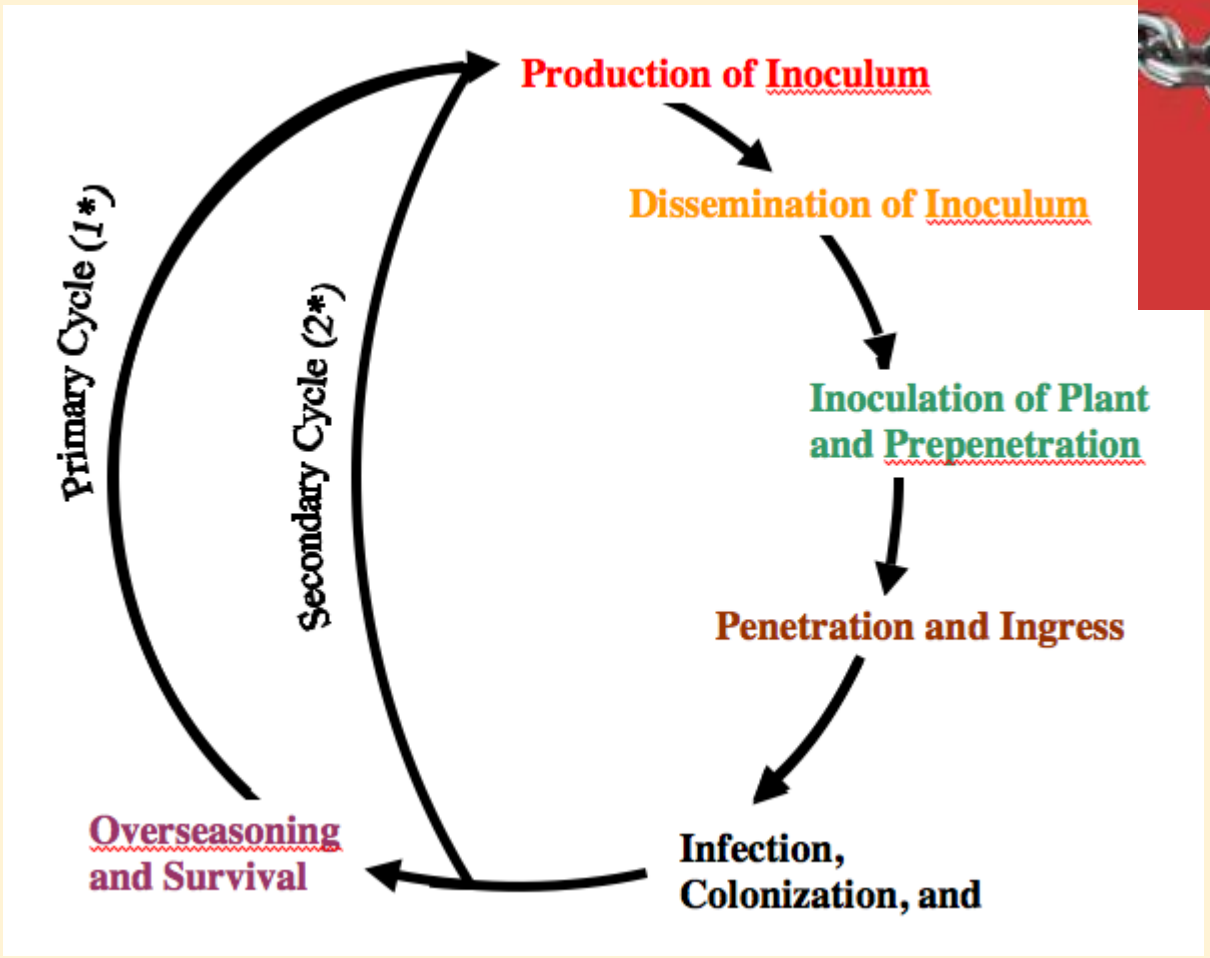
- Quarantine vs. Monitoring & Surveillance
- Eradication vs. Management

Principles of Plant Disease Management[1]

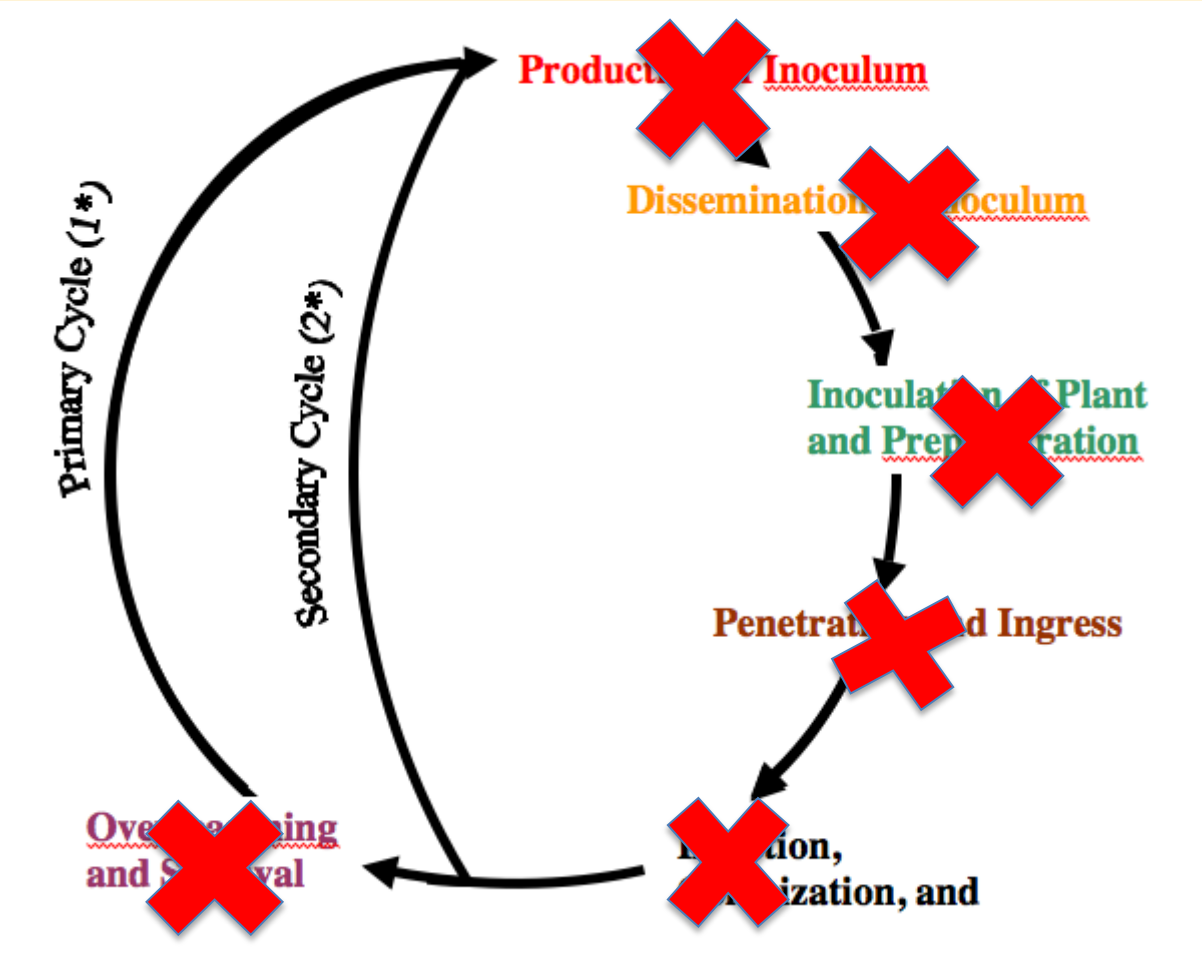
1. Exclusion
2. Eradication
3. Protection
4. Resistance
5. Therapy
6. Avoidance

[1]National Academy of Sciences. 1968. Principles of Plant and Animal Pest Control. Vol 1. Plant Disease Development and Control. NAS Publ. #1596. Washington, D.C. 205 pp.

The Disease Cycle



The Disease Cycle



Where to Begin?

- Critically examine the current plant disease recovery plans for epidemiological, response and management strategies.

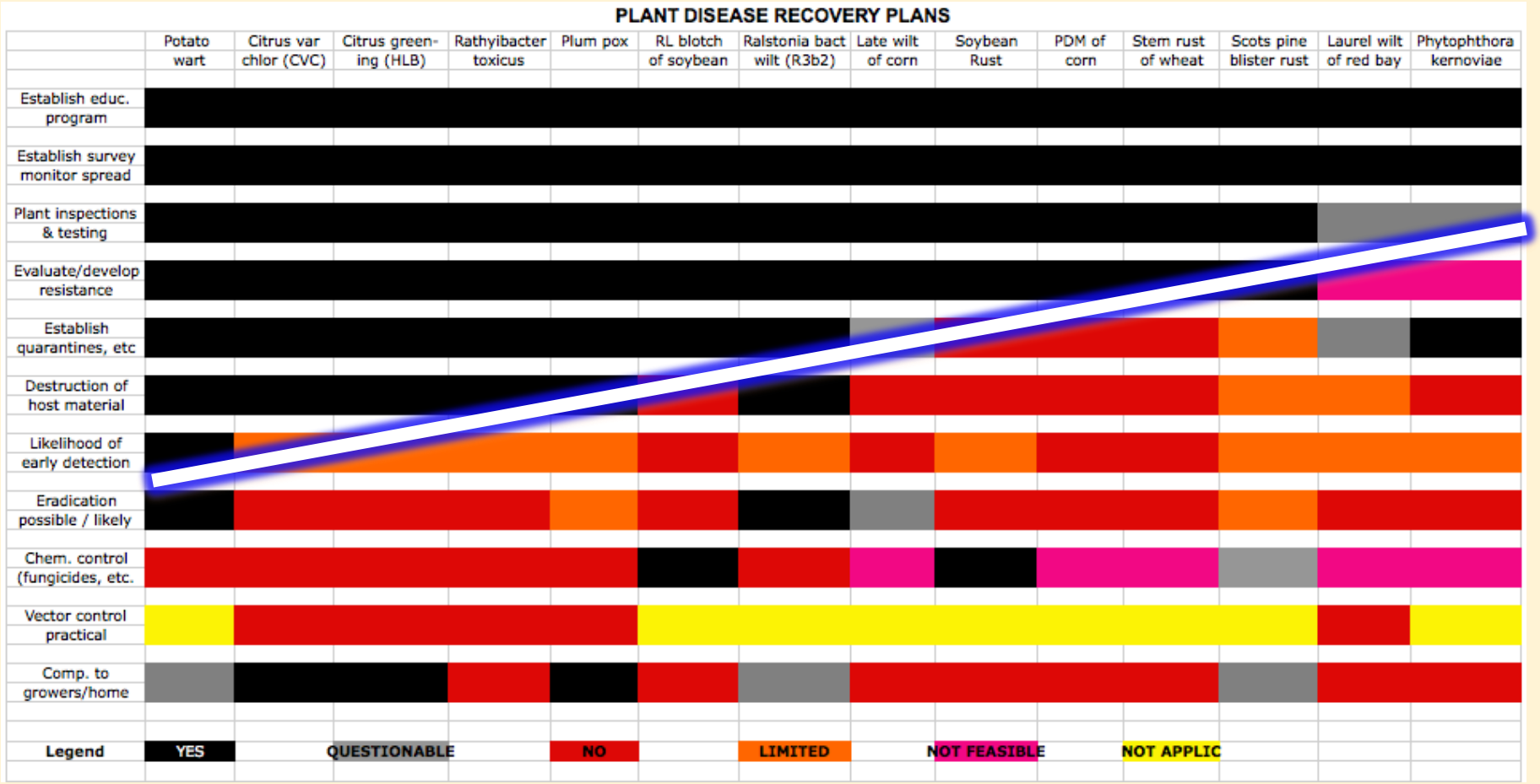
14 Completed Plant Disease Recovery Plans

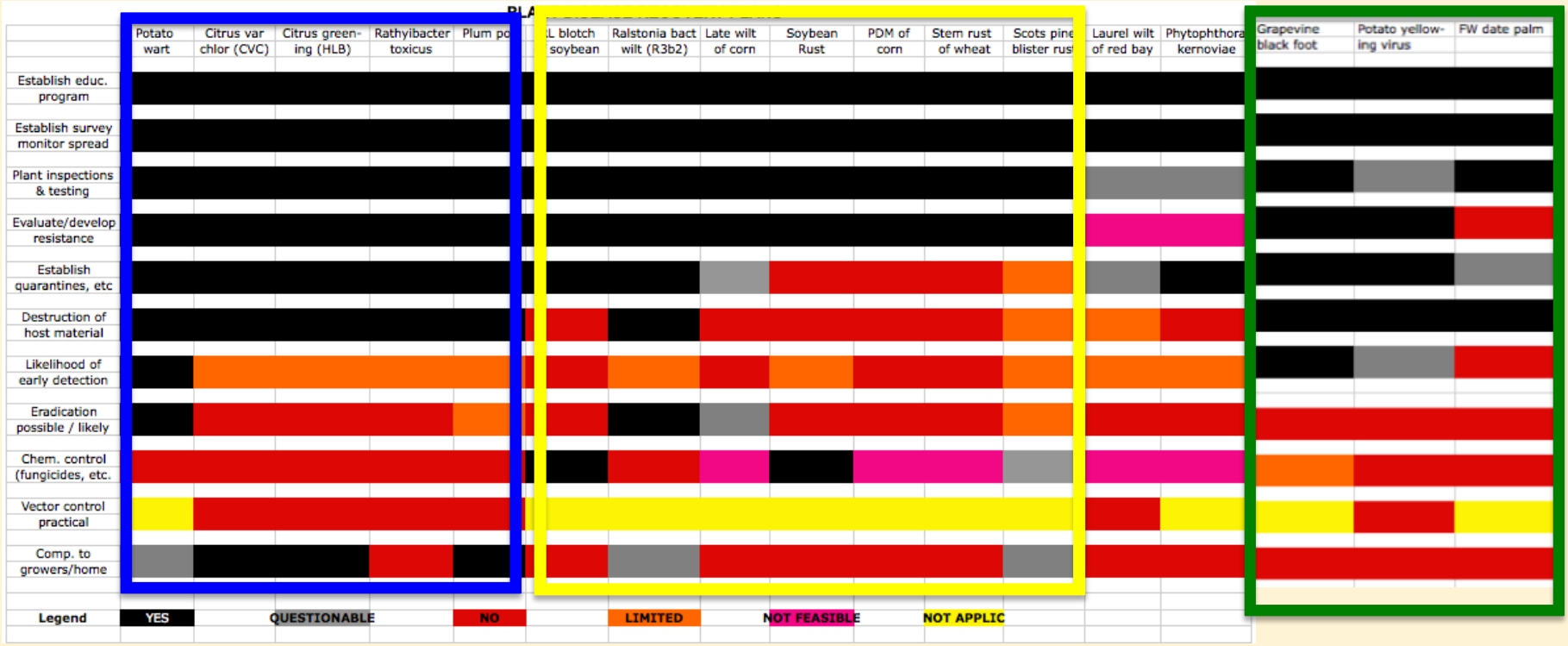
- Citrus variegated chlorosis
- Citrus greening
- Downy mildews of corn
- Late wilt of corn
- Red leaf blotch of soybean
- Laurel wilt of redbay
- Laurel wilt of avocado
- Plum pox
- Potato wart
- Ralstonia bacterial wilt
- Rathyibacter poisoning
- Scots pine blister rust
- Stem rust of wheat (Ug99)
- *P. kernoviae* tree / shrub diseases

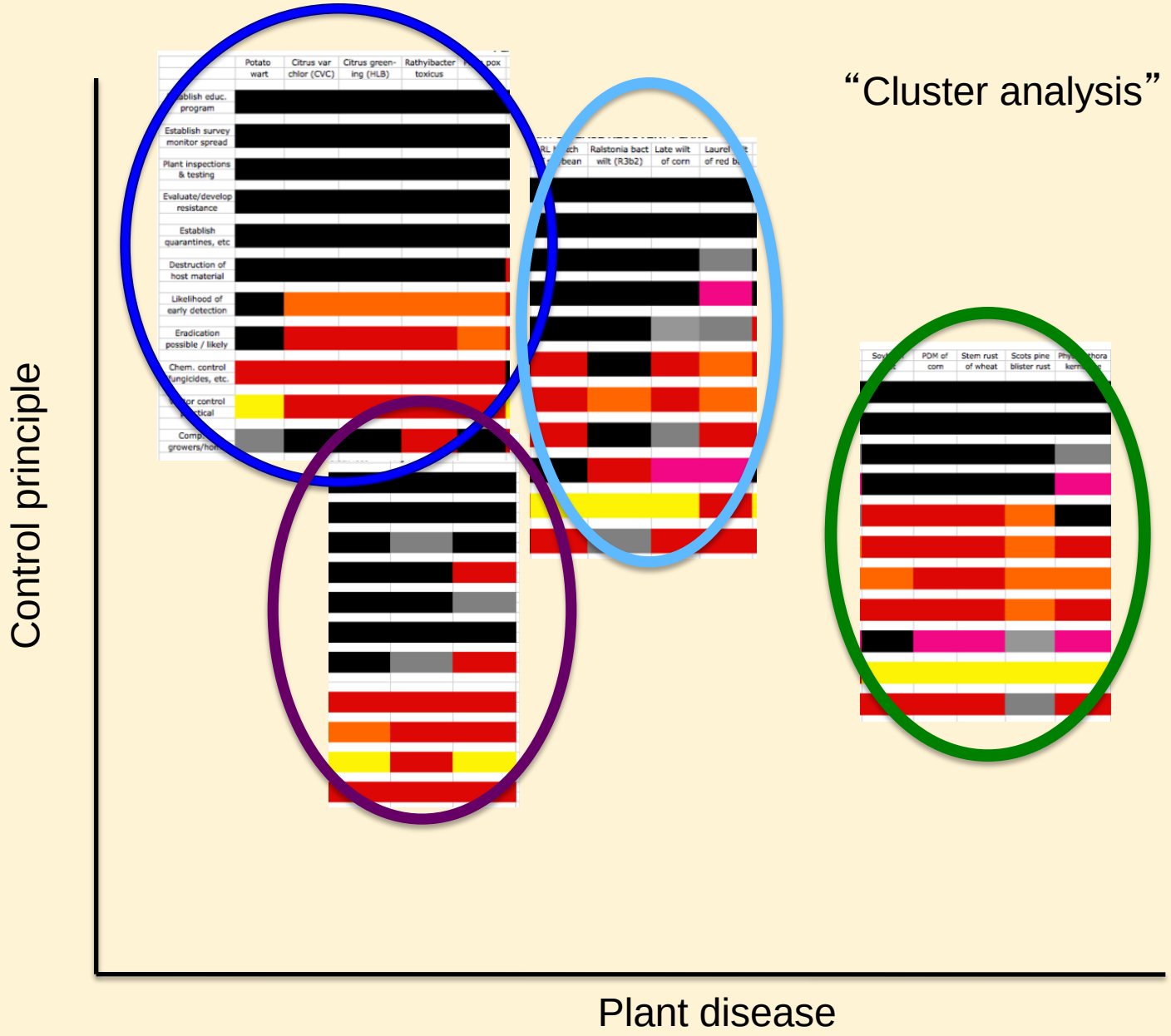
Recovery plan matrix by response and mitigation strategy

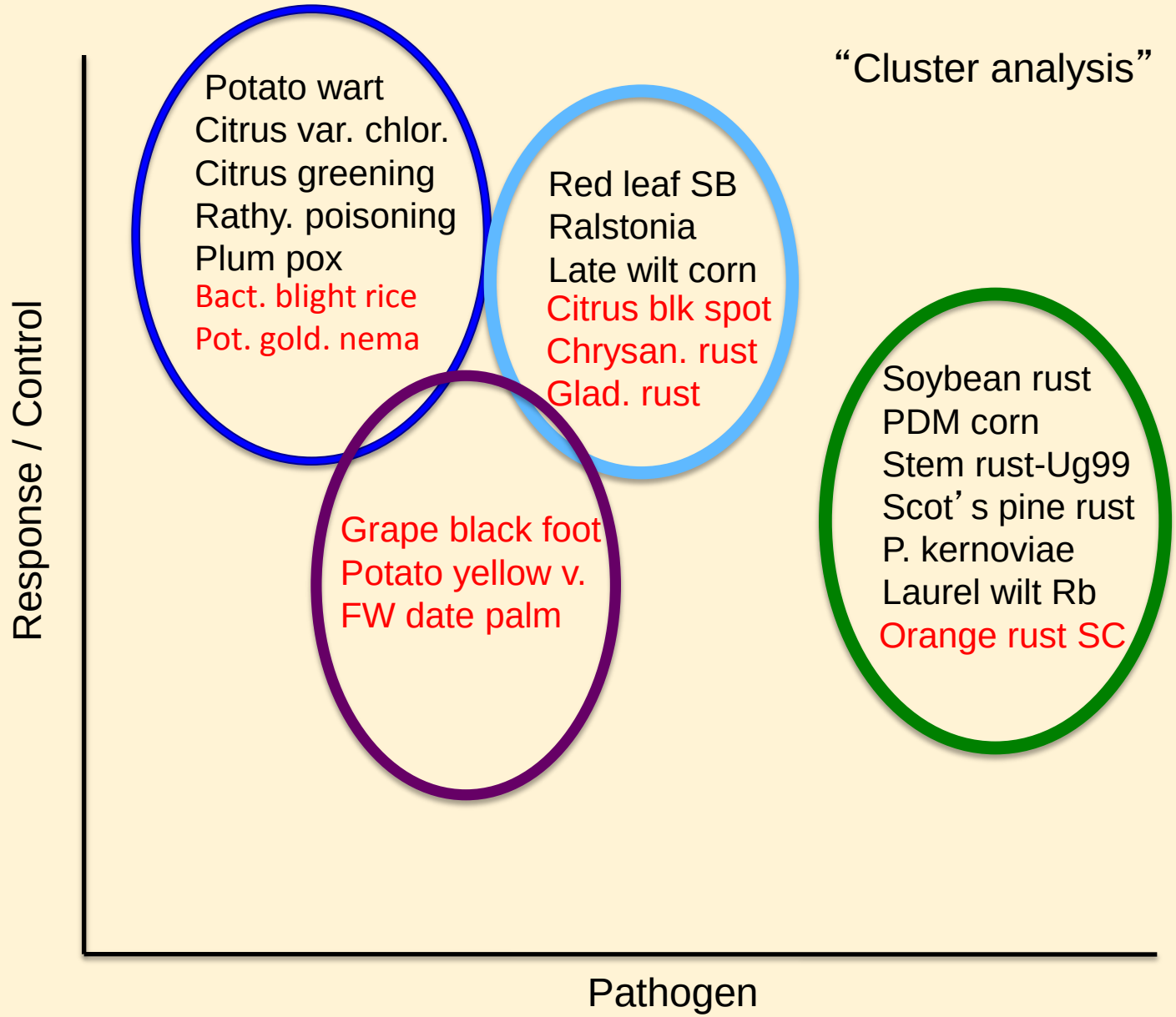
	Dis. 1	Dis. 2	Dis. 3	Dis. 4	Dis. 5	Dis. 6	Dis. 7	Dis. 8	Dis. 9	Dis. 10	Dis. 11
Educ. program											
Survey & monitor											
Plant test. & inspec.											
Eval / devel resistance											
Establish quarantine											
Destruction host mat.											
Likelihood early detec											
Eradication poss. / prob											
Chem. ctrl. practical											
Vector ctrl. practical											
Comp. to growers / homeowner											

PLANT DISEASE RECOVERY PLANS




Potato wart
Citrus var chlor (CVC)
Citrus green- ing (HLB)
Rathyibacter toxicus
Plum po
L blotch soybean
Ralstonia bact wilt (R3b2)
Late wilt of corn
Soybean Rust
PDM of corn
Stem rust of wheat
Scots pine blister rust
Laurel wilt of red bay
Phytophthora kernoviae
Grapevine black foot
Potato yellow- ing virus
FW date palm
Establish educ. program
Establish survey monitor spread
Plant inspections & testing
Evaluate/develop resistance
Establish quarantines, etc
Destruction of host material
Likelihood of early detection
Eradication possible / likely
Chem. control (fungicides, etc.
Vector control practical
Comp. to growers/home
Legend
YES
QUESTIONABLE
NO
LIMITED
NOT FEASIBLE
NOT APPLIC


"Cluster analysis"
Control principle
Plant disease
Potato wart
Citrus var chlor (CVC)
Citrus green-ing (HLB)
Rathyibacter toxicus
Establish educ. program
Establish survey monitor spread
Plant inspections & testing
Evaluate/develop resistance
Establish quarantines, etc
Destruction of host material
Likelihood of early detection
Eradication possible / likely
Chem. control fungicides, etc.
Ralstonia bact wilt (R3b2)
Late wilt of corn
PDM of corn
Stem rust of wheat
Scots pine blister rust


"Cluster analysis"
Potato wart
Citrus var. chlor.
Citrus greening
Rathy. poisoning
Plum pox
Bact. blight rice
Pot. gold. nema
Red leaf SB
Ralstonia
Late wilt corn
Citrus blk spot
Chrysan. rust
Glad. rust
Grape black foot
Potato yellow v.
FW date palm
Soybean rust
PDM corn
Stem rust-Ug99
Scot's pine rust
P. kernoviae
Laurel wilt Rb
Orange rust SC
Response / Control
Pathogen

Prioritizing Plant Diseases for the NPDRS

- 1st NPDRS Workshop – April 2006 (Memphis, TN)
  - Selecting pathogens for recovery plans (My list, your list, pathogen du jour)
- 2nd NPDRS Workshop – April 2007 (St. Louis, MO)
  - How to prioritize plant diseases for the NPDRS (The Martyn Method!)
- 3rd NPDRS Workshop – October 2008 (San Antonio, TX)
  - Prioritizing high risk pathogens for the NPDRS (So many pathogens; so little time)
- 4th NPDRS Workshop – March 2011 (Dallas, TX)
  - Developing methods for selection of recovery plans for the NPDRS (Are generic plans feasible and appropriate?)

Prioritizing Plant Diseases for the NPDRS

- 1st NPDRS Workshop – April 2006 (Memphis, TN)
  - Selecting pathogens for recovery plans (My list, your list, pathogen du jour)
- 2nd NPDRS Workshop – April 2007 (St. Louis, MO)
  - How to prioritize plant diseases for the NPDRS (The Martyn Method!)
- 3rd NPDRS Workshop – October 2008 (San Antonio, TX)
  - Prioritizing high risk pathogens for the NPDRS (So many pathogens; so little time)
- 4th NPDRS Workshop – March 2011 (Dallas, TX)
  - Developing methods for selection of recovery plans for the NPDRS (Are generic plans feasible and appropriate?

- 5th NPDRS Workshop – April 2013 (Falls Church, VA)
  - Refining the model for generic recovery plans (Are we getting closer to generic plans?)

The Process

1. Can we take the ‘cluster model concept’ and apply metrics instead of ‘color coding’?
2. What are the parameters / descriptors that are most important for discriminating between diseases (grouping or separating diseases)?
3. Can the model be validated statistically?
4. Can it be improved and how?

Process and Steps

- Several conference calls
- 1 ½ day project meeting in Dallas (Jun 2011)
  - Developed a set of descriptors that could be used to “score” each disease (yes or no)
  - List was intentionally long (75 individual descriptors)
  - Each project member (except one) reviewed each of the 14 current plant disease recovery plans and scored them for all 75 descriptors.

Method of Dissemination

BIOLOGY
Method of dissemination / dispersal
Null
Wind
Water
Rain
Seed/ plant parts
Vector (biotic) – arthropod, fungal, nematode, other
Circulative (not propagative, passes through insect without replication, transmitted for the life of the vector)
Semi-persistent
Non-persistent
Fomite – human clothing, trade, travel, tools, equipmen, etc.
Soil

Method of Survival

Method of overseasoning and survival (survival beyond season of introduction of outbreak)
Null
Resting structures
In planta (living plant or plant part)
In soil saprophytically
In soil
In water
In vector
Fomite - human, equipment, pots
Alternate host overseasoning

Type of Disease Cycle

Type of diseae cycle
Monocyclic
Polycyclic
Polyetic (monocyclic w/in a season, but appears polycyclic over multiple seasons)
Vector transmission
Non-persistent (older stylet-borne nature)
Semi-persistent
Circulative (pathogen circulates through the insect gut)
Propagative (pathogen reproduces within the vector)
Transovarial (pathogen is transferred to the vector offspring)

Host Range and Ecosystem

Pathogen reproductive potential
Low / Medium
Medium / High
Host range / specificity (many hosts or only one or a few)
Narrow – Single species or genus host
Moderate –multiple genera, same family
Broad – multiple plant families
Geospatial pattern of host plant
Contiguous
Fragmented (random)
Site type (area at risk vs outbreak?)
Agricultural field
Orchard/vineyard
Natural landscape
Forest
Residential
Planting stock production facility
Retail outlet
Greenhouse production (plants grown under shade cloth, plastic or glass)
Commercial nursery

Symptom Expression

Latency period for symptom development (relative to host / detection method)
Unknown
Short (< 14 days)
Medium (15 days - 60 day)
Extended (61-365)
Long (1 or more years)

Disease Management Principles

Exclusion
Quarantine (Is a quarantine practical? e.g. Karnal bunt vs soybean rust!)
Surveillance and monitoring
Testing/certification program
Sanitation practices (Are sanitation practices practical? e.g. Citrus canker vs stem rust of wheat)
Vector management practical? Would it likely succed or significanlty slow the spread?
Eradication
Host destruction (e.g., burning, tillage, rouging, alternate host destruction)
Fumigation / pesticide/ pheromone confusion / sterile vector/pest release
Host and / or pathogen free period/ restricted planting (fallow)
Seed / propagative plant part treatment
Residue / soil treatment management (tillage, liming, flooding, etc.)
Vector management likley to succed?

Disease Management Principles

Protection (protective fungicides, insecticides)
Known efficacious protective treatments exist
Effective chemisties exist but not labled
Not known if efficacious protective treatments exist
Efficacious protective treatments exist but not feasible or practical
Protection not feasible regardless
Resistance
Resistance exists
Resistance is known but not available
Resistance is not currently known / evaluation of germplasm
Begin a race-specific breeding program
Avoidance (Is it practical to practice avoidance strategies?)
Yes
No

Public / Social Impact

Public / Social Impact
Is crop insurance available?
Yes
No
Would there likely be public assistance / grower compensation available?
Yes
No
Would an emergency declaration be a likely action?
Yes
No
Length of recovery from significant outbreak?
Short
Long
Would there be a significant trade impact
High
Low
Is there a relevance to food safety?
Yes
No
Is there a relevance to food security?
Yes
No
What is the potential economic damage - Private/Commercial incl. loss of profit/cost of response/ loss of trade
High
Low
Would economic damage to the public be likely? e.g., tax payer cost response e.g., citrus canker?
High
Low
Would a social impact be likely? / public response? e.g. citrus canker?
Low
High

Process and Steps (con't)

- Project meeting at APS annual meeting in Hawaii (Aug 2011)
  - Neil M^{c}Roberts joined the group.
  - Data from the initial scoring for each evaluator was compiled.
  - Converted "yes / no" responses to "0 / 1"
  - Dropped some descriptors.
  - A preliminary principal component analysis (PCA) performed on the data; evidence of clustering
  - Conference calls to discuss analysis.

Process and Steps (con't)

- Project meeting at APS annual meeting in Providence, RI (Aug 2012)
  - Each project member was asked to re-evaluate and revise the descriptor list individually; eliminate those that were redundant, ambiguous, and/or irrelevant and reduce the # descriptors.
  - Descriptors reduced from 75 to 35.
  - Principal component analysis performed on the revised (reduced) list of descriptors.

Questions Asked

- Are there diseases that cluster based on epidemiological and management parameters?
- Is there inter-rater agreement among evaluators?

What did these exercises tell us?

- Conceptually plant diseases do cluster around common aspects of their biology and epidemiology and the principles of plant disease management – even diseases that on the surface might be considered quite different.
- Knowledgeable raters can agree, within reason, and consistently rate in a similar manner.
- More refinement may be needed in the descriptors
- But ….

The ‘devil is in the details’.