



Developing Matrices for the Selection of Recovery Plans in the National Plant Disease Recovery System

(or)

Are Generic Plans Feasible and Appropriate?

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4th National Plant Disease Recovery System Workshop, Mar 6-8, 2011, Dallas, TX

Prioritizing Plant Diseases

- λ 1st NPDRS Workshop – April 2006 (Memphis, TN)
- λ 2nd NPDRS Workshop – April 2007 (St. Louis, MO)
- λ 3rd NPDRS Workshop – October 2008 (San Antonio, TX)
- λ 4th NPDRS Workshop – March 2011 (Dallas, TX)



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Generic Plans

- λ General consensus on the concept of generic plans, although there was some discussion if generic plans were appropriate at all, given the diversity of pathogens, hosts, environments, etc.
- λ However, there was no consensus on exactly what a generic plan would look like and which pathogens and diseases might serve as models.



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Generic Plans

- λ Plant diseases that might serve as models for many others might be those that –
 - are caused by similar types of pathogens
 - occur on similar hosts
 - are disseminated in similar ways
 - survive in similar ways
 - are managed in similar ways



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Plant Disease Recovery Plans

Completed

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

In development

- λ Citrus leprosis
- λ Cyst nematode
- λ Laurel wilt of avocado
- λ *Phytophthora* spp. of trees / shrubs
- λ Walnut thousand cankers
- λ Wheat blast



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Criteria for prioritization

- λ USDA Select Agent and Toxins List



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USDA Select Agent and Toxins List (2008)

- λ *Peronosclerospora philippinensis* (Philippine downy mildew of corn)
- λ *Phoma glycinicola* (Red leaf blotch of soybean)
- λ *Ralstonia solanacearum* race 3 biovar 2 (Bacterial wilt of solanaceous crops)
- λ *Rathayibacter toxicus* (Slime disease / Rathyibacter poisoning)
- λ *Sclerophthora rayssiae* var. *zeae* (Brown stripe downy mildew of corn)
- λ *Synchytrium endobioticum* (Potato wart)
- λ *Xanthomonas oryzae* – all pathovars (Bacterial leaf blight of rice)
- λ *Xylella fastidiosa* CVC strain (Citrus variegated chlorosis)



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Criteria for prioritization

- λ USDA Select Agent and Toxins list
- λ Economic value of host crop



Criterion A. Economic value of host

(USDA Agricultural Statistics 2008)

- λ Corn - \$52.1 billion (92.6 million acres)
- λ Soybeans - \$26.7 billion (62.8 million acres)
- λ Wheat - \$13.7 billion (51 million acres)
- λ Cotton - \$6.2 billion (10.5 million acres)
- λ Forest lumber - \$5.2 billion
- λ Potatoes – \$3.9 billion (1.1 million acres)
- λ Rice - \$3.4 billion (2.9 million acres)
- λ Citrus - \$2.9 billion (876,000 acres)
- λ Apples - \$2.4 billion (615,000 acres)
- λ Cucurbits - \$1.6 billion (503,000 acres)



Criterion: Economic value of host

(USDA Agricultural Statistics 2008)

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- λ Cucurbits - \$1.6 billion (503,000 acres)



Criterion A. Economic value of host

(USDA Agricultural Statistics 2008)

- λ Mushrooms - \$9.5 million (NA)
- λ Cherries - \$6.5 million (118,000 acres)
- λ Pistachios – \$5.5 million (114,000 acres)
- λ
- λ
- λ
- λ
- λ



Economic value of host

- λ The reality is that any plant disease worthy of having a recovery plan prepared would be on a high value crop!

Criteria for prioritization

- λ USDA Select Agent and Toxins list
- λ Economic value of host crop
- λ Type of host (crop)

Type of Host

- λ Field crops (soybean, cotton, maize, etc.)
Soybean rust, PDM, late wilt, brown stripe mildew, red leaf blotch
- λ Small grains (wheat, rice, barley, etc.)
Stem rust Ug99, wheat blast (in develop.)
- λ Forage crops
Rathyibacter poisoning
- λ Vegetables (tomatoes, potatoes, beans, etc.)
R.s.r3b2, potato wart, (potato cyst and root-knot; in develop.)
- λ Ornamentals (cut flowers, potted plants, landscape, etc.)
R.s.r3b2, Ramorum blight (SOD)

Type of Host

- λ Fruit and nut trees (citrus, stone & pome fruits, nuts)
CVC, HLB, citrus canker, plum pox, (laurel wilt avocado, walnut canker, in develop.)
- λ Landscape, plantation and forest trees
P. ramorum, *P. kernoviae*, Scots pine blister rust, *Phytophthora* spp.
- λ Annuals
Potato wart, R.s.r3b2, stem rust, wheat blast (in develop.), DM corn, late wilt, soybean rust, red leaf blotch, potato cyst nematodes (in develop.)
- λ Perennials
CVC, HLB, canker, laurel wilt avocado, plum pox, laurel wilt redbay, Scots pine rust, *P. kernoviae*, *P. ramorum* et al., walnut canker & citrus leprosis (in develop.)

Criteria for prioritization

- λ USDA Select Agent and Toxins list
- λ Economic value of host crop
- λ Type of host (crop)
- λ Type of pathogen

Type of pathogen

- λ Fungi (chytrids, ascos, basidos)
- λ Stramenopiles (downy mildews, *Phytophthora* spp)
- λ Bacteria (Eubacteria, XLB, PLB)
- λ Viruses
- λ Nematodes

Which taxa and how many of each?

Type of pathogen

- λ Fungi (chytrids, ascos, basidos)
Stem rust of wheat, soybean rust, Scots pine rust, late wilt of corn, laurel wilt redbay, laurel wilt avocado, potato wart, wheat blast, walnut canker
- λ Stramenopiles (Oomycota)
Philippine DM corn, brown stripe mildew corn, *P. kernoviae*, *P. ramorum*, *Phytophthora* spp.
- λ Bacteria
R. solanacearum r3b2, Rathayibacter poisoning, citrus greening (HLB), citrus variegated chlorosis
- λ Viruses
Plum pox, citrus leprosis (in develop.)
- λ Nematodes
Cyst and root-knot nematodes (in develop.)

Criteria for prioritization

- λ USDA Select agent and toxins list
- λ Economic value of host crop
- λ Type of host (crop)
- λ Type of pathogen
- λ Type of host x type of pathogen matrix

Host x Pathogen Taxa

Pathogen Taxa	Host						
	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Ornamentals
Viruses							
Bacteria							
Fungi (Rusts)							
Fungi (Other)							
Downy mild. (Oomycota)							
Phytophthora (Oomycota)							
Nematodes							

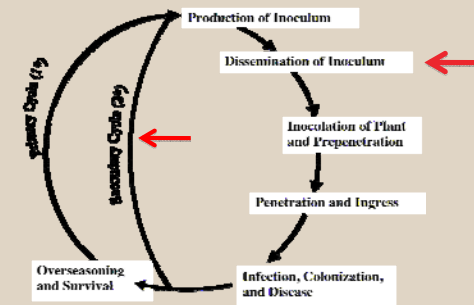
Host x Pathogen Taxa

Pathogen Taxa	Host						
	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Ornamentals
Viruses				CLV, PPV			
Bacteria	Rb tox.			CVC, HLB		Rsr3b2	Rsr3b2
Fungi (Rusts)		SRW	ASR		SPBR		
Fungi (Other)		WB	LWC, RLBS	LWA	WC, LWR	PW	
Downy mild. (Oomycota)			PDM, BSDM				
Phytophthora (Oomycota)					Pk, Pr, P. spp.		
Nematodes						PGCN	

Criteria for prioritization

- λ USDA Select agent and toxins list
- λ Economic value of host crop
- λ Type of pathogen
- λ Type of host (crop)
- λ Type of host x type of pathogen matrix
- λ Pathogen epidemiology / dissemination

Generic plant disease cycle



Pathogen Dissemination

- λ Wind or wind-blown rain
- λ Water-borne
- λ Soil-borne
- λ Seed / plant-borne
- λ Vector-borne
- λ Mechanical (equipment, etc.)
- λ Others

Host x Pathogen Dissemination

		Host						
		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals
Dissemination	Wind dispersed							
	Wind / rain dispersed							
	Seed-borne							
	Vector-borne							
	Soilborne							
	Over-season.							

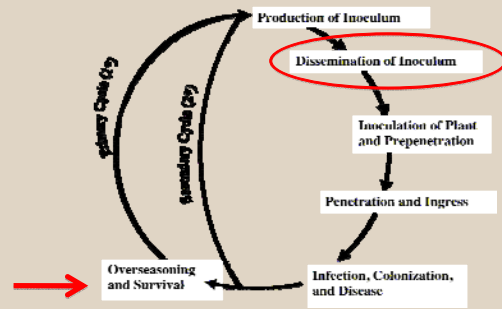
Host x Pathogen Dissemination

		Host						
		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals
Dissemination	Wind dispersed		WSR, KB, WB	ASR, RLB, PDM		SPBR, Pk, Pr		
	Wind / rain dispersed				CC	Phytoph. spp	Rsr3b2	Rsr3b2
	Seed-borne		KB	LWC			Rsr3b2	Rsr3b2
	Vector-borne	Rb tox			CLV, PP, HLB	LWRb		
	Soilborne	Rb tox		LWC, RLB			PW, PCN, Rsr3b2	Rsr3b2
	Over-season.		KB, WB, WSR	RLB, PDM		Phytoph. spp	PW, PCN	

Criteria for prioritization

- λ USDA Select agent and toxins list
- λ Economic value of host crop
- λ Type of pathogen
- λ Type of host (crop)
- λ Type of host x type of pathogen matrix
- λ Pathogen epidemiology / dissemination
- λ Pathogen epidemiology / survival and establishment

Generic plant disease cycle



Pathogen survival and establishment

- λ Obligate vs. non-obligate parasite
- λ Alternant or alternative hosts
- λ Survival structures
- λ Vector survival
- λ Survival in association with host (seed, bud wood, cuttings, etc.)
- λ Continual reintroduction of inoculum
- λ Climatic constraints (Environmental Risk Zones)
- λ Other

Host x Survival Mechanism

		Host							
		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals	
Survival mechanism	Obligate parasite								
	Non-obligate								
	Survival structures								
	Vector								
	Seed or plant part								
	Reintro-duction								
	Environ. Risk Zones								

Host x Survival Mechanism

		Host							
		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Orna-mentals	
Survival mechanism	Obligate parasite		WST	PDMC BSDM	CLV,CVC HLB, PPV	SPBR	PGCN		
	Non-obligate	Rb tox	WB,	LWC,	LWA	Pk, Pr. P. spp.	Rsr3b2 PW	Rsr3b2	
	Survival structures		WST, WB	LWC,PDM RLBS	LWA	Pk, Pr. P. spp.	PGCN PW		
	Vector	Rb tox			HLB, CLV PPV	LWRb			
	Seed or plant part	Rb tox		LWC	HLB, PPV, CVC		PW		
	Reintro-duction		WST, WB			SPBR, LWRb	Rsr3b2	Rsr3b2	
	Environ. Risk Zones			PDMC LWC		P. spp.			

	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Ornamentals
Viruses		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies Ornamentals
Bacteria							
	Foliar		Forage crops	Small grains	Field crops	Fruits & Nuts	Forest & Landscape Veggies Ornamentals
Fungi (Rusts)	Root rots	Wind dispersed		Forage crops	Small grains	Field crops	Fruits & Nuts Forest & Landscape Veggies Ornamentals
Fungi (Other)	Vascular wilts	Wind / rain dispersed	Obligate parasite				
Downy mild (Oomycota)	Seed rots	Seed-borne	Non-obligate				
Phytophthora (Oomycota)	Fruit rots	Vector-borne	Survival structures				
Nematodes	Rusts	Soilborne	Vector				
	Mildews	Over-seasoning	Seed or plant part				
			Reintroduction				

Criteria for prioritization

- λ USDA Select agent and toxins list
- λ Economic value of host crop
- λ Type of pathogen
- λ Type of host (crop)
- λ Type of host x type of pathogen matrix
- λ Pathogen epidemiology / dissemination
- λ Pathogen epidemiology / survival and establishment
- λ Risk or threat factor

The risk (R) of a given pathogen can be defined as:

$$R = A \times E \times S \times H \times (1 - C)$$

R = Risk

A = Probability of introduction

E = Probability of pathogen establishment

S = Probability of spread from initial point

H = Probability of major damage (hazard)

C = Probability of control or containment

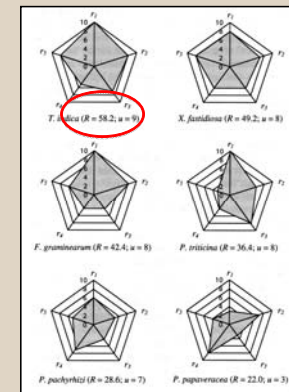
L.V. Madden & M. Wheelis 2003. Ann. Rev. Phytopathol. 41:155-176

Risk Evaluation Scheme (RES)

Fig. 1 Risk profile, completed by risk aggregated score and degree of uncertainty, as the result of the risk evaluation scheme (RES) for the nine selected plant pathogens. The five sections (scored on the [0-10] integer scale) of the RES are: importance of the target crop (r_1), ease of use of the pathogen (r_2), epidemic potential of the pathogen (r_3), obstacles to swift and effective response (r_4), potential global or regional consequences (r_5). The risk aggregated score A is given by the equation

$$R = \frac{1}{n} \left(\sum_{i=1}^{n-1} r_i \times r_{i+1} \right) + r_n \times r_1$$

with $n=5$. The degree of uncertainty u (scored on the [0-10] integer scale) is an empirical assessment of the quality and quantity of scientific information available for completing the RES



$$R = (r_1 \times r_2 + r_2 \times r_3 + r_3 \times r_4 + r_4 \times r_5 + r_5 \times r_1) / 5$$

u = degree of uncertainty of information

Suffert, et al. 2009. Food Sec. 1:221-232

Most diseases of concern are exotic!



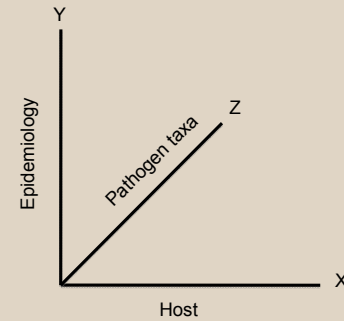
NASA, The World at Night - "City Lights"

Bad guesses = bad decisions!

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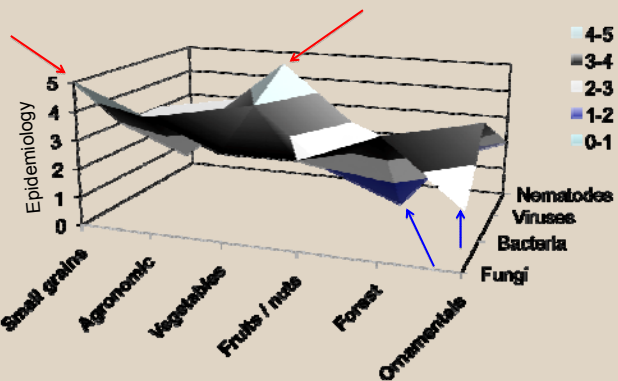
3-Dimensional Matrix (Pathogen x Host x Epidemiology)



Martyn, 2011. 4th NPDRS workshop

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- λ Type of host x type of pathogen matrix
- λ Pathogen epidemiology / dissemination
- λ Pathogen survival and establishment
- λ Risk or threat factor
- λ Response and management strategy

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Principles of Plant Disease Management¹

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

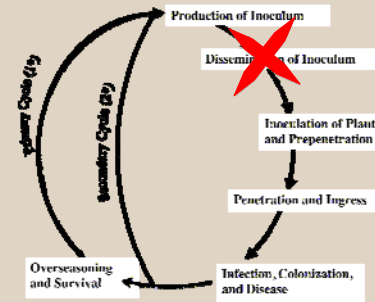
¹National Academy of Sciences. 1968. Principles of Plant and Animal Pest Control. Vol 1. Plant Disease Development and Control. NAS Publ. #1596. Washington, D.C. 205 pp.

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λ Exclusion (Dissemination of pathogen)

- Quarantines, inspections, certification programs, sanitation of equipment, etc., vector management, surveillance and monitoring programs,

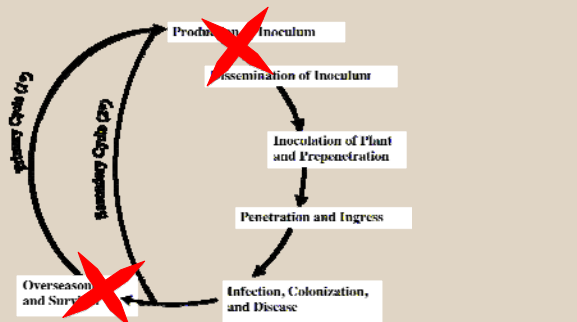


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λ Eradication (Overseasoning & Survival and production of inoculum)

- Host destruction, sanitation, seed or plant treatment, fumigation, alternate host destruction, certification programs, vector management, crop rotation / fallow, residue management,

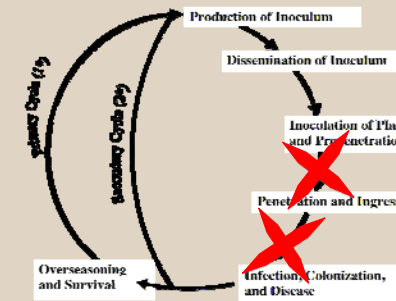


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λ Protection, Therapy and Host Resistance (Penetration, Infection, Ingress and Colonization)

- Fungicides (protective & systemic), insecticides, germplasm screening and cultivar development, ...



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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
Plan program											
Survey & monitor											
Plant test. & inspec.											
Level / delay resistance											
Establish quarantine											
Quarantine host mat.											
Likelihood early detect.											
Eradication pink / prob.											
Chem. ctrl. practical											
Vector ctrl. practical											
Change to growers/home											

PLANT DISEASE RECOVERY PLANS

	Potato wart	Citrus virus (CVC)	Citrus greening (HLB)	Raffinose	Plum pox	Ri. blight of soybean	Rubivora leaf with (R302)	Late wilt of corn	Soybean Rust	POB of corn	Stem rust of wheat	Scots pine blister rust	Laurel wilt of red bay	Phytophthora ramorum
Establish resp. 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.								

Potential diseases for new recovery plans

- λ Bacterial leaf blight & streak of rice ✓
- λ Grapevine black foot
- λ Fusarium wilt of date palm
- λ Potato yellowing virus
- λ Citrus black spot
- λ Sweet orange scab
- λ European Larch canker
- λ Chrysanthemum white rust
- λ Gladiolus rust
- λ Japanese oak wilt

Grapevine Black Foot Disease

- λ *Vitis vinifera*, *Vitis* spp.
- λ Complex (?) of *Cylindrocarpon* spp.



- λ First reported in France (1961); from Italy (1984), Portugal (2000), Argentina (2001), Germany (2003), Brazil, New Zealand & South Africa (2004), California (2005), Spain & Chile (2007), Uruguay (2010)
- λ Root lesions and necrosis (black foot), reduced root biomass, reduced vine vigor, scorched foliage, reduced yield and death.
- λ Most serious on grapevine nurseries and young vineyards



How does grapevine black foot disease fit in the recovery plan matrices?

- λ Important host (grape)
- λ Fungal pathogen
- λ Soilborne (long-lived survival structures)
- λ Control strategy
 - Exclusion (disease-free rootstock certifications)
 - Eradication (fumigation, host destruction, replant)
 - Host resistance (rootstock)
 - Therapy (systemic fungicides)

Fusarium Wilt of Date Palm

- λ *Fusarium oxysporum* f. sp. *canariensis*; f. sp. *palmarum*
- λ Limited distribution in US (CA, FL, NV; SC, TX - 2011)
- λ Primarily an ornamental landscape palm in U.S. (25° N - 35° N)
- λ Approx. 5,300 acres of commercial date production in California



How does Fusarium wilt of date palm fit in the recovery plan matrices

- λ Important hosts (*Phoenix canariensis*, *P. dactylifera*, other palm species)
- λ Soilborne pathogen
- λ Long-lived survival structures (chlamydospores)
- λ No significant aerial inoculum
- λ Control strategy
 - Exclusion (seedling certification, nursery inspections)
 - Eradication (host destruction, replant)
 - Therapy (systemic fungicides - ?)

Potato Yellowing Virus (PYV)

- λ Bromoviridae: *Ilarvirus*
- λ *Myzus persicae* (aphid)
- λ First reported from Peru & Chile (1992)
- λ March 2011 reported from Ecuador
- λ EPPQ Quarantine Pest
- λ Hosts – cultivated and wild potatoes, tomatoes, peppers
- λ Symptoms – yellowing, stunting, reduced yield



How does potato yellowing virus fit into the recovery plan matrices?

- λ Important hosts (Solanaceous crops)
- λ Aphid-transmitted (*Myzus persicae*)
- λ Seed-transmitted in potato and pepper
- λ Control strategy
 - Exclusion (quarantine, seed certification)
 - Eradication (host destruction - tillage)
 - Genetic resistance (selection and breeding)
 - Vector control not practical or of limited effectiveness

Citrus black spot



- λ *Guignardia citricarpa* (*Phyllostica citricarpa*)
- λ *Citrus spp.* (oranges, lemons, grapefruit, limes, etc.)
- λ Occurs throughout world (Asia, Africa, So. Am., Australia)
- λ Confirmed in US in two FL counties - Apr 7, 2010
- λ Primary inoculum is ascospores from lesions on fallen leaves
- λ Long latency period for fruit symptoms



How does citrus black spot fit into the recovery plan matrix?

- λ Important host - Citrus
- λ Fungal pathogen
- λ Survival in leaf and fruit debris
- λ Spread by wind and rain, fruit movement and nursery stock
- λ Control strategy
 - Exclusion (quarantines)
 - Protection (fungicides)
 - Eradication (sanitation, destruction of infected fruit and nursery stock)

Sweet orange scab



- λ *Elsinoë australis*
- λ Sweet orange in addition to tangerines & grapefruit
- λ Primarily a fresh market concern. Prevalent in South America (ARG, BOL, BRA, ECU, PAR, URG)
- λ First detected in U.S. (TX, LA, MS - Jul 2010) and then in FL (Dec 2010) and AZ (Jan 2011)
- λ Control would be same as for citrus scab (*E. fawcetti*)
 - Quarantines, fungicides, inspections, surveys, sanitation, fruit destruction
- λ Requires significant moisture, Florida and Texas would be impacted most. Establishment unlikely in CA & AZ (Thayer, et al. 2003. Pest assessment: Sweet orange scab. USDA,APHIS,PPQ)

Chrysanthemum white rust

- λ *Puccinia horiana*
- λ Established in Europe, Asia, Africa, CA, SA, Australia
- λ Has occurred in U.S. (CT, MI 2008) but eradicated
- λ Primarily affects florist mums. Many other varieties are resistant
- λ Economic impact of \$4 – \$20 million (1997 dollars)
- λ Control strategy
 - Exclusion (quarantines, surveillance and monitoring)
 - Eradication (plant destruction)
 - Protection (fungicides)



Gladiolus rust

- λ *Uromyces transversalis*
- λ Established throughout Africa, limited distribution in southern Europe (France, Italy, Portugal, Malta, Spain)
- λ Localized in South America (Brazil, Argentina), Caribbean, Mexico, Australia and New Zealand.
- λ Detected in U.S. (FL, CA, MN) in Apr 2006.
- λ Eradicated from FL & MN. Still reported in one CA county (<http://pest.ceris.purdue.edu/searchmap.php?selectName=FJAAUBU>)
- λ Control strategy
 - Eradication (plant destruction), quarantines, surveys, fungicides

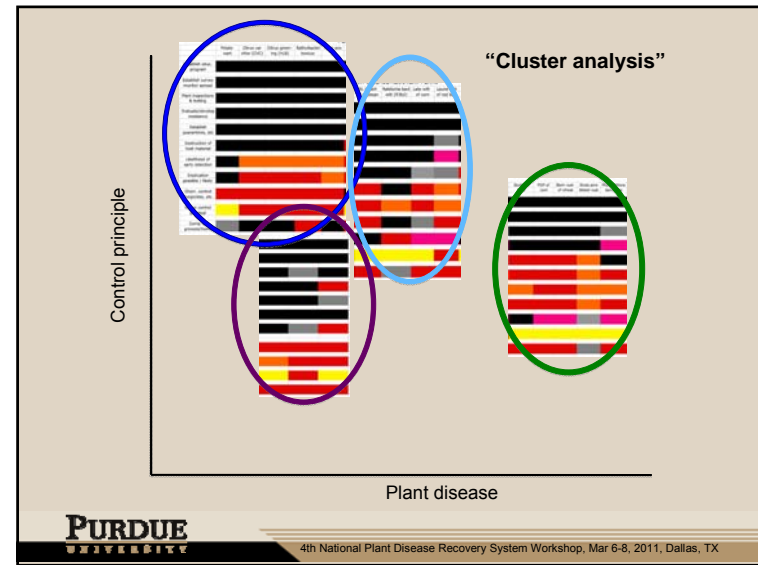
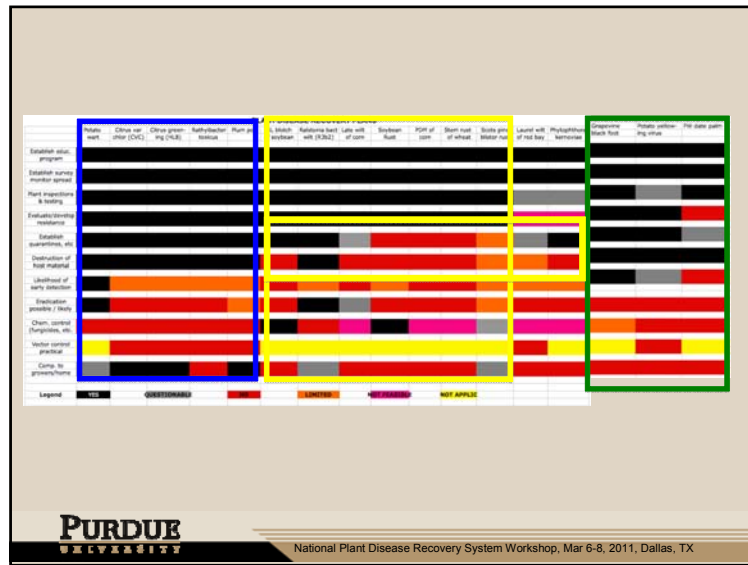
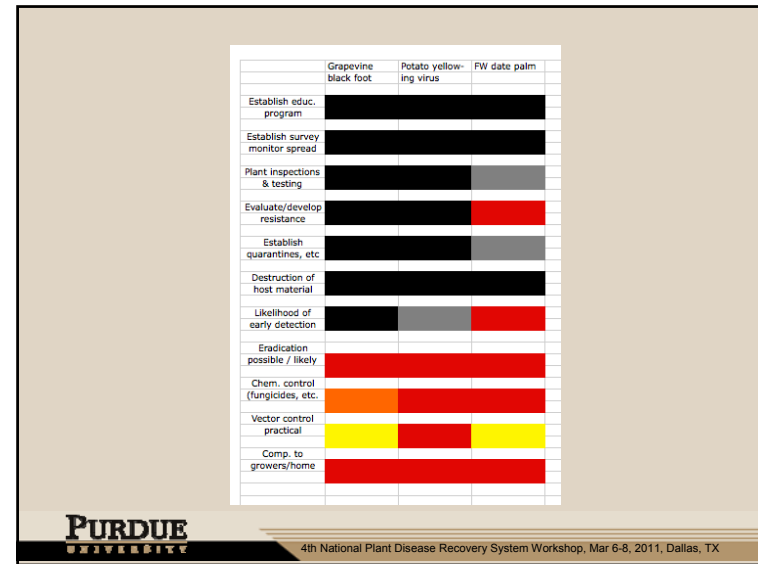
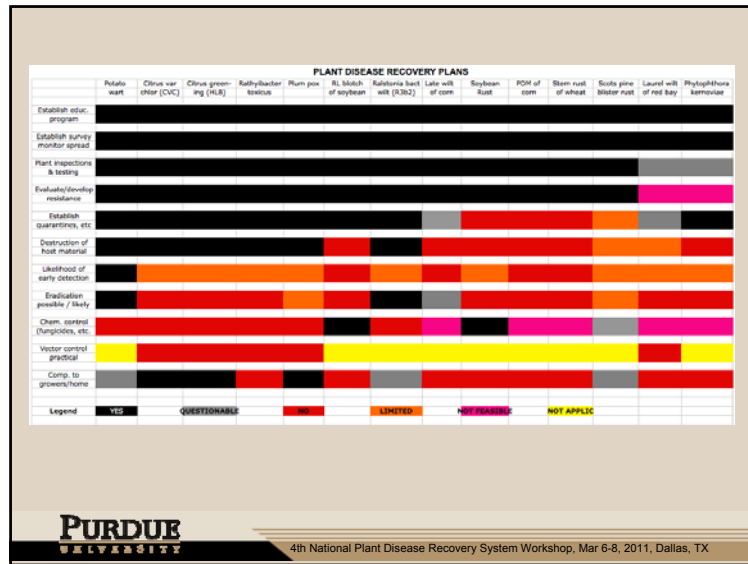


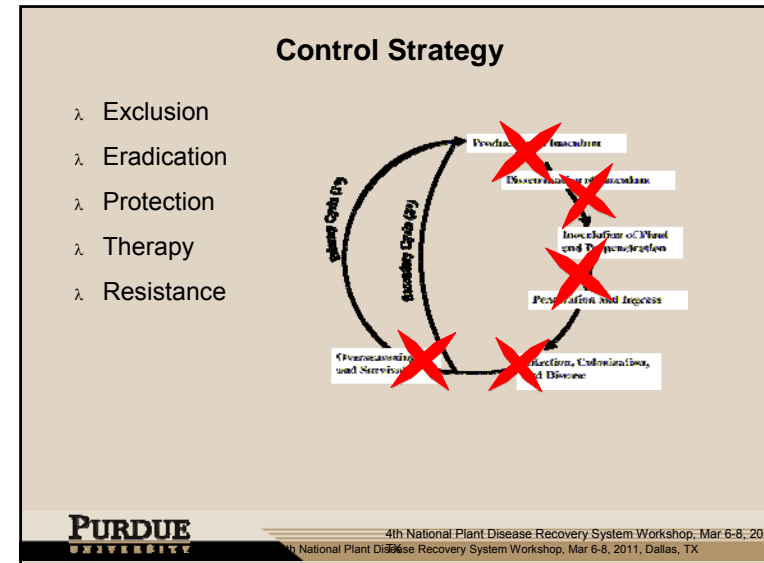
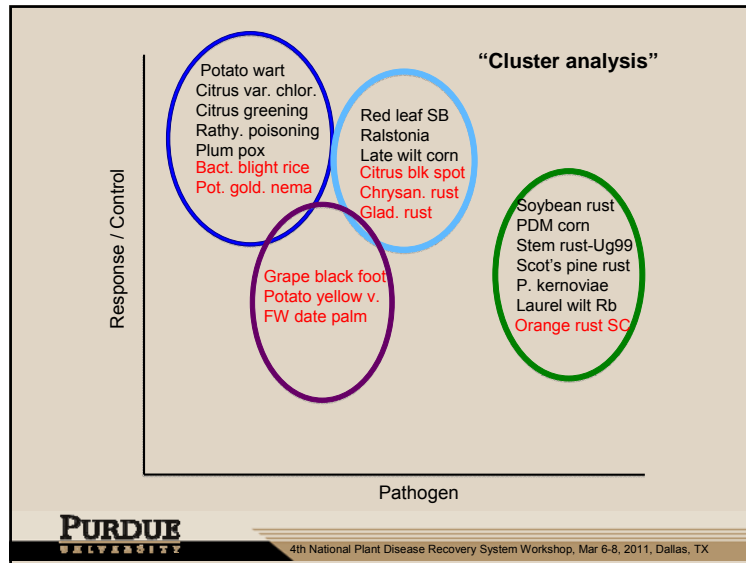
Host x Pathogen Taxa

Pathogen Taxa	Host						
	Forage	Small grains	Field crops	Fruits & Nuts	Forest & Landscape	Veggies	Ornamentals
Viruses				CLV, PPV			
Bacteria	Rb tox.			CVC, HLB		Rsr3b2	Rsr3b2
Fungi (Rusts)		SRW	ASR		SPBR		
Fungi (Other)		WB	LWC, RLBS	LWA	WC, LWR	PW	
Downy mild. (Oomycota)			PDM, BSDM				
Phytophthora (Oomycota)					Pk, Pr, P. spp.		
Nematodes						PGCN	

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Pathogen Taxa	Host						
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Fungi (Rusts)		SRW	ASR ORS		SPBR		CWR, GR
Fungi (Other)		WB	LWC, RLBS	LWA, GB, F CBS, SOS	WC, LWR, FWDP, ELC, JOW	PW	
Downy mild. (Oomycota)			PDM, BSD				
Phytophthora (Oomycota)					Pk, Pr, P. spp.		
Nematodes						PGCN	





What is generic about generic plans?

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- ### Recovery Plan Components
- λ Introduction
 - λ Symptoms
 - λ Spread
 - λ Monitoring, Detection and Identification
 - λ Response
 - λ USDA Permits
 - λ Economic Impact
 - λ Mitigation & Disease Mgt
 - λ Infrastructure & Experts
 - λ Research, Extension & Education Priorities
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Recovery Plan Components

- λ Introduction - **Specific**
- λ Symptoms - **Specific**
- λ Spread - **Generic**
- λ Monitoring, Detection and Identification – **Specific**
- λ Response - **Generic**
- λ USDA Permits - **Specific**
- λ Economic Impact - **Specific**
- λ Mitigation & Disease Mgt - **Generic**
- λ Infrastructure & Experts - **Specific**
- λ Research, Extension & Education Priorities - **Specific**

Generic Plans: Are They Feasible?

- λ 2-D matrix design based on various combinations of type of host, type of pathogen, type of disease, etc.
 - Advantage: Straight-forward, simply fill in the boxes
 - Disadvantage: Too many boxes, where to stop?
- λ Risk / Threat Analysis
 - Advantage: Quantifies diseases on likely introduction and establishment scenarios
 - Disadvantage: Often lacks critical data for assigning values – “bad guesses = bad decisions”

Generic Plans: Are They Feasible?

- λ 3-D matrix based on type of host, type of pathogen and basic epidemiology (spread, survival, disease cycle)
 - Advantage: Quantifies diseases
 - Disadvantage: Difficult to assigned values; unknowns
- λ Cluster analysis based on basic response and control strategy.
 - Advantage: Groups similar diseases by response
 - Disadvantage: Grey areas - “Lumpers and splitters”; defining criteria

Summary

- λ Which of the prioritization methods is the most appropriate?
- λ Are any of the methods appropriate or feasible?
- λ Can recovery plans be “genericized”?
- λ If not, why not?
- λ We are at the point to either -



Economic value of host

- λ The economic value of a particular plant is more than just the cash value. It also encompasses the regional or global impact.
 - For example, small specialty crops, like mint. Approximately 25,000 acres in U.S
 - Northern Indiana, Pacific northwest
 - Ranked 4th (peppermint) and 5th (spearmint) globally; 1st in oil quality and U.S. has 60% of world market
 - Approximately 30% of US mint oil is exported
- λ The reality is that any plant disease worthy of having a recovery plan prepared would be on a high value crop!

Exclusion and Eradication

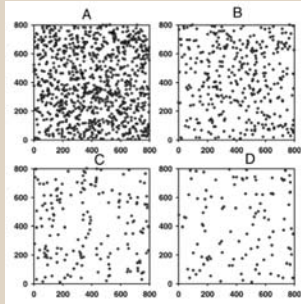
- λ Often the first strategies attempted for exotic pathogens
- λ Quarantines, certification and inspection, surveillance and monitoring, removal of symptomatic and asymptomatic hosts
- λ Expensive & controversial
- λ Not always appropriate – disease and situation specific
 - ✓ Citrus canker and plum pox
 - ✗ Asian soybean rust and wheat stem rust

Can eradication be optimized and 'generalized'?

- λ 1900 ft rule for citrus canker (groves), 125 ft (door-yard) and 1640 ft rule for plum pox.
- λ Optimal eradication distance is dependent on the density and spatial pattern (aggregation) of the host in the landscape (trees, plantation, fields).
- λ Optimal eradication radius minimizes the total # of hosts removed and still effective at eradicating the disease.
- λ Optimal eradication radius increases with both the aggregation and density of the host

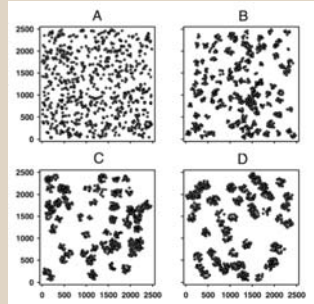
S. Parnell, T.R. Gottwald, C.A. Gilligan, N.J. Cunniffe and F. van den Bosch. 2010. The effect of landscape pattern on the optimal eradication zone of an invading epidemic. *Phytopathology* 100:638-644.

Density



1,000 hosts per A) 0.7 km², B) 1.9 km²,
C) 4 km², D) 5.8 km²

Clustering



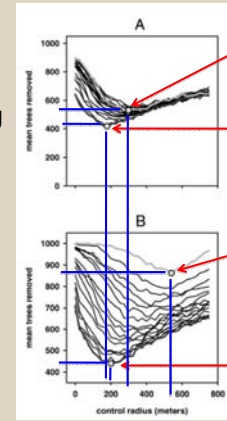
1,000 hosts per A) 1,000 clusters, B) 143 clusters,
C) 71 clusters, D) 50 clusters

Parnell, et al. 2010. Phytopathology 100:638-644



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A. Clustering



B. Density

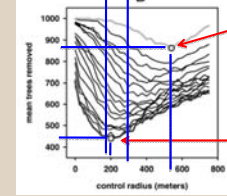


Fig. 3. The mean number of hosts removed during eradication for different lengths of control radius. A) The effect of varying the level of clustering of hosts. B) The effect of varying the density of hosts. (Parnell, et al. 2010)



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