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Objective Prioritization of Exotic Pests (OPEP): Developing a framework for ranking exotic plant pests

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Who are we?

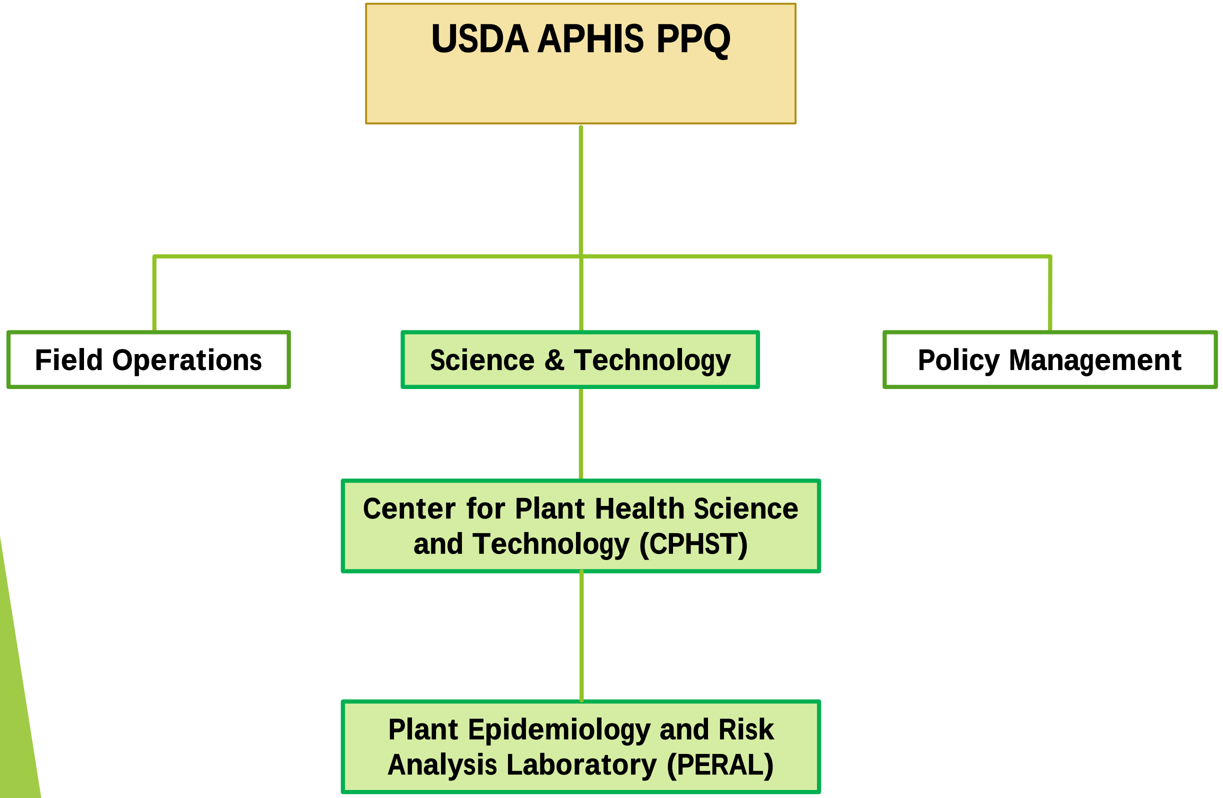
CIPM

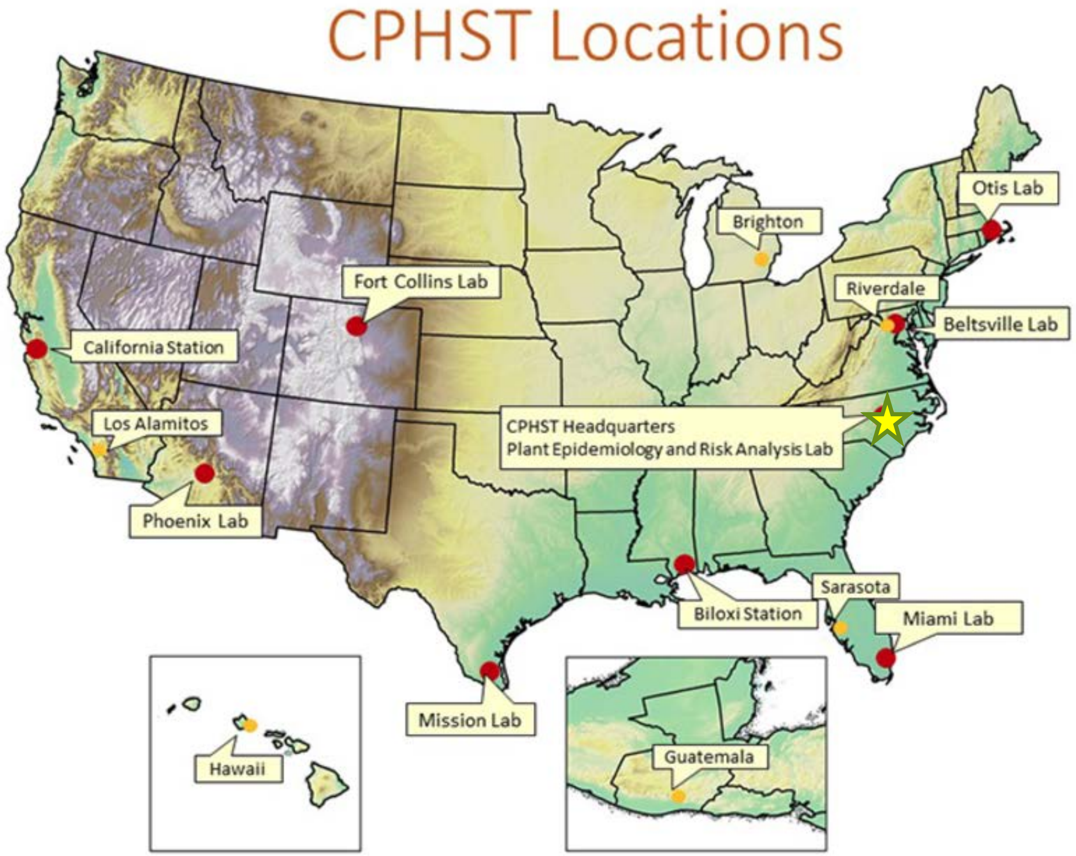
NC STATE UNIVERSITY

NSF Center for Integrated Pest Management

Raleigh, North Carolina, United States

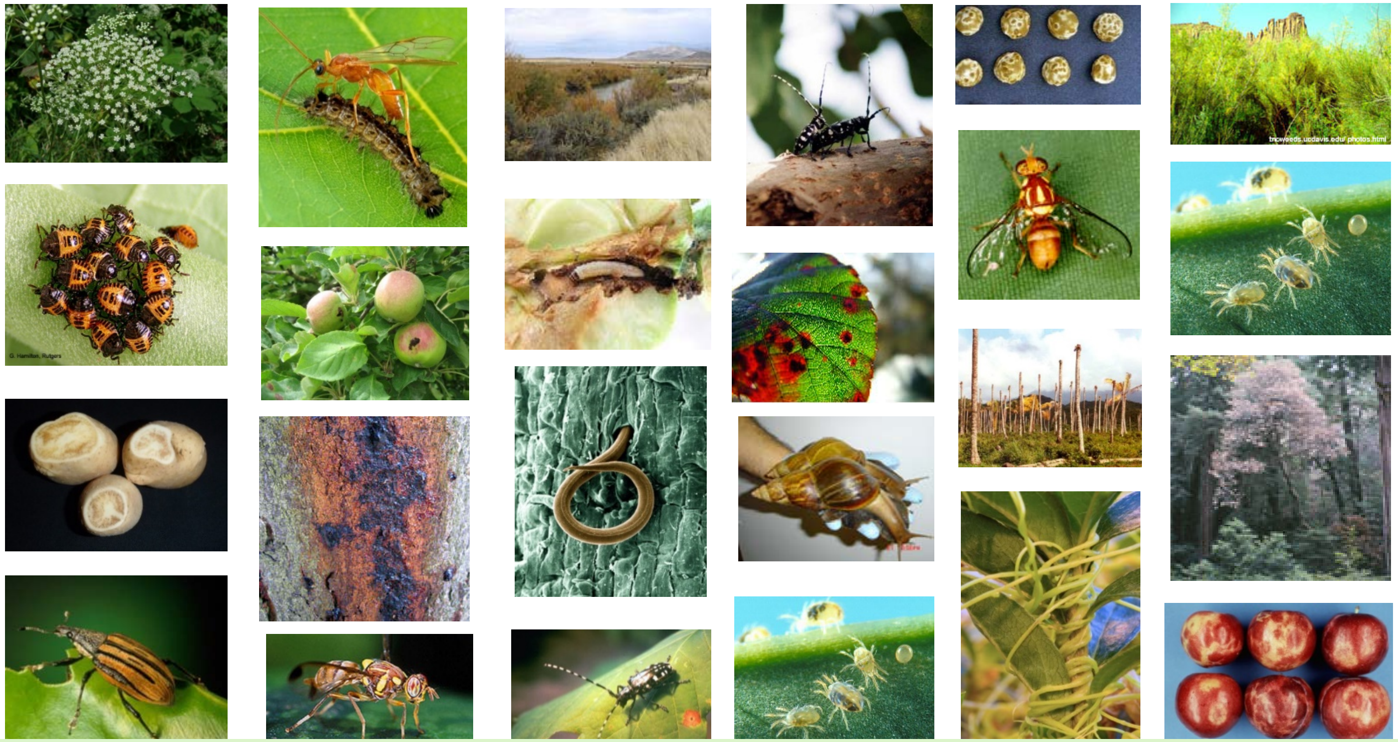
Who are we?

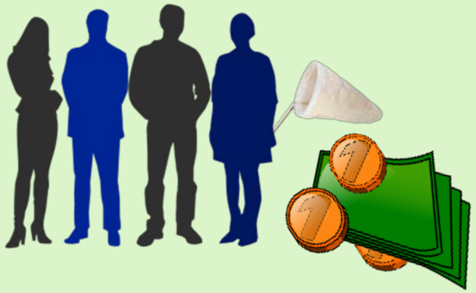

USDA APHIS PPQ
Field Operations
Science & Technology
Policy Management
Center for Plant Health Science and Technology (CPHST)
Plant Epidemiology and Risk Analysis Laboratory (PERAL)


CPHST Locations
Otis Lab
Brighton
Riverdale
Beltsville Lab
Fort Collins Lab
California Station
Los Alamitos
Phoenix Lab
CPHST Headquarters
Plant Epidemiology and Risk Analysis Lab
Sarasota
Biloxi Station
Miami Lab
Mission Lab
Hawaii
Guatemala

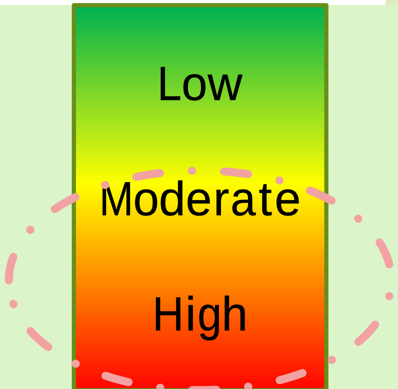
Why do we need to prioritize the exotic pests?

Image source: bugwood.org





Spend our limited resources on pests that pose the greatest risk



Our Stakeholders:
Cooperative Agricultural Pest Survey (CAPS)

Select to survey?

Risk analysis, evidence, uncertainty and decision-making

We wanted the model to be

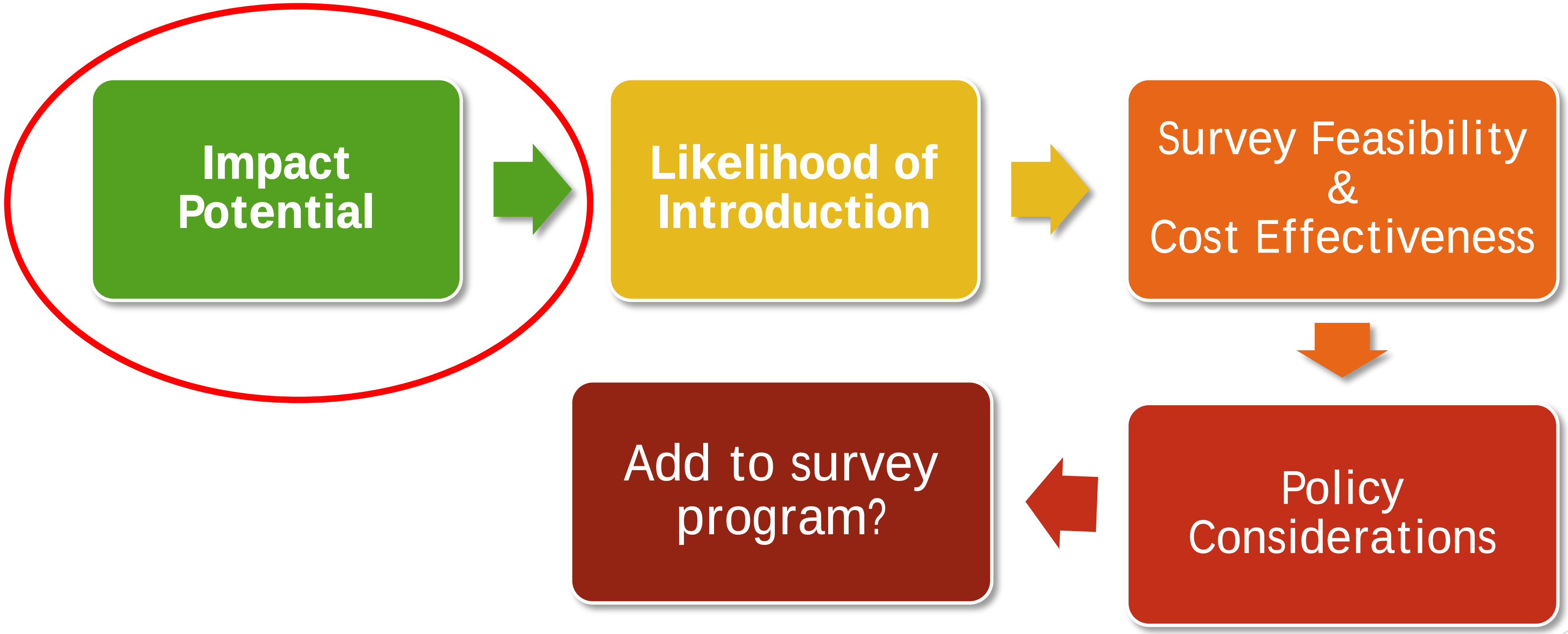
- **Objective** – evidence-driven, not opinion-driven
- **Transparent** – separates analysis based on scientific information from that based on policy
- **Separate uncertainty from risk score**
- **Flexible** – can be used to look at risk by region and host
- **Defendable**

How should pests be prioritized?

Pest Risk

1. **Consequences of introduction**
   - Is the pest likely to cause **serious impacts** upon introduction & spread
2. **Likelihood of introduction**
   - How likely is the pest to enter the United States, **establish a viable population?**
3. **Feasibility** and **Cost Effectiveness**
   - Is it **possible** to survey for the pest?
   - Do the expected impacts of the pest justify the **cost** of a survey program?
4. **Policy considerations**

Objective Prioritization of Exotic Pests (OPEP)



OPEP: Categorizing by Impact Potential

Select Criteria & Training Data

↓

Develop Model

↓

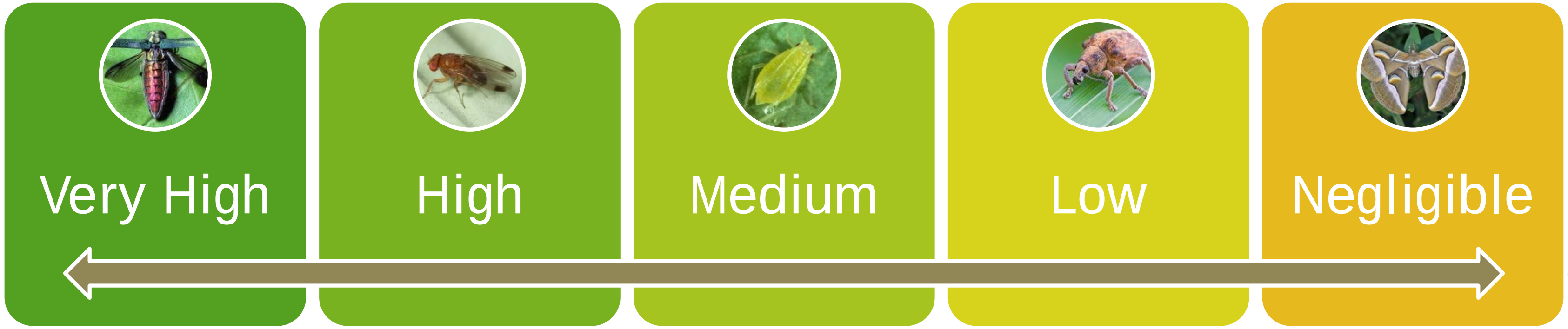
Validate Model

↓

Model Use

Training Data and Observed Impacts

- Identified over 100 non-native arthropods and 80 pathogens that have become established in the United States (> 25 years)
- Team of entomologists/pathologists & economists classified each pest/pathogen in terms of its observed impacts in the United States



Impact Potential: Select Criteria

We developed a set of yes/no and multiple choice questions (criteria) we thought might be predictive of impact

Impact Potential – Training data

- **Pests that were introduced into the U.S.**

100 non-native arthropods
(Training data)

Selection Criteria
- Biology
- Pest Damage
- Control Measures

(Excel template)

Impact Potential – Criteria

When left unmitigated, the organism causes losses up to:

[a] > 50%

[b] 26-50%

[c] 10-25%

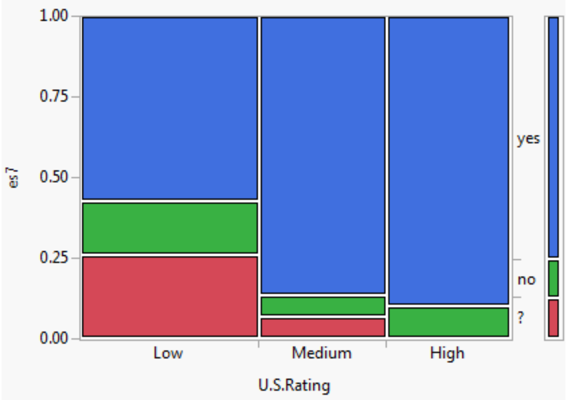
[d] < 10%

[?]

Directions | **Background Questions** | Impact Potential | Endangered Area-Validation | US Impacts | References cited

Selecting important criteria

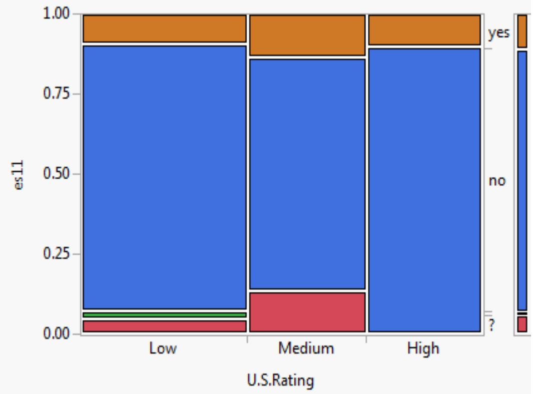
- Chi-square Test and contingency table



Contingency Table

es7

U.S.Rating	Count / Total % / Col % / Row %	?	no	yes	
Low	Count	11	7	24	42
	Total %	10.89	6.93	23.76	41.58
	Col %	84.62	58.33	31.58	
	Row %	26.19	16.67	57.14	
Medium	Count	2	2	26	30
	Total %	1.98	1.98	25.74	29.70
	Col %	15.38	16.67	34.21	
	Row %	6.67	6.67	86.67	
High	Count	0	3	26	29
	Total %	0.00	2.97	25.74	28.71
	Col %	0.00	25.00	34.21	
	Row %	0.00	10.34	89.66	
	Count	13	12	76	101
	Total %	12.87	11.88	75.25	



Contingency Table

es11

U.S.Rating	Count / Total % / Col % / Row %	?	NA	no	yes	
Low	Count	2	1	35	4	42
	Total %	1.98	0.99	34.65	3.96	41.58
	Col %	33.33	100.00	42.17	36.36	
	Row %	4.76	2.38	83.33	9.52	
Medium	Count	4	0	22	4	30
	Total %	3.96	0.00	21.78	3.96	29.70
	Col %	66.67	0.00	26.51	36.36	
	Row %	13.33	0.00	73.33	13.33	
High	Count	0	0	26	3	29
	Total %	0.00	0.00	25.74	2.97	28.71
	Col %	0.00	0.00	31.33	27.27	
	Row %	0.00	0.00	89.66	10.34	
	Count	6	1	83	11	101
	Total %	5.94	0.99	82.18	10.89	

Selected Criteria - Insights

- Number of hosts was not found to be related to impact
- Ability to survive harsh conditions was not found to be related to impact for pathogens

Selected Criteria - Insights

- Best predictor of pest behavior in the United States is behavior outside the U.S. and the level of control/ research on the organism*
- *If an organism is not a pest in its native range & if it has not been introduced into a novel area, we may not be able to make a prediction
- Specific biological characteristics are not as important in predicting impact
  - parthenogenic reproduction
  - ability to serve as vector for plant pathogen

OPEP Impact Potential

Select Criteria & Training Data

↓

Develop Model

↓

Validate Model

↓

Model Use

Model Use: Consideration of U.S. Conditions

- Are there already organisms in the U.S. that fill the same ecological niche?
- Are there tools in the U.S. that have already been developed and are in use that would be effective at controlling the pest?
- Would current production practices or conditions in the United States be effective at mitigating the pest?

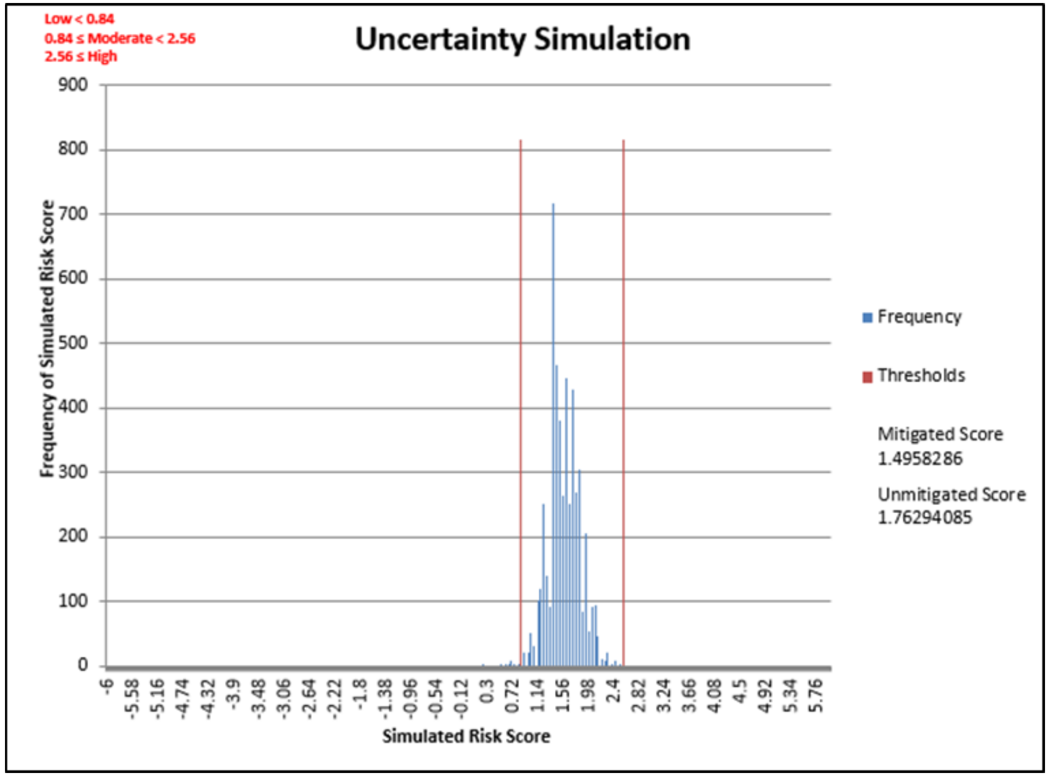
Results

- Results (based on logistic regression) are provided as probabilities for a pest resulting in High, Moderate, or Low impact

Risk Rating and Probabilities	
Biology and Natural History	5
Pest Damage	15
Research and Management	13
raw score sum	33
Impact of Current US Conditions	-5
zeta1 (Low | Medium)	0.588047
zeta2 (Medium | High)	2.8025218
coefficient	0.05342245
Risk Score - OLR fitting	1.495829
Logit1	-0.907781
Logit2	1.306693
Probability (Low)	28.7454066%
Probability (Moderate)	49.9505216%
Probability (High)	21.3040718%
sum	1
95% CI for the high probability	15.007% ~ 32.760%
Predicted Pest Category	Moderate Impact Pest

Uncertainty analysis

- We consider uncertainty through a Monte Carlo simulation (5000 iterations) where alternate answers are applied based on uncertainty rating

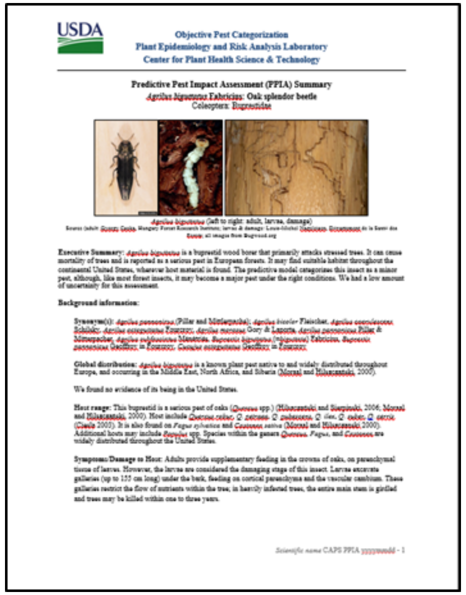


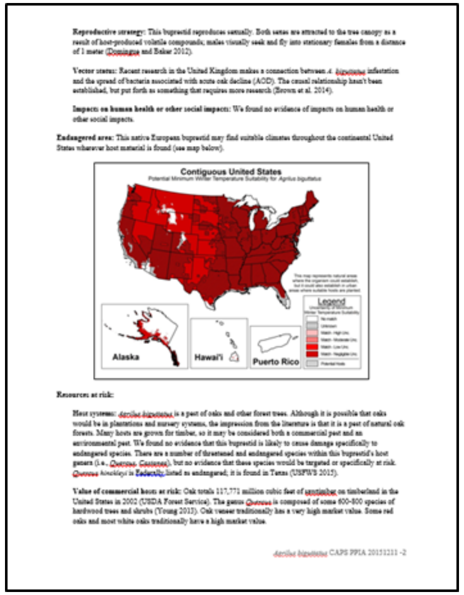
Model Use: Communicating with stakeholders

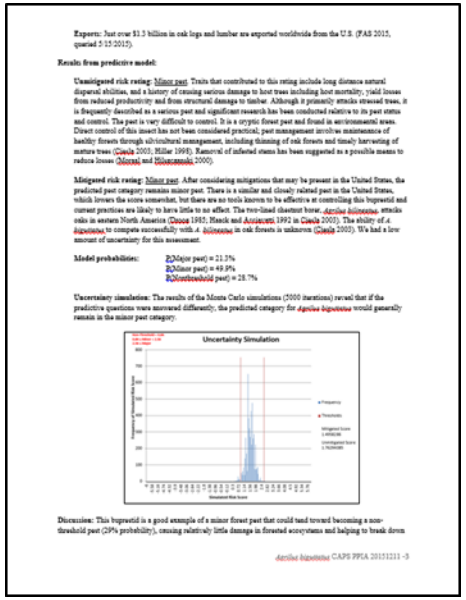
- A list of prioritized exotic pest species with the following information
  - Impact potential category
  - Uncertainty

Model Use: Communicating with stakeholders

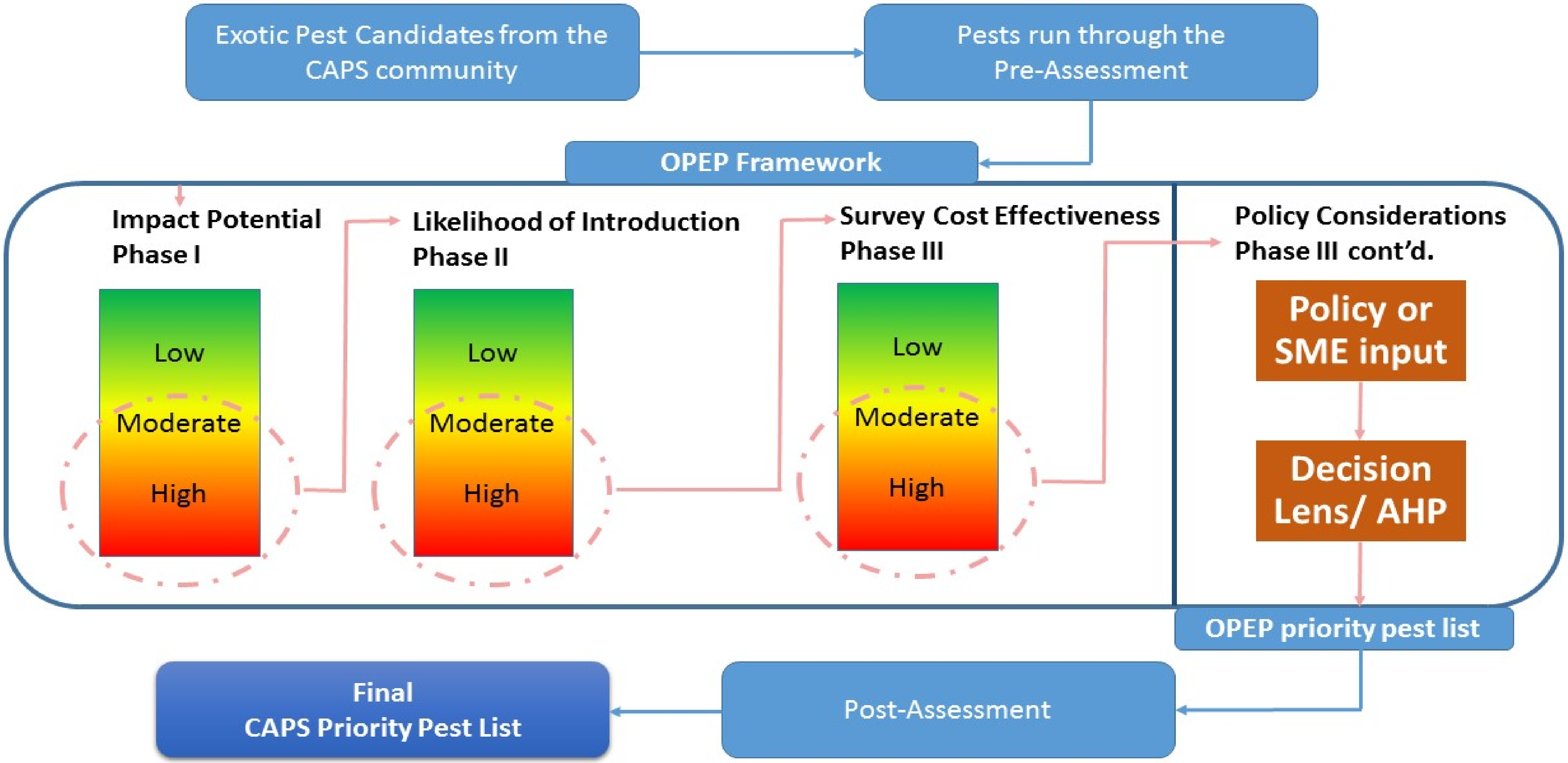
- A summary document encapsulates the assessment with background information, results from the predictive model, endangered area, references, and an appendix with predictive questions & answers



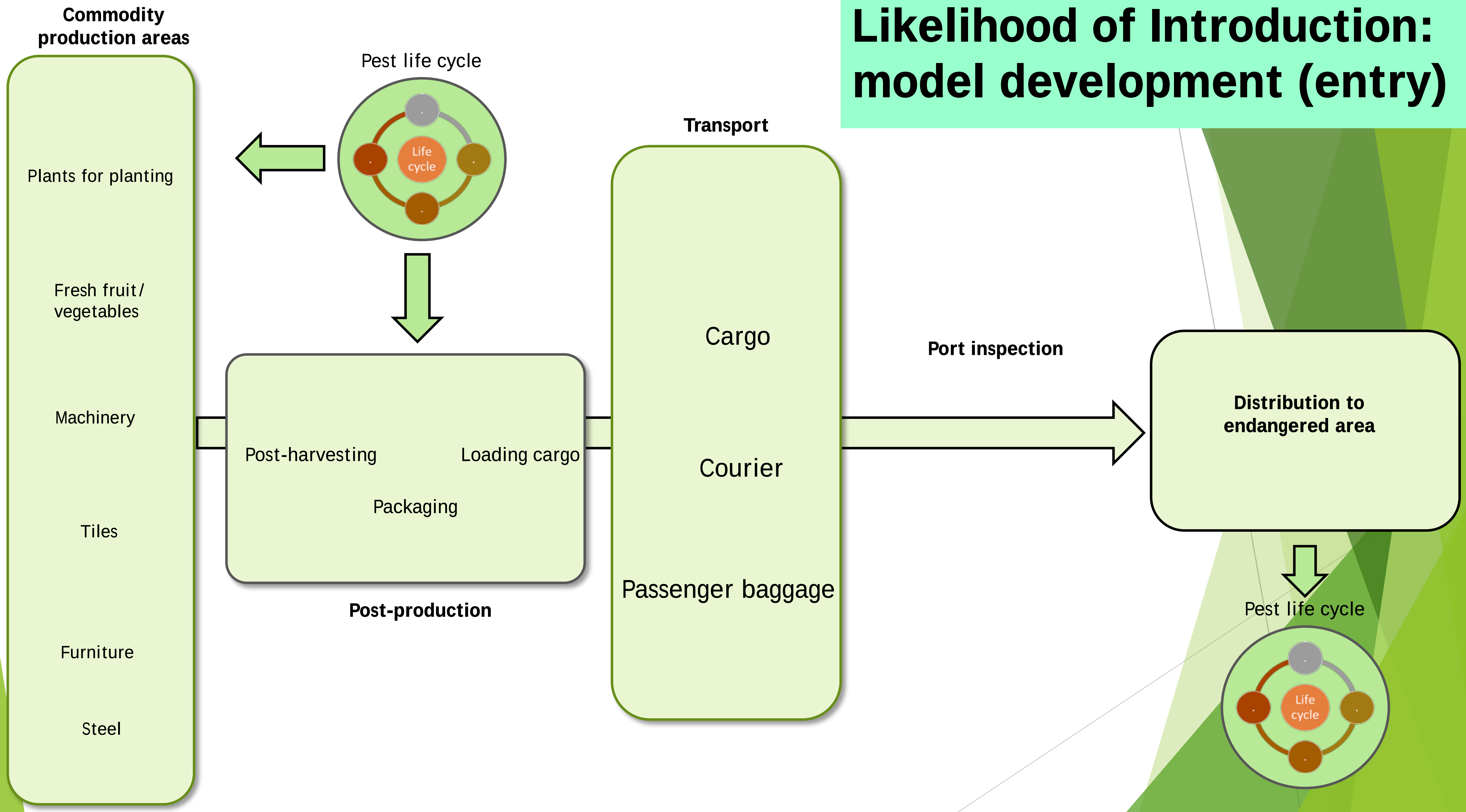




Overall OPEP model



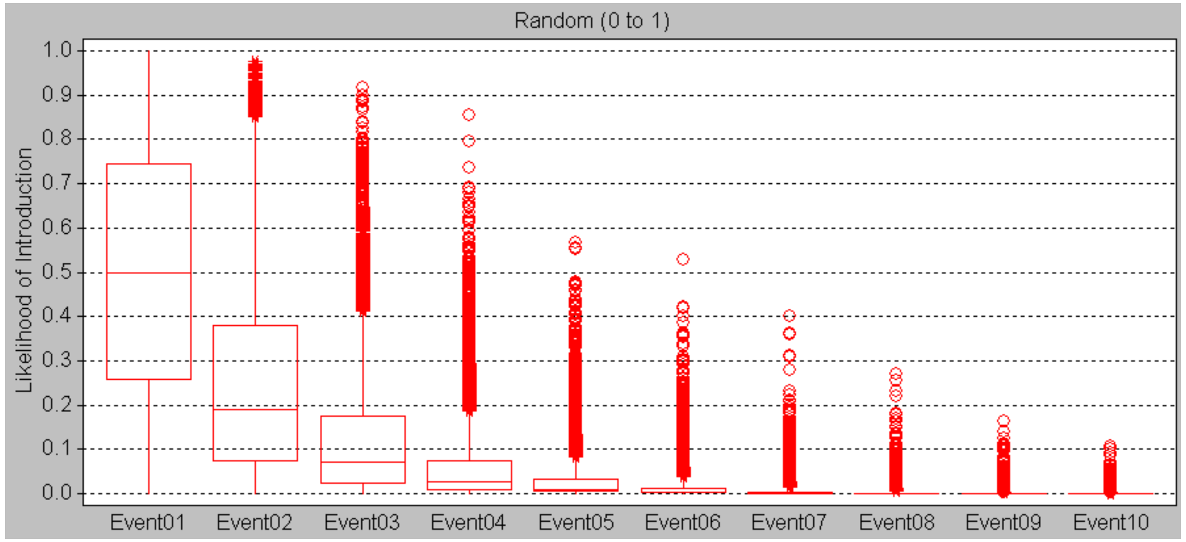
Likelihood of Introduction: model development (entry)



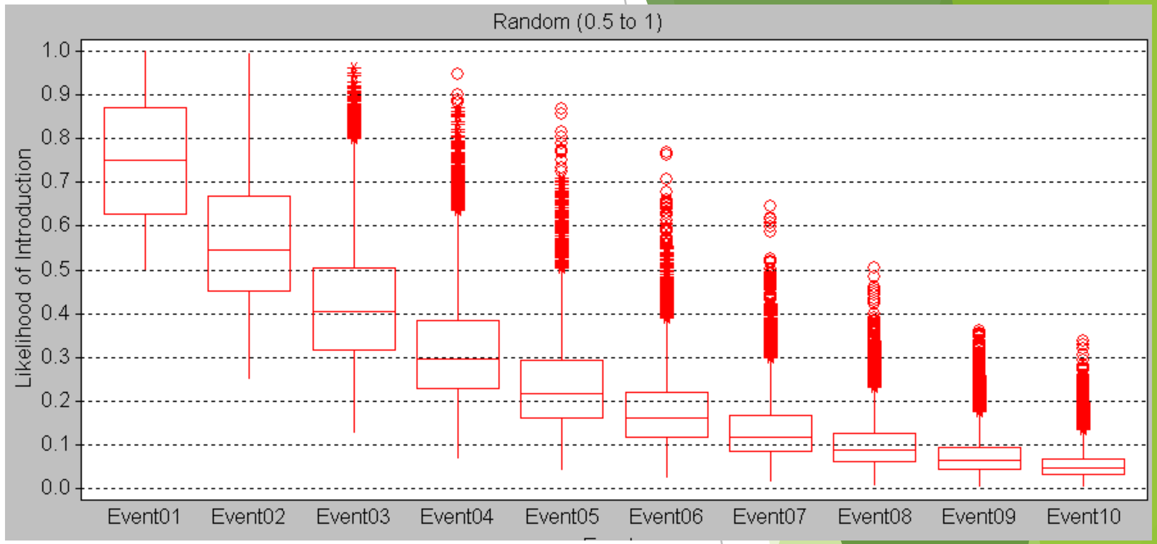
Knowledge about likelihood of an event	Model probability
Higher than 0.5	0.5 – 1.0
Lower than 0.5	0.0 – 0.5
No way the pest will make it	0.0
Absolutely the pest will make it	1.0
Not documented in literature	0.0 – 1.0
Probability (P) well documented	Enter optimum, maximum, minimum
Event not applicable for this pest	1.0 (for practical purposes)

(10,000 simulations)

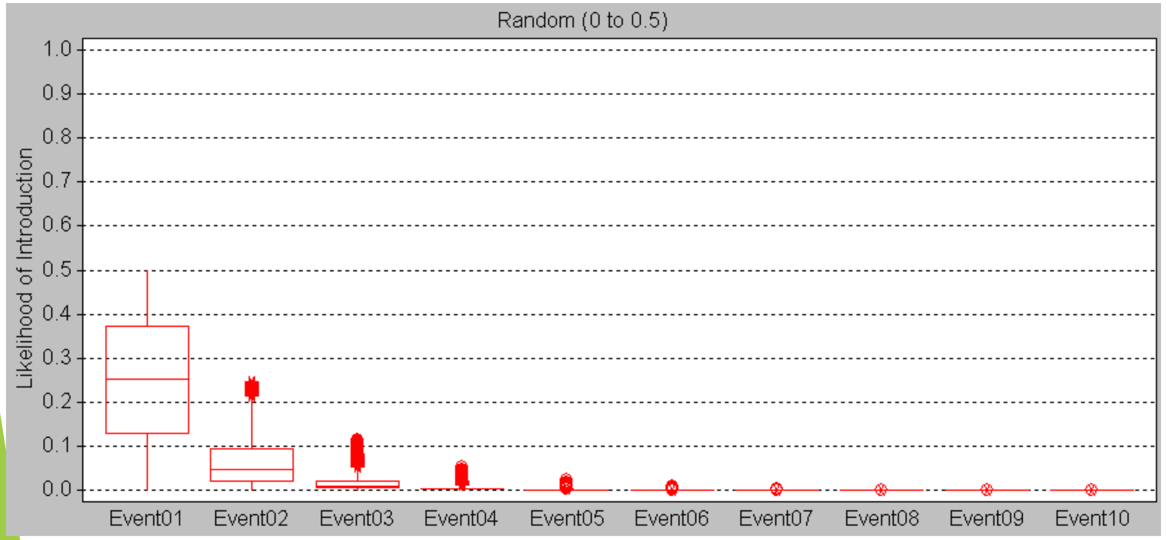
Totally random (any value between 0 and 1)



High random (any value between 0.5 and 1)

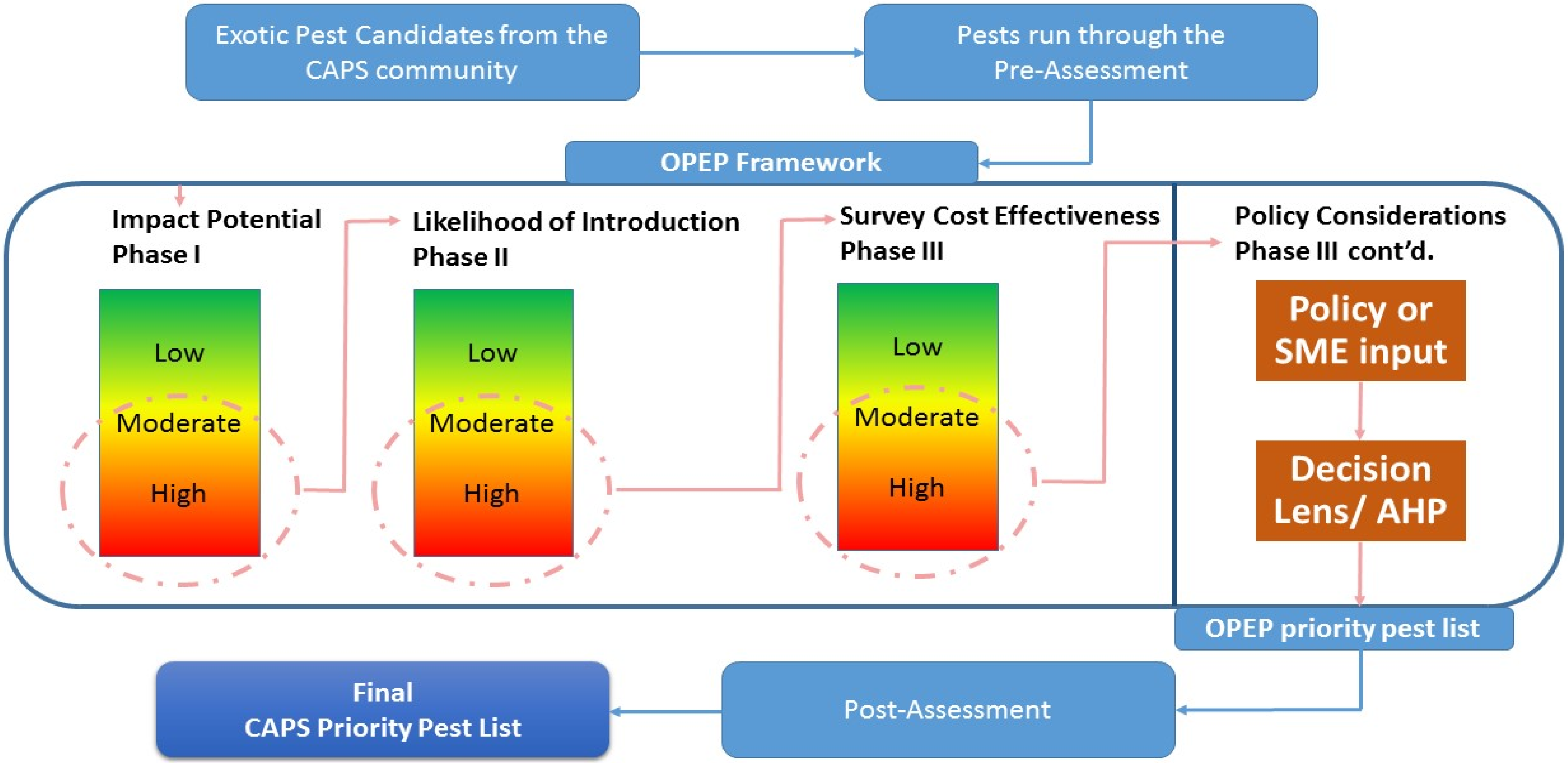


Low random (any value between 0 and 0.5)



- Attrition increases with the number of events in a pathway (i.e., the more elements the lower the probability of entry, establishment)
- A totally random simulation could estimate probability of entry, establishment if we know the number of events involved (although the spread of the resulting distribution reflects the uncertainty)
- An increase in information for an event (high, low) improves performance

Overall OPEP model



Pest Prioritization Modeling Team

- **CPHST PERAL & NCSU CIPM Cooperators**
  - **USDA Team Leads**: Alison Neeley, Leslie Newton, Manuel Colunga Garcia
  - **NC State PIs:** Godshen Pallipparambil, Ernie Hain
  - **Economists**: Lynn Garrett, Trang Vo, Alan Burnie
  - **Entomologists**: Glenn Fowler, Cynthia Landry, Ignacio Baez, Jim Smith, Holly Tuten, Amanda Anderson, Grayson Cave, Robert Mitchell, April Hamblin, Senia Reddiboyina, Douglas McPhie, Jeremy Slone, Alejandro Hector Merchan
  - **Plant Pathologists**: John Rogers, Lisa Kohl, Amanda Kaye, Betsy Randall-Schadel, Jarrod Morrice, Heather Hartzog, Walter Gutierrez, Andrea Sato, Sofia Pinzi, Jennifer Kalinowski
  - **Statistician**: ByeongJoon Kim
- **CPHST CAPS Core Team**
  - Heather Moylett, Lisa Jackson, Melinda Sullivan, Daniel Mackesy, Talitha Molet
- **Others**
  - APHIS-PPD, CIPM Cooperators