Crop Biosecurity Threat Rating Using Analytical Hierarchy Methods

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Douglas G. Luster
USDA, ARS,
Foreign Disease- Weed Science Research Unit
Ft. Detrick MD

Emphasis on Biosecurity

- Protect all natural and agricultural resources- Australian/NZ Model,
- Invasive Species - Pres. Executive Order
  - Weeds
  - Insects and other animals
  - Pathogens!
- USDA-APHIS - Programs
  - Offshore Pest Information System (OPIS)
  - Cooperative Agricultural Pest Survey (CAPS)
  - Ports Inspection
- HSPD-9 language:

"The United States agriculture and food systems are vulnerable to disease, pest, or poisonous agents that occur naturally, are unintentionally introduced, or are intentionally delivered by acts of terrorism."

Vulnerabilities in U.S. Agriculture

- Imported Commodities
  - Seed
  - Produce
  - Animal Feed grain & hay
- Field Production
- Storage
  - Local
  - Regional
- Transportation
- Export Commodities

What to Protect?

- Defend against all pathogens, pests and weeds?
- Base on Economic value and set threshold?
  - "Death by a thousand cuts" *vs.* "Disregards threats under $10B"
  - "Agricultural losses are solely economic"
  - National vs. State Interests

USDA Major Crop Values, 2005 (crops with values > $1B)

Crop	Value of Production (Millions of Dollars)
Corn for Grain	21,040.7
Soybeans for Beans	16,927.7
All Hay, Baled	12,491.3
Wheat, all	7,140.4
Cotton	5,517.1
Potatoes	2,903.1
Grapes	3,013.4
Citrus, all	2,389.3
Tobacco	1,053.4
Rice	1,789.2
Apples	1,786.7
Lettuce, Head	1,982.3
Strawberries	1,637.4
Tomatoes	2,259.6

Note: Values calculated by multiplying Market Year Average (MYA) price by amount of yearly production.

Other Commodities for Consideration

- Strategic Vulnerabilities:
  - Rubber,
  - Biofuels,
  - Cellulose-Based Plastics,
  - Regionalized, concentrated seed production nurseries (e.g. potato)
- Total value: Floral and Nursery crops
- Fear Factor: Fresh Vegetables

History of Crop Threat Assessment

- 1929 APS “Committee on Investigations of Foreign Pests and Plant Diseases”
- 1973 “MacGregor Report”
- 1983 Kingsolver et al., Plant Dis.
- 1999 USDA-ARS/DoD Workshops
- 1999 APHIS Cooperative Agreements with:
  - APS
  - ESA
  - WSSA
- 2002 APHIS 7 CFR part 331 list (revised @ 2 yr intervals)
- 2002 APHIS/ERS CAPS Survey Prioritization -AH
- 2003-2004 DHS NBACC Workshops- AH

Current Stakeholders for Prioritized Lists of Threatening and Emerging Crop Pests:

- Regulatory Agencies (USDA-APHIS)
- Extension Pathologists, NPDN Diagnostic Clinicians (USDA-CSREES)
- Port Inspectors (DHS, USDA-APHIS)
- Research Funding Agencies (genomic targets) (USDA, NSF)
- DHS, DoD, Intelligence Community

Threat Rating - Pathways (APS Subcommittees)

- Accidental invasion by:
  - Natural Pathway (environmental/weather)
  - Man-Made Pathway (trade or transport)
- Biological terrorism (low-cost, one or few foci of introduction)
- Anti-crop warfare (state-sponsored, inundative attack)
- Contamination of feed/commodity with toxin/allergen producer
- Introduction of genetically-enhanced pathogen

Threat Rating Scenarios-Targets

- Deliberate infestation of imported commodity
- Epidemic in Field/Production area
- Contamination of e.g. grain during Storage/Transportation
- Export Commodity contamination

Threat Rating Matrix

Pathways

Targets

	Accidental-Natural	Accidental-Trade, etc	Bio-Terrorism	BioT-Toxins	BioT-GEP
Import	+	+	+	+	+
Field Production	+	+	+/?	-	+
Storage/ Transport	+	+	+	+	?
Export	-	-	+	+	?

Rationale

- Pathogens have definable biological characteristics that make them more or less amenable to exploitation or invasion under different threat scenarios

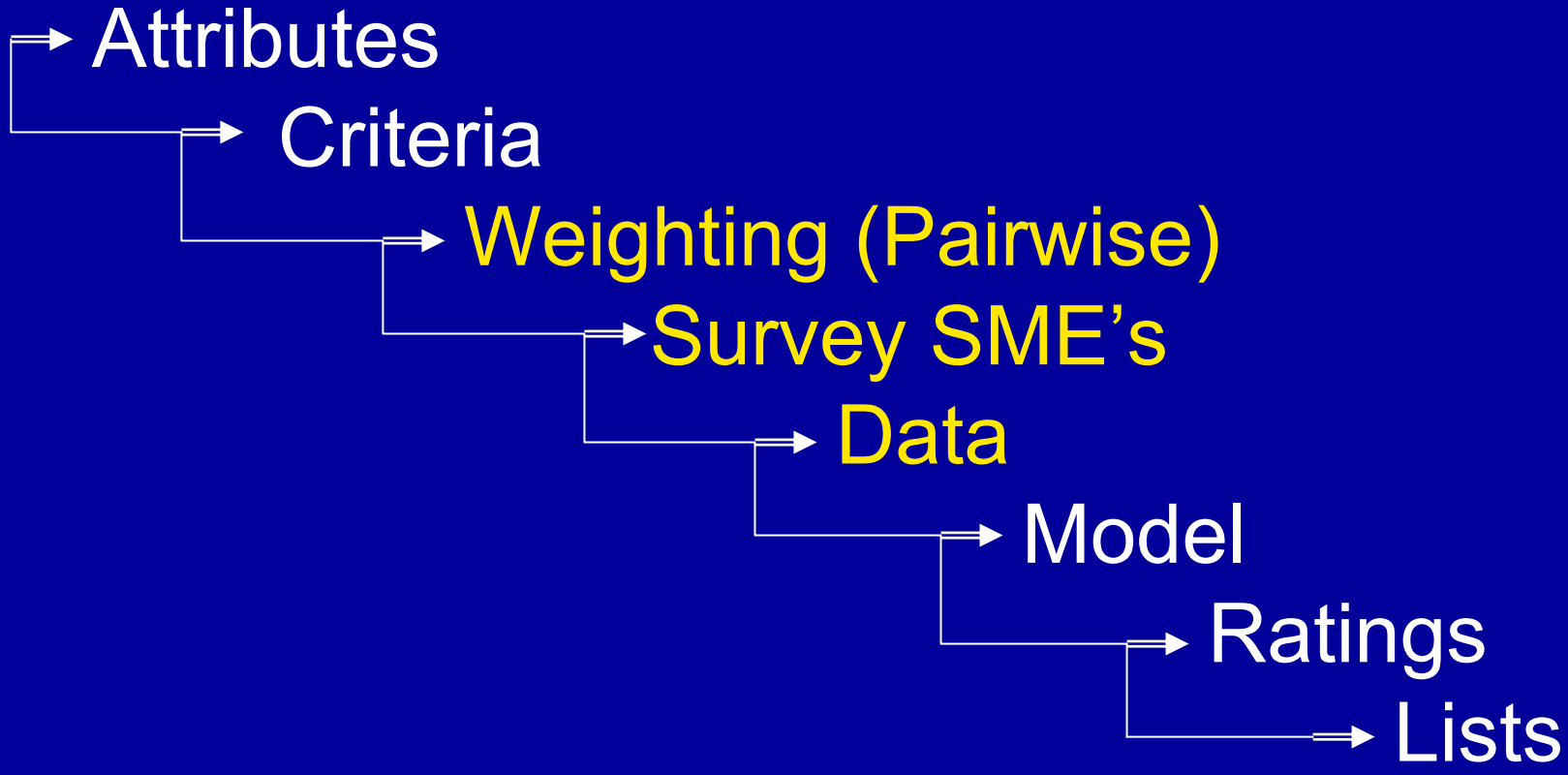
- Criteria can thus be developed, weighted, and rating models customized to assess the threat posed by individual pathogens under each scenario

The Process

- Hierarchical Analysis[1]:
  - Identify criteria
  - Group criteria hierarchically into categories
  - Weight categories and criteria based upon the opinions of SME's regarding their relative importance within each scenario (matrix of pairwise comparisons)
  - Develop model for data input

[1]Saaty TL, 1980, The Analytic Hierarchy Process, NY, McGraw Hill.

The Process


Attributes
Criteria
Weighting (Pairwise)
Survey SME's
Data
Model
Ratings
Lists

The Process (ctd)

- Develop “criteria” relevant to all scenarios
- Breakout by expertise - assign weights, to develop separate model for each scenario
- Address major agricultural vulnerabilities :
    1. Deliberate infestation of imported commodity
    2. Epidemic in Field/Production area
    3. Contamination of e.g. grain during Storage/Transportation
    4. Export Commodity contamination (e.g. wheat, corn)

The Process (ctd)
The Hierarchy

- Criteria Categories:
  - Pathways
  - Pathogen establishment
  - Direct economic effects
  - Trade-related economic costs
  - Eradication and Management costs
  - Production and delivery
  - Social or psychological shock value

The Process (ctd)
The Hierarchy

- Pairwise Comparison of Categories, e.g.:
  - Pathways vs Pathogen establishment
  - Pathways vs Direct economic effects
  - Pathways vs Trade-related economic costs
  - Pathways vs Eradication and Management costs
  - Pathways vs Production and delivery
  - Pathways vs Social or psychological shock value
  - Pathogen establishment vs. Direct economic effects
  - Pathogen establishment vs. Trade-related economic costs
  - Etc., Etc.---i.e. Develop a Matrix of all possible pairwise comparisons

The Process (ctd)

- **Example Criteria - Pathogen Establishment:**

- Pathogen infection units (spores,mycelium, sclerotia, etc.) remain viable for a long period of time under natural conditions.
- There is a natural (wind, vectors, water, etc.) or mechanical (equipment, such as harvesters,sprayers, misters, airplanes crop dusters, etc.) means of dissemination within and among growing areas.
- The pathogen is highly infectious under several cropping or growing conditions and /or easily established.
- The pathogen has high natural reproductive potential in the field.
- The pathogen has numerous alternative or asymptomatic hosts.
- U.S. germplasm is particularly susceptible to the pathogen.
- The pathogen's U.S. germplasm is densely and widely distributed.
- No effective or economical control(s) of the pathogen is available.

The Process (ctd)
Pairwise Comparison

- **Conduct Pairwise Comparison of all Criteria - under each category <u>Pathogen Establishment</u>**
- **---** i.e. Develop a Matrix of all possible pairwise comparisons

The Process (ctd)

- Develop Questionnaires from Criteria lists
- Develop Rating Scale
- Apply Social Survey Format;
  - Rating scale #1-5 best (?)
  - K.I.S.S.

The Process (ctd)

Example Rating Scheme:

Disagree **Neutral*** **Agree**

1 2 3 4 5

* Score of Don't Know or N/A does not skew result

- Allows SME to answer only questions they know the answers to without negative effect

The Process (ctd)

- Input raw data from surveys into models
- Expected Results:
  - Numerical “rating” for each pathogen
    - 3 models by scenario = 3 sets of results
  - Consider break points in rating data as potential prioritization thresholds; H-M-L
  - Identify pathogens of High Priority

Problems and Issues

- Which hosts to consider? National vs. State interests
- Which pathogens to rate? Starting Point?
- How to evaluate exotic pathogens or new strains, etc. with little (or no) data-
- What good is a numerical rating ? (need break points and comparative data)
- Weights may differ according scenarios
- Crosscutting between models/scenarios
  - E.g. “Establishment” not applicable for export contamination

Future Needs

- Should be a periodic (minimum yearly) process
- Long-term buy-in depends upon community acceptance and results
- Need periodic data input on foreign threats (databases), new research results to maintain robust process

  => Foreign SME's vital to process