Crop Biosecurity
Threat Rating Using Analytical Hierarchy Methods

March 15, 2006

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)

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

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”
- 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

<table>
<thead>
<tr>
<th>Targets</th>
<th>Import</th>
<th>Field Production</th>
<th>Storage/Transport</th>
<th>Export</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>++</td>
<td>+/+/?</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Accidental-Natural</td>
<td>++</td>
<td>+/+/?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Accidental-Trade, etc</td>
<td>+</td>
<td>+/+/?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Bio-Terrorism</td>
<td>+</td>
<td>+/+/?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>BioT-Toxins</td>
<td>+</td>
<td>+/+/?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>BioT-GEP</td>
<td>+</td>
<td>+/+/?</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Legend:**
- **+** indicates a high rating.
- **-** indicates a low rating.
- **?** indicates uncertain or variable rating.
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 Analysis¹:
  - 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

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 **Pathogen Establishment**
- 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:

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Agree</th>
<th>Neutral*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

* 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