Introduction to Quantitative Analysis

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History of US Pest Risk Concepts

- No risk: Tariff Act of 1939, Delaney Amendment, other fed. Acts
- Almost no risk: “If in doubt, keep it out”, probit 9 fumigation std, redundant entry protocols
- Facing Reality: McGregor Report, Ford-Mussman Top 100, other quasi rational approaches

History of US Pest Risk Concepts, cont.

- Risk Analysis Era
  - Ranking schemes (qual., quasi-quant.)
  - Taxonomic risk assessment (qualitative)
  - Quantitative assessment (deterministic)
  - Probabilistic risk assessment

Why Interest in Quantitative Analysis

- Tenet of management science (F. Taylor):

  If you can't measure it,

  you can't manage it.

Quantification provides better information; better-informed decisions are better decisions.

What's So Bad About Qualitative Assessments/Analysis?

- Example 1: Job Offer
- Example 2: Space Shuttle
- Other objections: no metric, no calculus for combining qualitative information (can't tell if we have done it wrong), not validated in most cases **, elusive & arbitrary definitions

Tools for Quantification in Risk Analysis

- Skills needed for modern, quantitative risk analysis and
- Where we can use these in processes of risk analysis and management
- Do we already have these skills?
- How to acquire, find, etc.

Skills For Risk Analysis
(adapted from Tony Cox)

- Direct subject matter expertise
- Reliability modeling, probability, statistics, data analysis, epidemiology
- Economics, decision sciences, public choice How to acquire, find, etc.

The Bad News

- Most of what we learned in statistics is of little use in doing risk analysis, esp. pest risk analysis.
- The range of techniques is sufficiently broad, range of difficulty also considerable, that no one can aspire to master more than a portion of it.

The Good News

- Much of it is NOT rocket science, even though rocket scientists do it.
- Higher math rarely needed.
- Mastering a set of core skills will allow you to do a lot of good work.
- It’s interdisciplinary, it’s interesting: EO Wilson on “Conscilliance of Knowledge”.

Example for Risk Management: Pareto Optimality

- Used by rocket scientists (and lots of others): makes life much simpler.
- Recognize that of the often very large number of possibilities, only a few are rational.
- Being used in food safety risk management, veterinary medicine, soon to used, by you, in plant health risk management.

Pareto Optimality…first a little math

In serial risk mitigation situation (one after the other, typical import risk mitigation) with *n* mitigations, there are

$2^n - 1$ unique combinations.

Do the math:

n	2^n –1
5	31
10	1,023
20	1,048,515

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Quantitative Methods for Scenario Type Risk Analysis

- Scenario Structuring: Tools and techniques of reliability engineering: event trees, fault tree analysis, Boolean algebra, probability logic and distributions.
- Data Analysis: determining parameter values/distributions for elements of scenario tree/fault tree models.

Data Analysis in Assessing Pest Risk

- Often in data-poor or weird data environment; conventional stats often not helpful (slight digression).
- Techniques:
  - Exploratory data analysis (Ronald Tukey)
  - Bayesian methods
  - Engineering approaches (plotting methods; censored data techniques)
  - Regression of different types, canned approaches available (digression)

Example: evaluting evidence of rate of interceptions

- Often only a few observations.
- We use what we know of probability theory and do some exploratory data analysis/Bayesian analysis of the data.
- Real problem delivered by Ed Miller some years back on how to develop distribution for rate of infestations per unit time, using limited data.
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Using Predictions of Pest Potential

- Predictive models have tremendous potential. Have been developed in many fields recently.
- Appropriate method for making inference from those models has been problem.
- We suggest approach from epidemiology & human medicine.

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Developing Predictive Models

- Major uncertainty is behavior and pest status of non-indigenous organism in new environment.
- The extensive data we have accumulated suggests we should be examining these data to determine if this can provide good predictive models of fate of NIS in new environment (if it doesn’t we are in trouble).

Multi-Variate Approaches for Classification

- Discriminant analysis (first use as example: classify by bone measurement).
- Principal components
- Variety of other regression techniques
  - Logistic etc.

- Very promising; should have been done before relying on the whole array of non-quantitative approaches.

Multi-Variate Approaches for Classification: Warning

Don’t try this at home.

* Find highly qualified, experienced people to help you in this area.
* Evaluation of results and determining if model is properly specified takes experience and skill.