Assessing Disease Risks to Inform Decision Makers

IBMP Partners Meeting

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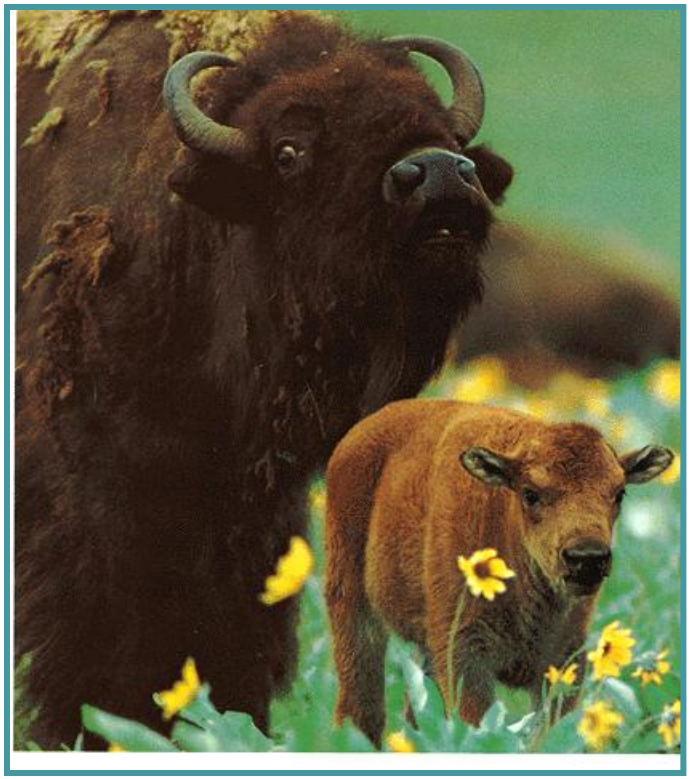
Dr. Keith Aune's Presentation

- Investigated bacterial persistence across varying environmental and climatic conditions

- Investigated fetal disappearance

- Microclimates has major impact on decay

- Major conclusion – no persistence of B. abortus past June 11th.



Disease Control Decision Making

- Consider disease transmission locally
- Consider the affect on the “national” herd
- Consider the economic impacts from producer, state and agency perspective

A predictive epidemiological model to inform decision making for managing tuberculosis-affected herds

Background

- Consideration of alternative strategies to whole herd depopulation in managing tuberculosis-affected herds
- Objective: Develop a tool to evaluate various test-and-removal protocols versus depopulation
  - Estimate probability (RISK) that a herd may contain TB-infected animal(s) following a series of herd tests
  - Estimate the number of animals to be purchased under various test-and-removal protocols (inform COST analysis) compared to depopulation
  - Estimate the uncertainty of potential outcomes
- While such a tool can inform decisions about test-and-removal strategies, a herd plan requiring sound management and biosecurity practices is key to preventing reintroduction of infection in the herd

Methods (Tool) – Simulation Model

- Way to organize and use knowledge about diagnostic tests, specific herd, and disease to describe possible outcomes of a test-and-removal protocol
- Inputs to the model
  - Prior knowledge (data, literature, expert opinion)
  - Distributions (estimate uncertainty)
- By incorporating uncertainty we have about inputs (test sensitivity, specificity, prevalence, etc.), predicted outcomes are derived with attendant uncertainty

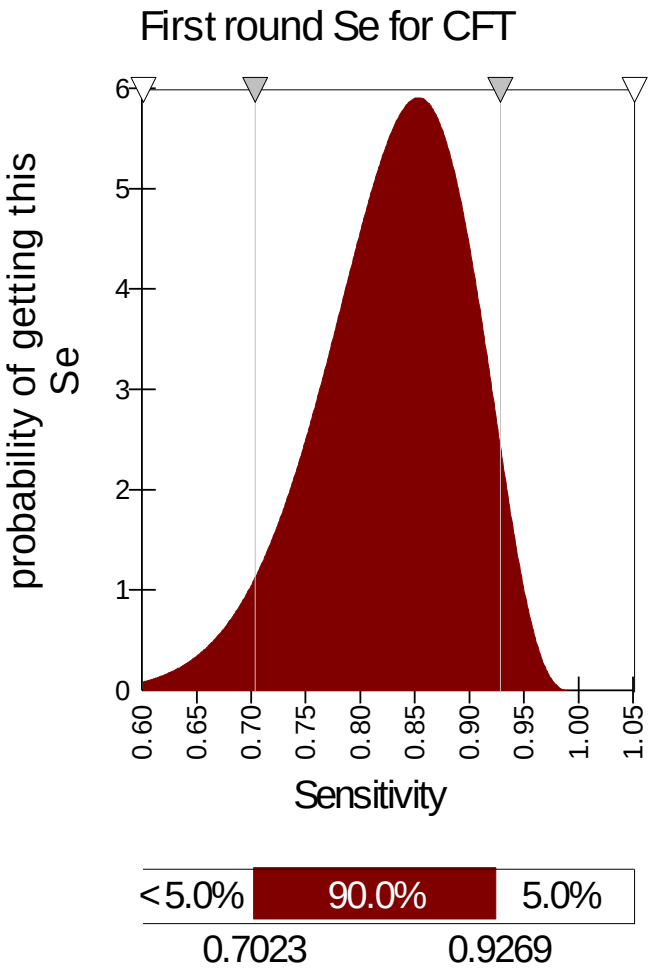
Methods – Simulation Model

Example – Model input uncertainty

- CFT test sensitivity (Se) ~ 82%
- Wide variation:
  - –Person, region, cattle (type, age)

Model:

- Uses distribution (range) of values
- Picks single value each iteration
- Runs 10,000 iterations
- Like 10,000 vets testing 10,000 similar herds
- On average Se = 82%
- Uncertainty
  - – 5% of time < 70%
  - – 5% of time > 92%



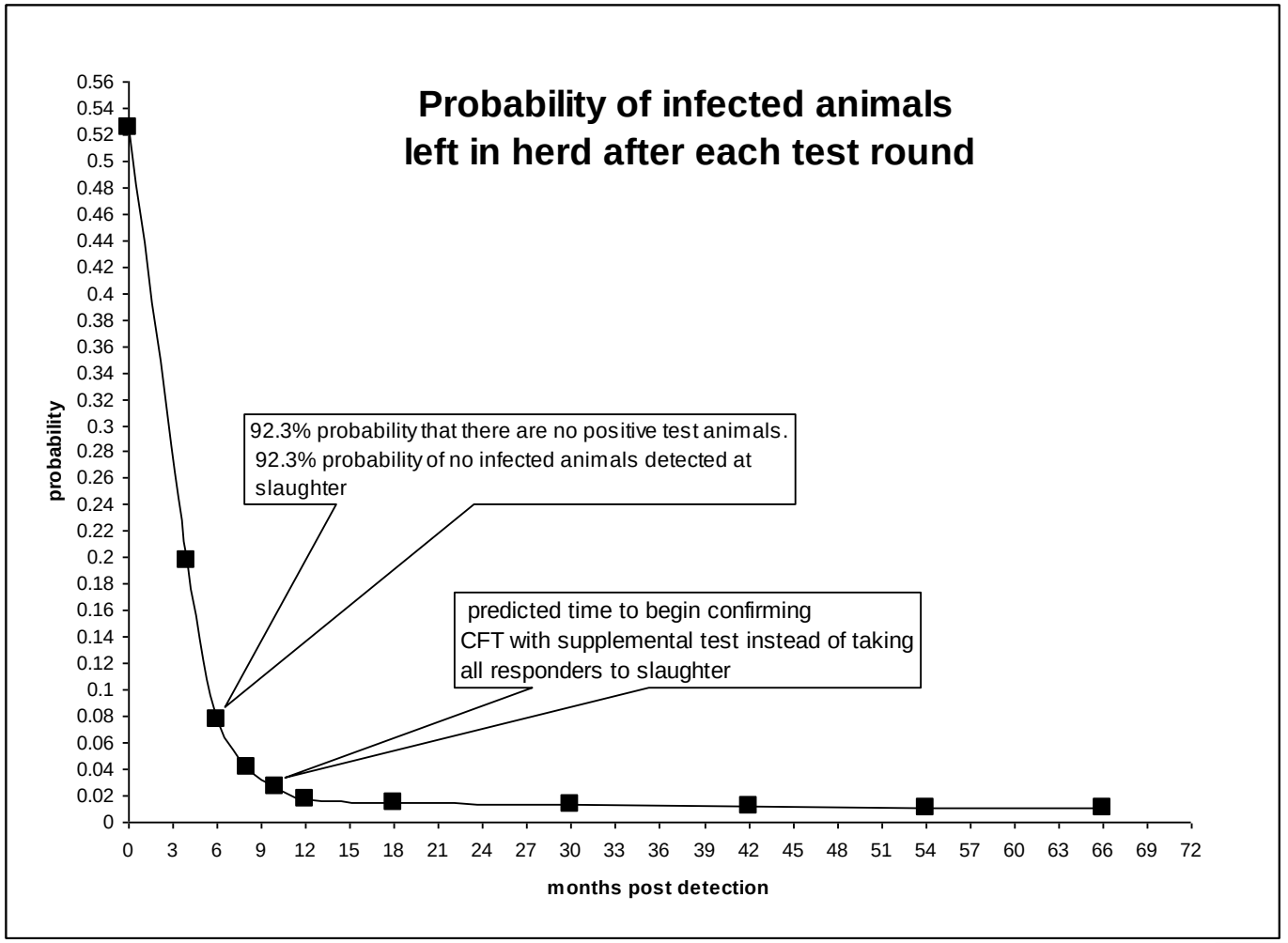
Model Inputs

- Test Sensitivity (Se)
- Test Specificity (Sp)
- Initial Prevalence
- Cull Rates
- Risk of Introduction (via replacement animals)
- Spread Within Herd
- Time Between Herd Tests

Model Outputs

- True Positives (TP)
- True Negatives (TN)
- False Negatives (FN) - Risk
- False Positives (FP) - Cost
- Prevalence of herd post test (used as prior for next test)
  - Prevalence + within-herd spread + new introduction – infected but undetected (FN) culled
- Probability herd is free from disease

Results



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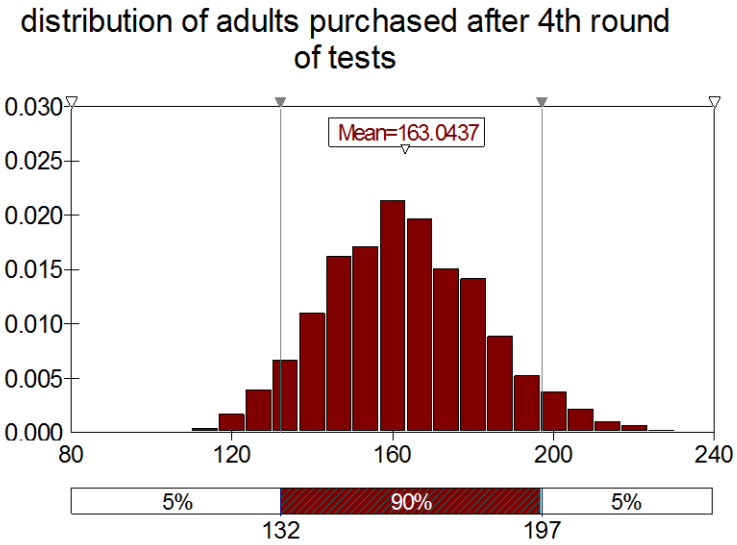
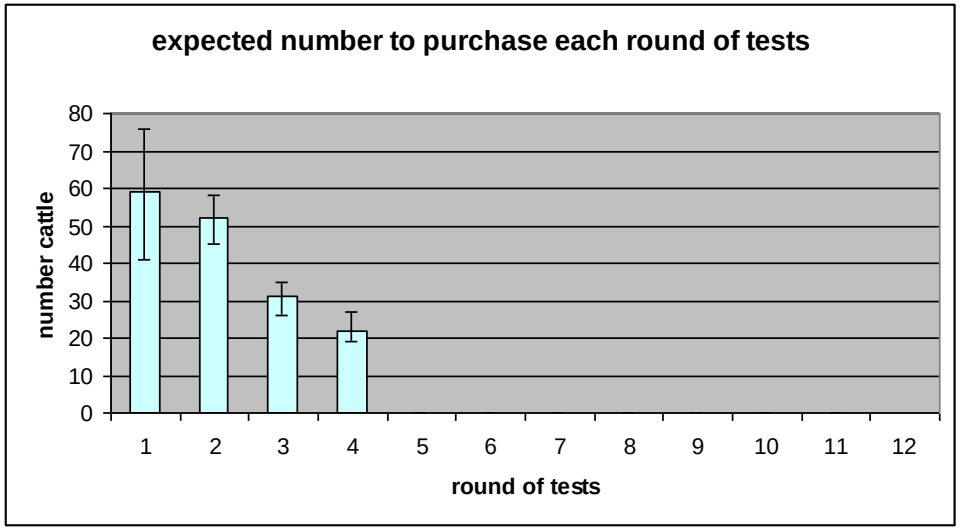
Results





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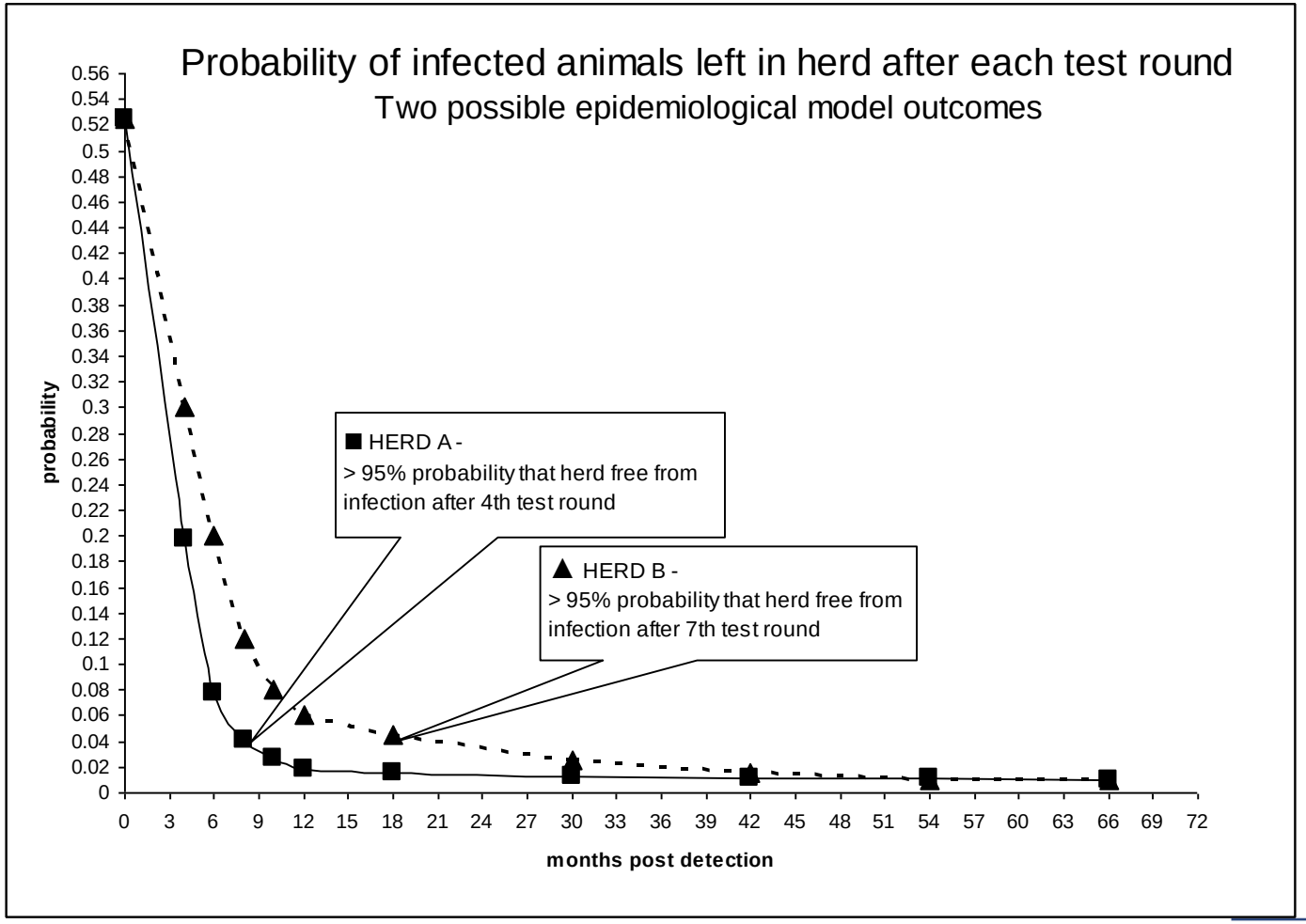
Proposed Model Application

Model:

- Predictions assist in testing protocol development
- Estimates number of rounds of testing and type of tests needed to be highly confident herd is free from disease
- Provides *estimated* time for quarantine release
  - Actual test data used to refine predictions after each herd test
- When results provide > 95% confidence herd free of disease
  - Retest; if >95% confidence, and no infection, quarantine lifted
  - Assurance test conducted 12-18 months

Proposed Model Application



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Advantages of Approach

- Risk-based approach to disease management of TB-affected herds; specific to each herd
- Allow release of quarantine as soon as possible while providing high level of confidence herd is free of disease
- Establishes performance-based conditions for quarantine release rather than inflexible design standards

Tool for Assessing Intervention Options (TAIO)

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TAIO – Background

Utilizes best available data and knowledge on economics, epidemiology, and biology of intervention options under consideration

Does not consider all factors affecting decisions; for example the political or social climate or budgetary constraints

Intended to support the decision making process, not replace it

TAIO – Structure

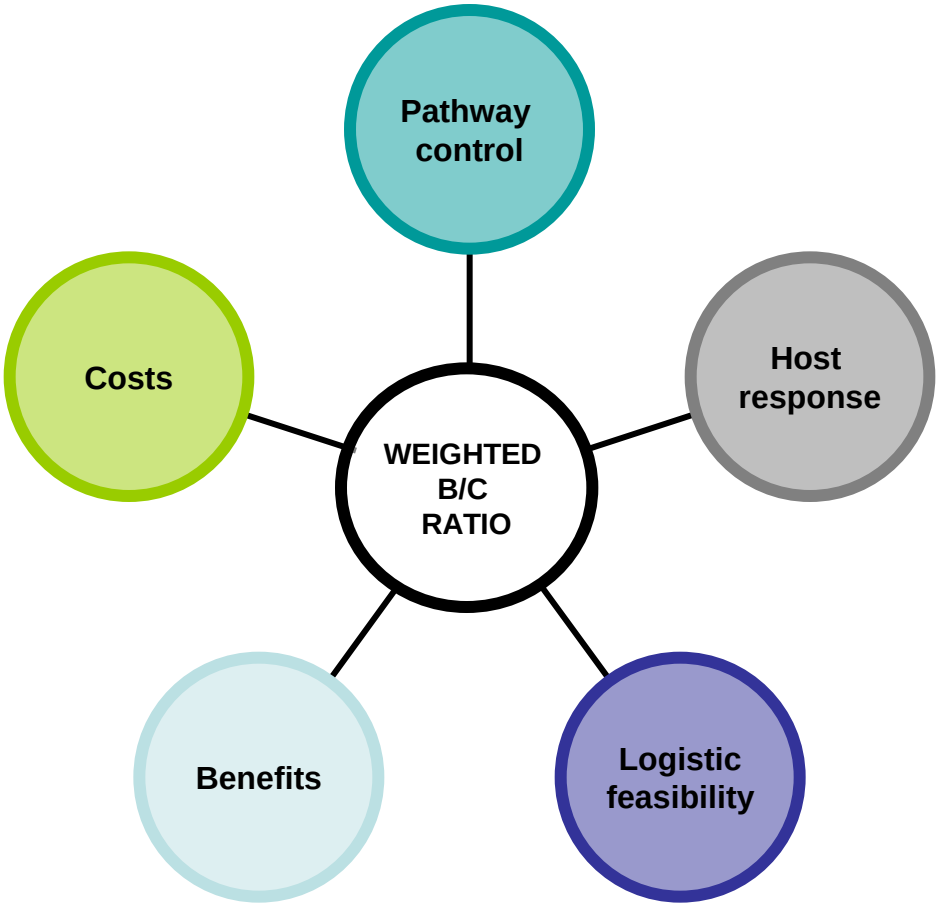
Repeatable structured process for evaluating data and knowledge in a systematic manner

Documents all inputs to increase transparency of arguments for various options

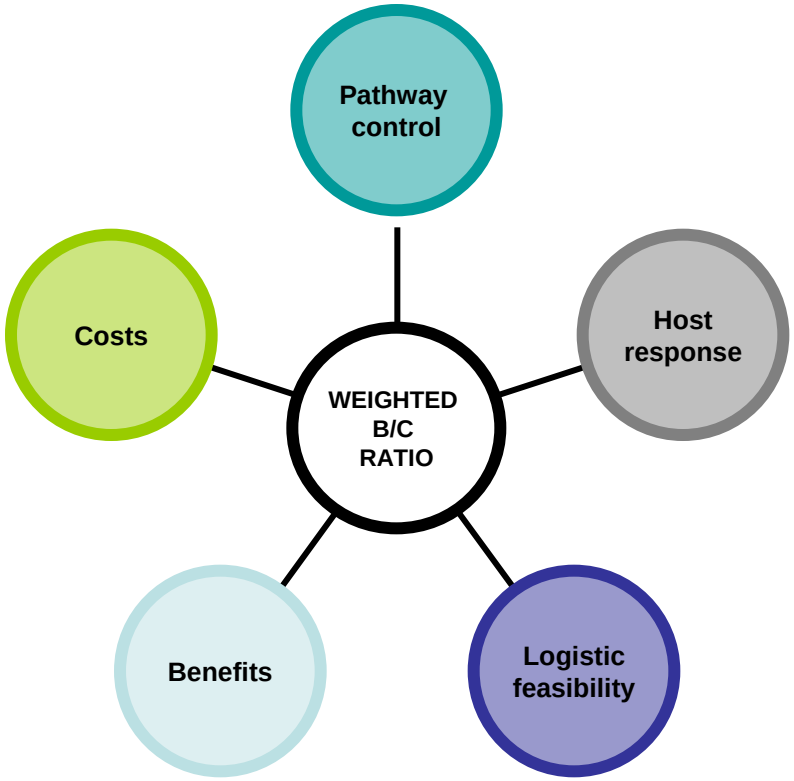
Iterative nature allows for revised analyses as inputs are developed and improved

Can be used to assess intervention options for FADs, endemic, or emerging diseases

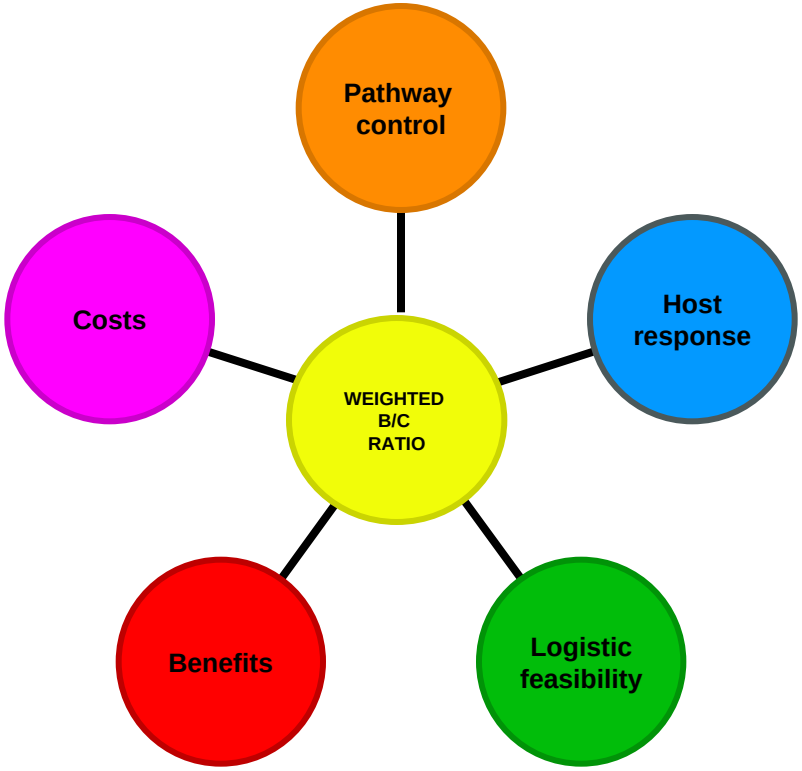
TAIO – Overview



Used to compare options



Option A



Option B

PRRS - an endemic, and economically significant, disease

The most economically significant disease in the U.S. swine industry today

Lack of consistent control

- Virus constantly changing
- No overarching program
- Results in unpredictable production

Two hypothetical intervention options compared

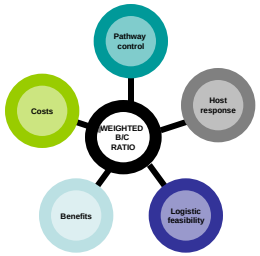
Compare Federal Options: voluntary vs. mandatory program

Certification Program

Voluntary surveillance and separation of PRRS-free farms

Voluntary response to positive findings

Regionalization goal

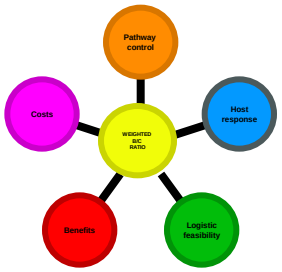


Eradication Program

Mandatory surveillance and separation of PRRS-positive/free regions

Mandatory response to positive findings

Eradication goal



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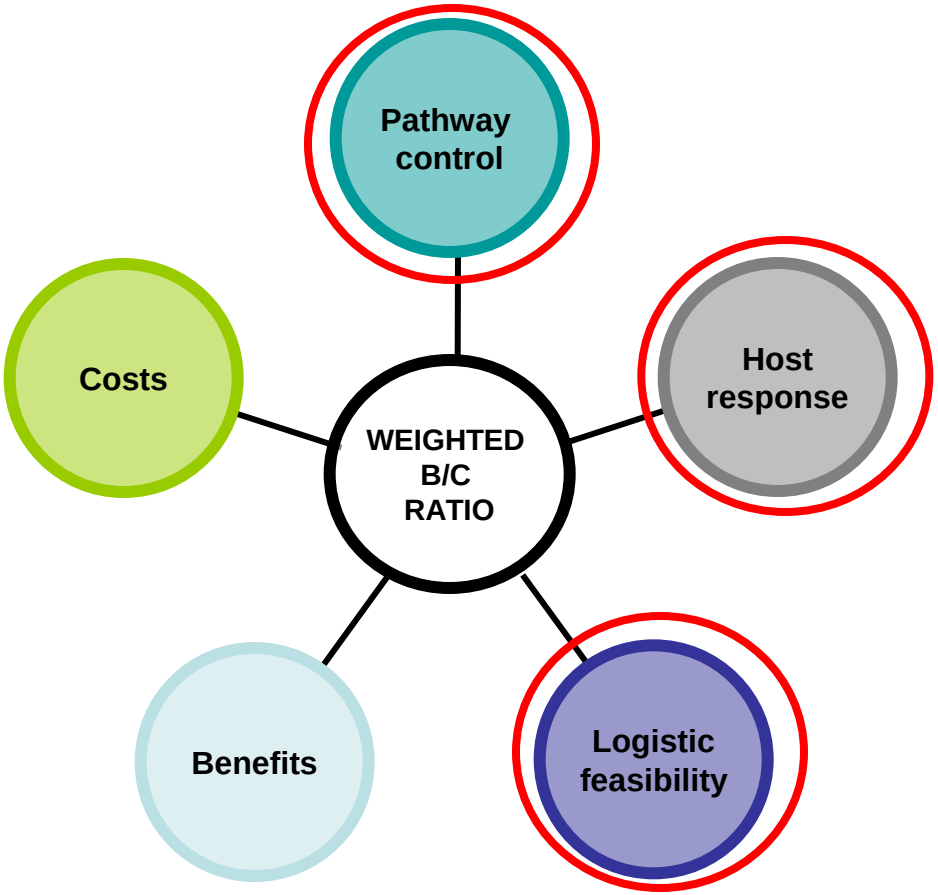
Technical Feasibility



Animal movement control
Wildlife
Vectors
Fomites

Host infectivity
Host susceptibility

Detection system
Infrastructure

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Decision Support Framework

Supporting Information

Fomites

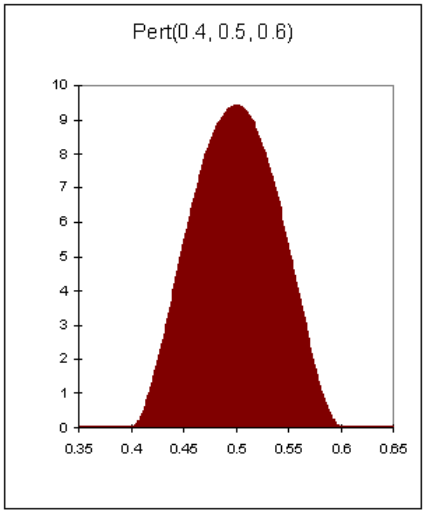
What is the probability of *negligible* transmission via fomites to the population of interest given: 1) the current status of the disease and 2) the control actions taken?

Discussion/References

Trucks moving from farm to farm and truck drivers are the most important (50% C&D). Some farms use vaccination crews or company vets, these would represent a lower risk as they use clean boots and clothes. 50% of farms allow commercial trucks on the farm, 40-70% of these require some form of cleaning and/or disinfection (inside and outside). Airborne spread between farms is unlikely except if an infected and a clean farm are in very close proximity.

Notes: This incorporates biosecurity protocols (including housing, foot baths, waste water treatments, etc.) to reduce spread on or from products, germplasm, equipment, personnel, vehicles, etc.

Uncertainty



Estimated Values

Probability of **negligible transmission via fomites**

Minimum	Likely	Maximum		
0.40	0.50	0.60	Pert dist =>	0.50

prob = 1 represents the best case; closed system or no fomite transmission

prob = 0 represents the worst case; open system or no control of fomites

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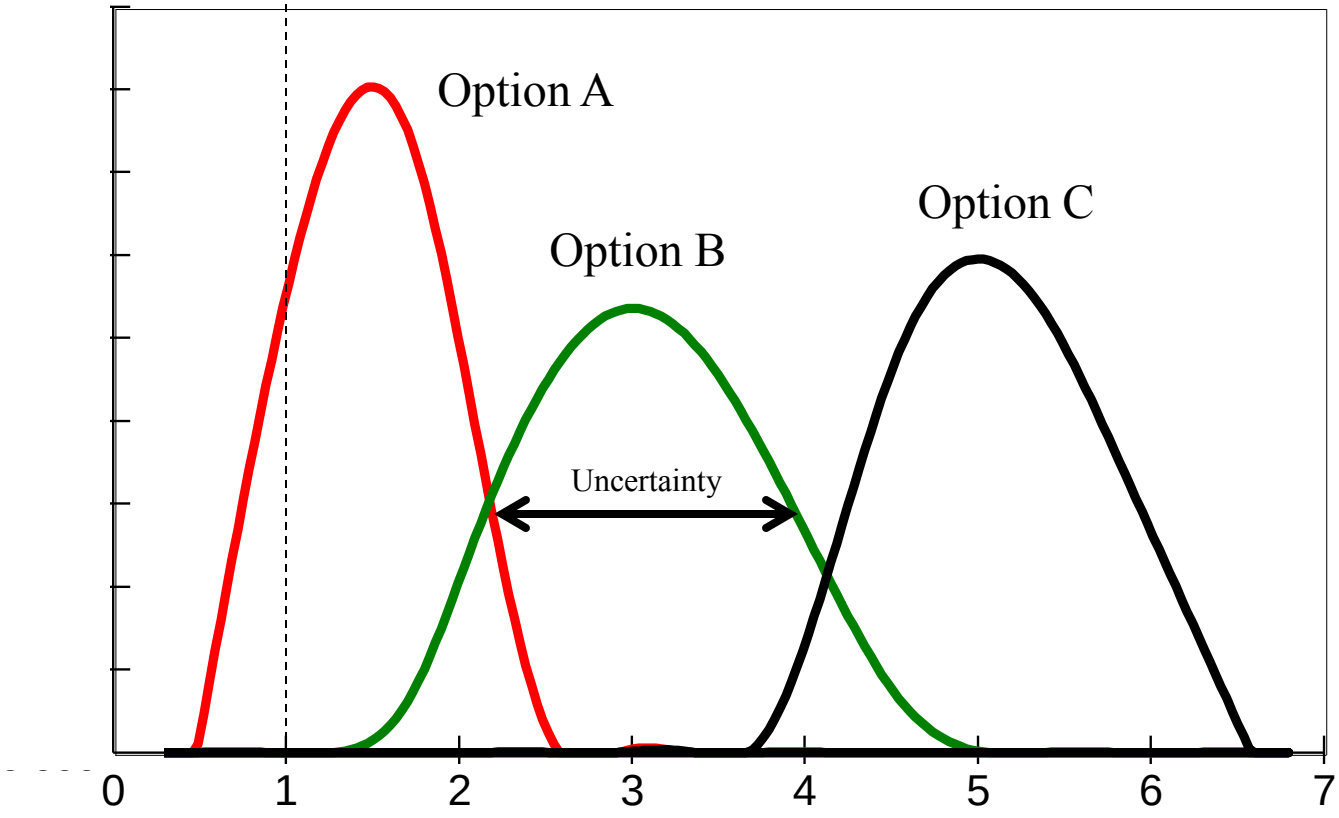
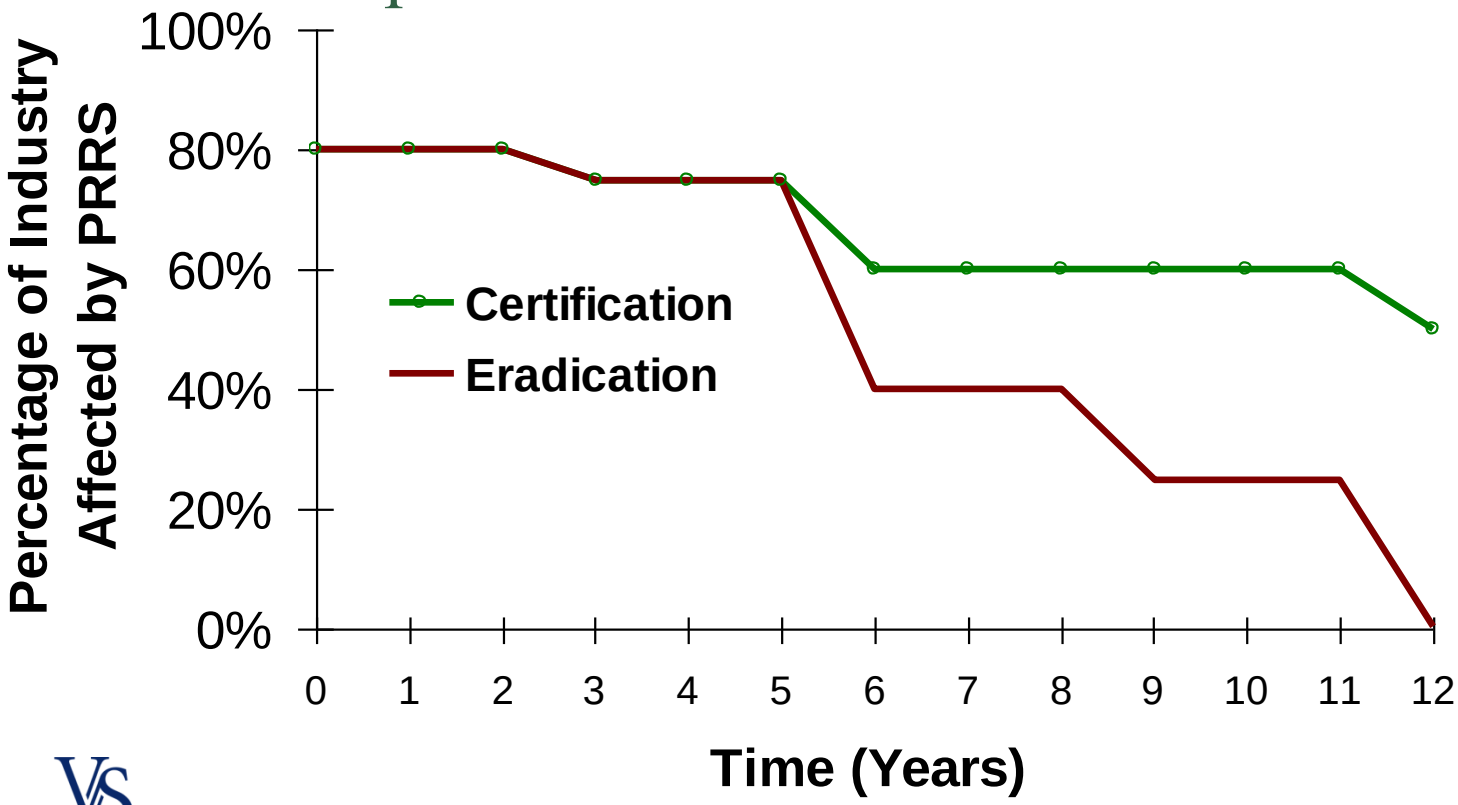
Weighted benefit-cost ratio of different options



Epidemiological curve

Impact of intervention over time



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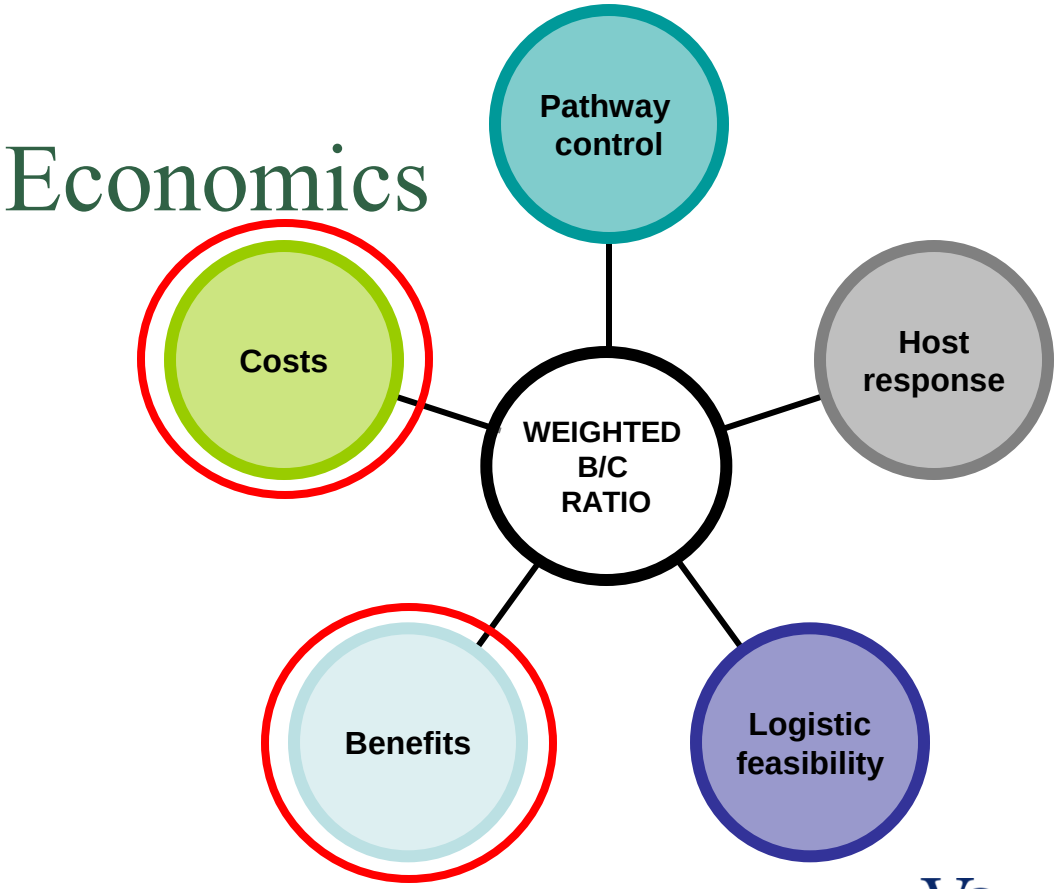
Costs include monetary costs as well as negative impacts

Benefits are considered in terms of averted economic consequences, both trade and non-trade-related



Economics specific to PRRS

Benefits

(Averted economic consequences)

Economic impacts as reapportioned between acute and chronic case (Neumann, et al.)

Averted consequences informed by epidemiologic curve as derived by experts

Total benefits presented in present value form

Costs

Developed with input from experts

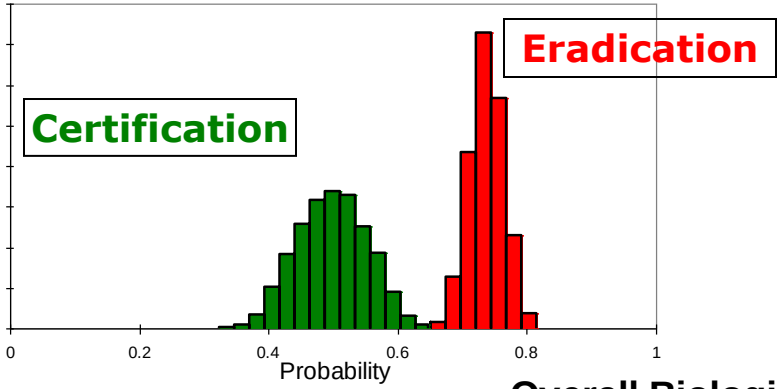
Derived from experience with other swine disease programs

Includes testing costs and considers participation rates over life of program

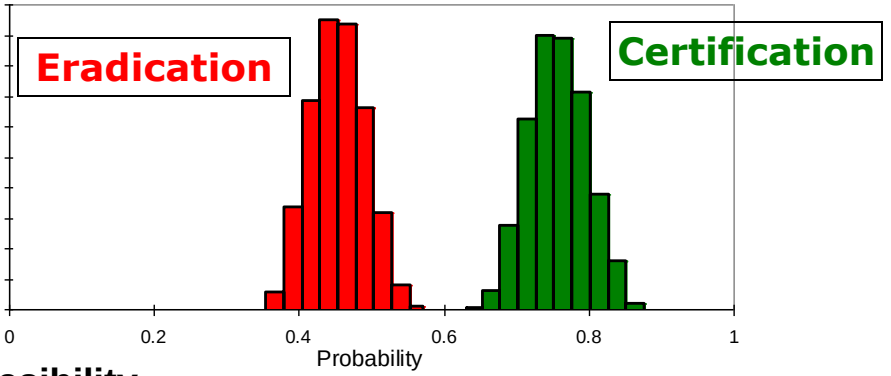
Total costs presented in present value form

Certification vs. Eradication

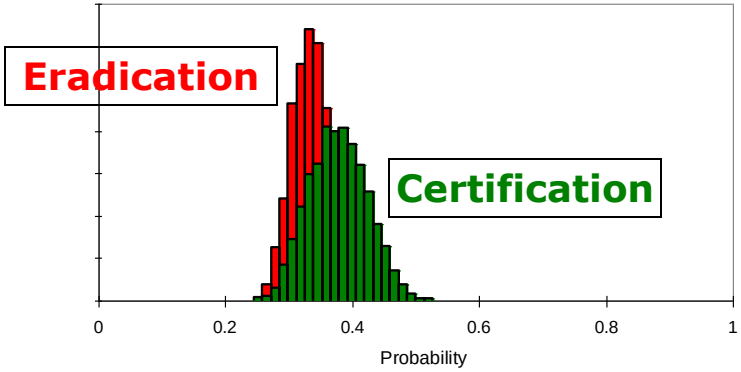
Epi Control



Logistic Feasibility



Overall Biological Feasibility



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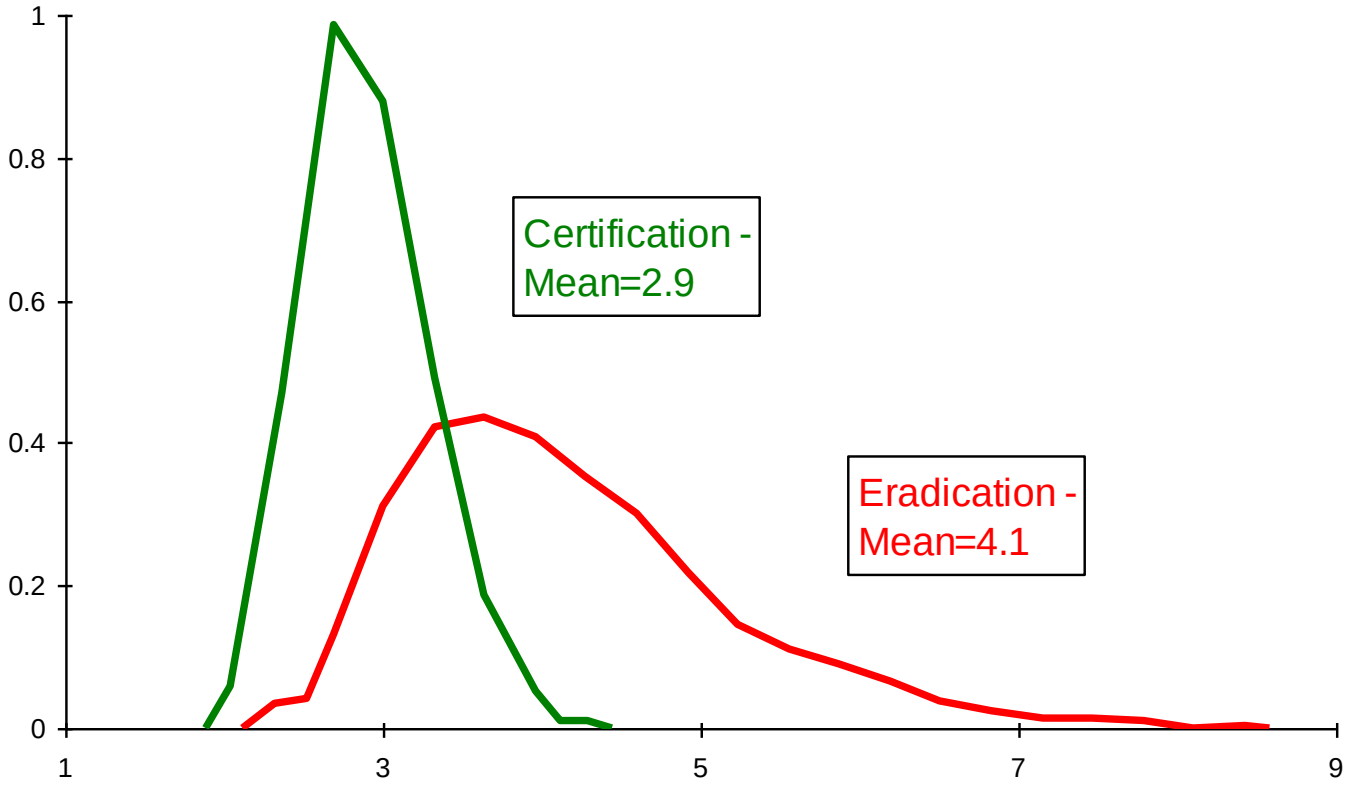
1
0.8
0.6
0.4
0.2
0
1
3
5
7
9
Certification - Mean=2.9
Eradication - Mean=4.1

Summary of Results

Certification

Easier to implement

Less variability

Very high chance of being cost-beneficial

Eradication

Greater biological control

More cost-beneficial in the long run

Potential for very high pay-offs

TAIO – Summary

Framework for evaluating defined intervention options

Requires understanding TAIO process, composition, and interactions – Not a “black box”

Encourages multidisciplinary approach

Captures uncertainty – improves transparency

Determine sensitivity to inputs

Support tool informs decision makers, outputs should not be considered the decision

Outputs may suggest a need for other options to be evaluated