Using NAADSM: Strengths, Limitations, and Appropriate Use

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Team Collaboration

- Animal Population Health Institute, CSU
- Canadian Food Inspection Agency
- Ontario Ministry of Agriculture and Food
- United States Department of Agriculture
- University of Guelph, Ontario

- Input from experts from other countries

NAADSM Characteristics

- Stochastic
- State transition
- Spatial and temporal
- Built-in economic components
- Herd based

Applications

- Emergency planning and preparedness
  - Exercise design
  - Discussion, awareness forums
  - Training

Applications

- Developing plans for emergency response procedures and strategies
  - North American FMD vaccine bank issues
  - Lab capacity
  - PRV vaccine
- Learning and discussion tool in emergency preparedness

Applications

- Model disease spread under different conditions
  - Compare levels of spread and detection
  - Test population variation – density and production types
- Control Strategies
  - Compare the effects movement control, mass depopulation, vaccination

Limitations

- Vector borne diseases
- Slow spread (BSE)
- Wildlife diseases – populations don’t exist as agricultural units

Using NAADSM

Population Data

- Characteristics of herds - location, type of operation, animal number, status

Set up starting units

File Edit

Sort by: Order Sort order: Ascending Descending

Filter by: (No filter)

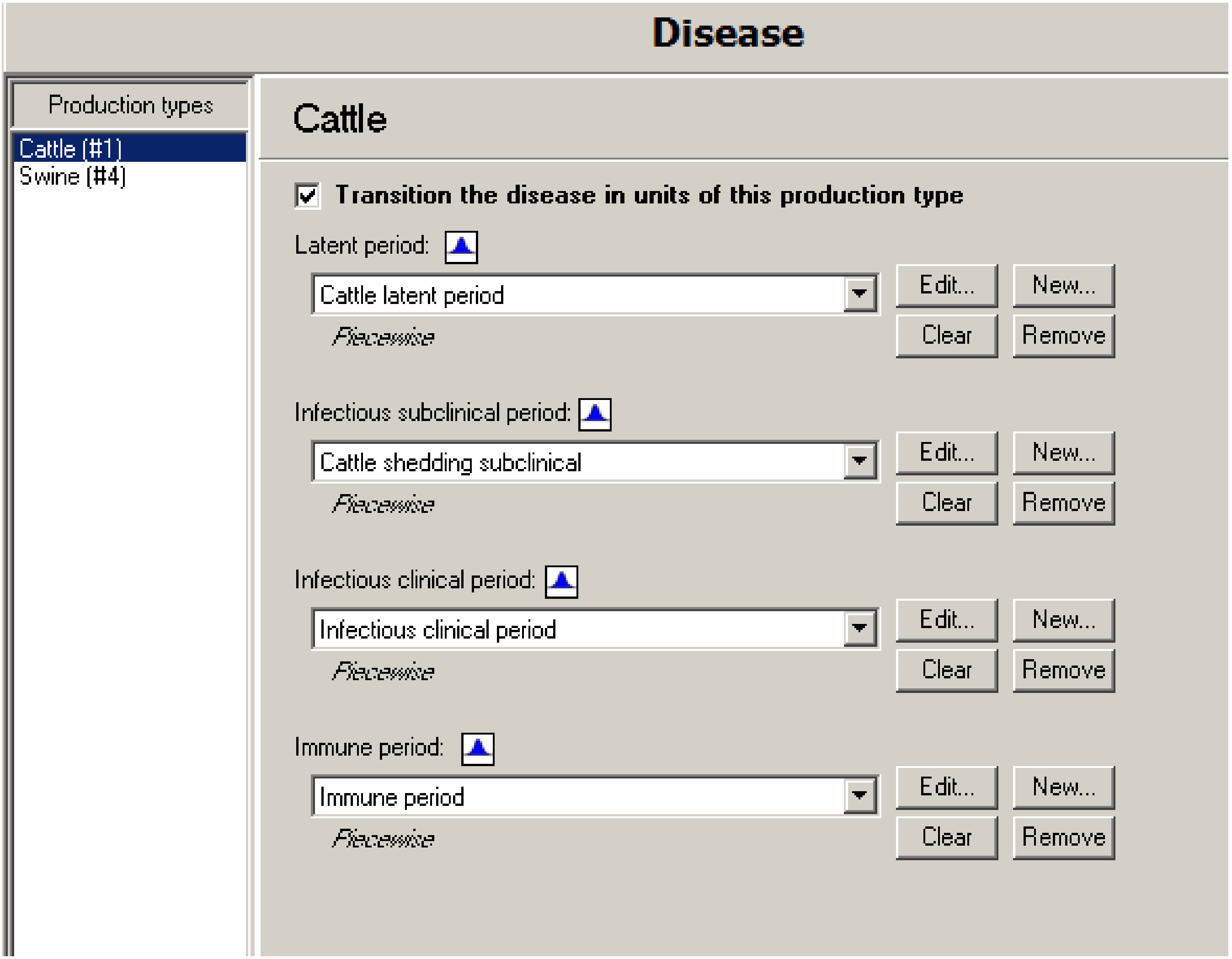
Order	ID	Production type	Unit size	Latitude	Longitude	Status	Days left in status
1	1	Swine (#4)	19	41.30028	-91.96638	Susceptible	Unspecified
2	2	Swine (#4)	15	43.28833	-96.31611	Susceptible	Unspecified
3	3	Swine (#4)	20	42.98333	-96.13111	Susceptible	Unspecified

Using NAADSM

Disease Parameters

- State characteristics: latent period, subclinical, infective, vaccine immune, natural immune, for each operation type
- Probability of spread, given contact between infectious and susceptible
- Use distributions rather than point estimates
- Describe herd situation, not individual animals

Using NAADSM



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Contact

- Direct, indirect movements and airborne spread
- Frequency, distance
- For each type of operation

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Detection parameters

- Time before disease is identified, based on two factors:
  - Days that the herd is in the contagious period
    - The longer, more clinical animals, more chance of the producer and veterinarian identifying signs of disease
  - Days since disease outbreak was first detected
    - Expect more awareness of foreign disease after first case in area/country has been identified

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Control

- Vaccination, Destruction, Movement control,
- Define circumstances, available resources for vaccination and destruction

Using NAADSM

Operational Cost

- Appraisal, C&D, Indemnification, Euthanasia, Carcass disposal, Vaccination

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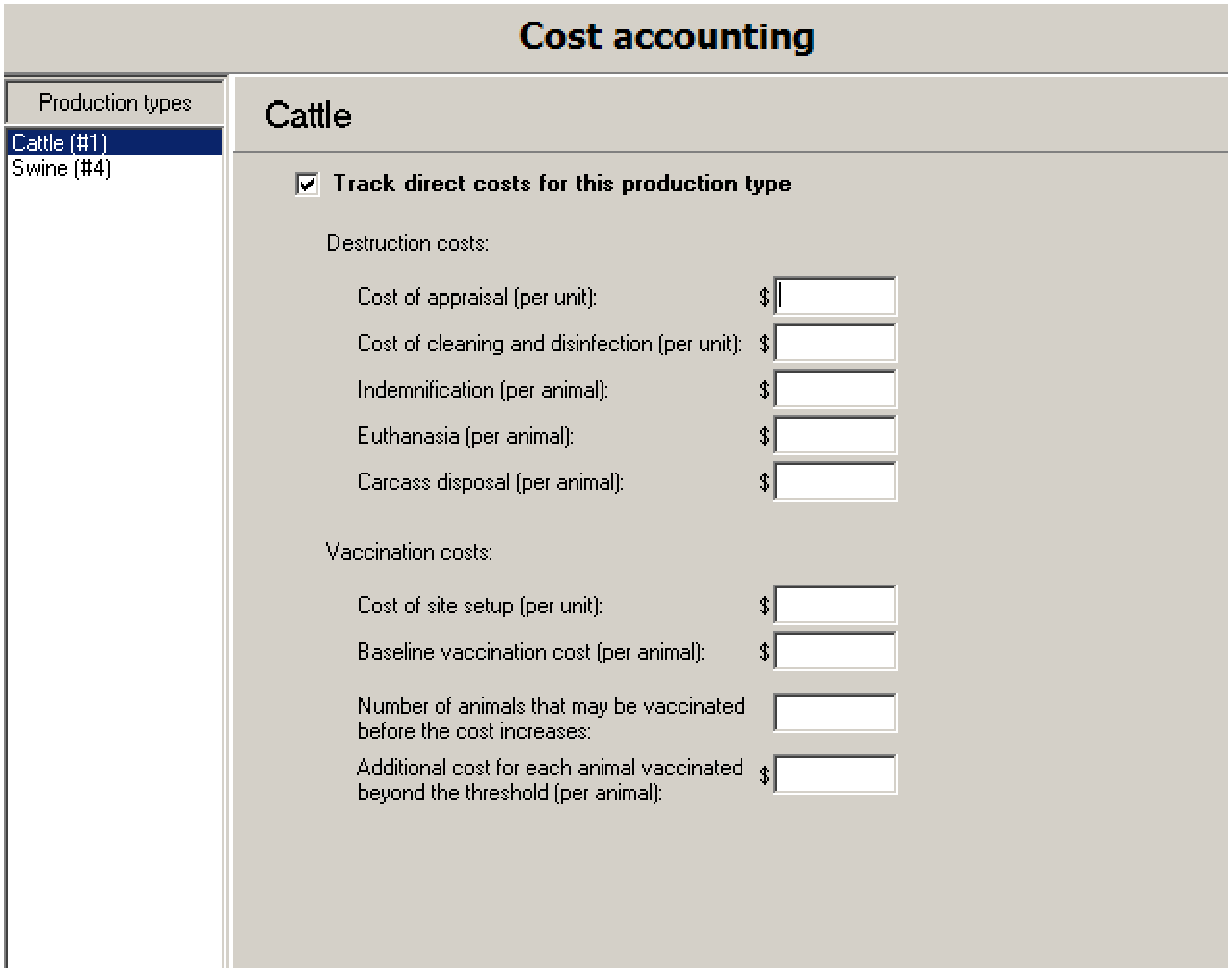
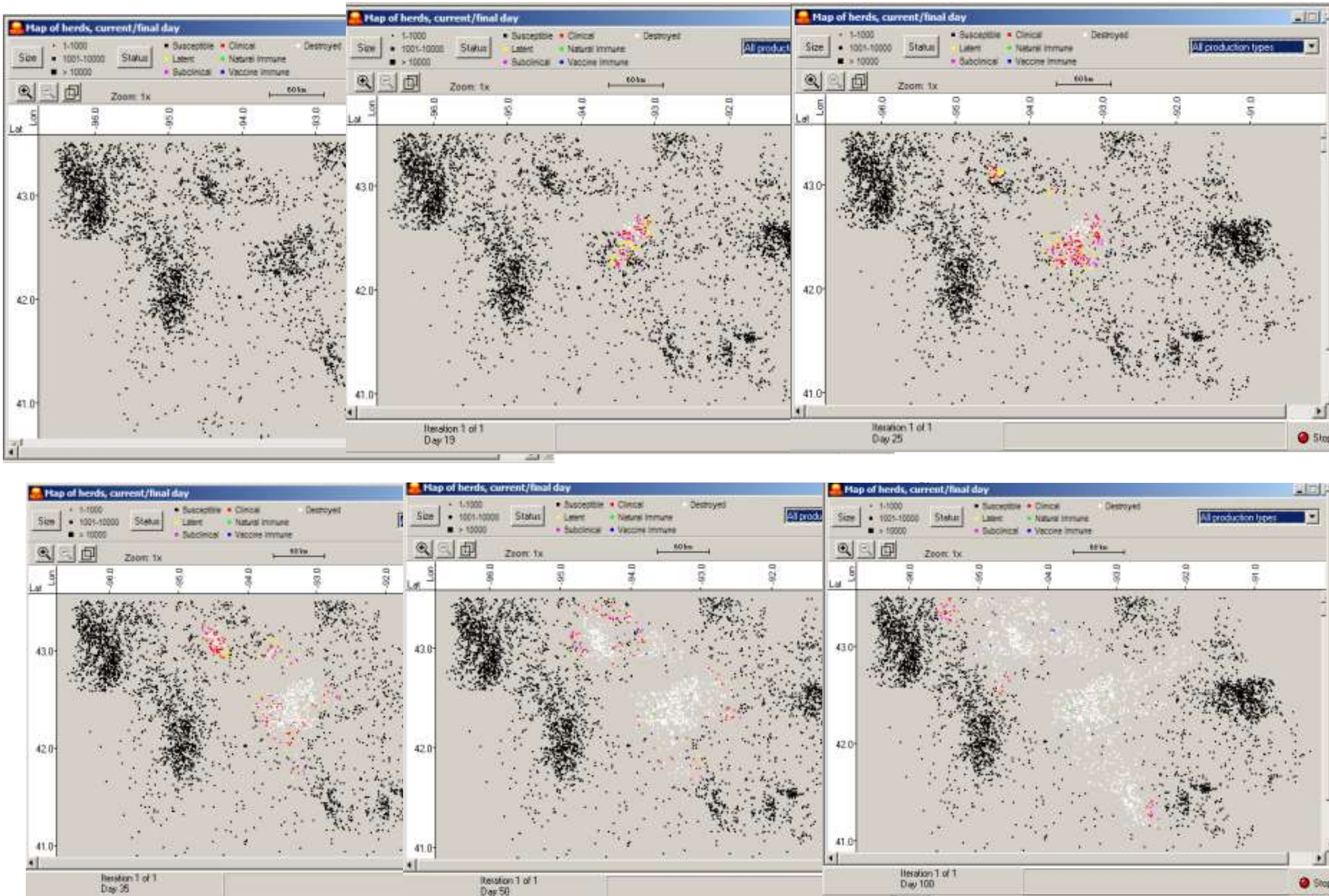
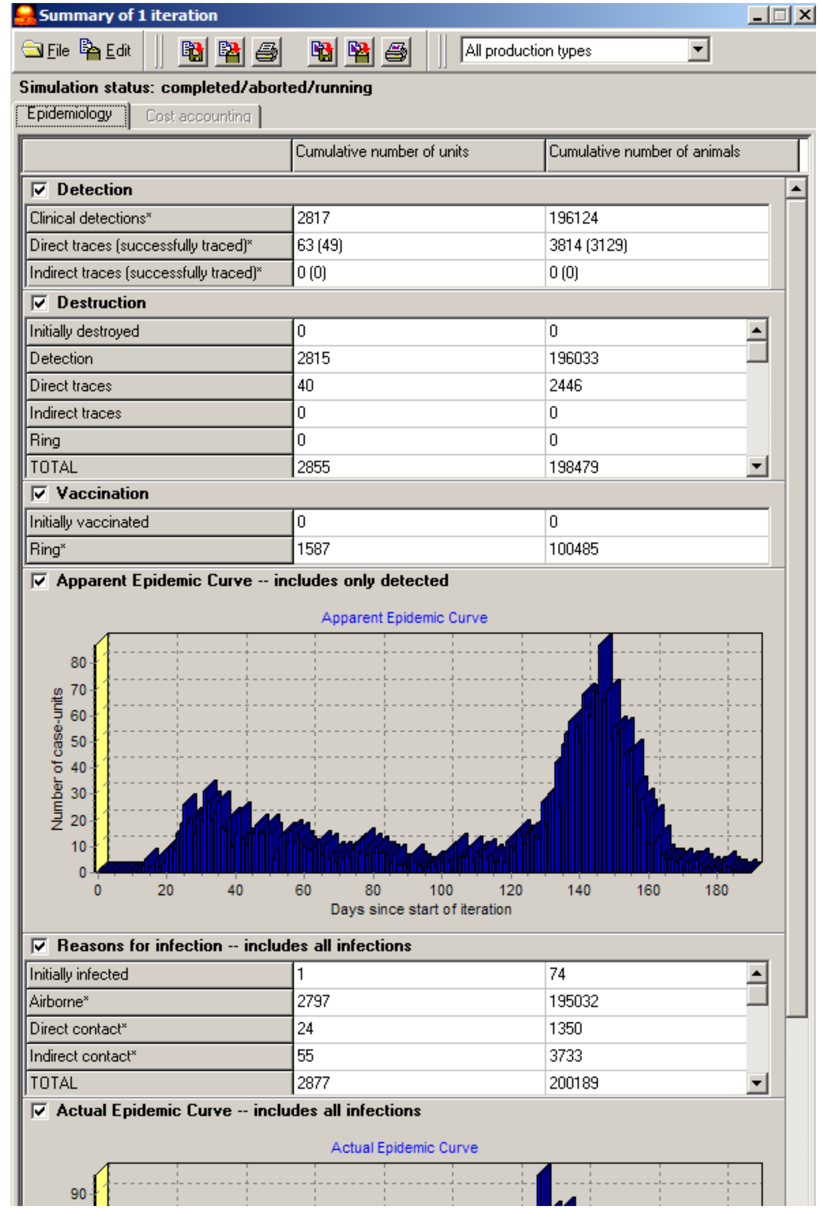


Using NAADSM

- Run multiple simulations
- Change parameters - situation or control activities - run again if desired
- Analyze output - number of herds and animals in different statuses, costs associated with activities


Map of herds, current/final day
Size
1-1000
1001-10000
> 10000
Status
Susceptible
Latent
Subclinical
Clinical
Natural Immune
Vaccine Immune
Destroyed
All production types
Zoom: 1x
60 km
Lat
Lon
43.0
42.0
41.0
96.0
95.0
94.0
93.0
92.0
91.0
Iteration 1 of 1
Day 19
Iteration 1 of 1
Day 25
Stop
Iteration 1 of 1
Day 35
Iteration 1 of 1
Day 50
Iteration 1 of 1
Day 100

- Analyze output - number of herds and animals in different statuses, costs associated with activities



Using NAADSM

Review output

- Map, chart
- Statistics for all iterations
- Details for last iteration
- Summarized
  - Maximum, minimum, average, percentiles, for each variable for multiple iterations
  - Calculated values for time to end of outbreak and time to first detection for multiple iterations
  - Epidemic curve
  - Day by day statistics for all variables and daily units detected for multiple scenarios

Interpret output

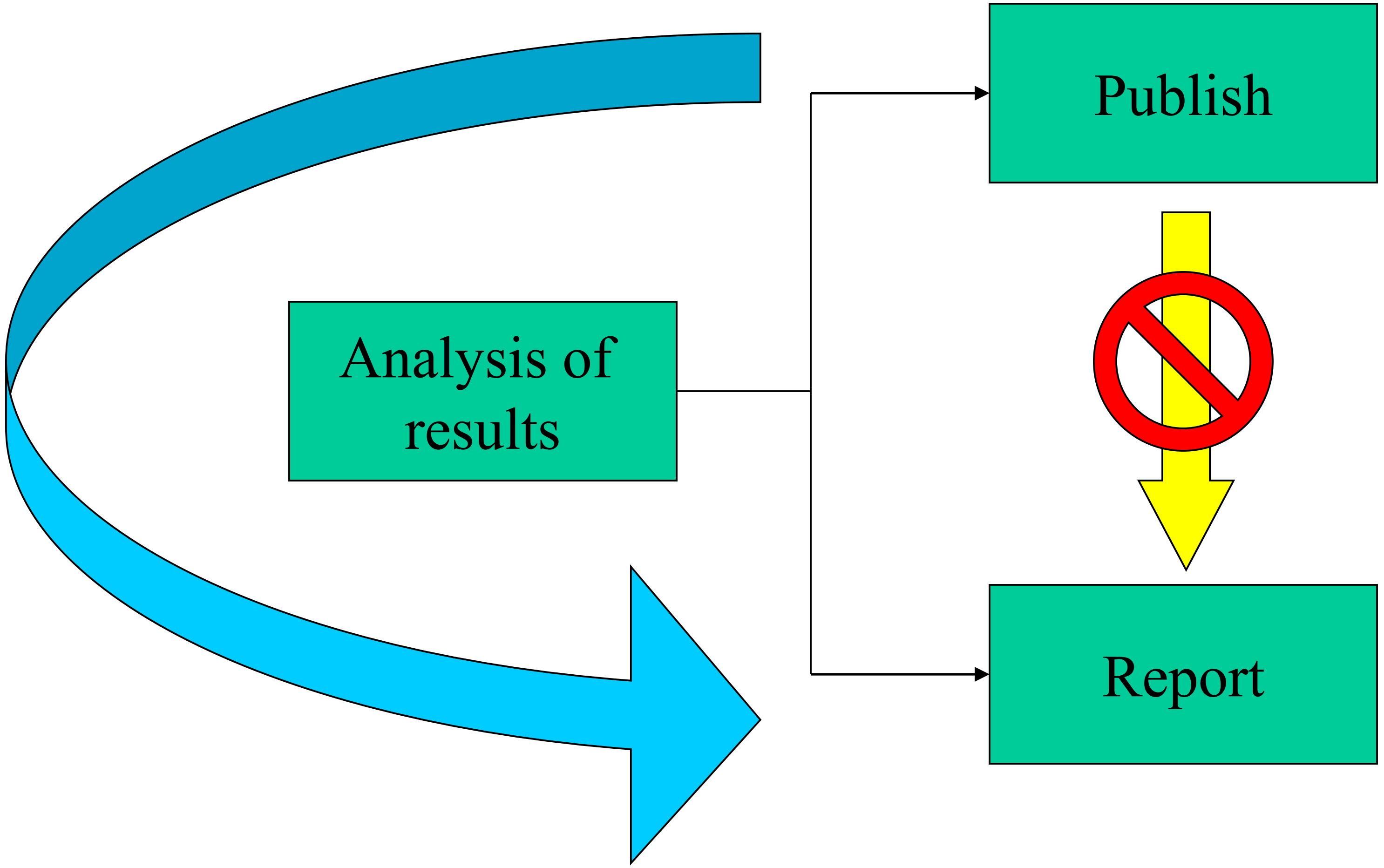
- Determine what outputs are important – how do you define success?
  - Faster eradication
  - Less expensive
  - Fewer animal killed
  - Fewer farms infected
  - Confining disease to one geographic area or production type
- Interpretation requires knowledge of how the model works, as well as inputs and assumptions
- Disease experts need to compare their opinion to model output, raise areas for discussion, further investigation, etc.

Communication of results

Model

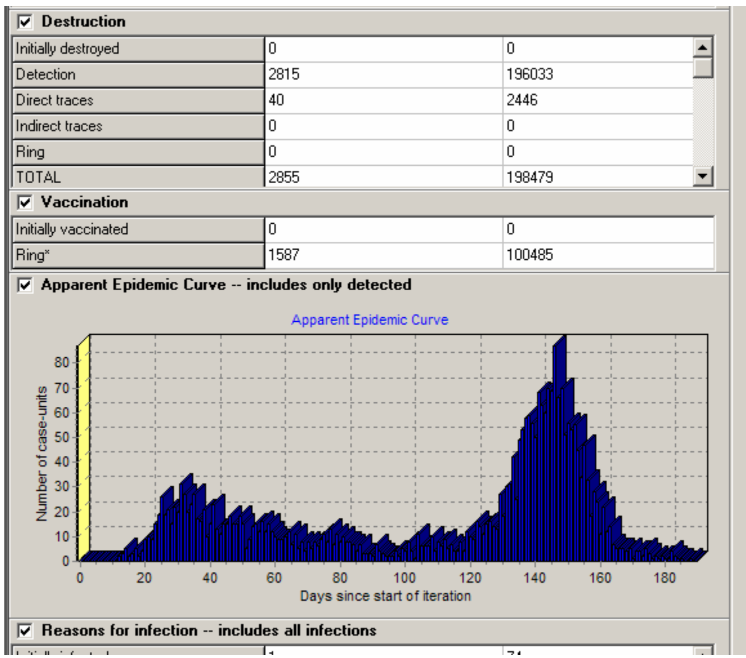
Reality

Communication of results



Communication of results

Model

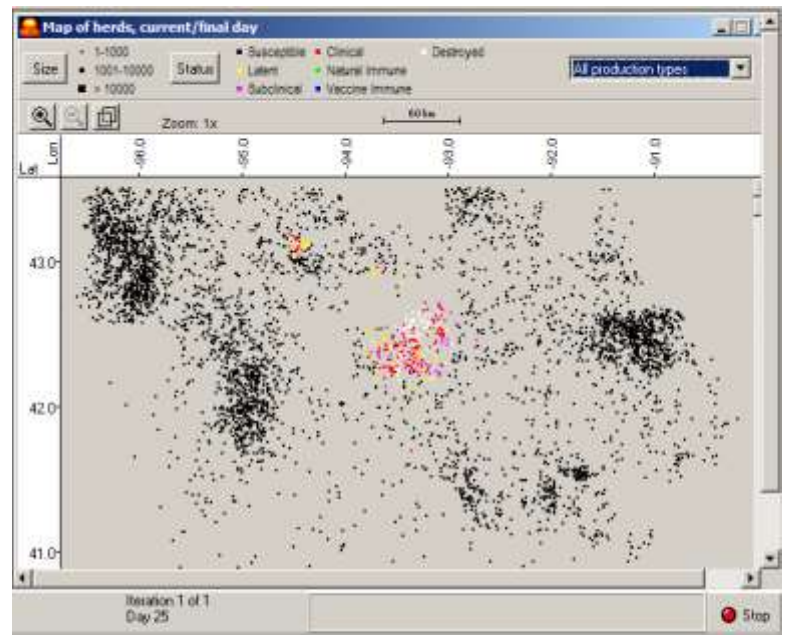


Destruction

Initially destroyed	0	0
Detection	2815	196033
Direct traces	40	2446
Indirect traces	0	0
Ring	0	0
TOTAL	2855	198479

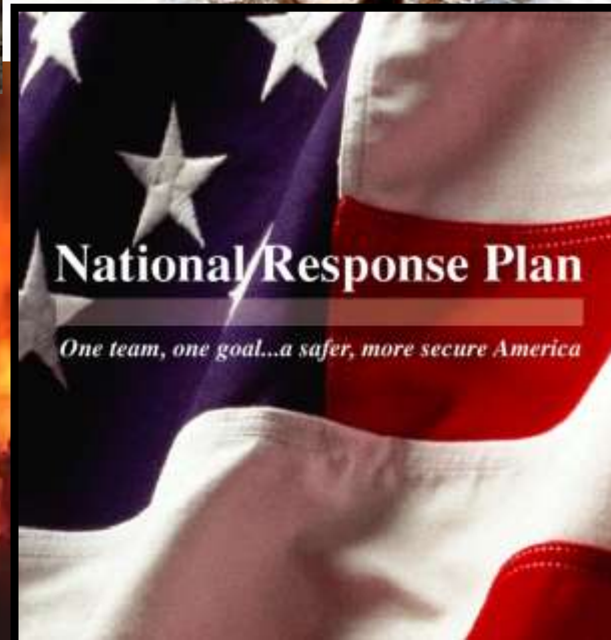
Vaccination

Initially vaccinated	0	0
Ring*	1587	100485



Communication of results

Reality



Communication of results

PNAS

Predicting the global spread of H5N1 avian influenza

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The spread of highly pathogenic H5N1 avian influenza into Asia, Europe, and Africa has resulted in enormous impacts on the poultry industry and presents an important threat to human health. The pathways by which the virus has and will spread between countries have been debated extensively, but have yet to be analyzed comprehensively and quantitatively. We integrated data on phy-

commercial trade in wild birds (4), making this another potentially important pathway unless all imported birds are quarantined, tested for avian influenza, and culled where necessary.

We determined the most likely pathways for the introduction of H5N1 into each of 52 countries by using global data on country-to-country imports and exports of live poultry, trade in

Communication of results

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Use and abuse of mathematical models: an illustration from the 2001 foot and mouth disease epidemic in the United Kingdom

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Summary
Foot and mouth disease (FMD) is a major threat, not only to countries whose economies rely on agricultural exports, but also to industrialised countries that maintain a healthy domestic livestock industry by eliminating major infectious diseases from their livestock populations. Traditional methods of controlling diseases such as FMD require the rapid detection and slaughter of infected

Communication of results

+ Models
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The *North American animal disease spread model*: A simulation model to assist decision making in evaluating animal disease incursions

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The *North American Animal Disease Spread Model* Project:
Month #, 2007

Simulation models have the potential to play a significant role in the development and testing of animal disease control and eradication plans. The *North American Animal Disease Spread Model* (*NAADSM*) is one such model, intended to simulate the spread and control of highly contagious foreign animal diseases in susceptible livestock populations.

Development of *NAADSM* is now an international collaborative activity involving researchers from the Animal Population Health Institute at CSU, the Canadian Food Inspection Agency, the Department of Computing and Information Science at the University of Guelph, the Ontario Ministry for Food and Rural Affairs, and USDA-APHIS-Veterinary Services, as well as subject matter experts from all over the world.

Among the goals of the *NAADSM* project are the following:

- To produce a practical modeling application suitable for the study of highly contagious foreign animal disease spread in the absence of an actual outbreak;
- To offer a tool for the evaluation of proposed disease control strategies, preparedness planning, and policy formation;
- To aid the assessment of potential economic impacts of disease and associated control measures;
- To offer training in the use of disease models in general and of *NAADSM* in particular to the scientific and veterinary medical communities.

NAADSM has the following key characteristics:

- *NAADSM* is a stochastic simulation model: it attempts to imitate the random processes responsible for disease spread. Each simulated outbreak is the end result of a unique series of random events and processes.
- *NAADSM* simulates spatial and temporal aspects of disease spread.
- *NAADSM* is a state transition model: each newly infected herd undergoes a progression from a susceptible state through several infected states to an immune (recovered) state.
- *NAADSM* includes cost accounting components: the direct costs associated with simulated outbreaks may be estimated.
- *NAADSM* has sufficient flexibility to allow it to be used for a variety of diseases. Questions concerning foot-and-mouth disease, highly pathogenic avian influenza, pseudorabies, classical swine fever, and exotic Newcastle disease are now being addressed by researchers using *NAADSM*.

Development of *NAADSM* is an on-going process, and continues to involve a broad, international pool of livestock health experts, disease modelers, and other specialists. New capabilities to simulate enhanced surveillance, disease control zones, and variability of within-herd disease prevalence are now being tested by the development team. The simulation of disease control and surveillance zones will improve our ability to fine-tune the application of control measures. Implementation of a model of disease mortality, enhanced trading capabilities, modeling of diagnostic testing for disease detection, and refining the simulated effects of vaccination are planned for subsequent versions.