Using *NAADSM* 3.1

Part 3: Disease control

NAADSM Development Team
http://www.naadsm.org

NAADSM Development Team

How does *NAADSM* allow us to simulate disease control?

- Detection
- Movement controls
- Tracing
- Quarantine
- Destruction
- Vaccination

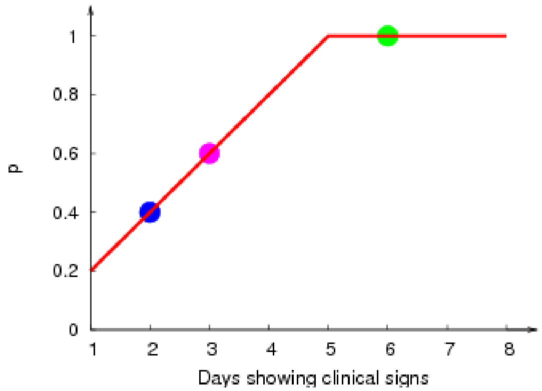
Detection of disease: Overview

- Detection is optional: the user can disable it
  - All subsequent control measures depend on detection: if it is disabled, no control is simulated
- Currently in *NAADSM*, only clinically infectious units (herds) can be detected
- Two probabilities affect the overall chance that an infected herd will be detected:
  - Probability of observing clinical signs in a herd
  - Probability that authorities will be alerted once clinical signs have been observed

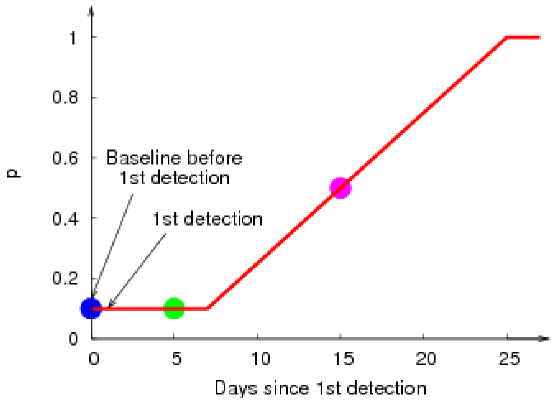
Detection: Probabilities of observing signs and reporting observed signs

- The probabilities describing detection are given as relational functions
- Overall probability of detection = P(observing clinical signs) x P(reporting)
- Probabilities of observing signs and reporting may be set individually by production type

P (observing signs)

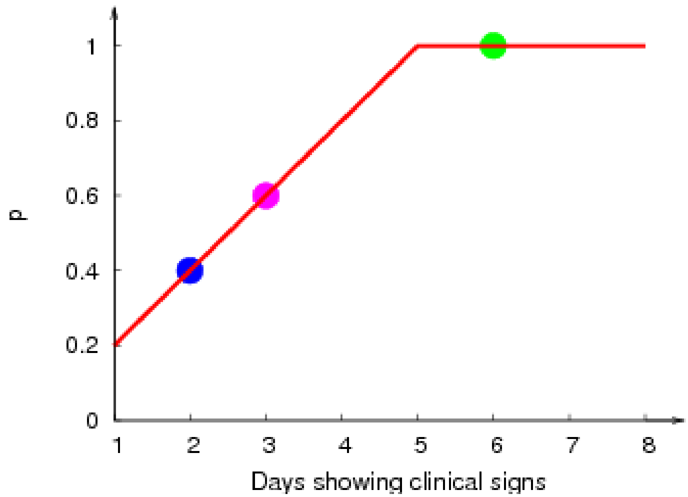


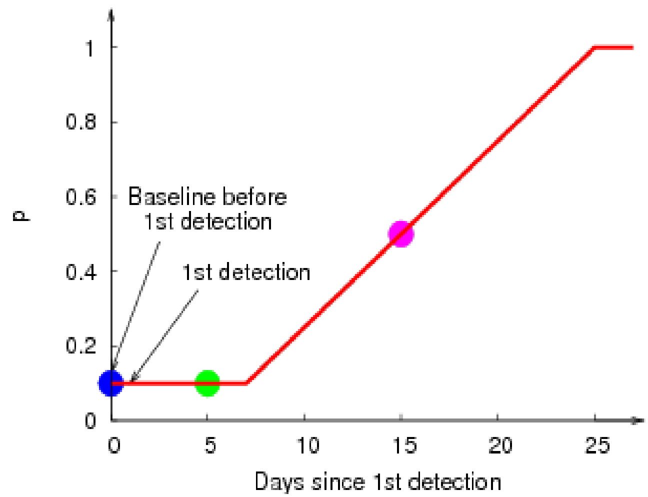
P (reporting)



Calculating the overall probability of detection

- Consider the following example:
  - A unit that has shown clinical signs for 3 days
  - An outbreak that has been recognized for 15 days





- Probability of detection is
  $0.6 \times 0.5 = 0.3$

Detection: Assumptions in *NAADSM*

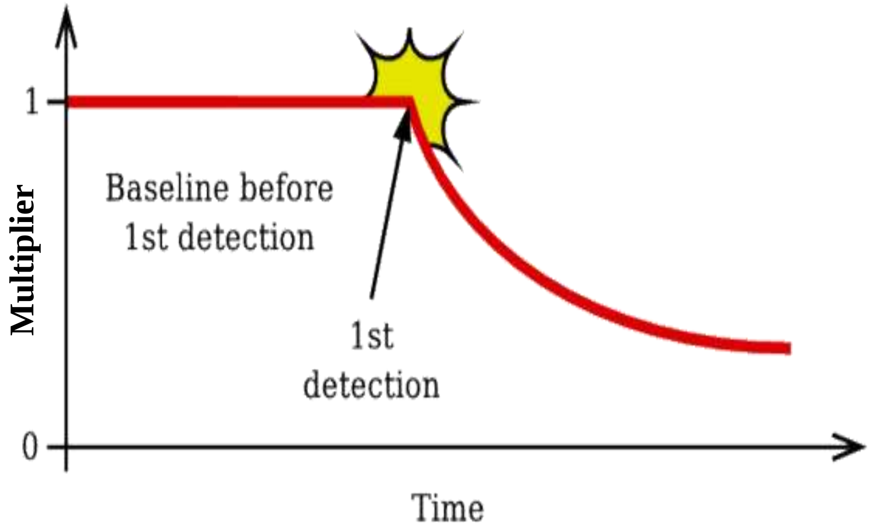
- Detection is assumed to be *100% specific*
  - There are no false positive detections
- Detected units are *automatically quarantined* the following day

NAADSM demo (IX): Detection

- Viewing "Production type settings for detection" window
  - Overview of relational functions in *NAADSM*
  - Creating or editing a relational function
  - Setting the relational function for the probability of observing clinical signs
  - Setting the relational function for the probability of reporting observed clinical units

Movement restriction

- After the initial detection of disease in any unit, the average frequencies of contact for each production type can be altered
  - *e.g.*, the frequency of direct and indirect contact can be reduced to simulate the effect of movement restrictions
  - Over time, the frequency of contact can be further reduced to simulate better implementation of movement restrictions over time

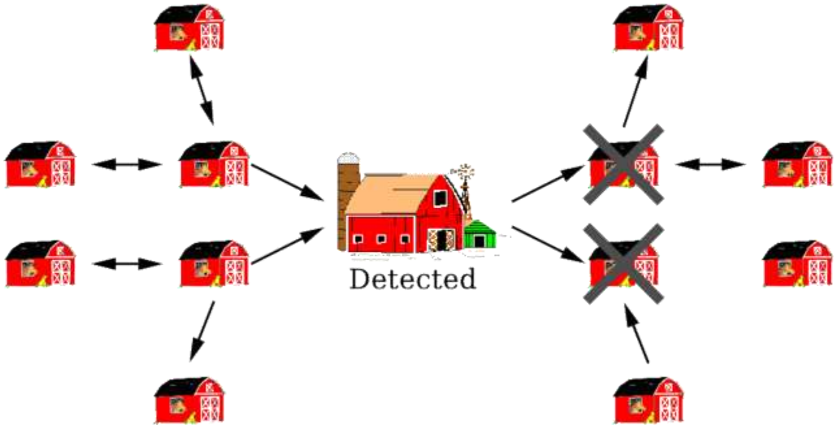


NAADSM demo (X): Movement restrictions

- Viewing the "Contact spread" window
  - Recalling the baseline contact rate
  - Creating or editing a relational function to adjust the baseline contact rate

Tracing: Overview

- Trace-forward (trace-out) investigations may be simulated in *NAADSM*
- Units that have had direct and/or indirect contact with an infected unit before it was detected can be identified



- Tracing occurs only one step forward
- Note that *NAADSM* currently does not simulate trace-back (trace-in) investigations

Parameters for tracing

- Tracing parameters are assigned for the production type that is the *source* of contact
  - When units (herds) of a particular production type are detected, should trace-forward investigations from those units be simulated?
  - From the day of detection, how far back should contacts be traced?
    - *e.g.*, it might make sense to go back one or two typical incubation periods
  - What level (probability) of success of trace-forward investigations should be simulated?

Tracing: Assumptions in *NAADSM*

- Trace-forward investigations in *NAADSM* occur immediately
  - There is currently no delay in finding recipients of contact
- If a recipient of contact is successfully traced, it is *automatically quarantined*
  - Traced units may also be preemptively destroyed: more on this in a minute
- Detection of disease operates independently of tracing
  - When an infected unit is successfully traced, disease is *not* automatically detected
  - Consequently, tracing can only go one step forward from a detected unit

NAADSM demo (XI): Tracing

- Viewing "Global tracing options" window
  - Use tracing or not?
- Viewing "Production type settings for tracing" window
  - Setting options for tracing direct and/or indirect contacts
    - Period prior to detection for which tracing of contacts should be attempted
    - Probability of success

Quarantine

- A unit is *automatically* quarantined when it is:
  - Detected
  - Successfully traced
  - Designated for destruction
- Quarantine is permanent
  - There is currently no capacity in *NAADSM* to lift a quarantine
- Units designated for vaccination are *not* quarantined

Disease spread from quarantined units

- Quarantined units cannot participate in direct contact, either as sources or recipients
- Quarantined units *can* participate in indirect contact
  - The frequency of indirect contact is *not* changed by quarantine
- Airborne spread may still occur from a quarantined unit

Destruction: Overview

- Destruction (stamping out or depopulation) may be modeled as a method of disease control
- Several strategies may be implemented for destruction:
  - Destruction of infected, detected units
  - Preemptive destruction of units that have had contact with an infected, detected unit
  - Preemptive destruction based on proximity to infected, detected units (ring destruction)
- These strategies may be applied on a production type-specific basis

Ring destruction

- When an infected unit is detected, a destruction ring may be initiated around the it
  - Units of some or all production types may act as ring "triggers"
- Other units located within a specified radius of the infected unit may be marked for destruction
  - Units of some or all production types may be targets of preemptive ring destruction

Destruction capacity

- The number of units that can be destroyed within a particular timeframe may be limited by available resources
  - Personnel to carry out depopulation activities
  - Capacity to dispose of destroyed animals
- This capacity might change over time
  - Capacity might increase as resources are made available
  - (Could capacity decrease over time?)
- *NAADSM* allows the simulation of changing capacity to carry out destruction activities over time
  - Destruction capacity is given in terms of herds that can be destroyed per day
  - Destruction capacity is specified with a relational function

Destruction priorities

- If destruction capacity is limited, the priority with which units are destroyed may depend on:
  - Reason for destruction
    - Units known to be infected might be destroyed first
  - Production type
    - Animals of some species might be more likely to spread disease and thus should be destroyed first
  - Length of time a unit has been waiting to be destroyed

NAADSM demo (XII): Destruction

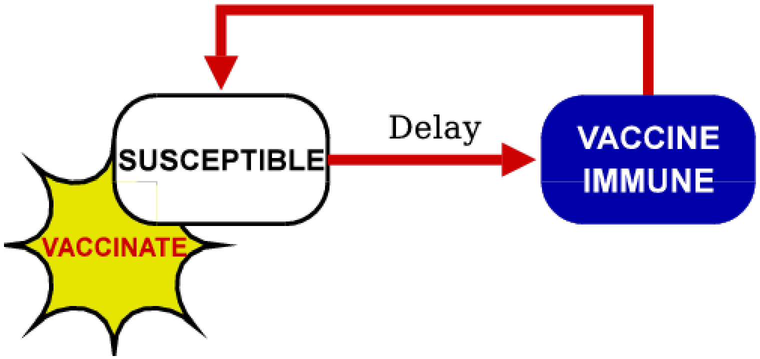
- Viewing “Global destruction options”
  - Yes or No?
  - Delay before implementing a destruction program
  - Destruction capacity
- Viewing “Destruction priorities”
  - Primary and secondary priorities
- Viewing “Destruction”
  - Production type specific options

Vaccination: Overview

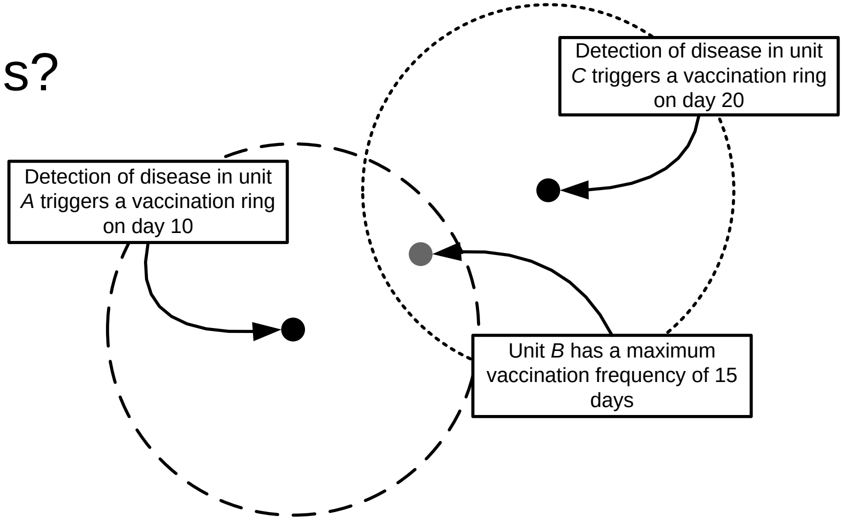
- Vaccination campaigns may also be modeled as a method of disease control
  - A campaign consists of vaccinating units within circles around infected, detected units
  - The user selects the production types that can act as vaccination ring “triggers”
  - The user also selects the production types that will be vaccinated

Vaccination: Assumptions in *NAADSM*

- When a unit is vaccinated, it remains susceptible for a time while immunity develops
  - The user specifies the length of time required for development of immunity after vaccination
- If a unit is infected after being vaccinated but before immunity develops, vaccination has no effect and the unit acts like any other infected unit in the simulation
- If immunity does develop, the duration of the immune period is determined stochastically for each vaccinated unit
- Vaccine immunity is 100% effective and conveys complete immunity to the entire vaccinated herd
- After the immune period has elapsed, the unit reverts to a susceptible state
- Vaccinating a unit that is not susceptible has no effect on its disease state
  - Vaccinating an infectious unit will have no impact on its infectiousness



Minimum time between vaccinations



- What happens when a unit is in overlapping vaccination rings?
- The use specifies a minimum time that must elapse before a unit can be revaccinated
  - This duration should be related to the vaccine immune period
- Suppose that unit "B" falls within vaccination rings triggered by both "A" and "C"
- If the elapsed time between these two trigger events is *less* than "B"'s minimum time between vaccinations, "B" *will not* be revaccinated.
- If the elapsed time is *greater* than "B"'s minimum time between vaccinations, unit "B" will be vaccinated again

Vaccination: Capacity and priorities

- Vaccination capacity (number of herds that can be vaccinated per day) is specified with a relational function
- If vaccination capacity is limited, the priority with which units are vaccinated may depend on:
  - The production type of the unit to be vaccinated
  - The length of time a unit has been waiting to be vaccinated

NAADSM demo (XIII): Vaccination

- Viewing "Global vaccination options"
  - Yes or No?
  - Delay before implementing a vaccination program
  - Vaccination capacity
- Viewing "Vaccination priorities"
  - Primary and secondary priorities
- Viewing "Vaccination"
  - For each production type, the user may specify:
    - Whether units of this production type will be vaccinated
    - The duration of immunity following vaccination
    - The delay of immunity following vaccination
    - The number of days which must pass before a unit may be revaccinated
    - Whether other production types will be marked for vaccination when the infected unit is detected

Cost accounting of disease control

- The direct costs associated with destruction and vaccination may optionally be tracked by *NAADSM*
- *Teaser:* Cost accounting will be the topic of Dr. Seitzinger's talk tomorrow morning
- *Another teaser:* Dr. Pendell will talk about the broader economic implications of disease outbreaks tomorrow afternoon

Summary

- *NAADSM* is designed especially to evaluate disease control strategies that might be employed in a livestock disease epidemic
  - These strategies include:
    - The restriction of movement of animals as well as personnel and equipment
    - Destruction of known infected units
    - Preemptive destruction
    - Vaccination
  - The impact of limitations on the resources available for disease control can be assessed
  - Additional strategies for disease control will be discussed in *Part 4: Advanced Features*
- The assumptions made by *NAADSM* need to be evaluated and considered when interpreting model results

Questions?

The *NAADSM* development team (past and present)

- Animal Population Health Institute at Colorado State University
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- United States Department of Agriculture
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  - Mark A. Schoenbaum
  - Ann H. Seitzinger
- University of Guelph Department of Computer and Information Science
  - Neil Harvey
  - Deb Stacey

Recommended reading

- Harvey, N., Reeves, A., Schoenbaum, M.A., Zagmutt-Vergara, F.J., Dubé, C., Hill, A.E., Corso, B.A., McNab, W.B., Cartwright, C.I., Salman, M.D., 2007. The North American Animal Disease Spread Model: A simulation model to assist decision making in evaluating animal disease incursions. *Preventive Veterinary Medicine* 82: 176–197.
- Hill, A., and Reeves, A. 2006. User’s Guide for the *North American Animal Disease Spread Model*, 2nd ed. Fort Collins, Colorado: Animal Population Health Institute, Colorado State University. Available at *http://wwww.naadsm.org*