Using *NAADSM* 3.1

Part 1: Basic operation & disease characteristics

NAADSM Development Team

http://www.naadsm.org

Purpose and design

- *NAADSM* is a framework for the development of epidemiologic simulation models
  - It is not just one model!
- *NAADSM* is designed to evaluate potential strategies for control of animal diseases
- *NAADSM* is:
  - A *state-transition* model
  - A *Monte Carlo simulation* model
  - A *spatially explicit* model
    - Were our Reed-Frost models spatially explicit? (*Hint*: what is assumed about contact among individuals in a Reed-Frost model?)

Capabilities & limitations

- *NAADSM* is designed for contagious diseases of livestock
- *NAADSM* is currently best suited for foreign animal diseases, where a pathogen is introduced into a previously unexposed population
- *NAADSM* is not currently intended for:
  - Chronic or endemic diseases
  - Fatal diseases
  - Vertically or sexually transmitted diseases
  - Vector-borne diseases
  - Diseases in highly mobile populations (*e.g.*, migratory wildlife)
- *NAADSM* does not simulate population dynamics (*e.g.*, births, deaths, business failures, *etc.*)

Overview of simulation parameters

- Herd-based animal populations
  - Herds may be classified by user-defined *production types*
- Disease states
  - *NAADSM* is a state transition model
- Disease transmission among herds
  - By direct or indirect contact among herds
  - By aerosol spread of the disease agent
- Detection and tracing
- Control measures
  - Quarantine
  - Destruction/stamping out
  - Vaccination
- Direct costs of disease control

Topics for later talks

Populations for *NAADSM*

- Most of the disease models we've seen so far deal with individuals within populations
- *NAADSM* is a *herd-based* model: it deals with individual herds (units) within a population of herds (units)
  - *NAADSM* simulates the spread of disease among herds
  - This is an important (and potentially confusing) abstraction used in *NAADSM*-based models
- *NAADSM* populations are static: the number and size of herds do not change*
  - *Except by destruction of a herd: more on that later today
- Each herd is characterized by:
  - The number of animals in the herd
  - Its location in space
    - Expressed as a latitude/longitude *point*
    - *Preview*: locations and distances are important for disease spread
  - Its *production type* (more on this in a minute)

NAADSM demo (I): Getting started

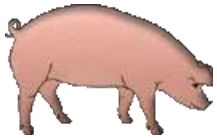
- Starting the *NAADSM/PC* application
- Glancing quickly at the menu options
- Creating a copy of the sample scenario file
- Viewing the map of herd locations
- Selecting a single herd to view its characteristics

Production types in *NAADSM*

- Every herd (or unit) has a production type
- Production types are used to define:
  - The duration of disease in an infected herd
  - The potential for spread from infected herds to susceptible herds
  - Control measures that will be applied to herds
- Production types might be characterized by:
  - Species or purpose of animals in a herd
  - Herd size
  - Management practices
    - Level of intensity of animal management
    - Level of biosecurity
  - Any combination of the above
- The *user* defines production types that are *appropriate for the question to be addressed by the model*

Some possible production types

"Cattle"



"Pigs"

"Mixed cattle and sheep"

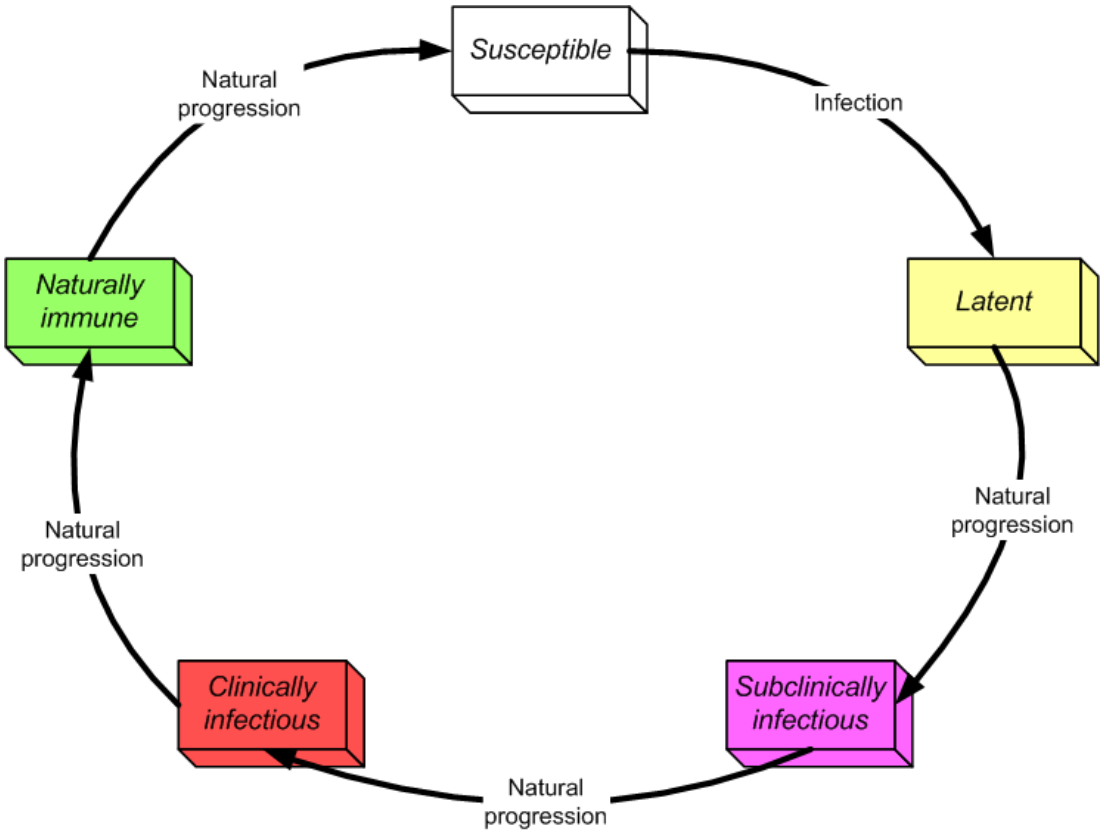
- Other possibilities:
  - Dairies
  - Extensive cow/calf farms
  - Swine operations with fewer than 100 animals
  - Nursery swine operations
  - Swine operations with high biosecurity
  - Feedlots
  - Backyard flocks
  - Commercial egg layer flocks

NAADSM demo (II): Production types

- Viewing herds of particular production types on the map
- Creating and renaming production types
- Viewing the list of units (herds) in the scenario

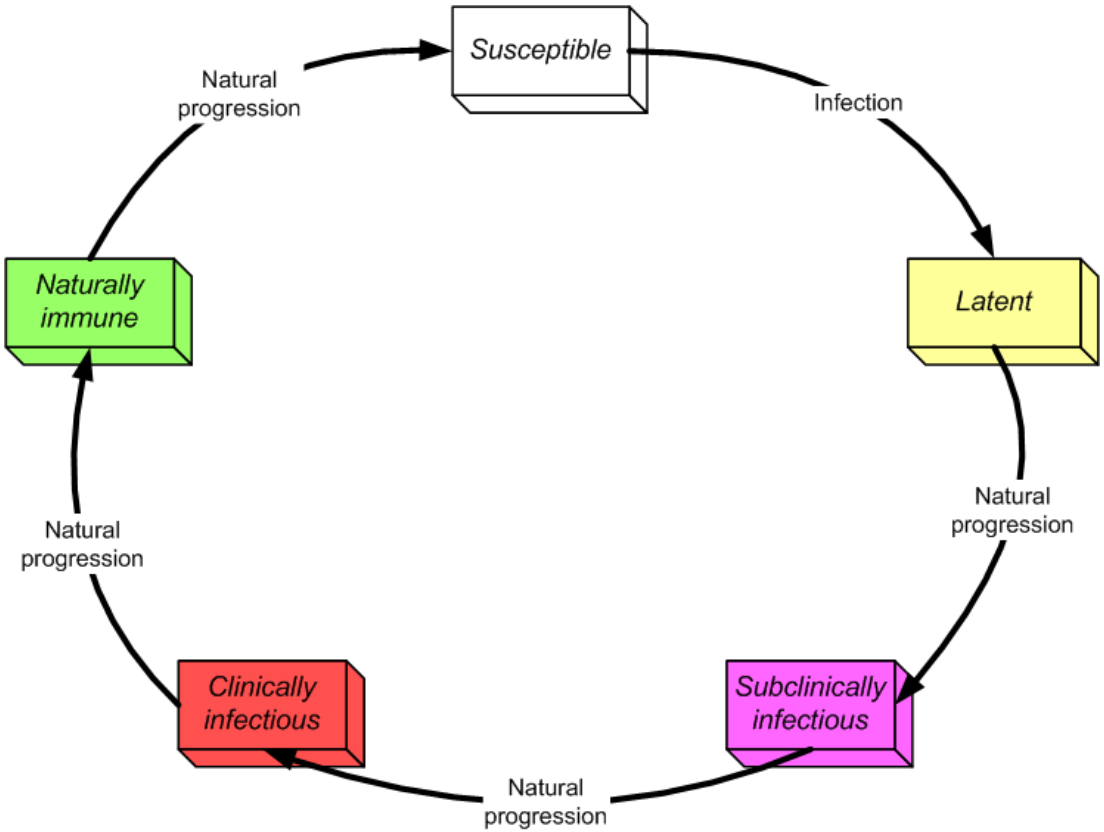
Disease states in *NAADSM*: The basics

- Each herd (unit) has a disease state
- Upon infection, a herd will enter a predictable cycle
  - How herds become infected will be covered in the next talk
- Probability density functions describe the duration (in days) of each state on a *herd-level* basis
  - The user specifies these probability density functions



Disease state definitions :A reminder from Monday

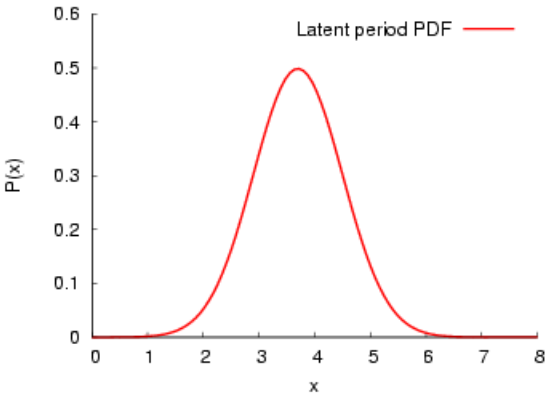
- *Latent* herds (units) are infected, but not yet shedding the disease agent
- *Subclinically infectious* herds are infected and infectious, but not yet showing clinical signs of disease
- *Clinically infectious* units are infected, infectious, and showing clinical signs of disease



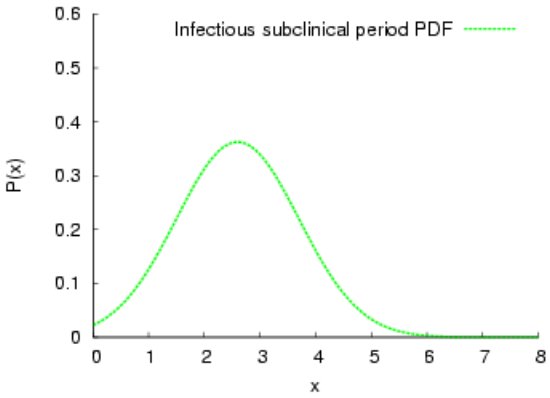
Disease state durations: An example (I)

- Suppose that we use the following probability density functions for the different infected periods of a particular production type:

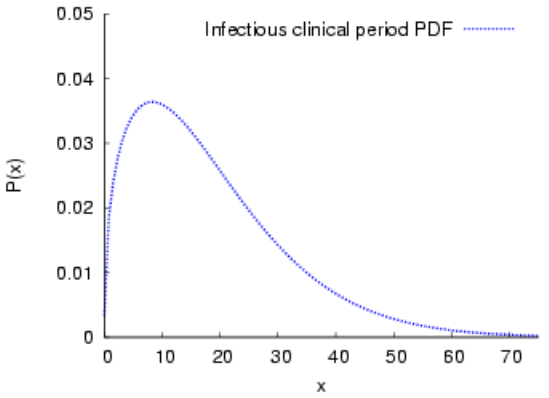
Latent = Normal(3.7, 0.8)



Subclinical = Normal(2.6, 1.1)



Clinical = Weibull(1.4, 20.2)



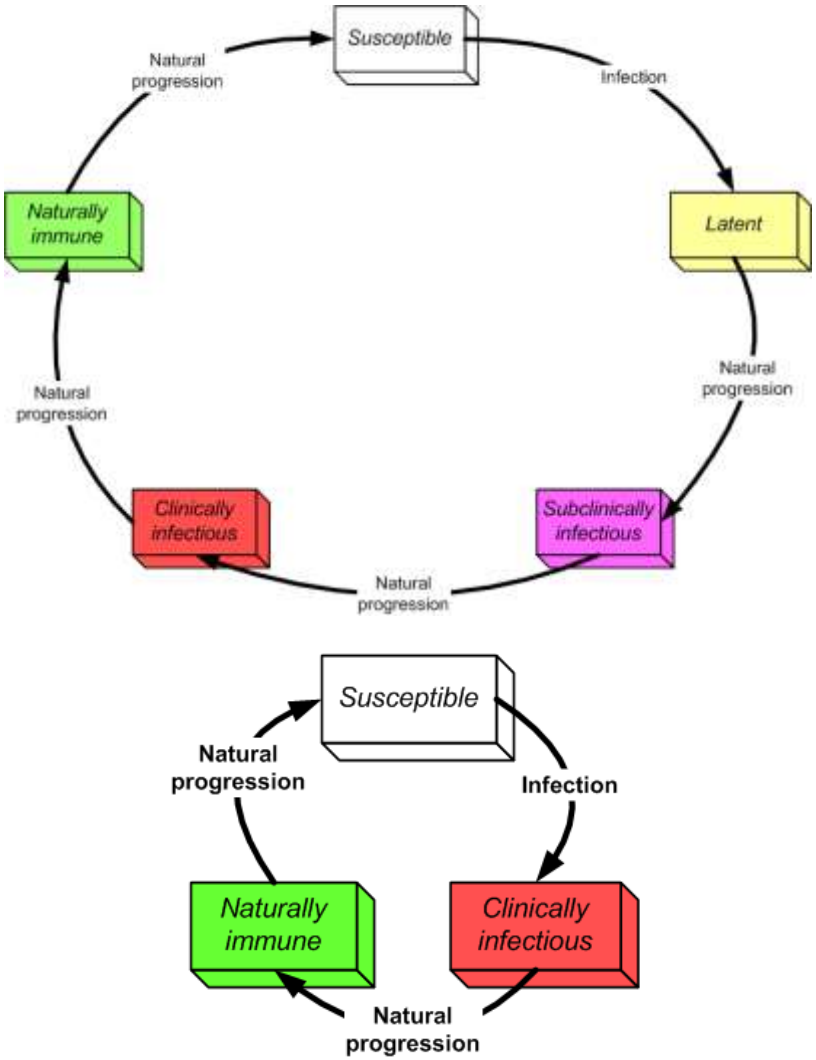
- How will *NAADSM* use these distributions for infected herds of this type?

Disease state durations: An example (II)

- To determine duration of disease states we sample from our input distributions for each new infected herd
- Results for three infected herds:
  - Latent for 4 days, subclinical for 3 days, clinical for 31 days
    Total = 38 days infected
  - Latent for 5 days, subclinical for 1 day, clinical for 15 days
    Total = 21 days
  - Latent for 3 days, subclinical for 1 day, clinical for 63 days
    Total = 67 days

Disease states in *NAADSM*: Intermediate use

- Unless control measures are applied, this cycle will continue for as long as there is at least one infected herd in the population
- Disease states can be skipped by specifying a duration of 0 days
- Permanent immunity could be simulated by specifying a very long duration for the naturally immune stage
  - (Would it ever make sense to do this?)



NAADSM demo (III): Disease states

- Viewing the "Disease options" window
  - We'll talk more about within-unit prevalence option in a few minutes
- Viewing the "Production type settings for disease" window
- Viewing, editing, and creating probability density functions

Disease states in *NAADSM*: More intermediate use

- Destruction of a herd (unit) can interrupt the normal state transition cycle
  - Herds with any disease state may be destroyed
  - Destroyed herds are never repopulated during a simulation
- Vaccination of a herd can short-circuit the normal state transition cycle
  - Only susceptible herds are affected by vaccination

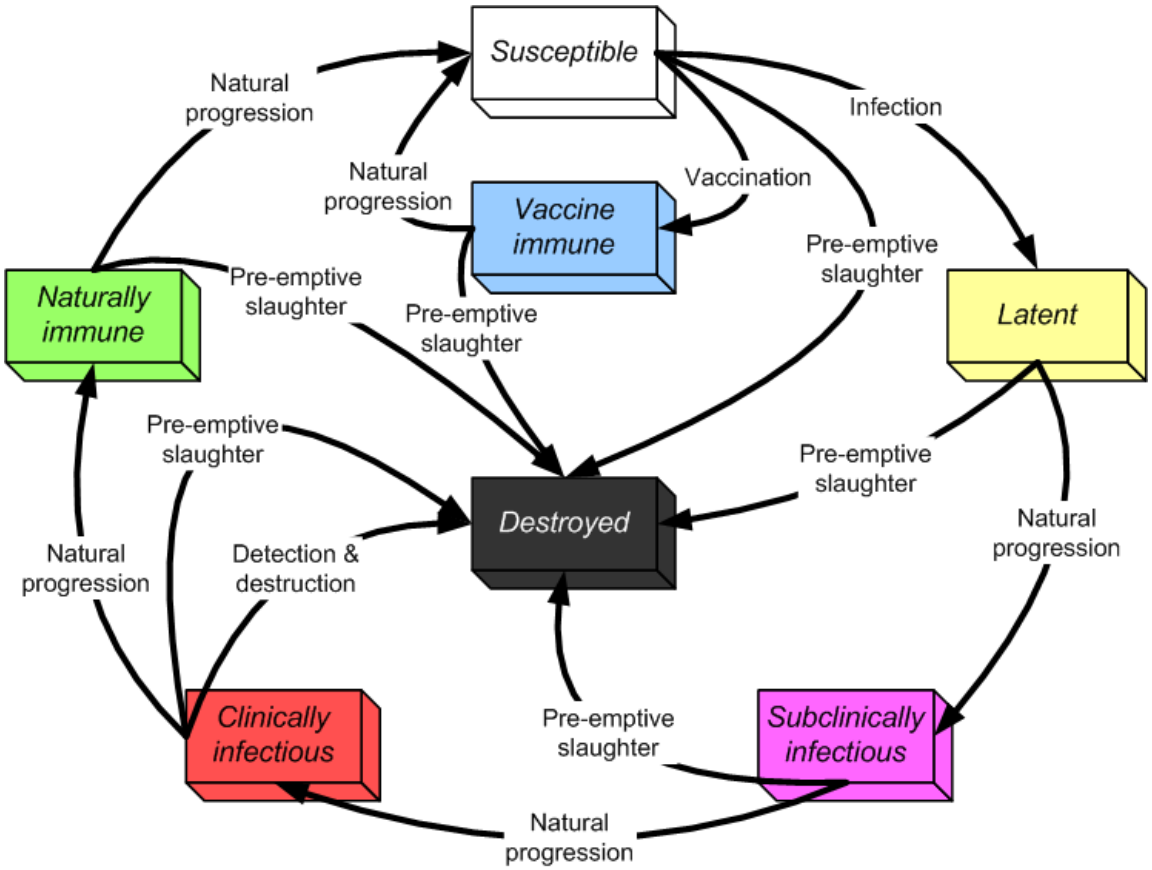


Figure modified from Harvey *et al.*, 2007

NAADSM demo (IV): Running *NAADSM*

- Running several iterations of the sample scenario
- Watching “daily” changes to herd status as simulated outbreaks progress
- Observing epidemic curves for simulated outbreaks in the “Summary of 1 iteration” window

Use of disease states in *NAADSM*

- The disease state of a herd determines:
  - Whether the herd can transmit disease
  - Whether the herd can be infected
  - Whether infection in the herd can be detected
- These will be covered in more detail in subsequent talks...

Summary

- *NAADSM* is a state transition model that supports up to 7 disease states
- The duration of most disease states is determined stochastically from probability density functions
  - “Susceptible” and “destroyed” are exceptions
- The disease state of a herd determines how disease is spread from or to the herd
  - More on this in the next session

Questions?

The *NAADSM* development team (past and present)

- Animal Population Health Institute at Colorado State University
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  - Ashley E. Hill
  - Aaron Reeves
  - Mo D. Salman
  - Francisco Zagmutt-Vergarra
- Canadian Food Inspection Agency
  - Caroline M. Dubé
- Ontario Ministry of Agriculture, Food, and Rural Affairs
  - W. Bruce McNab
- United States Department of Agriculture
  - Claudia I. Cartwright
  - Barbara A. Corso
  - Conrad Estrada
  - Kim Forde-Folle
  - 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. *(A complete, although terse, description of the* NAADSM *framework)*
- 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 (An indispensable, exhaustive, and delightfully humorous guide for* NAADSM *users. The 'must read' book of the summer!)*