North American Animal Disease SpreadModel

Disease Spread

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- Uses slides from presentations by:
  - Mark A. Schoenbaum
  - Neil Harvey
  - Francisco Zagmutt Vergara
- Additional material from
  - Neil Harvey, Aaron Reeves
  - Other colleagues
- As well as my own

Disease Spread

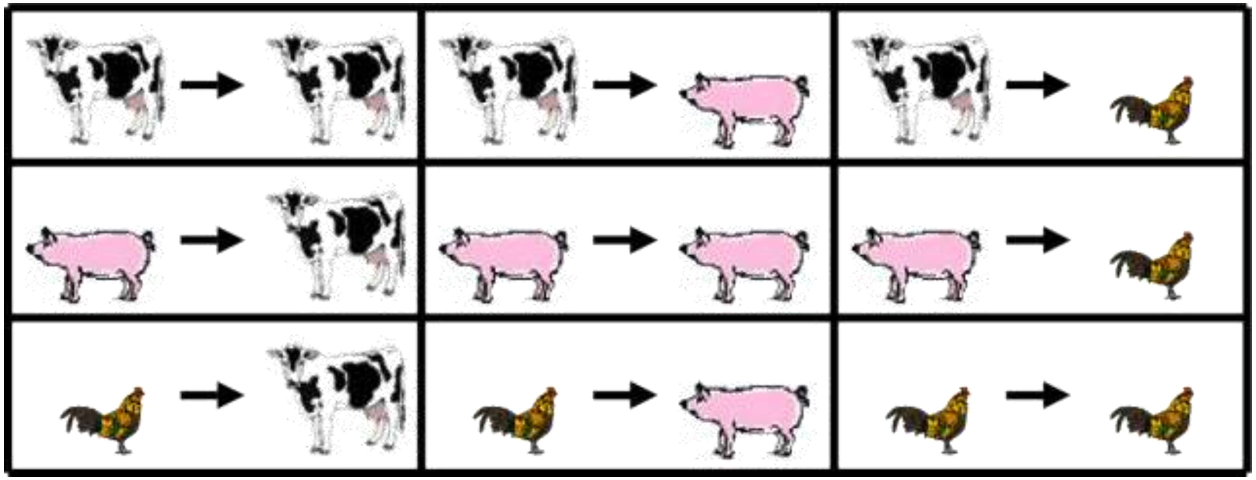
- How does NAADSM spread disease?
- What are the input parameters?
- Examples
- Concerns

How does NAADSM spread disease?

- Spread can occur via
  - Direct contact - movement of animals
  - Indirect contact - movement of people, equipment, vehicles, etc.
  - Airborne
- User-defined production-type-specific pairings of spread between units

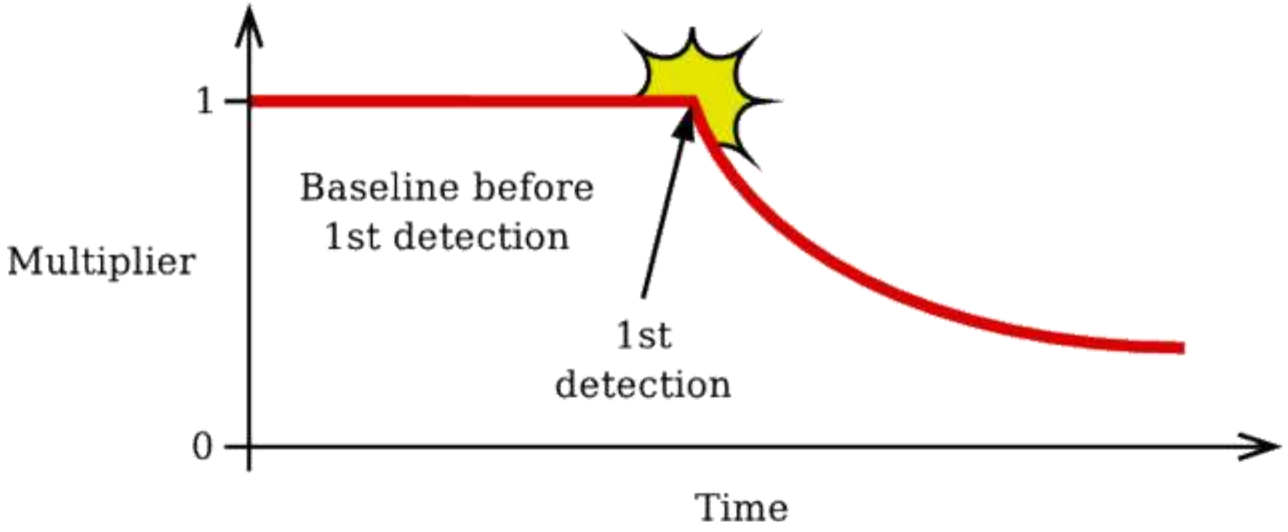
Direct contact spread

- Main parameter is *movement rate*: mean number of outgoing shipments per day from a unit
- Movement rate is specified independently for each pairing of production types



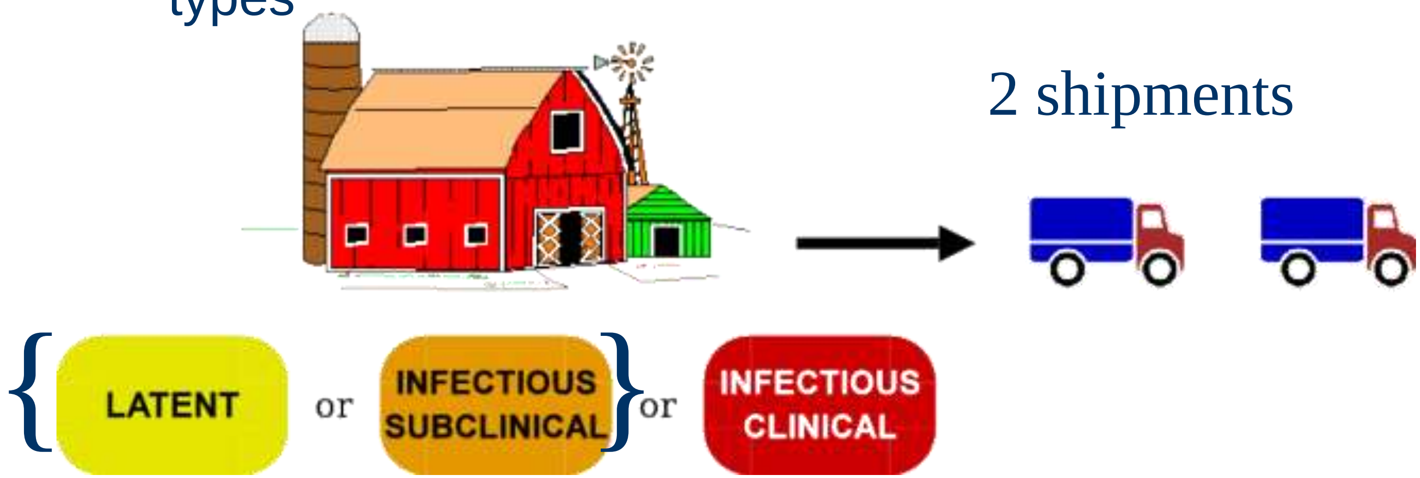
Direct contact spread

- Movement rate can be adjusted over time
  - Approximates applying movement controls



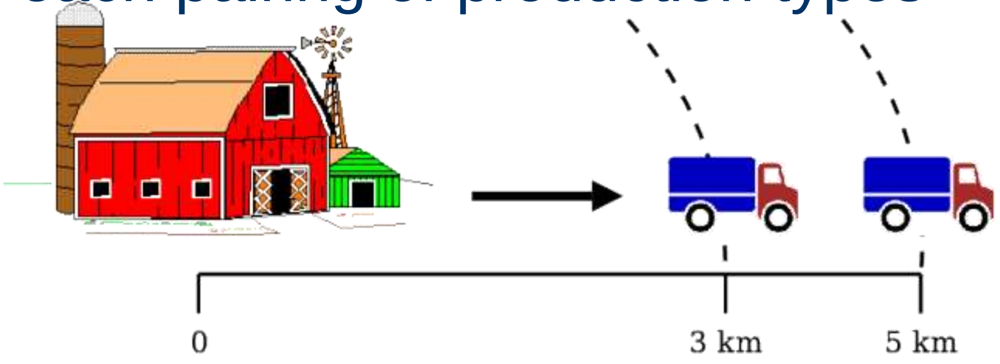
Direct contact spread

- For each unit that can infect others, simulate a number of outgoing shipments
  - Choose from a poisson distribution whose mean is the movement rate parameter for the pairing of production-types



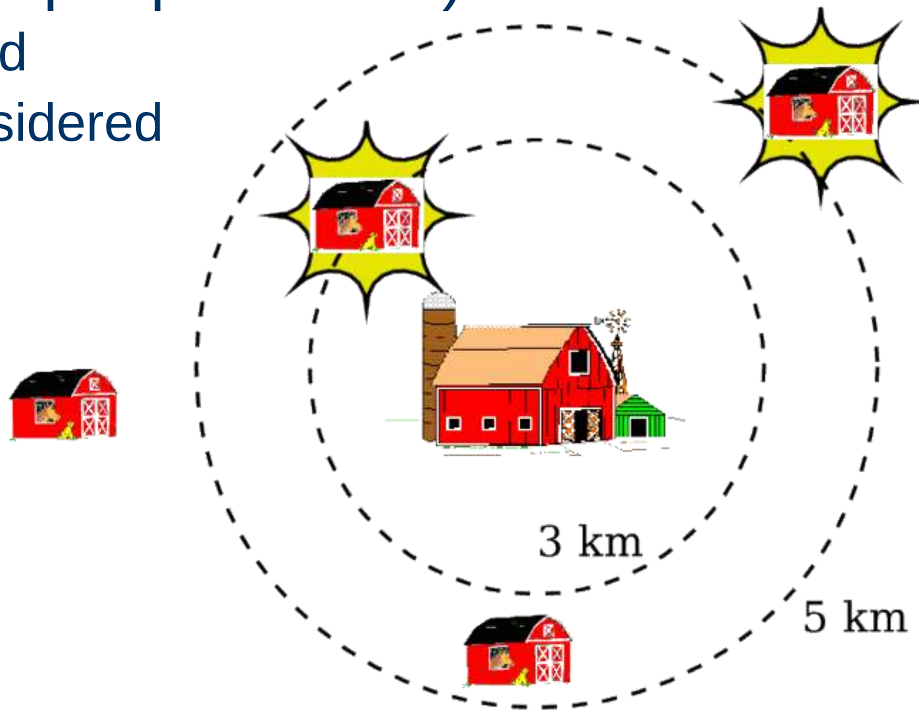
Direct contact spread

- From a probability function of movement distances, choose a distance for each shipment
  - Again, this parameter is specified independently for each pairing of production types



Direct contact spread

- Choose as potential destinations the units where distance from the source best matches the chosen distance (selected from input parameter)
  - Direction is not considered
  - Production types are considered



Direct contact spread

- If two destinations are the same distance from the source, choose one randomly

Direct contact spread

- If two destinations are the same distance from the source, choose one randomly
  - Weighted by size: a unit twice as large is twice as likely to be chosen

- If NO suitable destinations exist at the appropriate distance, NAADSM will search outside of input distribution to find a destination
- If ANY suitable destinations exist in the database, the movement will occur
- This is especially important in small populations, near the edges of the population, when movements are not restricted

- Direct movements from infected units are tracked by NAADSM
- Available if trace option is implemented

Probability of infection transfer

- Once movement destination is identified, used to determine whether infection will be transferred to that unit
- Recipient unit must be susceptible to get infected

Shipping delay

- Can add in a shipping delay, to simulate movements that take a while to arrive
- Be careful! Long shipping delays can result in odd results - may miss shipments if tracing occurs before shipment arrives
- We are using this less and less…

If within-unit spread option is used

- Don’t enter “Probability of infection transfer”
- System determines probability of infection transfer based on proportion of animals in unit that are infected
- Assumes single animal moves

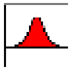
Indirect contact spread

- Works like direct contact, except:
  - Latent units cannot be a source of infection
  - Within-unit prevalence does not affect indirect contact
- Parameters for indirect contact are independent of those for direct contact
- Indirect contacts can also be tracked retrospectively for trace investigations

Contact-spread - summary

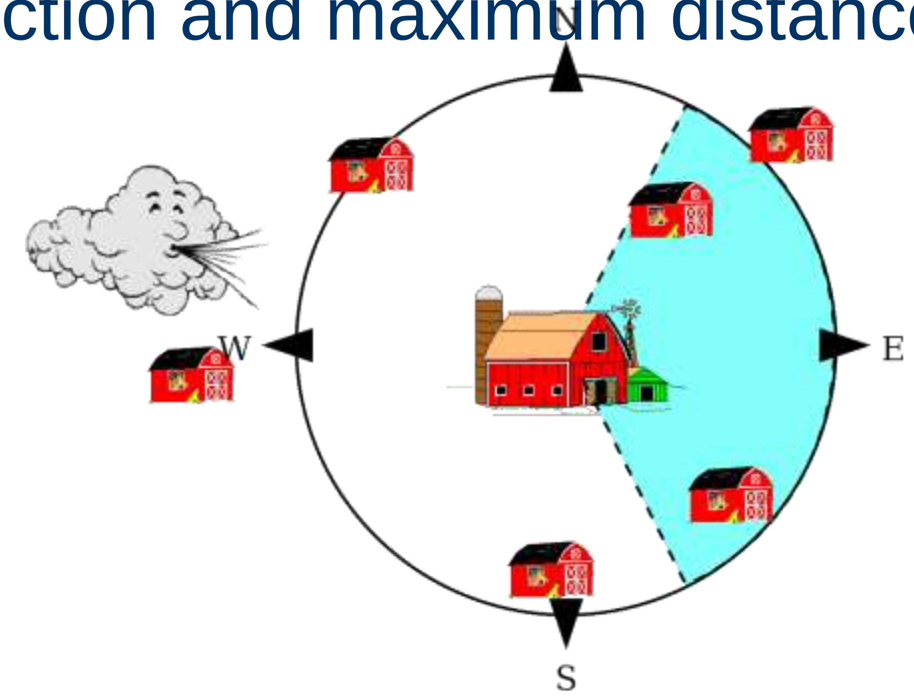
- Direct versus Indirect
- Contact versus transfer of infection
- Modeling only movements that may spread infection (shipments from infected units)
- Parameters for each pairing of one production-type to another

Airborne spread - parameters

- Parameters:
  - Rate of spread declines linearly or exponentially
  - Probability of infection at 1 km from source
  - Wind direction (0-360 degrees)
  - Maximum distance of spread (km – only for linear drop off)
  - Airborne transport delay (days) 
- As with direct and indirect contact spread, the parameters are specified independently for each pairing of production types

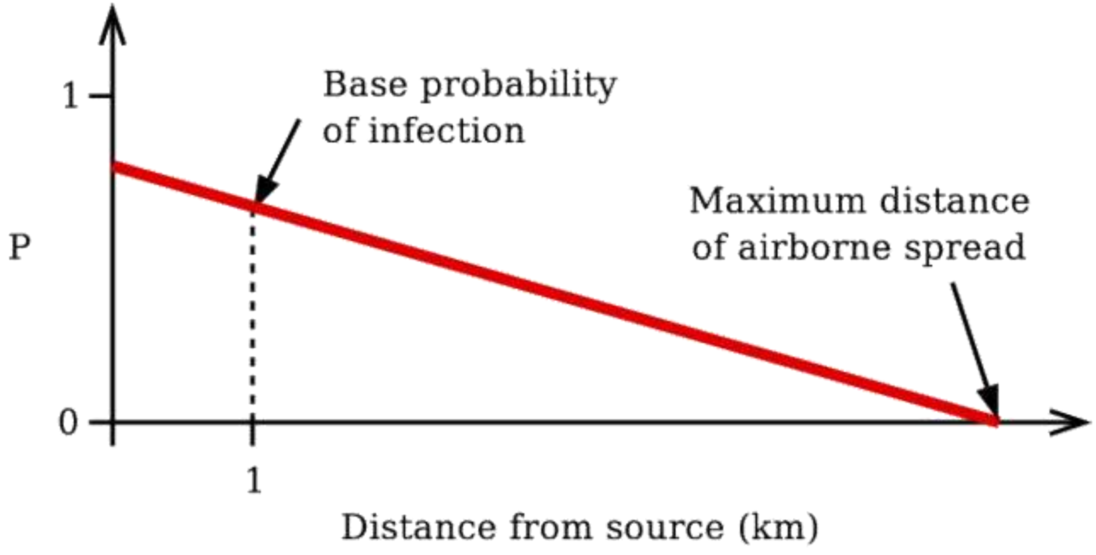
Airborne spread

- Consider all possible target units given wind direction and maximum distance of spread



Airborne spread

- The *DistanceFactor* term gives a probability that falls off linearly or exponentially with increasing distance from the source



Airborne spread

- Unit size is part of selection process
- Density affects actual number infected each day
- Formula when exponential drop off and within unit spread are selected:
  - *P* = (prevalence in *A*) × *HerdSizeFactor*(*A*) × (probability of infection at 1 km) × distance from *A* to *B* × *HerdSizeFactor*(*B*)
- If a within-unit prevalence chart has not been specified for the source unit production type, that term is dropped from the calculation.

Examples

- A shipment beef to dairy, 30 km is the movement distance selected from the input distribution
- Potential recipients:
  - Unit 1, swine, susceptible, not quar, 25 km away
  - Unit 2, dairy, susceptible, not quar, 40 km away
  - Unit 3, dairy, susceptible, not quar, 300 km away
- Which is selected?

- Small change:
  - Unit 1, swine, susceptible, not quar, 25 km away
  - Unit 2, dairy, Inf Clinical, not quar, 40 km away
  - Unit 3, dairy, susceptible, not quar, 300 km away
- Which is selected?

- Time passes:
  - Unit 1, swine, susceptible, not quar, 25 km away
  - Unit 2, dairy, Destroyed, 40 km away
  - Unit 3, dairy, susceptible, not quar, 300 km away
- Now which is selected?

- Things get worse:
  - Unit 1, swine, susceptible, not quar, 25 km away
  - Unit 2, dairy, Destroyed, 40 km away
  - Unit 3, dairy, susceptible, quarantined, 300 km away
- Now which is selected?

Concerns

- If an appropriate destination has been quarantined
  - It cannot accept an incoming direct movement
  - So that movement will go somewhere else
- Needs to be remembered when control strategies are implemented!

Questions?