Using Models to Communicate the Value of Prevention, Detection and Preparedness Before a Disease Outbreak

OIE / USDA Workshop on Epidemiological Modeling
Aug 11-13, 2008
Fort Collins, CO, USA

Bruce McNab DVM PhD
Animal Health & Welfare Branch
Ontario Ministry of Agriculture Food & Rural Affairs
Guelph, Ontario, Canada
bruce.mcnab@ontario.ca

Session Outline

- The importance of communication
- Example schematics to communicate disease concepts
- Example summary of factors influencing spread & control
- Example out-put from a complex model
- Example take-home message to stakeholders
- OIE take-home message today

The Importance of Communication

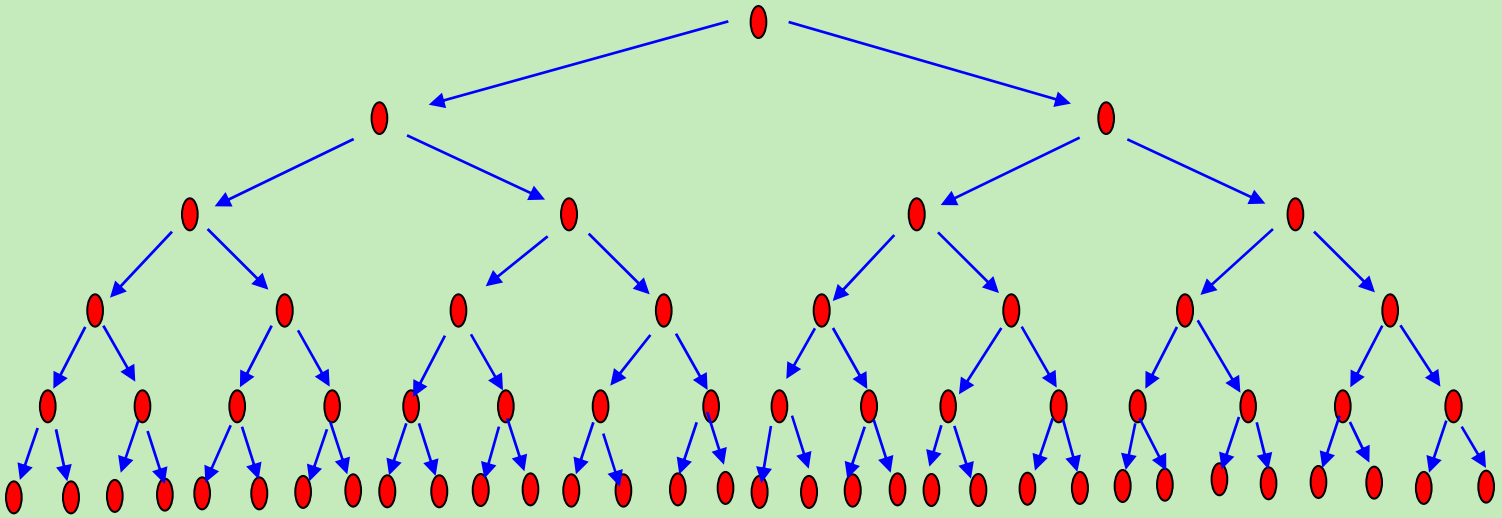
- Pathogens do not read papers or manuals
- Disease control guidelines must be routinely implemented to be of value
- We must encourage workers and officials to actually implement procedures
- Understanding the principles of disease spread may compel them to do so
- Various models have been developed to help understand and communicate core concepts of disease spread and control
- This presentation demonstrates some useful schematic diagrams, simple mathematical models, and out-put from a complex simulation

McNab & Dube, 2007, Simple models to assist in communicating key principles of animal disease control Veterinaria Italiana 43:317-326

Harvey *et al* 2007 The North American animal disease spread model: A simulation model to assist in decision making in evaluating animal disease incursions Prev. Vet. Med. 82:176-197

Example Schematics of Disease Spread Concepts

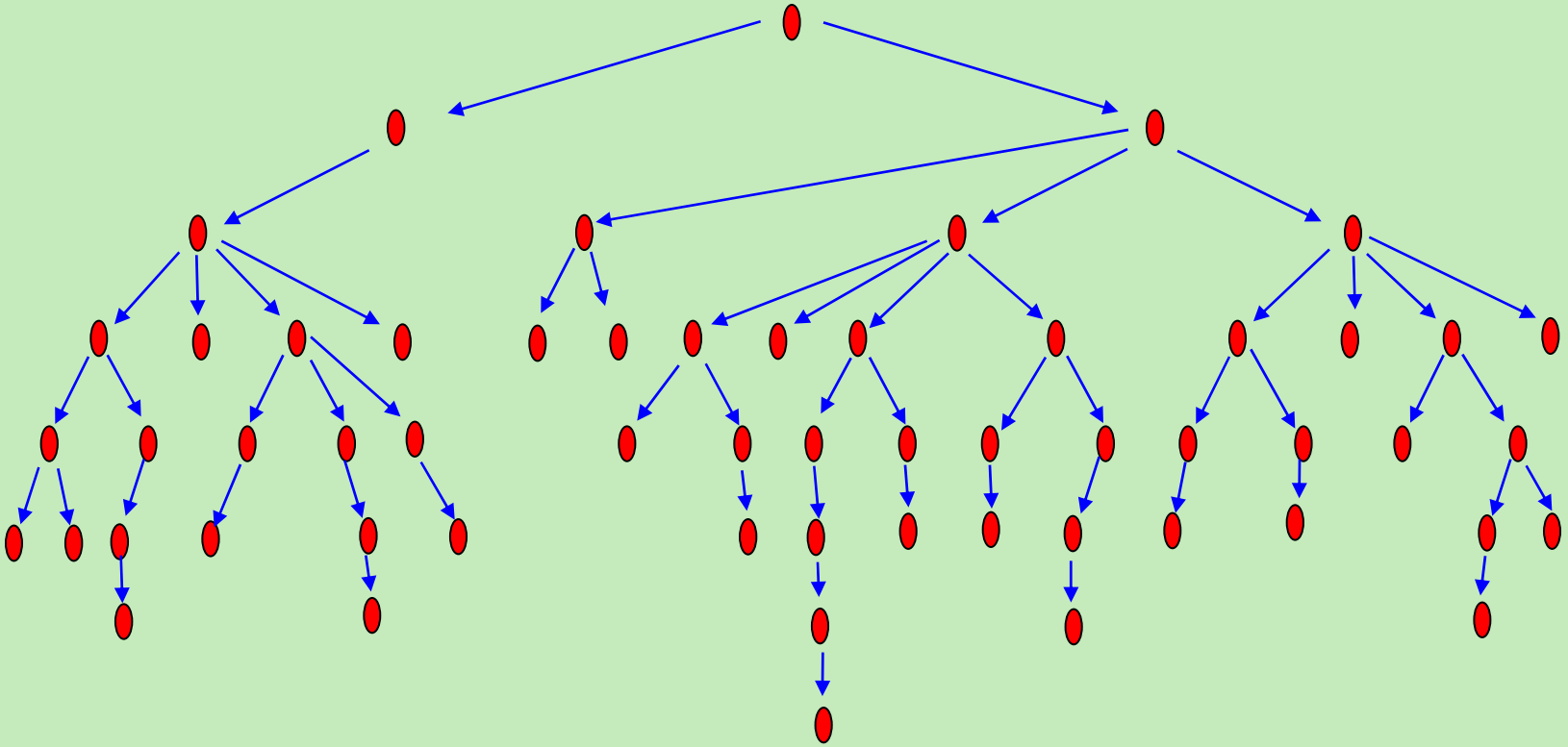
Consider spread of a cold
if you and each infected person
spreads it to two new people



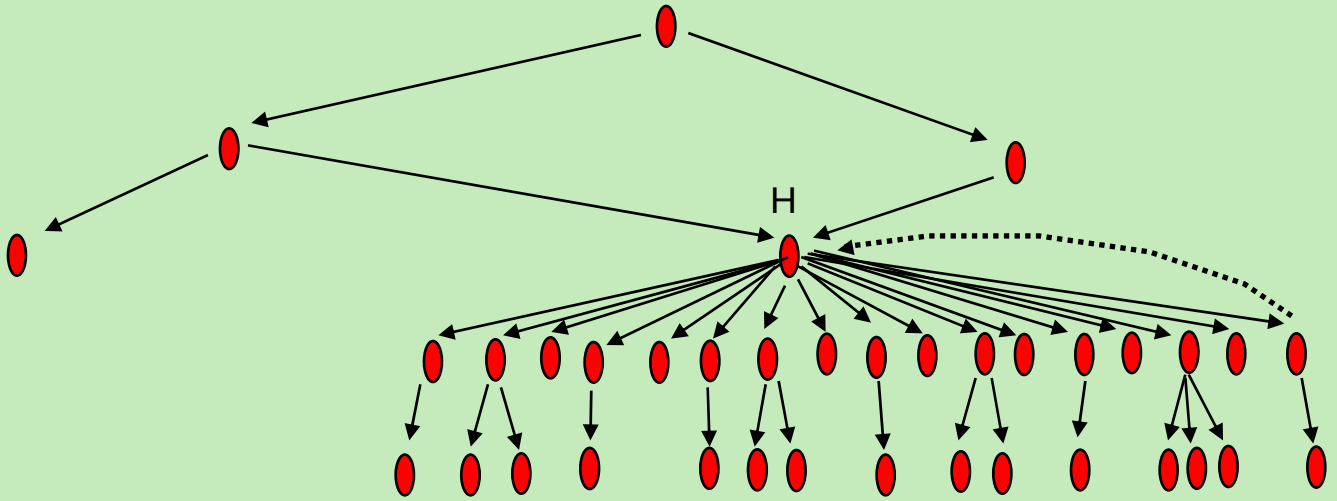
The “reproductive ratio” (R) = number of secondary cases generated per existing case
(in this example R= 2 new cases generated per existing case)

significance of R < 1 outbreak contracts
vs. R > 1 outbreak expands

Usually R Changes Between "Generations" and Cases



Hubs Can Have Great Influence



With H R = 1.6
Without H R = 0.9

(understanding “networks” is important)

Every Little Bit Helps

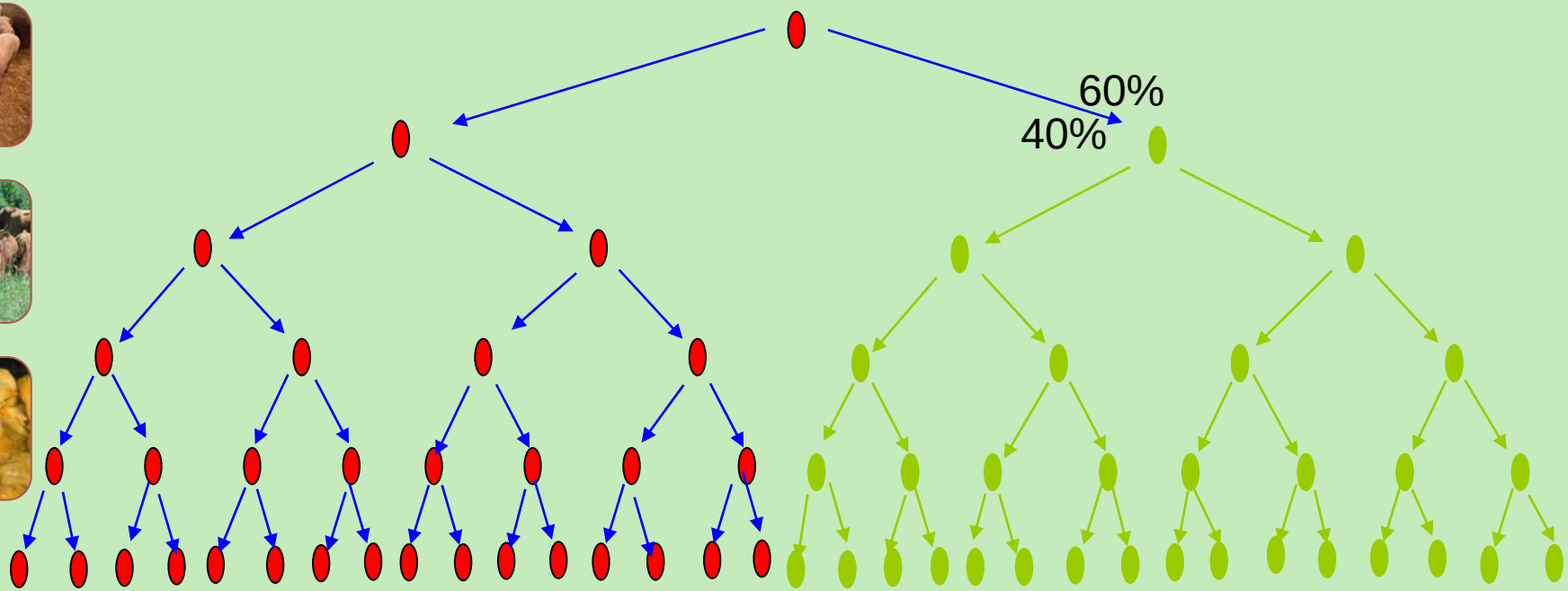
a) 100 → 100 → 100 → **100 %**

b) 90 → 90 → 90 → **73 %**

c) 20 → 20 → 20 → **0.8 %**

d) 40 → 5 → 10 → **0.2 %**

Every Little Bit Helps - Exponentially

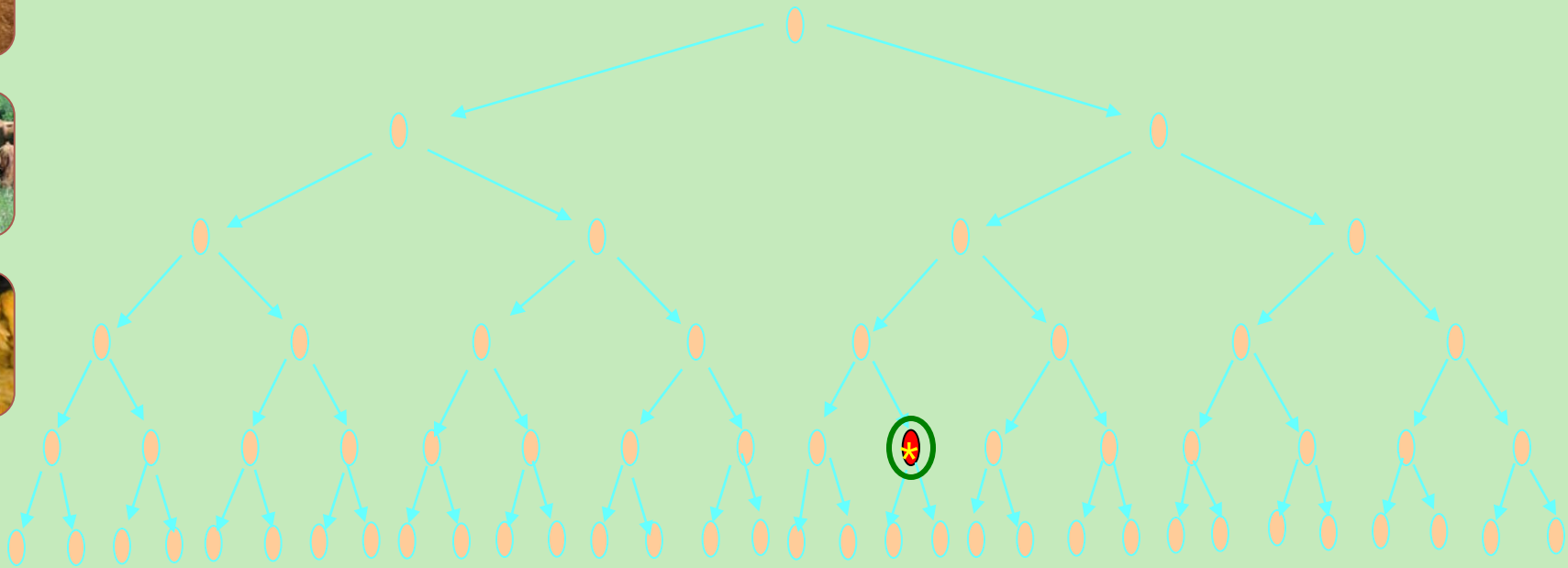


Spread AND Control are "exponential" in nature

- the impact of allowing or blocking spread, goes far beyond one farm
- often not aware of "saves"…. difficult to prove value, but it is real

Schematic Representation of Spread, Detection & Response

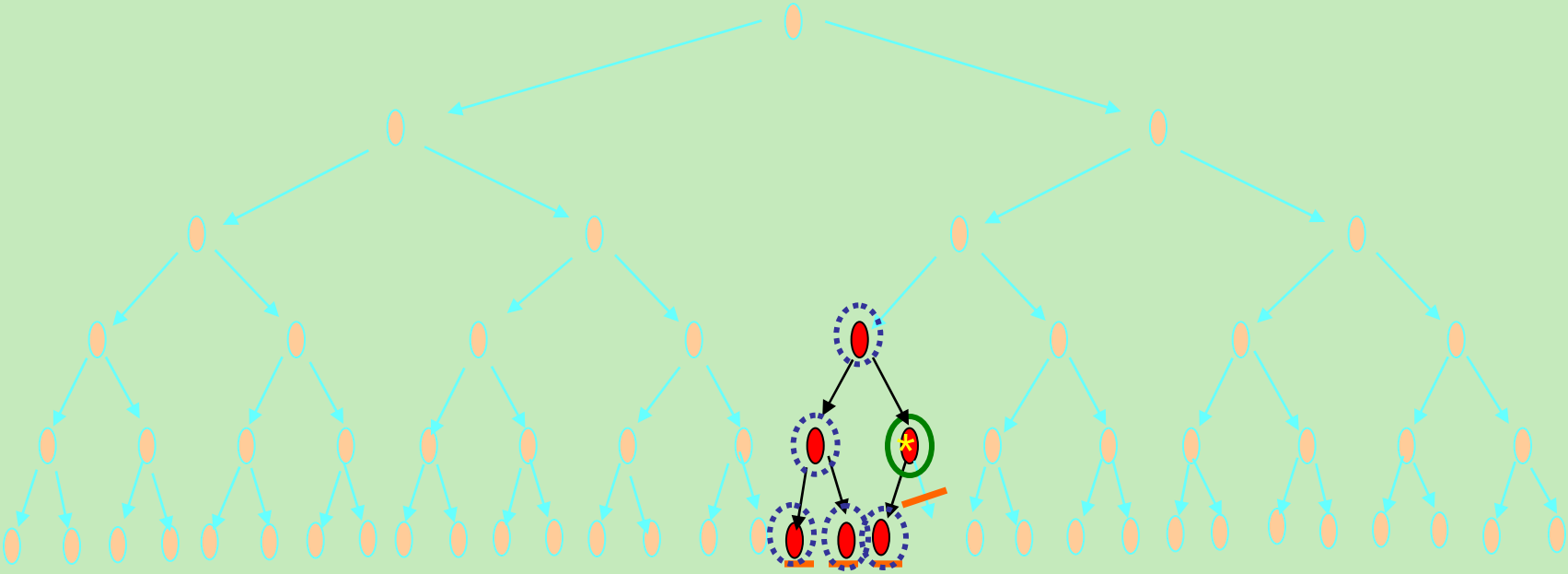
Consider:
- Detection of FAD but not aware of other cases



Schematic Representation of Spread, Detection & Response

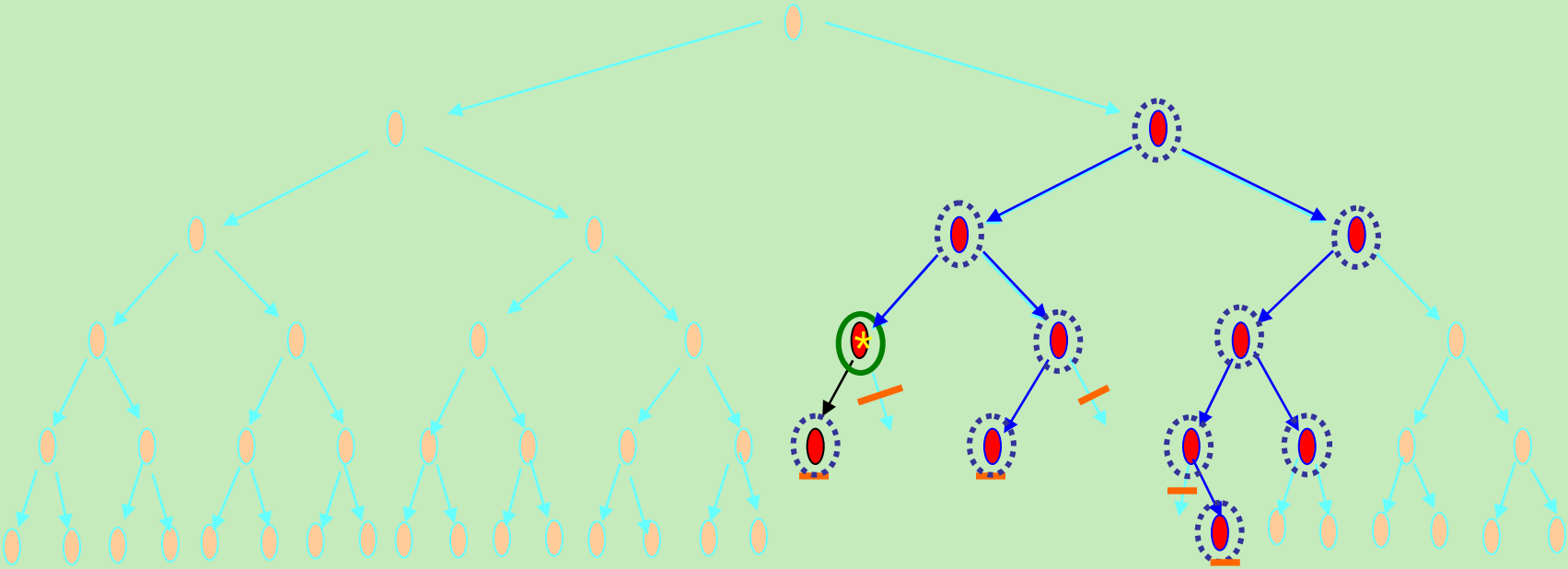
Consider:

- **Detection**
- **Controlling spread from detected**
- **Trace forward, trace back and forward again**



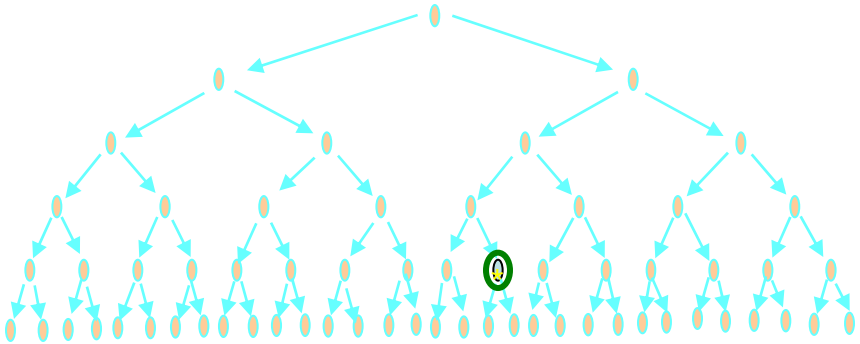
Earlier Detection & More Aggressive Response

Consider:
- **More rapid detection**
- **Better tracing**
- **Controlling spread from detected (when fast enough)**



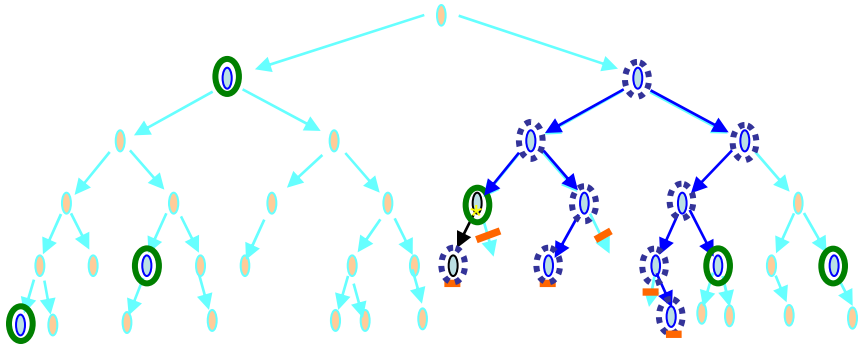
PREVENTION, Detection, response

1) @ 2 new/case, poor detctn & rspns



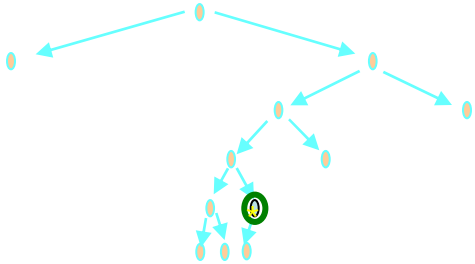
aware of 1, but 62 more (and spreading)

2) @ 2 new/case, reasonable detctn & rspns



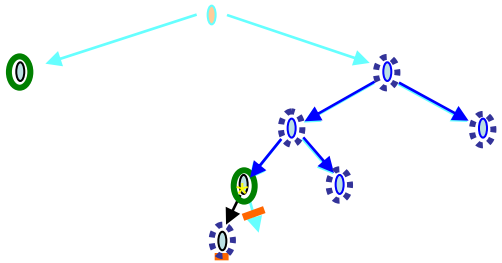
aware of 15, but 25 more (some spreading)

3) @ 1.2 new/case, poor detctn & rspns



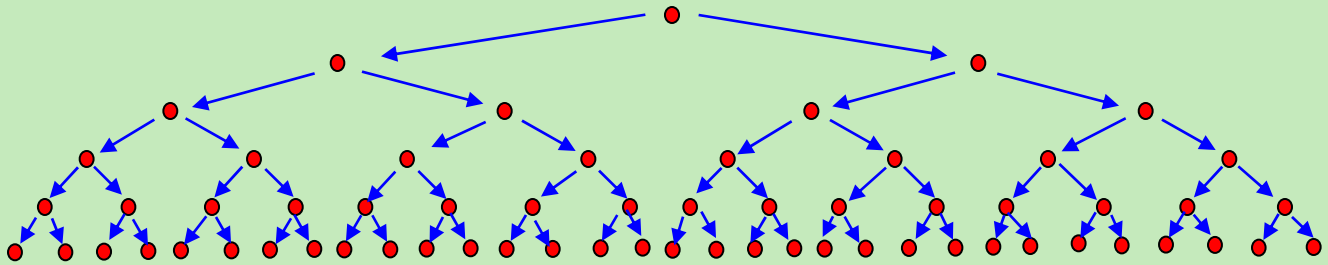
aware of 1, but 11 more (some spreading)

4) @ 1.2 new/case, reasonable detctn & rspns



aware of 7, but 1 more (little or no spreading)

PREVENTION, Detection, response



@ 2 new / case		
New	Total	
1	1	
2	3	
4	7	
8	15	
16	31	*
32	63	

incubation number	Total number of cases @ new cases per case 1.25	1.5	2
5	8	13	31 *
10	33	113	1023

earlier detection implement controls when fewer cases

increased biosecurity barriers
increased control
decreased # new cases / case

Disease Spread AND Control are Inherently Exponential

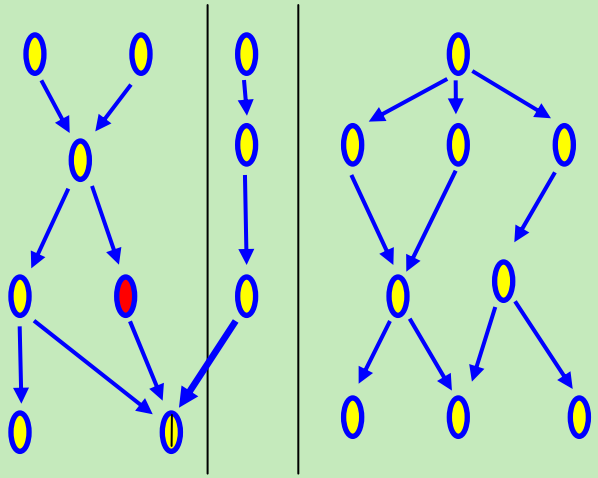
Collectively, we must address the biology

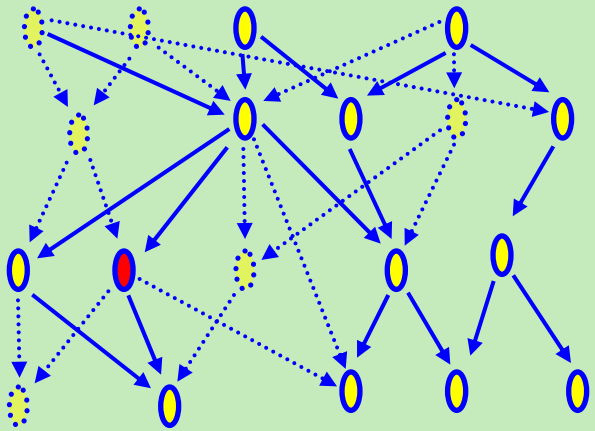
Schematic Representation of Movement, Networks, Flow & Traceability

Good Flow Design & Extensive Knowledge

vs.

Poor Flow Design & Limited Knowledge





1) **Network analyses of premises & movements helps anticipate & improve design.**

2) **Timely movement data within known networks, facilitates more precise response.**

A Simple Model to Highlight Factors Influencing Disease Spread & Control

Factors influencing to how many people **you** "give" **your** cold, or new farms **you** infect (ie new cases generated per existing case, or **your personal R**)

d = duration available as infectious e.g. 5 days

c = contact frequency e.g. 5 contacts per day

t = transmission probability per contact e.g. 20% of contacts

s = susceptibility probability per transmission e.g. 40% susceptible

R = d x c x t x s
R = 5 days/case x 5 cntct/day x .2 trns/cntct x .4 (susp) cases/trns
R = 2 cases/case
R = 2

If R > 1 the epidemic expands, if R < 1 it slows and burns out

Any combination of d, c, t, and s leading to R < 1 reduces spread

Example Factors Influencing Spread & Control

Duration available as infectious

- *stay home*
- early diagnosis (call veterinarian, lab diagnosis, surveillance)
- depopulation
- pre-emptive slaughter of contacts (while latent or sub-clinical)

Contact frequency

- *avoid meetings*
- avoid unnecessary livestock/equipment movements and contacts
- farm premises security
- livestock/equipment movement restrictions & quarantines

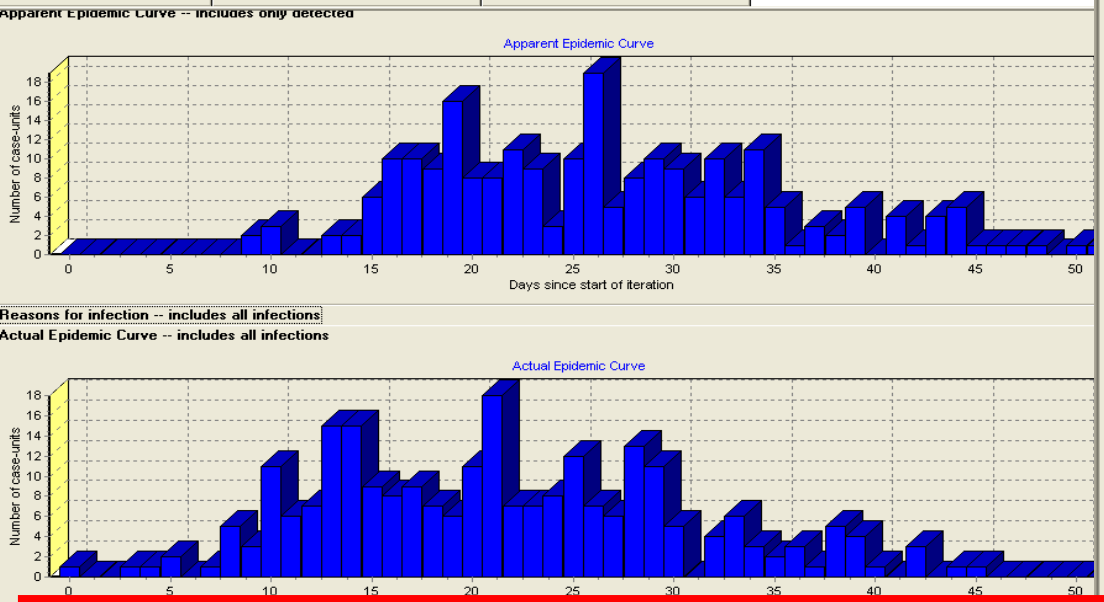
Example Factors Influencing Spread & Control

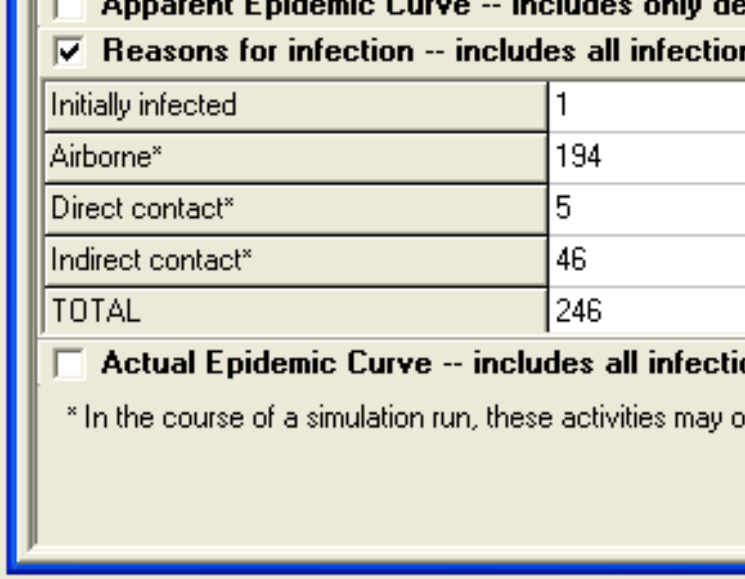
Transmission probability per contact

- *wash hands, don't shake hands / kiss at greeting*
- clean coveralls / boots
- clean and disinfect equipment
- shower-in / shower-out

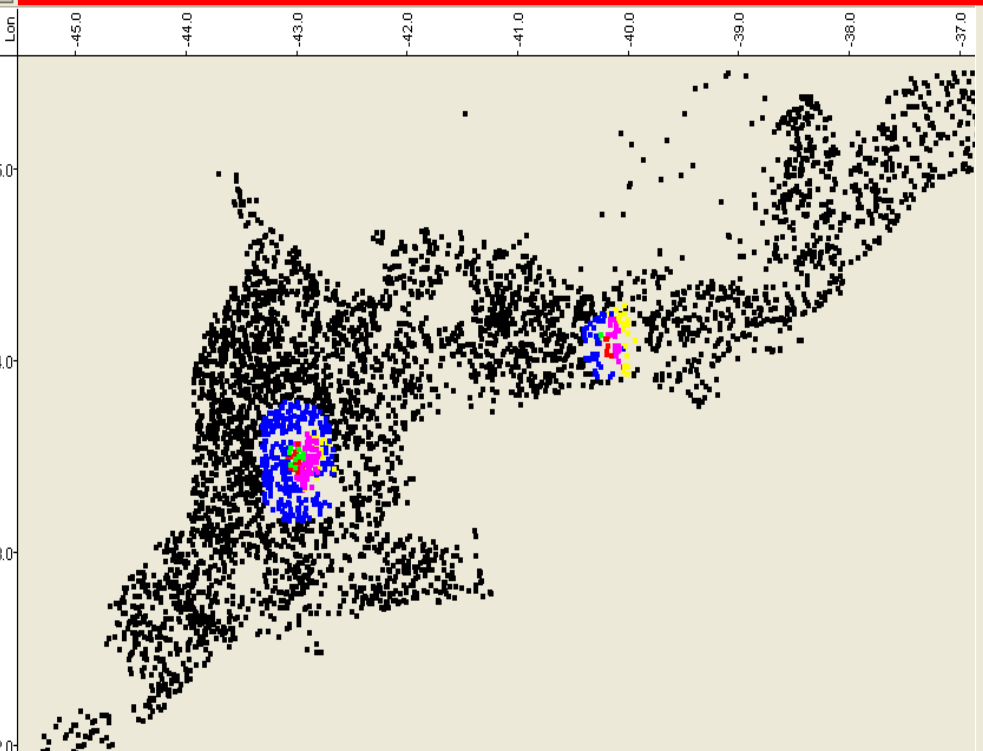
Susceptibility probability per transmission

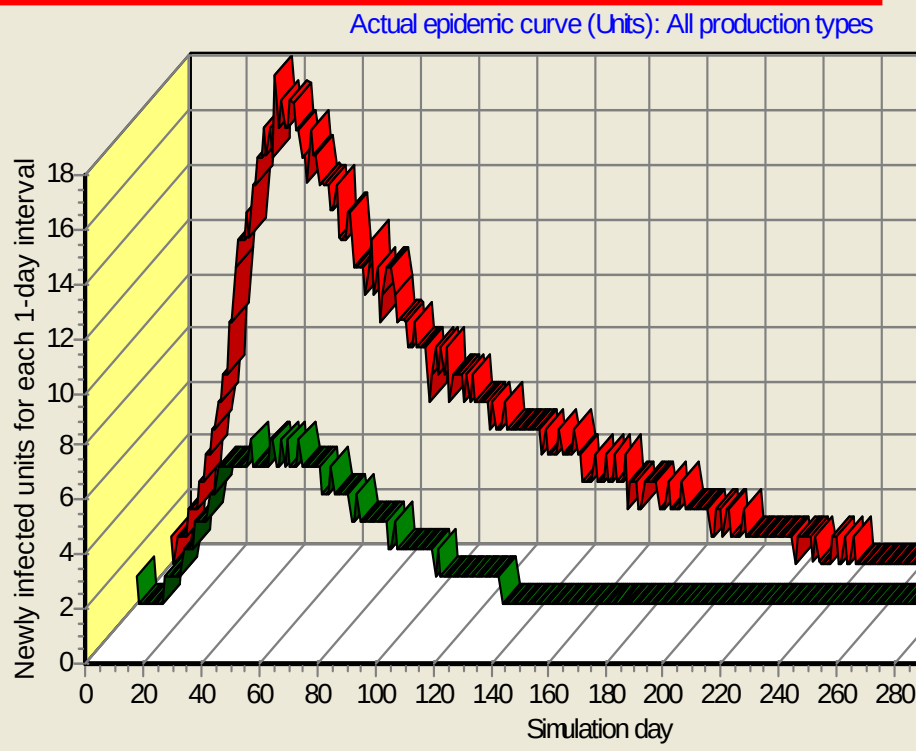
- susceptible ie not naturally immune
- susceptible ie not vaccine immune



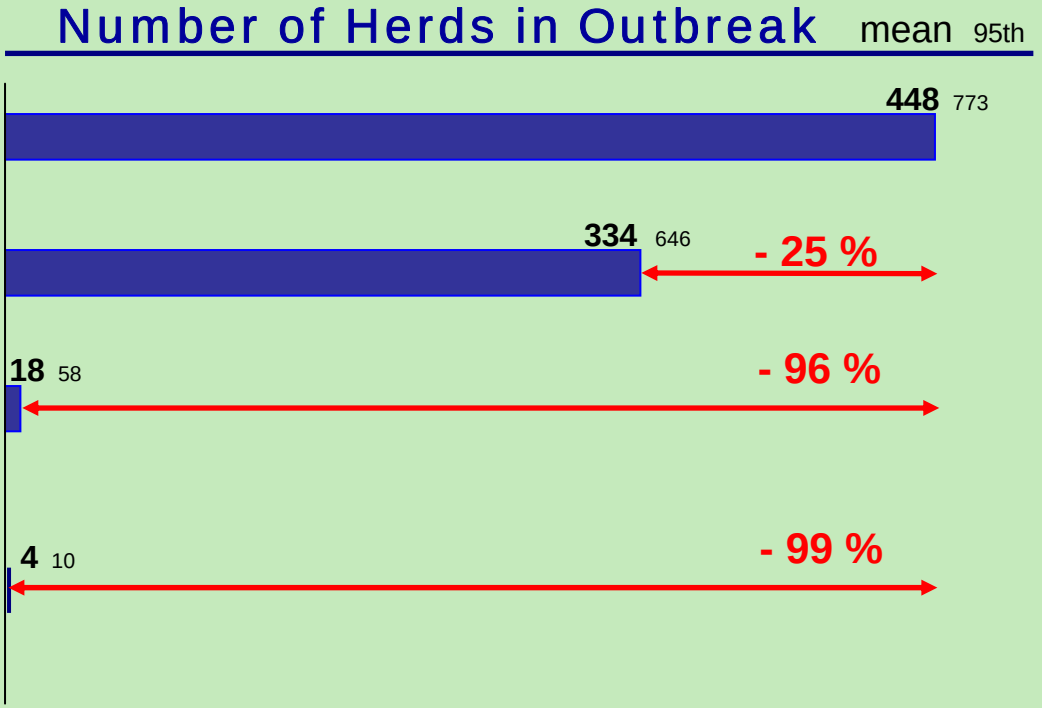


Brief "taste" of NAADSM outputs illustrating disease spread & control





NAADSM - Comparison of Strategies 1000 Iterations Each



Caution - do not interpret the above numbers too literally but recognize the utility of the modelling approach and communication of the direction and potential scale of impact

Example Take Home Messages

1. **Bugs / toxins do not read or act with intent; their spread is mostly passive; mostly, they move where you buy, carry or let them ride in.**

2. **Spread and control are "exponential"; so every little bit helps and little things matter.**

3. **Decision makers (farm level to national level) need to know what and how much is at risk; "who" is contaminated with what, where and when, AND how things flow; so can prioritize, anticipate, trace and respond appropriately.**

4. **Peacetime holistic bio-security and system-design that facilitate prevention of spread, early detection, rapid aggressive investigation / tracing / response; pays exponential biological dividends (often unknown).**

5. **Industry workers, physically addressing the biology is what matters; your (their) routine daily actions influence your animal disease future far more than you may have thought.**

This is (should be) empowering to YOU

OIE Take-Home Message

1. **Disease models may be used to improve the understanding and communication of spread and control concepts.**

2. **Therefore, models may be used to compel front-line-workers and senior-policy-makers to behave routinely in a manner that truly addresses the biology of disease spread and control.**

This is (should be) empowering !!