



# Principles of Disease Spread and Control

Workshop on Disease Control  
Month, 2008  
Location

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# Session Outline

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- **The importance of animal health ( ie. why control disease )**
- **How disease spreads and how we can control it**
- **Making sure we are contributing to control**
- **Take-home messages**



# Animal Health Is Important for Many Reasons

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- **efficiency and profits**
- **broader economy**
- **public health**
- **animal welfare**
- **the environment**

# Things That Influence Profits

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- **cost of inputs**

land, fuel, fertilizer, feed, equipment, labor etc.

- **weather**

- **price received for products**

- **exchange rate**

- **efficiency and marketability**

good management and quality  
animal health

**Unfortunately, have little influence over first 4 points**

**But can influence 5<sup>th</sup> point through animal health,**

Including: endemic, foreign, emerging and future diseases



# But The “Bugs” Don’t Care

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## **Disease causing bacteria, viruses, toxins do not care about:**

profits, economy, public health.....

scientific publications

laws, regulations

guidelines, manuals



**Bugs will go wherever you let them go**

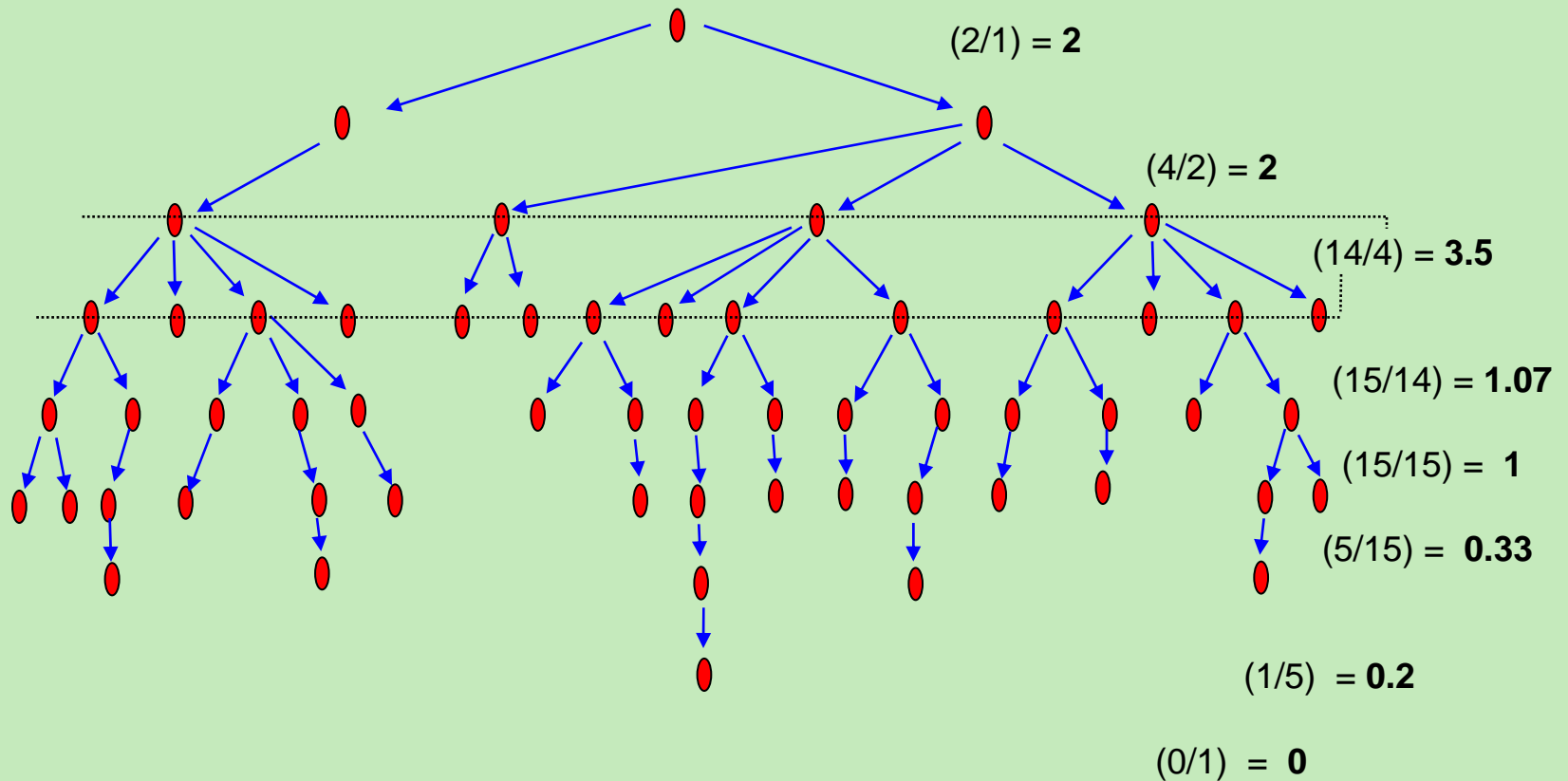
**OR**

**Bugs will stop at barriers you implement (they don’t care)**

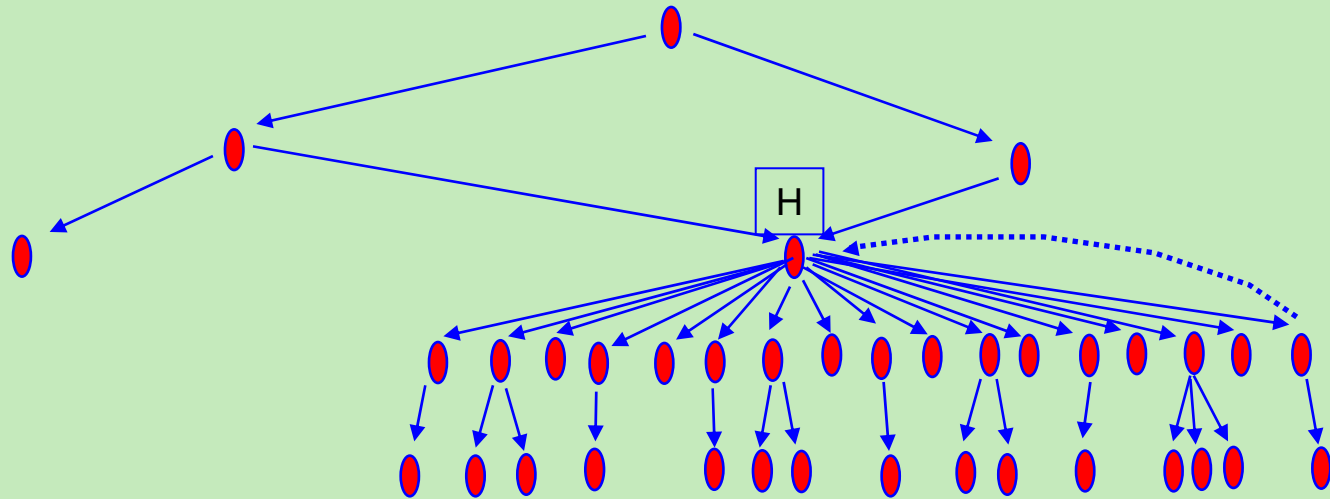
**Impacts are exponential !!!**



# Usually R Changes Between "Generations" and Cases



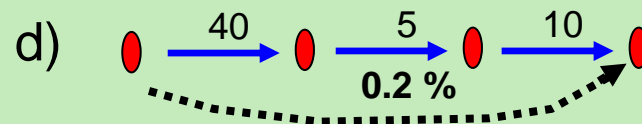
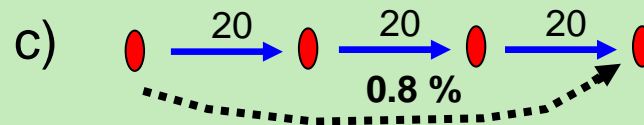
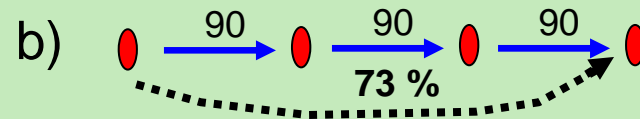
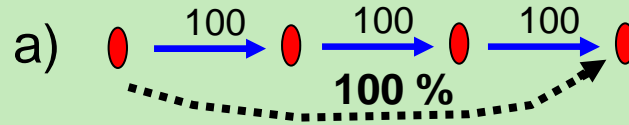
# Hubs Can Have Great Influence



With H  $R = 1.6$   
Without H  $R = 0.9$

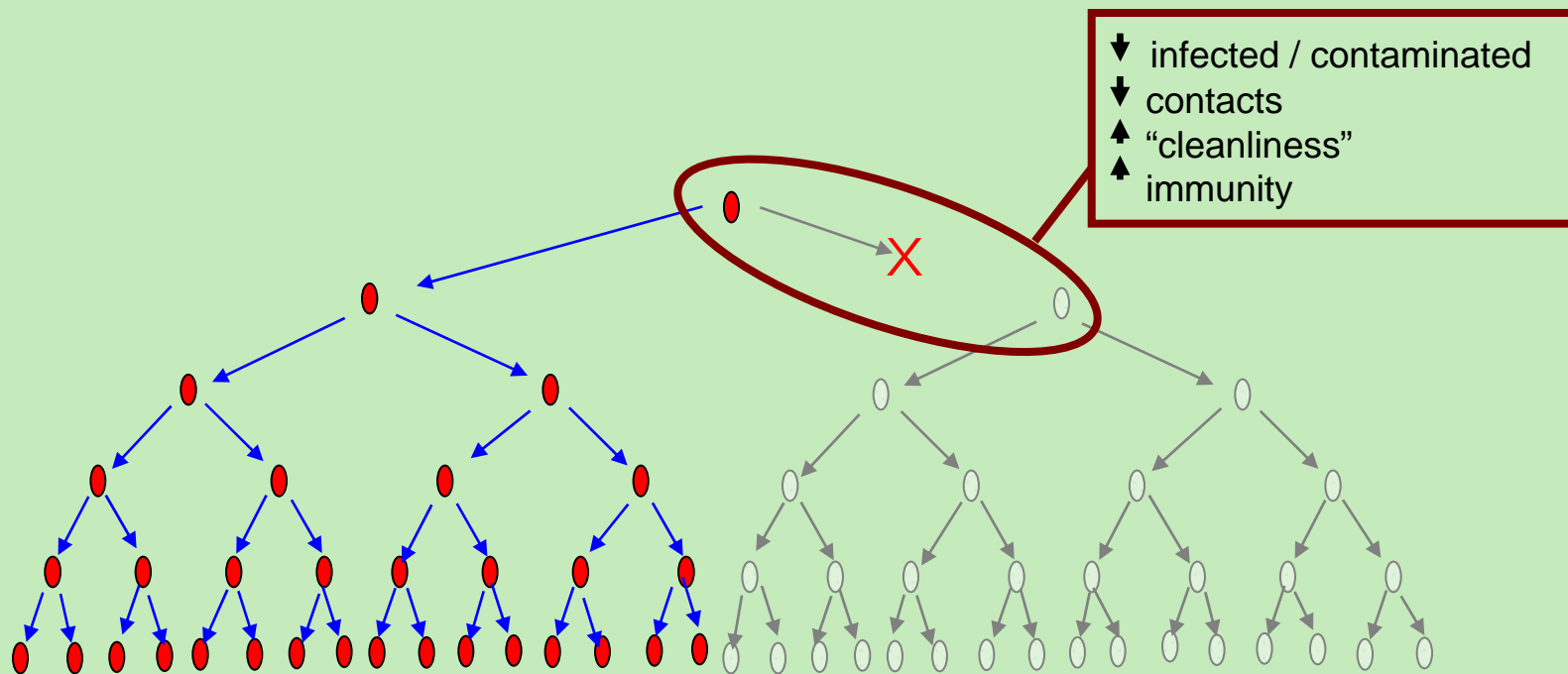
(understanding “networks” is important)

# Every Little Bit Helps



True of:  
animal to animal  
farm to farm  
barrier to barrier

# Disease spread is inherently exponential, so little things matter



- When an individual prevents spread (washing hands, staying home when sick, biosecurity between farms etc.) they protect not only their immediate co-workers/farms etc., but also prevent subsequent spread from those people farms and so on.
- Individuals must take responsibility for their personal (farm) disease reproductive ratio “R” i.e. the number of new cases they cause from themselves/farms as an existing case
- In the above example, for simple illustration, R is mostly 2 new cases produced per existing case, except the first case that had an R of 1
- “R” is not just important mathematically in disease modeling, it is important personally

# Factors Influencing Disease Spread



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

$$R = d \times c \times t \times s$$

$$R = 5 \text{ days/case} \times 5 \text{ cntct/day} \times .2 \text{ trns/cntct} \times .4 \text{ (sus) cases/trns}$$

$$R = 2 \text{ cases/case}$$

$$R = 2$$

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

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## Duration available as infectious

- *stay home*
- early diagnosis (call veterinarian, lab diagnosis, surveillance)
- remove infected/contaminated (e.g. shedders), or even depopulate
- 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

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## **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



# Summary of Factors Influencing R (new cases / existing case)

McNab & Dube, 2007 Vet Italiana 43:317-326



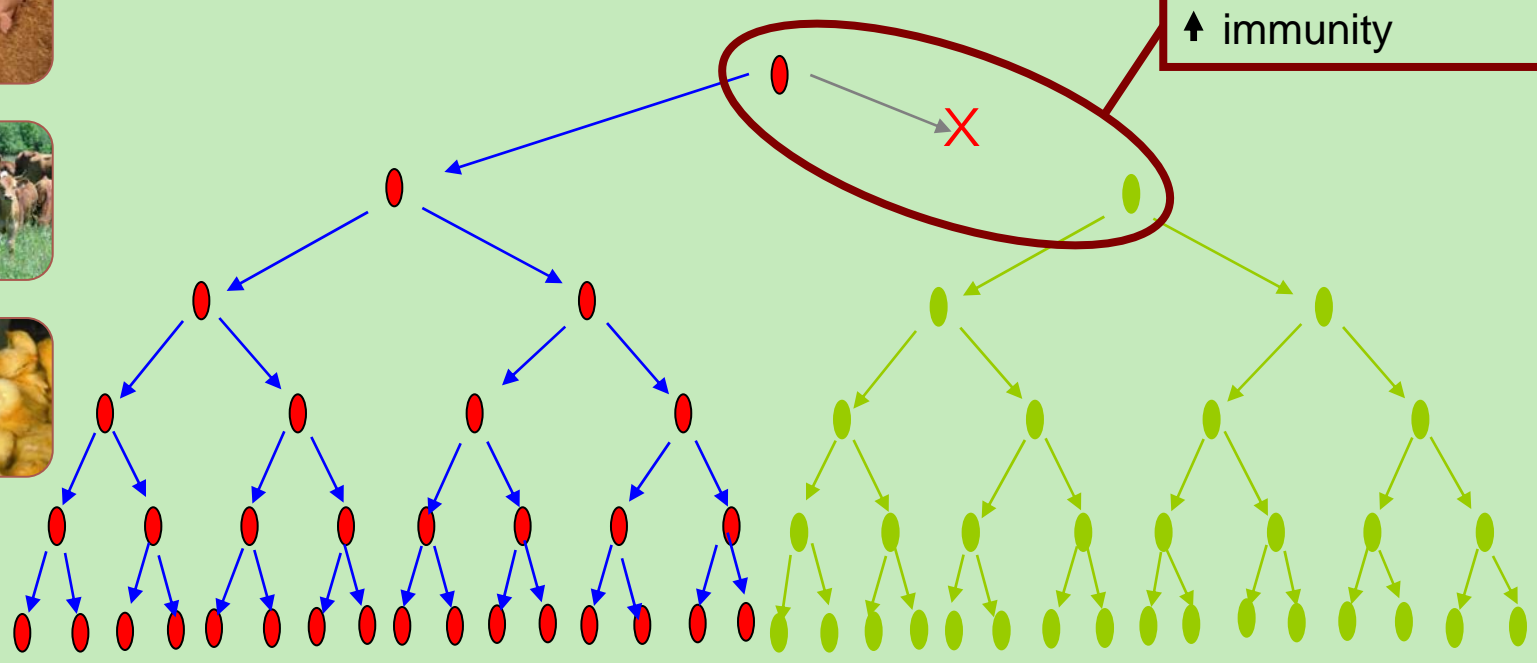
R new per existing e.g. 2 nwcs/cs =	=	duration available as "infectious" 5 da/cs	X	contact frequency 5 cnt/da	X	transmission probability 0.2 trns/cnt	X	susceptible proportion 0.4 susp/trns
get as low as possible	By	removing "infectious"		decreasing "contact"		increasing "cleanliness"		increasing "resistance"
OK	But	remove who what		allow who, what where		with what where, who how		select who, vaccinate with what
Increase precision		distinguishing true status <b>surveillance</b>		system flow ID tracing security		ongoing hard work		knowledge genetics vaccine

Ask not what "authorities" can do for you, do now what only you can do for society

# Every Little Bit Helps - Exponentially



- ↓ infected / contaminated
- ↓ contacts
- ↑ “cleanliness”
- ↑ immunity

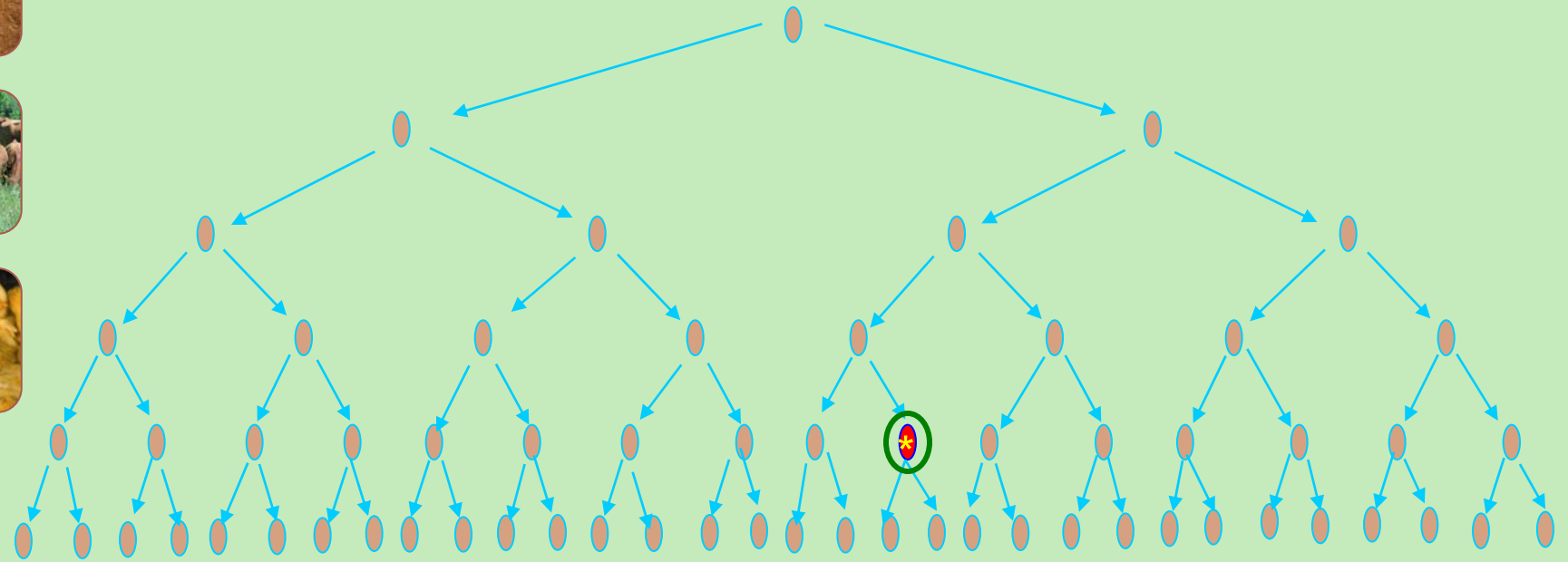


**Note: generic nature of at least 2 key factors**  
**Apply now to help control a wide range of diseases, even ones not yet here !!**

# Spread, Detection & Response

**Consider:**

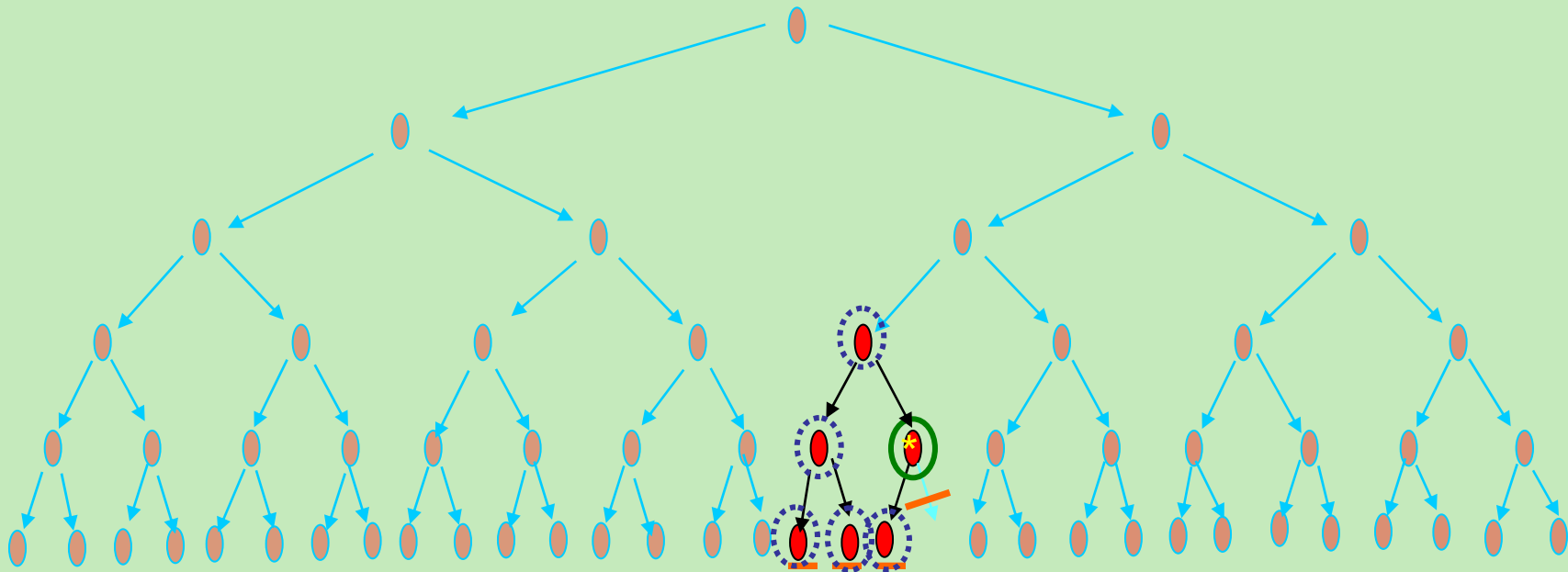
**- Detection but not aware of other cases**



# Spread, Detection & Response cont.

**Consider:**

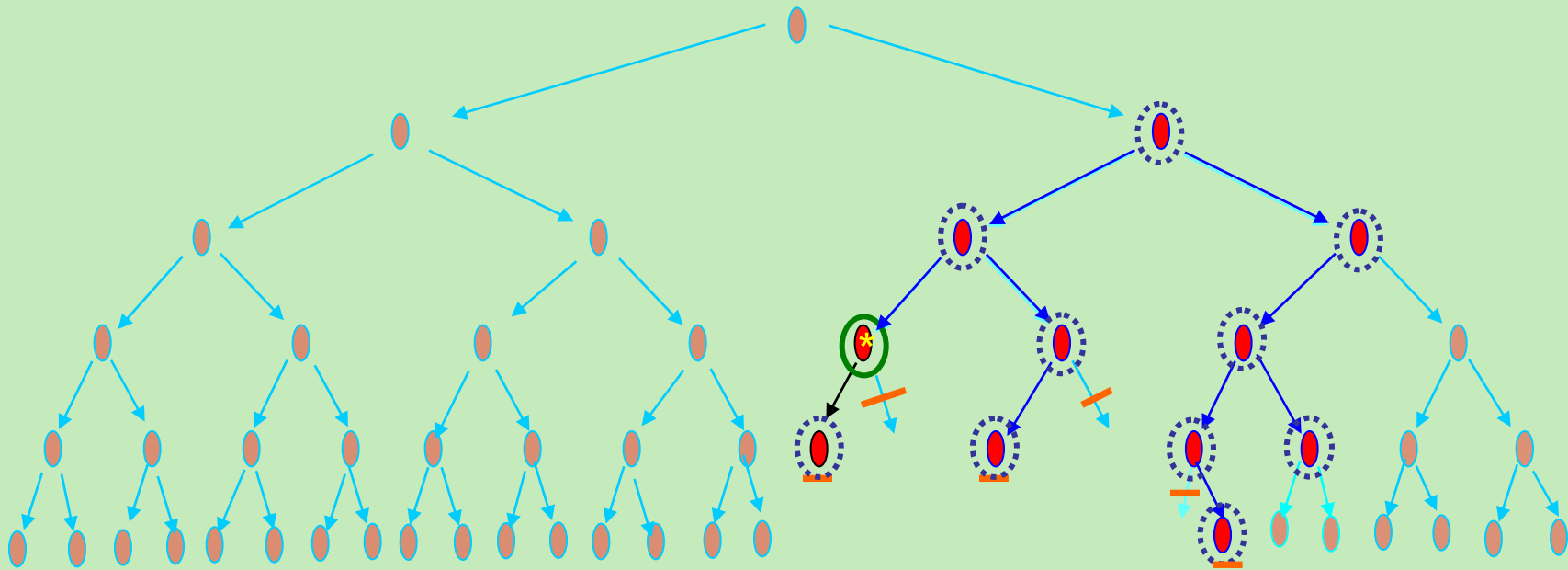
- **Detection**
- **Controlling spread from detected**
- **Trace forward, trace back and forward again**



# Earlier Detection & More Aggressive Response

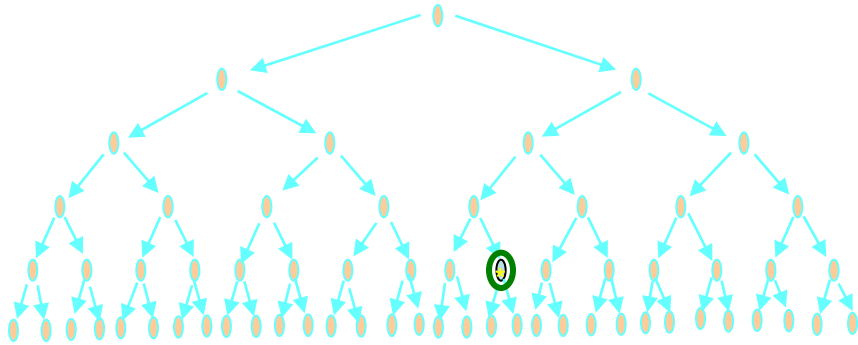
Consider:

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



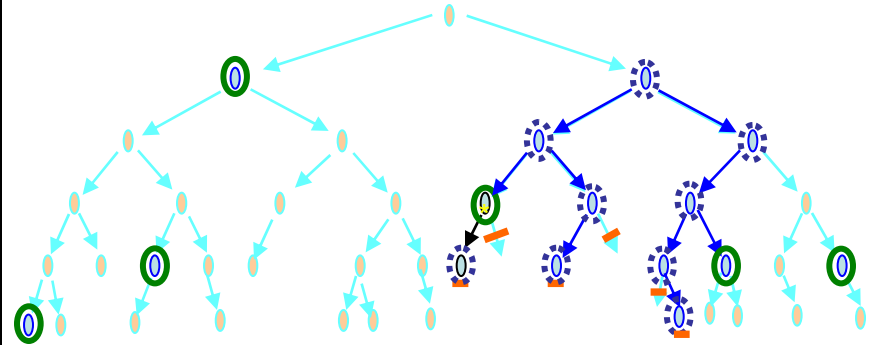
# PREVENTION, Detection, response

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



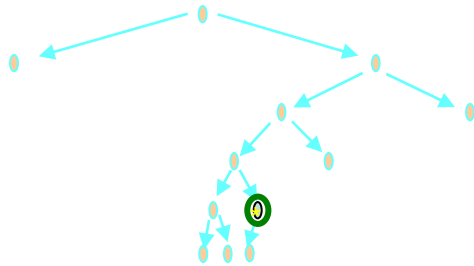
aware of 1, but 62 more (and spreading)

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



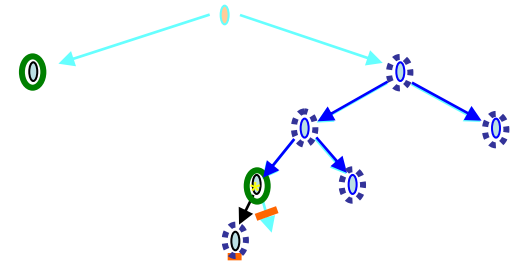
aware of 15, but 25 more (some spreading)

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

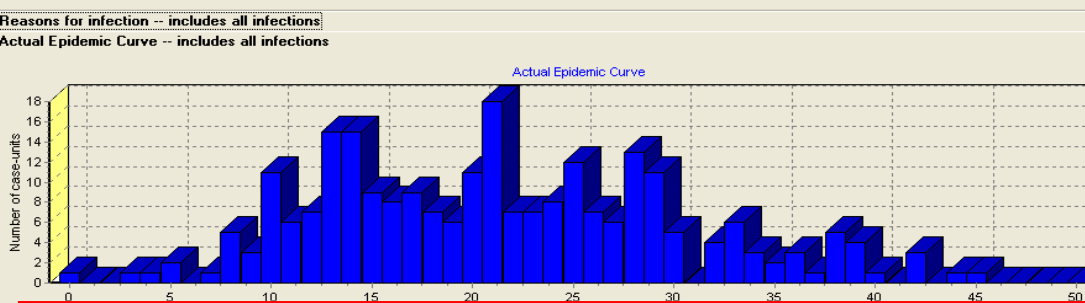
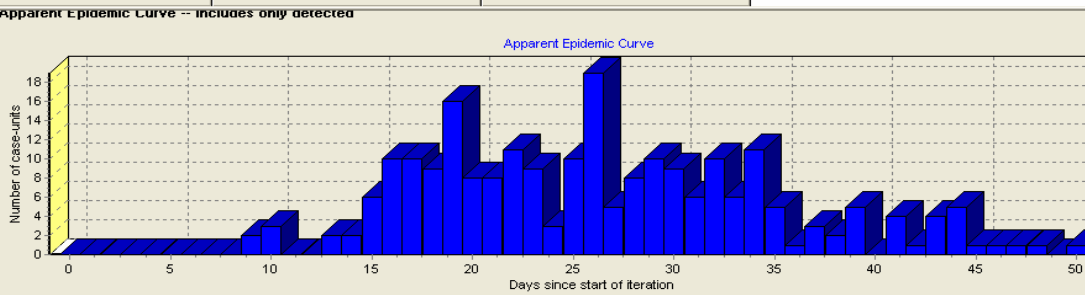


aware of 1, but 11 more (some spreading)

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



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



Apparent Epidemic Curve -- includes only detected

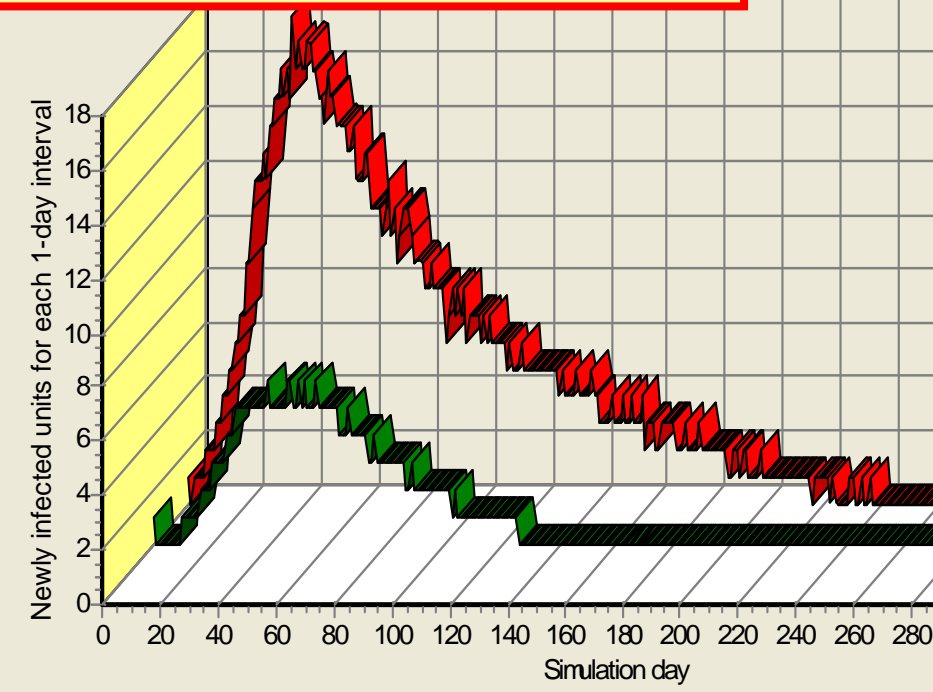
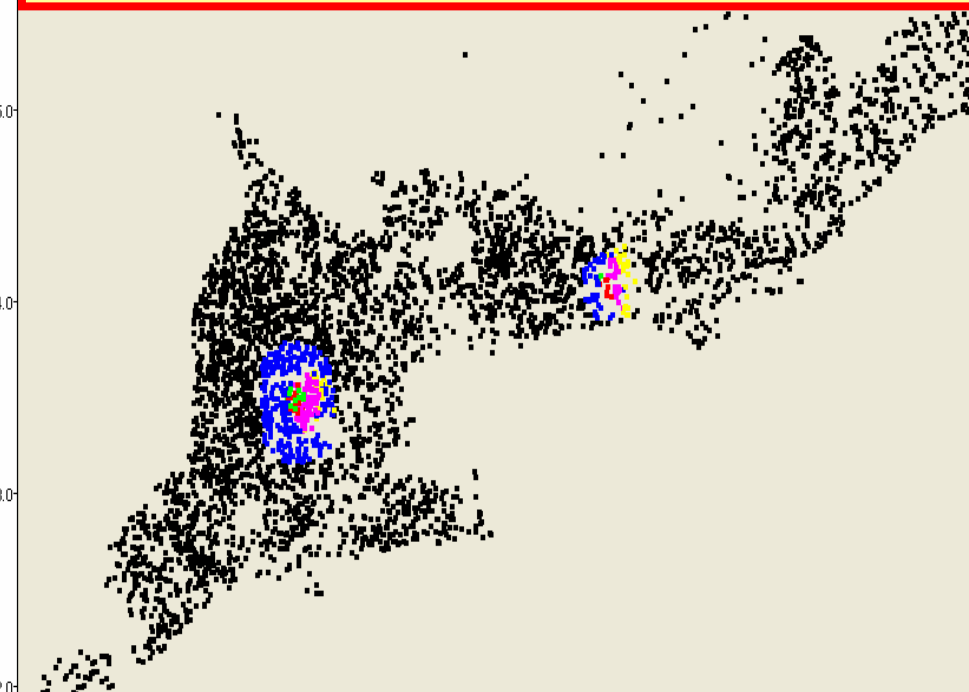
Reasons for infection -- includes all infections

Initially infected	1
Airborne*	194
Direct contact*	5
Indirect contact*	46
<b>TOTAL</b>	<b>246</b>

Actual Epidemic Curve -- includes all infections

\* In the course of a simulation run, these activities may occur

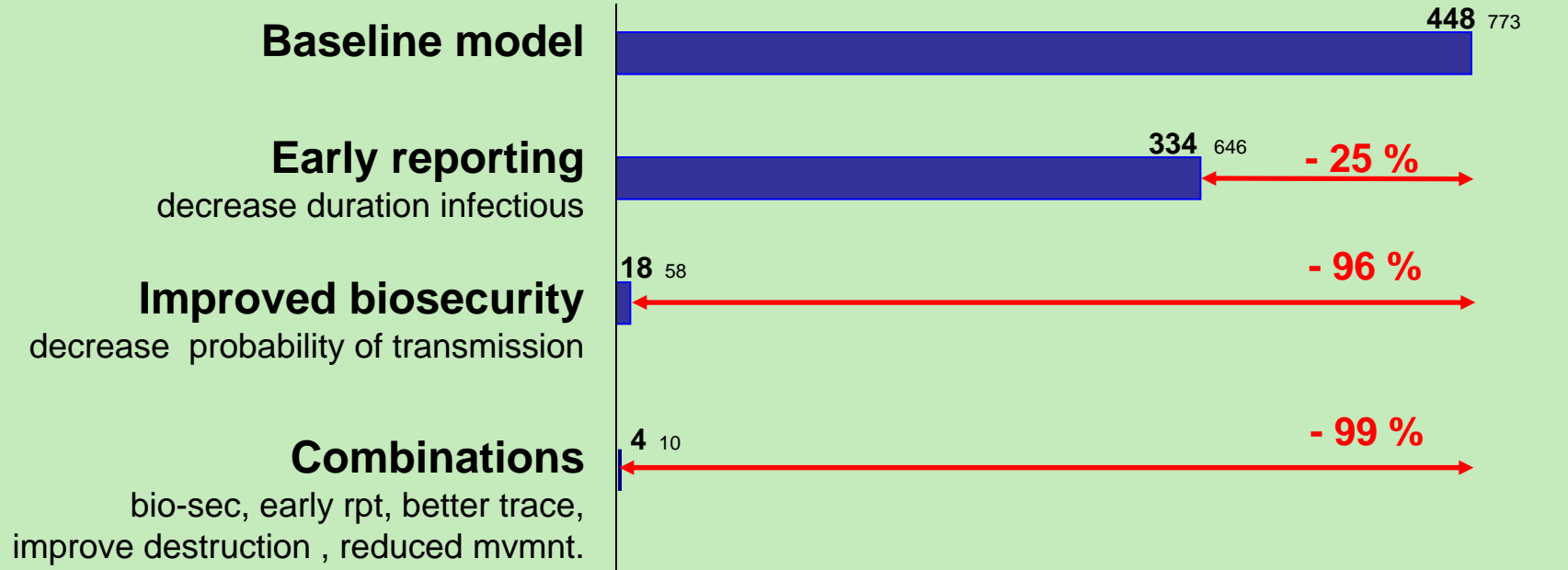
**Brief "taste" of NAADSM computer simulation outputs illustrating disease spread & control**



# NAADSM - Comparison of Strategies 1000 Iterations Each



Number of Herds in Outbreak mean 95th

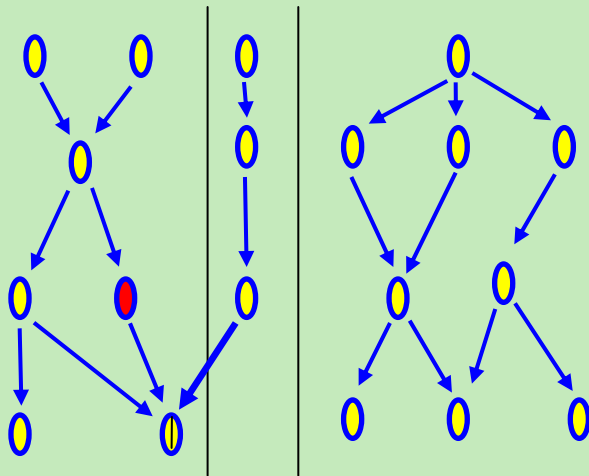


**Caution** - do not interpret the above numbers too literally  
but recognize the utility of the modelling approach and  
communication of the direction and potential scale of impact

# Schematic Representation of Movement, Networks, Flow & Traceability

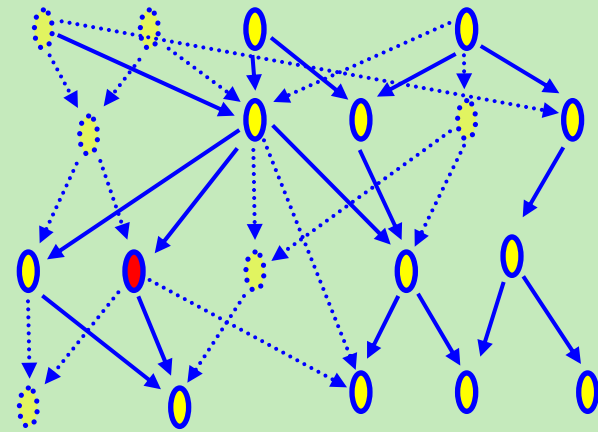


**Good Flow Design & Extensive Knowledge**



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.



# Take Home Messages

1. **Animal health is important far beyond the immediate farm affected.**
2. **Improving, maintaining animal health is one of the few things you can influence to improve your profits and income stability.**
3. **Bugs / toxins do not care about your problems; their spread is mostly passive; mostly they move where you buy or let them ride in.**
4. **Spread and control are “exponential”; so every little bit helps and little things matter.**
5. **Removing “infected”, decreasing “contacts”, increasing “cleanliness”, and increasing immunity/resistance, all help. Note that 2.5 of these actions are relatively non-specific. They work against most endemic, foreign, emerging and future “bugs”.**



# Take Home Messages cont.

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-  6. Peacetime systematic design and management that facilitate prevention of spread, early detection, rapid aggressive investigation / tracing / response; pays exponential biological dividends (often unknown) all the time and in crises.
-  7. Industry workers, system and facility design, **physically addressing the biology** are what matter; **your** (their) routine daily actions influence **your** animal health future far more than you may have thought.



This is (should be) empowering to YOU

**All animal health activities should directly or indirectly contribute to factors “respected” by “bugs & toxins” to reduce spread (R).**