Colorado’s HPAI Response

Maggie Baldwin, DVM - State Veterinarian

Colorado Poultry Industry

- ~ 4.25 million laying hens - 5 commercial sites
  - ~900M table eggs per year
- W. Slope - broiler breeders
  - ~650,000 breeders; 80.5M eggs year
- Niche layer flocks, specialty flocks
- Waterfowl, gamebirds
- Backyard, exhibition

Colorado Dairy Industry

- ~ 200,000 milking cows
- 105 licensed dairy farms
    - 86 individual dairy cow premises
- 2nd nationally - milk per cow
- 13th nationally - total milk production
- 5.2 billion pounds of milk annually


Partnerships

- One Health, balanced response
- State and federal animal health officials
- State, federal, local public health officials
- Industry - dairy, poultry
- Veterinarians
- Academia and research

Colorado HPAI Outbreak

H5N1 2.3.4.4b
B3.13

April 2024 - present

Dairy Cattle:

- 64 confirmed positive *(63 released from QT)*

Poultry:

- 2 backyard confirmed positive
- 3 commercial confirmed positive - **3.3M**

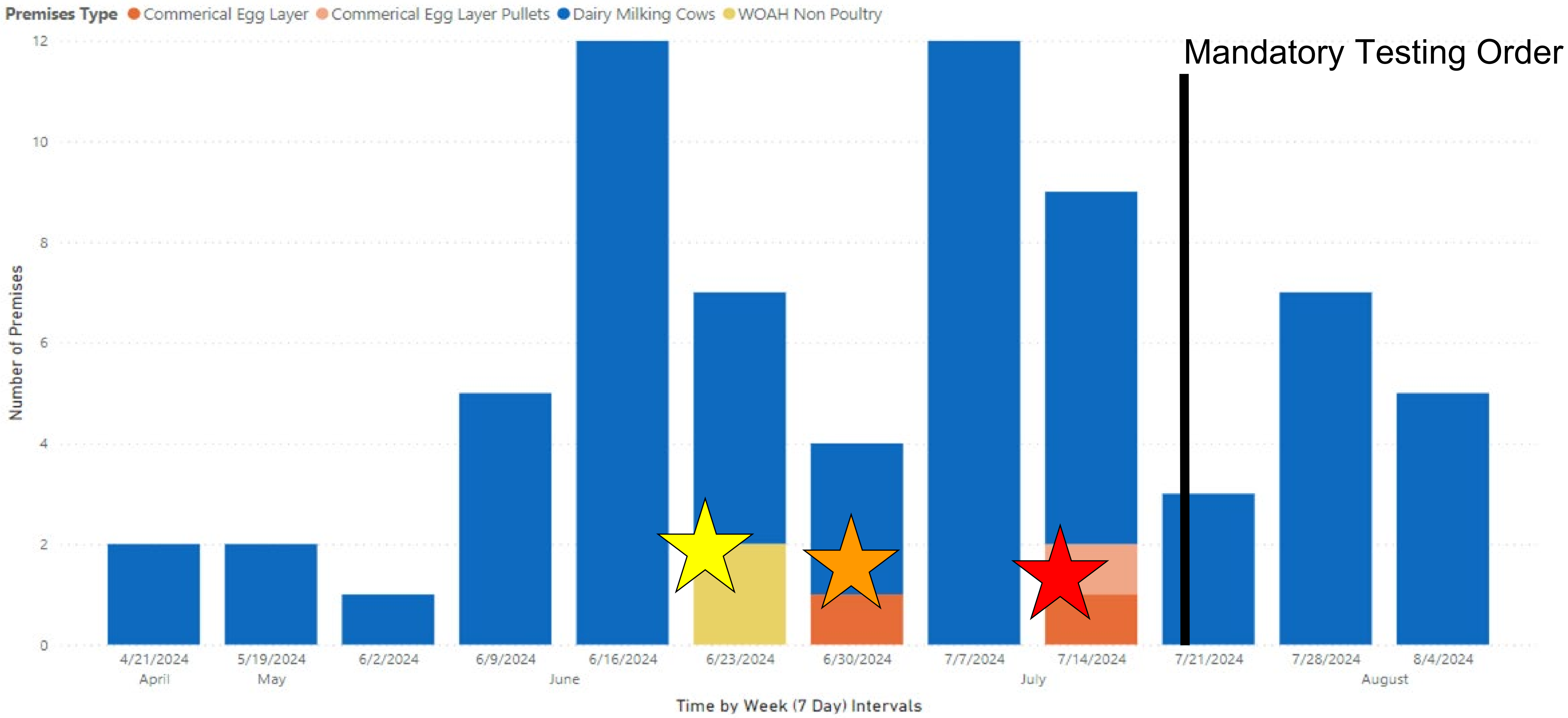
Domestic Cats:

- 6 confirmed positive

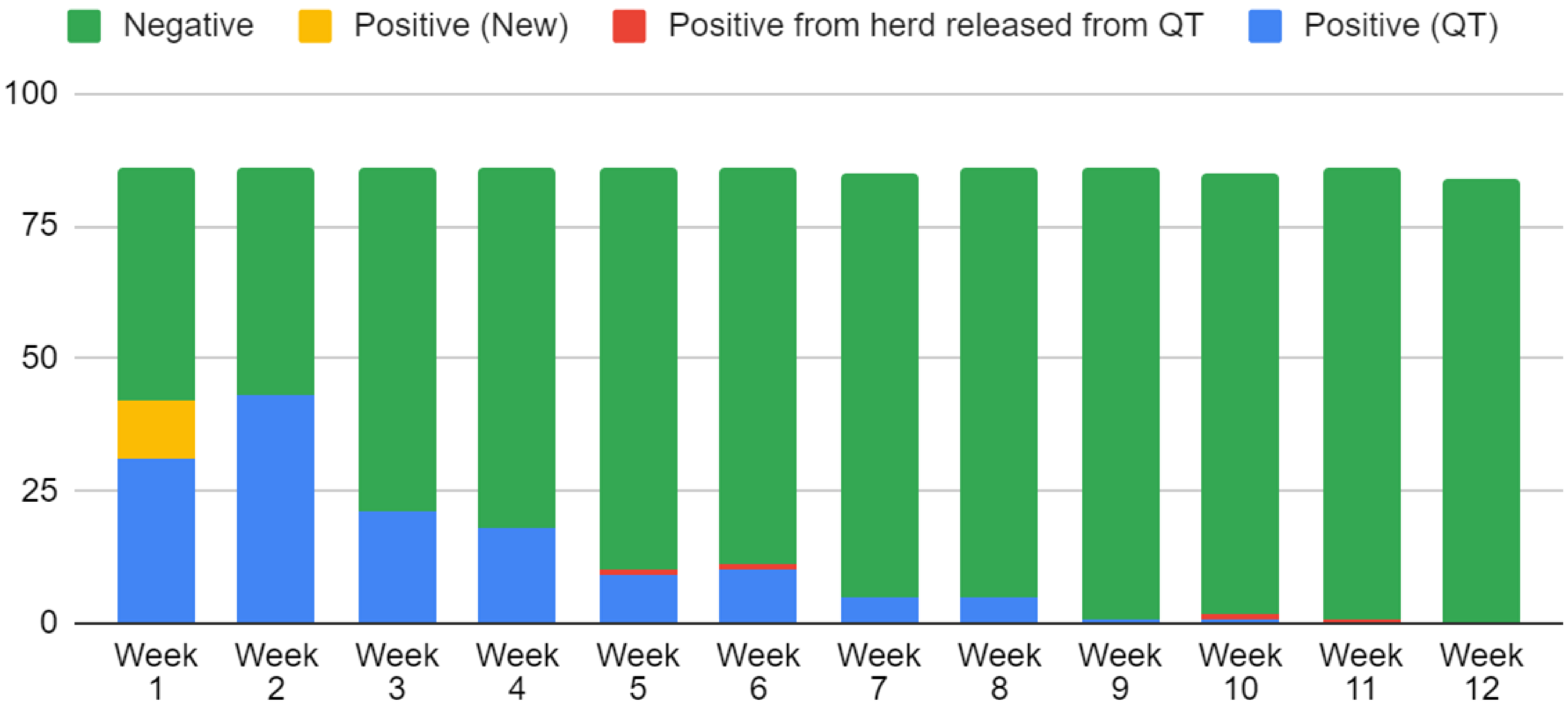
Human Cases:

- 10 confirmed positive

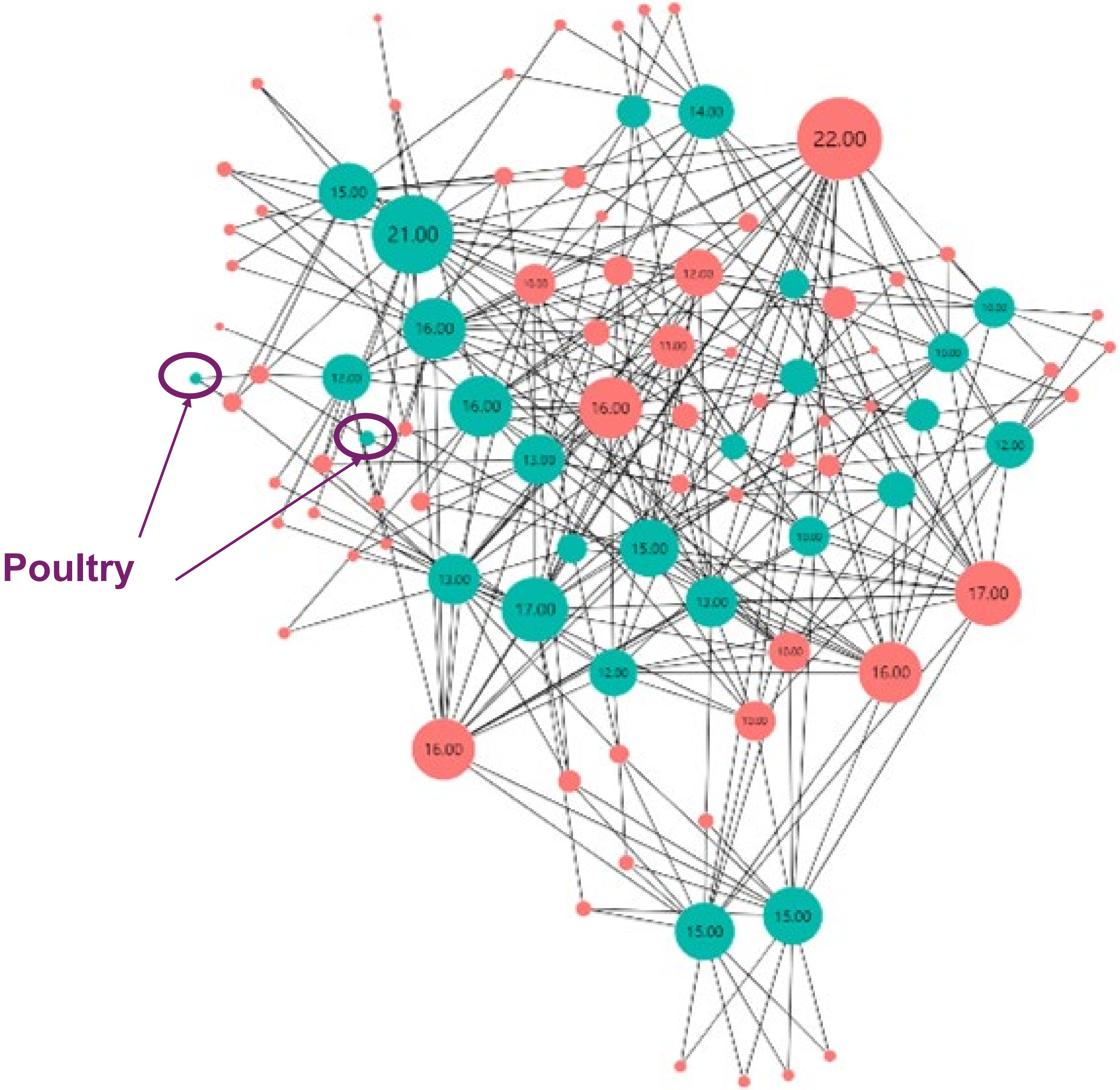
Epi Curve by Presumptive Positive Date



CO Bulk Tank Testing Results

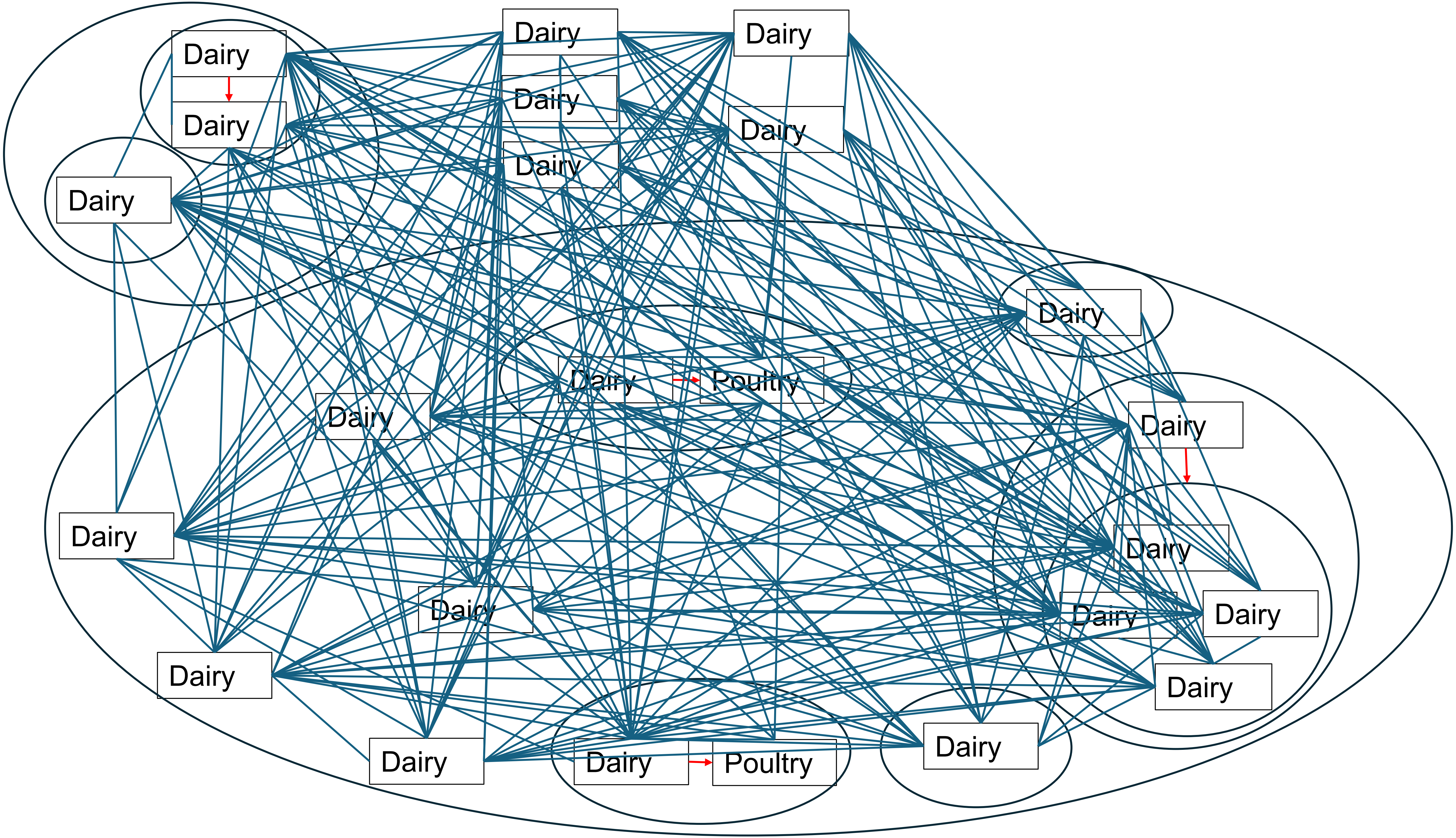


Colorado Network Visualization



Dairy

Service Provider



Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Poultry
Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Dairy
Poultry
Dairy

Next Steps

- Define state and national goals in response
  - elimination of HPAI/H5N1 in dairy cattle?
- Long-term surveillance strategy
- Update response as we understand disease
- Understand the long-term impacts to dairy herds
- Lessons learned from outbreak
  - biosecurity for FADs

Biocomplexity Institute

University of Virginia

Computational Epidemiology Perspective:

Foresight and Preparedness Across Public Health, Health Care, and Farming Systems

October 23rd, 2024

Bryan Lewis PhD MPH
on behalf of Abhijin Adiga, Ayush Chopra, Mandy Wilson, S. S. Ravi, Dawen Xie, Samarth Swarup, Andrew Warren, Ramesh Raskar, and Madhav Marathe

Funding Acknowledgement: Work funded in part by CDC PGCOE, NSF Expeditions, USDA NIFA-sponsored AgAID Institute, NSF PIPP-Phase 1 and DTRA Grants as well as University SIF Funds.

UNIVERSITY of VIRGINIA

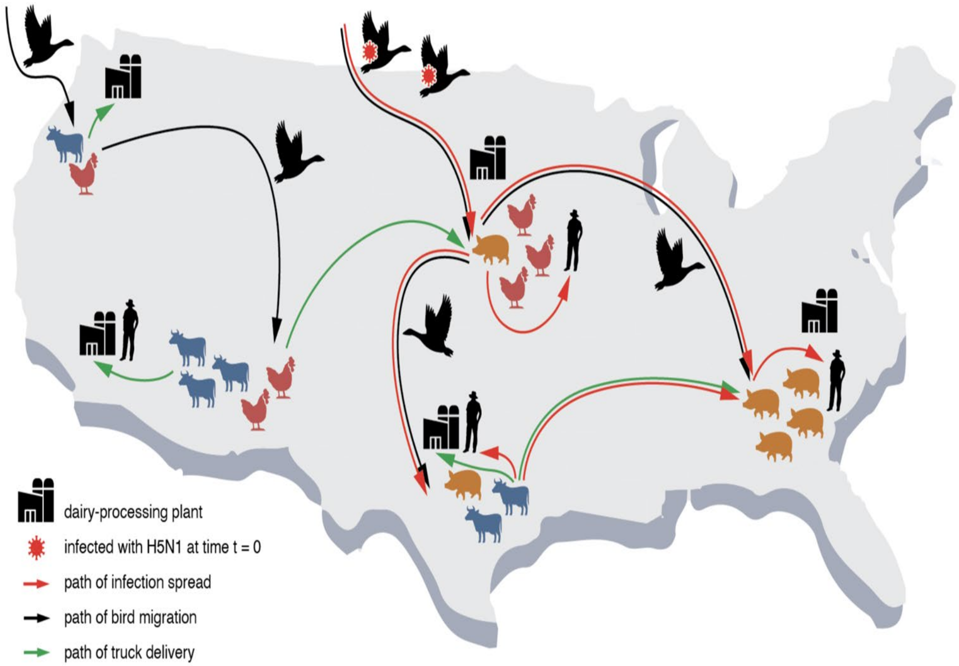
BIOCOMPLEXITY INSTITUTE

biocomplexity.virginia.edu

mit media lab

Where are we?

- COVID-19 lessons learned, and knowledge are still fresh
    - Accessible tools & methods
- HPAI (H5N1) spillover and spillback is more complicated than COVID-19
- Have more data and attention than previous potential pandemics
- Memory of COVID-19 and eroding of trust remains, challenges tracking and response



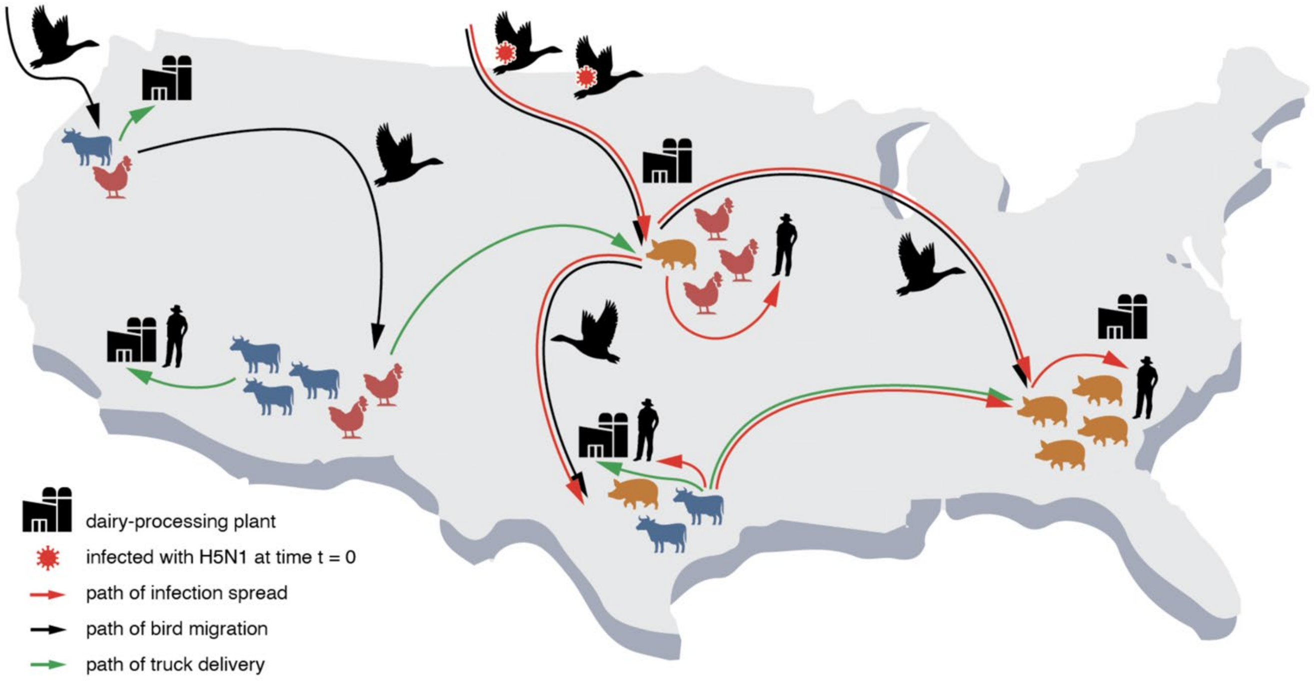
UVA | BIOCOMPLEXITY INSTITUTE

Limitations and Gaps

- Siloed nature of relevant data sources
- Communication channels between policy and researchers
  - What questions are most relevant to whom?
- Responsibilities and goals are myriad and split across several governmental agencies
  - Industry's role is central, yet has limited involvement
- COVID fatigue

Digital Similar of the System

- Need to account for multiple entities and the interactions in this complex system
  - Understanding the dynamics
  - Test significance of pathways
  - Design of robust surveillance
  - Evaluate courses of action for response and policies



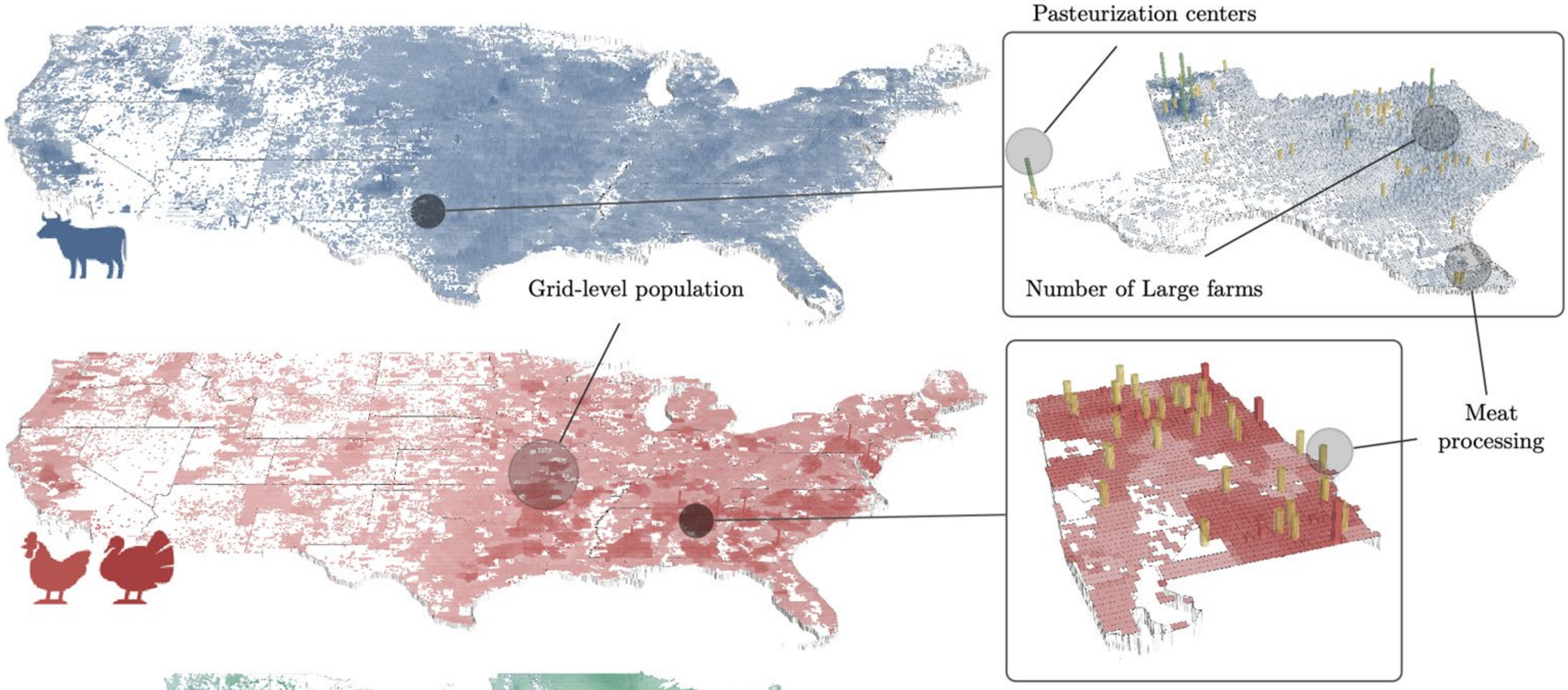
UVA | BIOCOMPLEXITY INSTITUTE

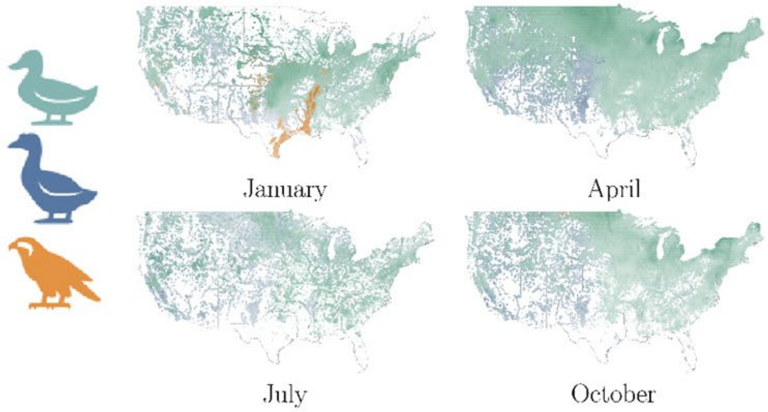
Digital Similar

A US-scale multi-layered high-resolution digital representation of

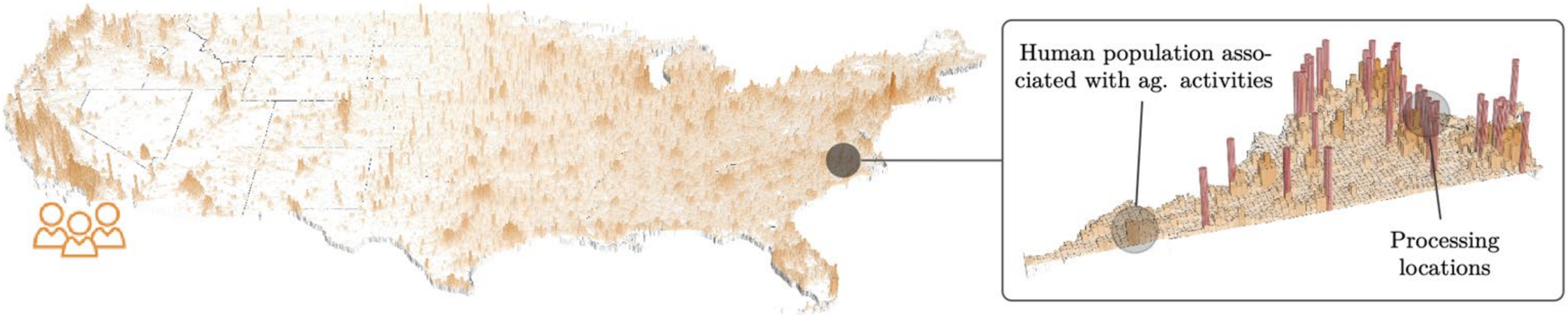
- **Livestock**
  - Multiple livestock populations
  - Operations by size
- **Processing centers:**
  - milk and meat
- **Wild birds**
  - Multiple species of migratory birds
  - Abundance & movement
- **Human population**
  - By size and occupation type.

Standardized to a grid-level representation. (approx. 5mile x 5mile)





	Subtype/Species/Group
Cattle	beef, milk, other
Poultry	chicken (layers, broilers, pullets, roosters), turkeys, ducks, pheasants, quails, chukars, etc.
Hogs	None included
Sheep	None included
Wild birds	mallards, geese, birds of prey and scavengers, American crow, etc.
Human population	Industry (NAICS) and occupation (SOCP) codes corresponding to animal production and animal slaughtering and population.



Datasets & Literature

Diverse data fusion

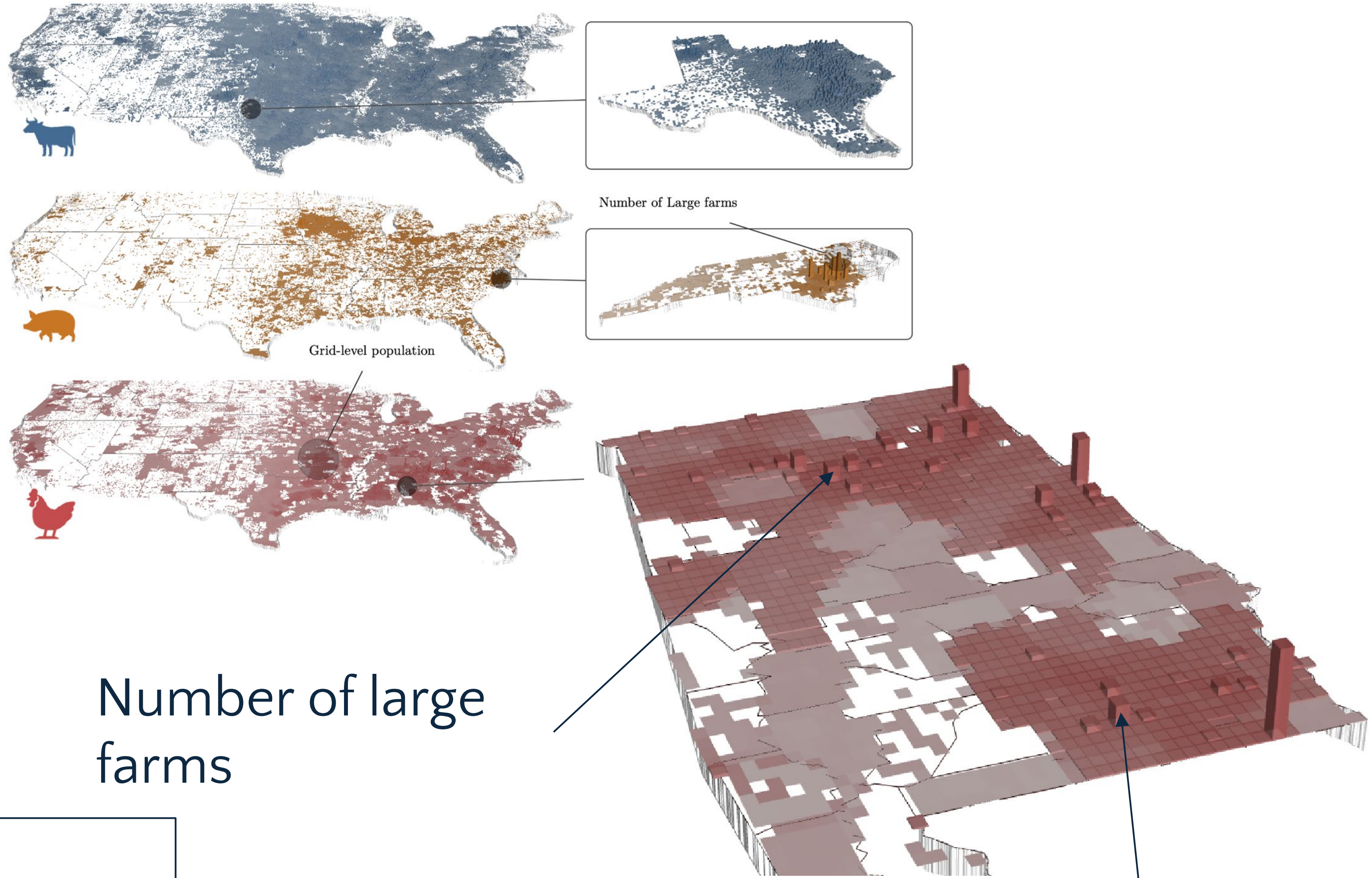
- Census
- Location data
- (data+model) derived synthetic datasets

Purpose: Construction & validation

Data/Work	Type	Purpose	Cattle	Poultry	Hogs	Wildbirds	Human pop.	County	Grid	Location	Operations
AgCensus	Census	Construction									
GLW	Model+data	Construction									
eBird	Model+data	Construction									
US pop. dig. twin	Model+data	Construction									
Meat processing	Location	Construction									
Dairy processing	Location	Construction									
APHIS/CDC	H5N1 incidence	Validation									
CAFOs	Location	Validation									
Prosser et al.	Literature	Methods									
Burdett et al.	Literature	Methods									
Humphreys et al.	Literature										
Our work											

Livestock

- A high-resolution spatial distribution of livestock at subcounty-level that is consisten with farm operations.
- Gridded representation
- Cattle, poultry, hogs and sheep.

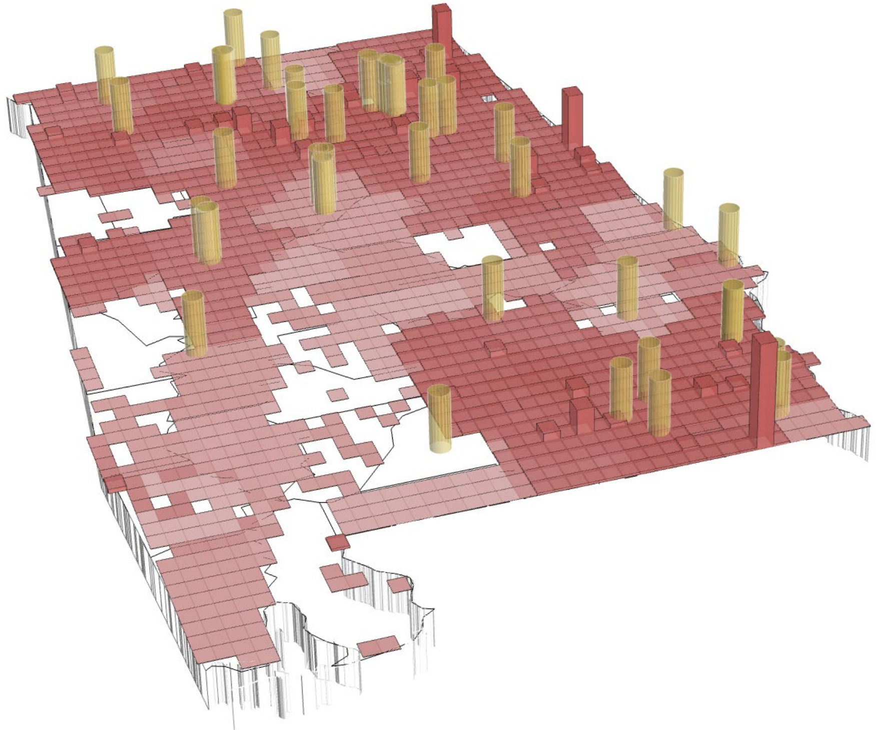


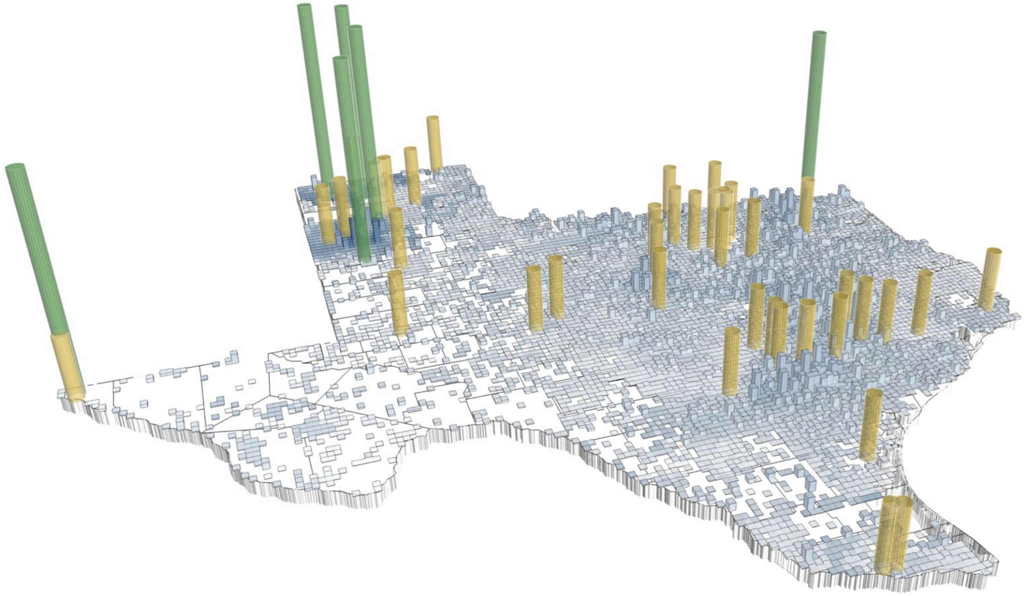
- Farm id
- Corresponding state, county
- Livestock type=chicken
- Coordinates x=1120, y=692
- Total heads: 107160

```
fid,state_code,county_code,livestock,subtype,x,y,heads
0,1,1,hogs,all,1122,692,24
1,1,1,hogs,all,1120,692,24
852,687,35,17,sheep,1,24,1,12
0,1,1,ckn-broilers,all,1120,692,107160
0,1,1,cattle,beef,1122,692,8
0,1,1,cattle,other,1122,692,1
0,1,1,cattle,all,1122,692,9
```

Processing centers

- Pasteurization plants
  - Food Safety and Inspection Service, USDA
  - Types of processing and products are provided
  - Large plants covered
- Meat processing
  - Agricultural Marketing Service, USDA
  - Poultry
  - Slaughter





Human Population and Activities

- Population distribution with special emphasis on subpopulations associated with livestock and related activities.
- **Data**: National-scale digital twin of population and activities derived from open, as well as proprietary datasets
- Population was filtered by **occupation** code (SOCP) and **industry** code (NAICS).
  - SOCP/NAICS codes corresponding to livestock activities were identified: farm workers, veterinarians, equipment handlers, processing, etc.
  - Population assigned to grids based on residence location.

Web Portal for digital similar

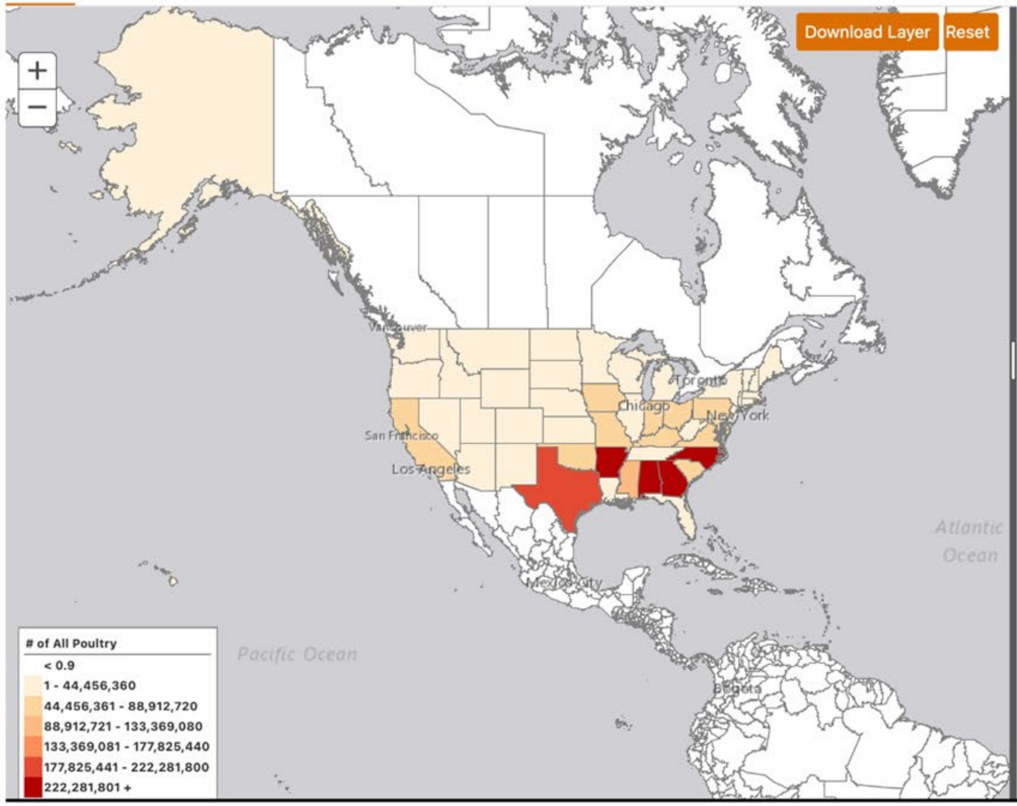
UNIVERSITY of VIRGINIA BIOCOMPLEXITY INSTITUTE | mit media lab | DiTTO: Digital Twin for Transboundary OneHealth 0.5

About | More Options

Population Type: - Poultry | Heatmap Measure: # of All Poultry | Search Region: Search by semi-colon separated names | Search

Map

Download Layer | Reset



Data

Download Table | Display All | Filter table data by

Region Name	US FIPS Code	# of All Poultry	# of Chukars
Idaho	16	1,199,243	2,983
North Dakota	38	1,104,904	12
Washington	53	12,596,616	5,863
Minnesota	27	42,027,813	35,130
Montana	30	1,670,510	262
Alaska	02	48,640	1,683
California	06	71,407,713	45,056
Oregon	41	7,924,143	5,595
Nevada	32	38,119	615
Colorado	08	4,091,105	11,474
Wyoming	56	96,928	1,682
Arizona	04	4,709,893	1,683
Utah	49	11,405,806	22,569
New Mexico	35	158,956	1,683
Iowa	19	65,915,517	1,708
Oklahoma	40	46,971,964	792
Missouri	29	79,384,187	7,286

https://ditto.bii.virginia.edu/

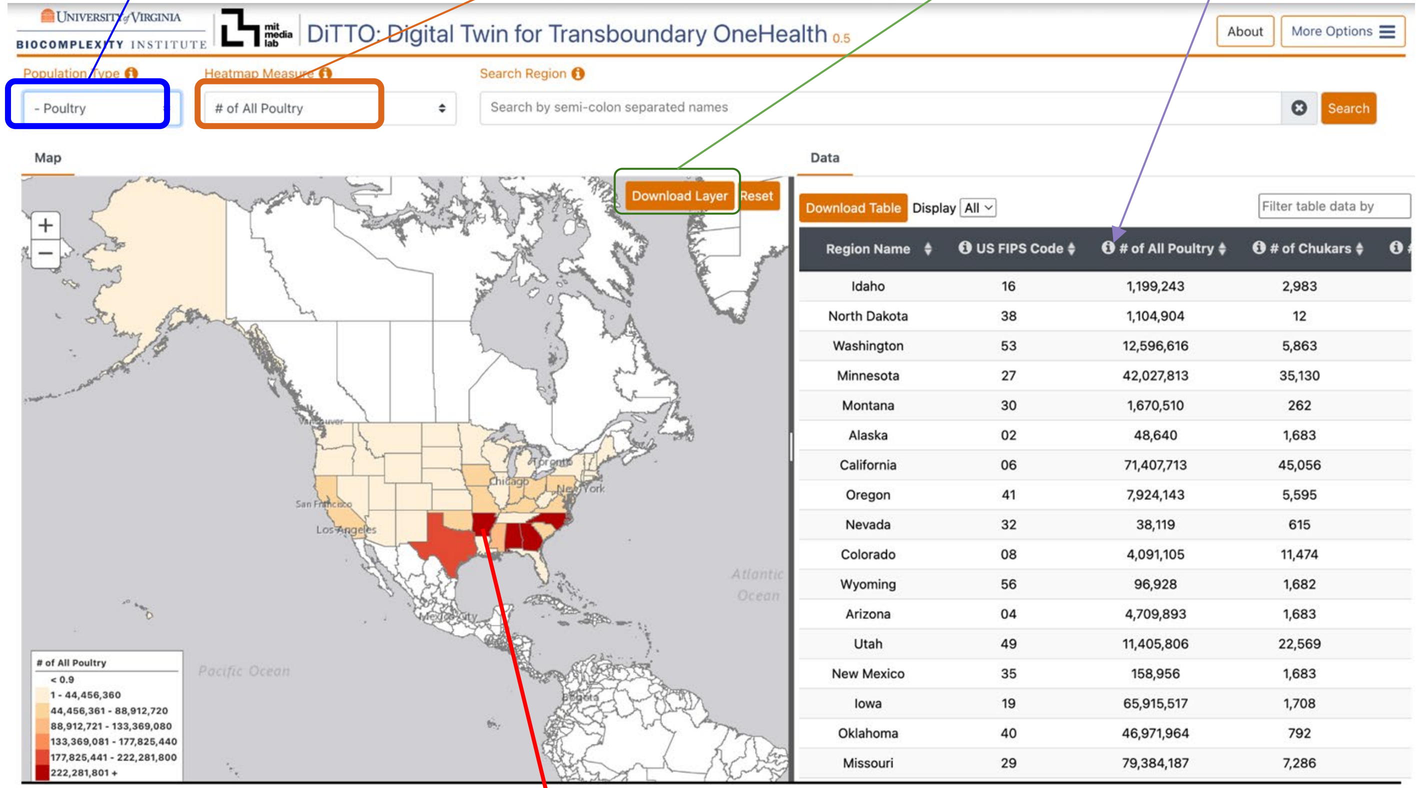
Web Portal and Data access through APIs

Choose between species types

Toggle between heatmaps (# of animals, abundance, etc.)

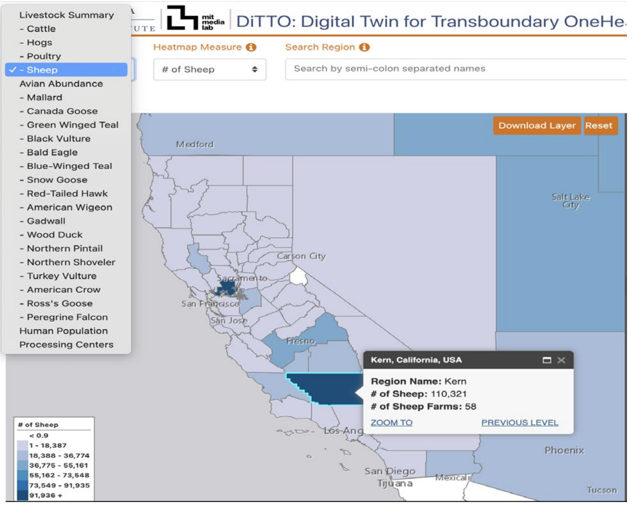
The Data tab allows for data browsing and download.

Download Dataset



Region Name	US FIPS Code	# of All Poultry	# of Chukars
Idaho	16	1,199,243	2,983
North Dakota	38	1,104,904	12
Washington	53	12,596,616	5,863
Minnesota	27	42,027,813	35,130
Montana	30	1,670,510	262
Alaska	02	48,640	1,683
California	06	71,407,713	45,056
Oregon	41	7,924,143	5,595
Nevada	32	38,119	615
Colorado	08	4,091,105	11,474
Wyoming	56	96,928	1,682
Arizona	04	4,709,893	1,683
Utah	49	11,405,806	22,569
New Mexico	35	158,956	1,683
Iowa	19	65,915,517	1,708
Oklahoma	40	46,971,964	792
Missouri	29	79,384,187	7,286

The web portal will allow users to view our datasets aggregated to the county level, download our datasets, and get more information about how the datasets were created.

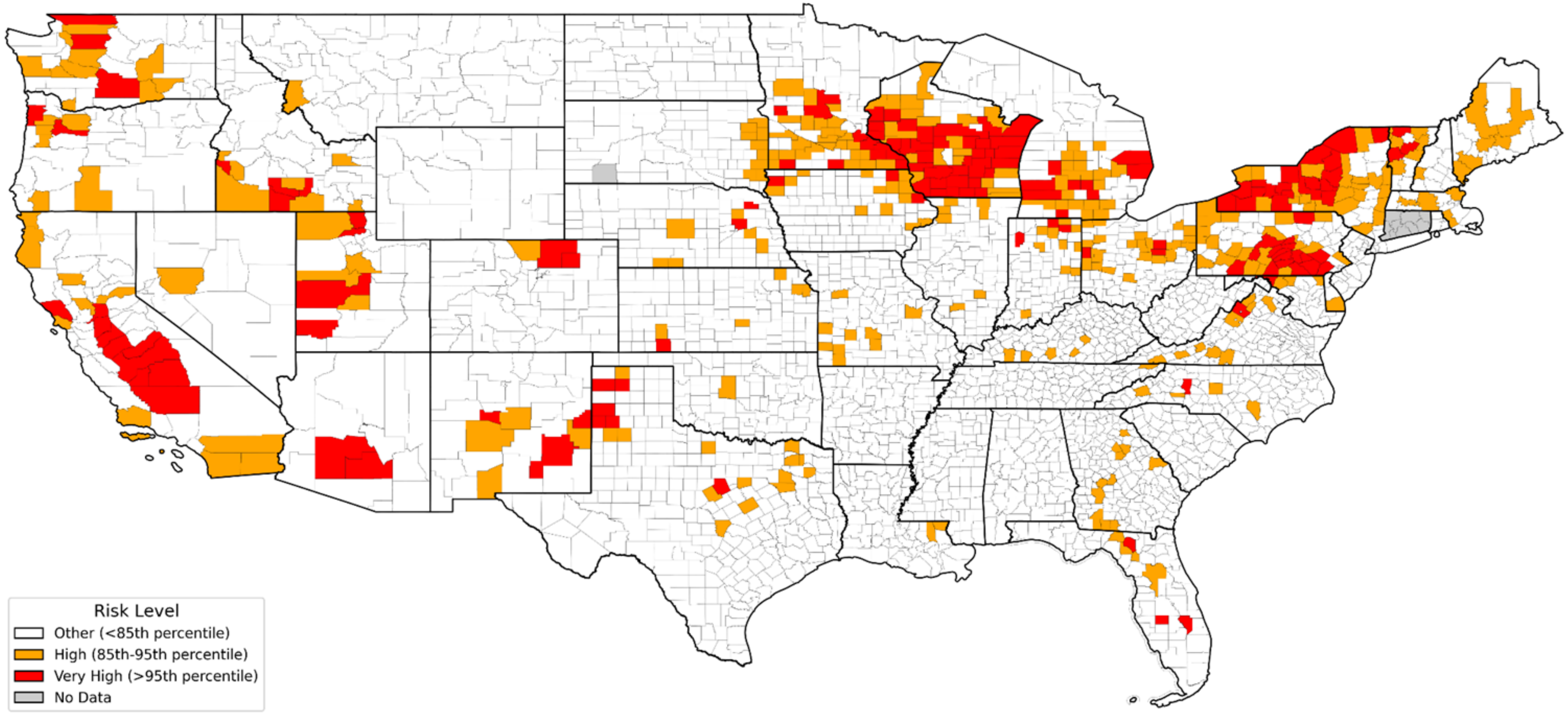


Click on the map to get information about the selected region or to drill down to the county level.

https://ditto.bii.virginia.edu/

Ag Workers and Dairy Cattle

Co-location Risk for Agricultural Worker from Dairy Cattle

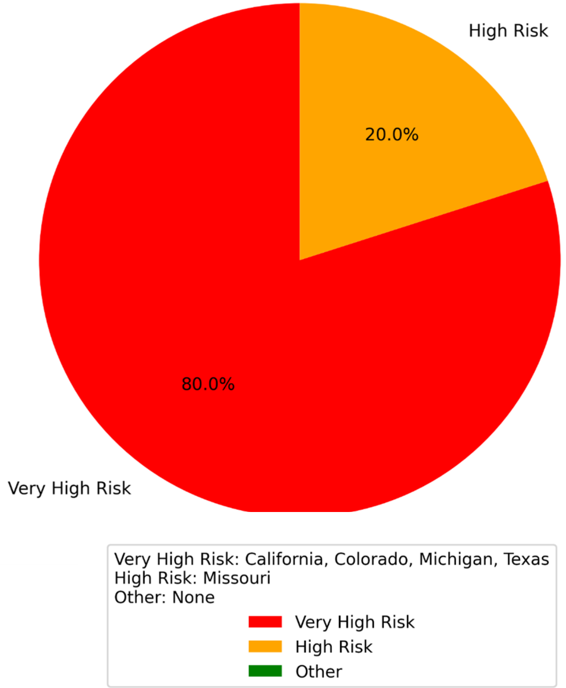


Human Case Summary during the 2024 outbreak, by state and exposure source

Exposure Source

State	Cattle	Poultry	Unknown	State Total
California	6	0	0	6
Colorado	1	9	0	10
Michigan	2	0	0	2
Missouri	0	0	1	1
Texas	1	0	0	1
Source Total	10	9	1	20

Estimated Risk Levels for States with Reported Cases



- Unconditional risk estimates aggregated from grid-level colocation of agricultural workers with dairy cattle.

$$R_{\text{human}}(i,t) = R_{\text{local}}(i,t) \cdot R_{\text{neighbor}}(i,t)$$

$$R_{\text{local}}(i,t) = [P_{\text{human}}(i,t)]^{\alpha} \cdot [P_{\text{cattle}}(i,t)]^{\beta}$$

$$R_{\text{neighbor}}(i,t) = \sum_{j \neq i} P_{\text{cattle}}(j,t) \cdot f(d_{ij})^{\gamma}$$

Next Steps and Priorities

- Starting more collaborative hubs
  - Focuses work towards a common goal and unifies data sources and analyses
- Continued support of projects focused on Pandemic Preparedness as well as data and tool provision
- Studies that capture the ”denominator” of drivers of transmission
  - For example, volumes of cattle transfer without transmission

COVID-19 ScenarioModelingHub

FluSight ›

Unlike CDC's traditional influenza (flu) surveillance systems, which measure flu activity after it has occurred, flu forecasting provides information about the future, allowing CDC to plan ahead and potentially reduce the impact of flu.

Centers for Disease Control and Prevention's
Pathogen Genomics Centers of Excellence

BRC
NIAID Bioinformatics Resource Centers

UVA | BIOCOMPLEXITY INSTITUTE

From Pandemic Fatigue to Readiness:

H5N1 Communication Research & Implementation Needs

Stefanie Friedhoff
Professor of the Practice
Director, Information Futures Lab
Brown University School of Public Health

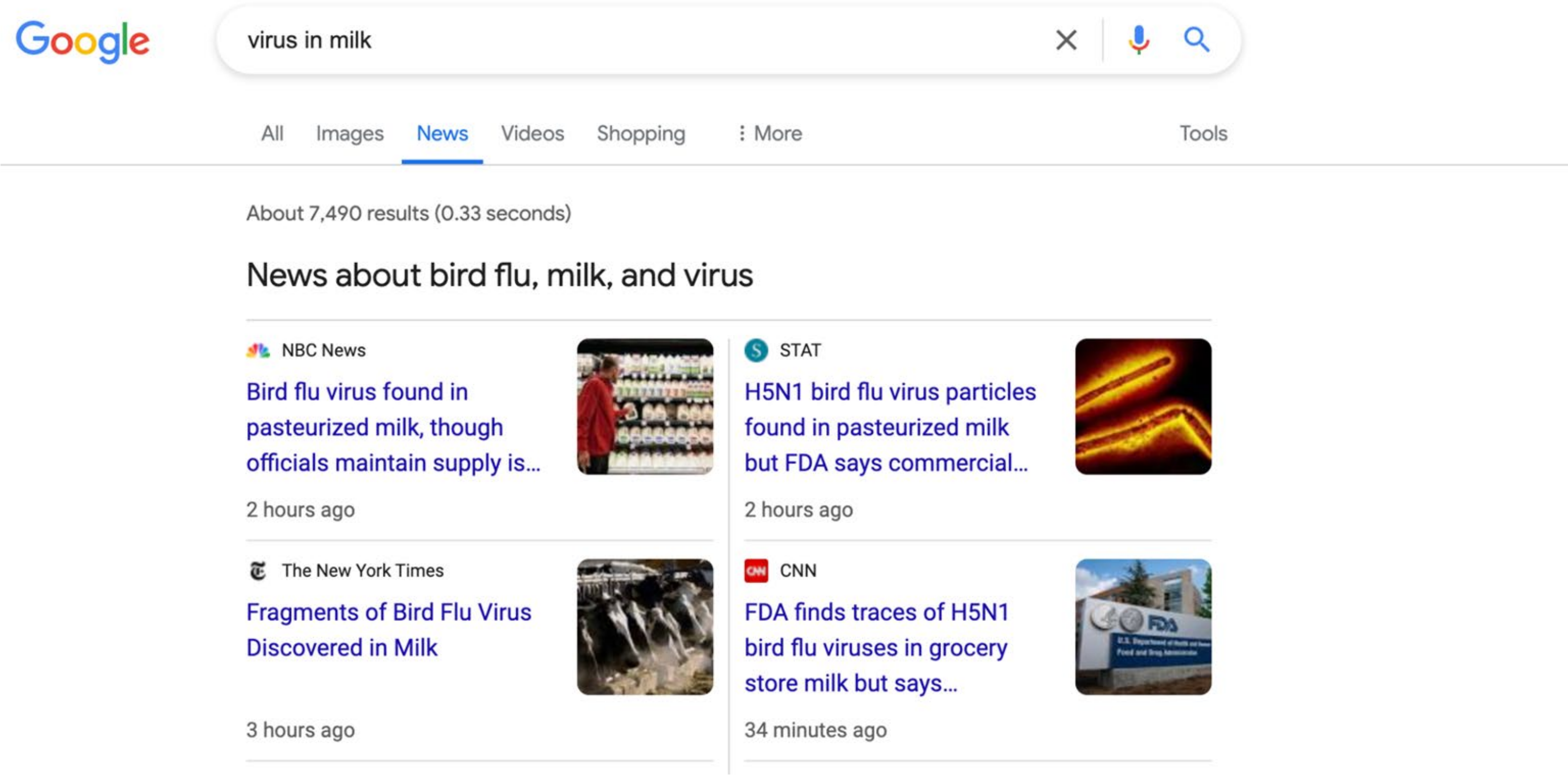
INFORMATION FUTURES LAB

School of Public Health
BROWN UNIVERSITY

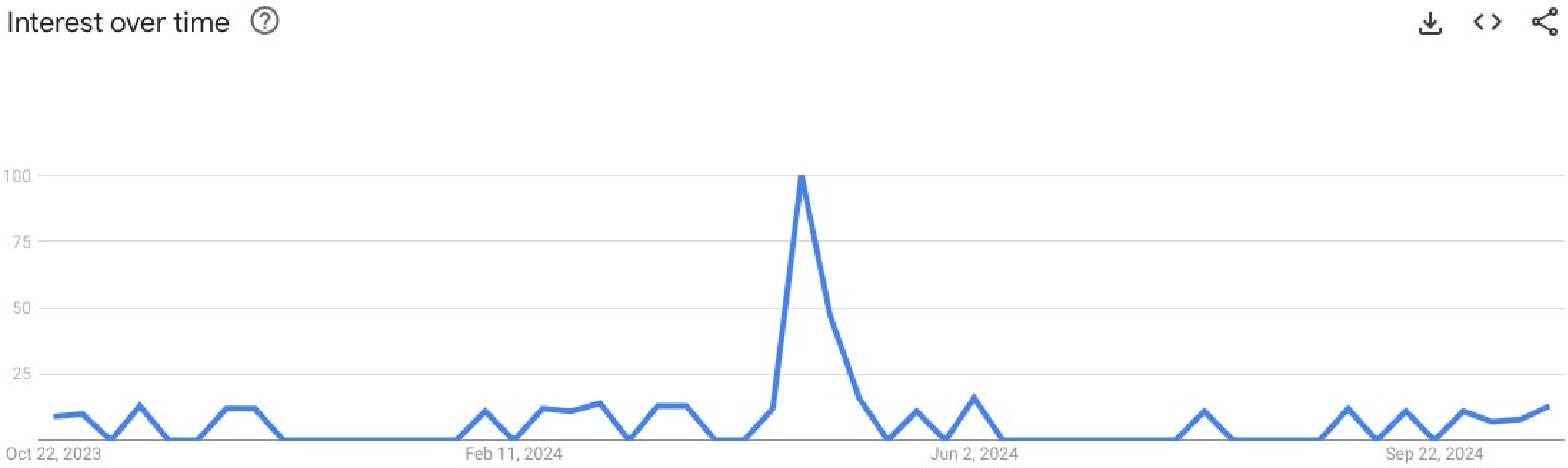
Where we (as responders) are finding ourselves

- Pandemic eroded trust in authorities & public health.
- Effective communications is articulated as a key priority in preparedness and response efforts.
- Nobody wants to think about another outbreak, let alone a pandemic.
- Politics are making cross-agency and federal-state collaboration complicated.

Where people are finding themselves



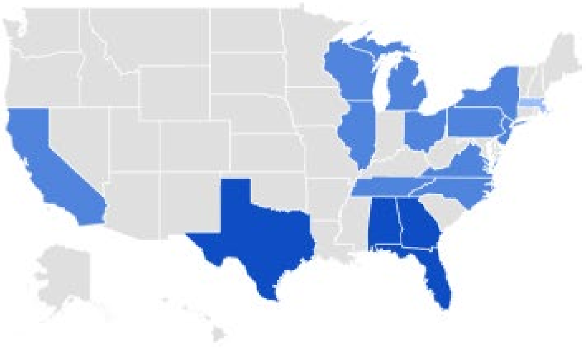
‘Virus in milk’: Google Trends



‘Virus in milk’: Where people were searching

Interest by subregion

Subregion



1	Alabama	100
2	Texas	100
3	Florida	100
4	Georgia	100
5	Wisconsin	50

Showing 1-5 of 16 subregions

Where people make sense of new information

Jennifer @jentleone1 · 1m

Replying to @lulusherwood

Nope, not it's not safe. If they've found the **virus in** the **milk**, it's not safe. Geebus, who would drink **milk** containing a known (deadly) contaminant? Our PH orgs are winding the clock back to the middle ages. Next they'll be discussing SARS **in** terms of Hippocrates' 4 humors 🤦‍♀️

R @plagueprose · 3m

"FDA finds evidence of bird flu **virus in** grocery store **milk** but expresses confidence **in** safety of dairy supply."

nope. uh uh. this "confidence" scares me more than if they'd admitted to being unsure.

Bird flu virus found in grocery milk as officials say supply still safe

From washingtonpost.com

Saint Negrita (Vaccine Shaw) @AsthmaPumpPuffa · 10m

I (begrudgingly) switched to oat **milk in** my iced lattes like 2-3 weeks ago, because there's no way any of us should trust these people when it comes to handling a **virus** with pandemic potential...

CBS Evening News @CBSEveningNews · 14h

BREAKING: The FDA has found evidence of the bird flu virus in grocery store milk, but says there is no threat to human health.

19

Who is present where people make sense of information

The Tinfôil Tricõrn 🇺🇸
Did the federal governmer
consumption? The cows a
frame where the FDA lost

@RepThomasMassie
@GregAbbott_TX
@mattgaetz

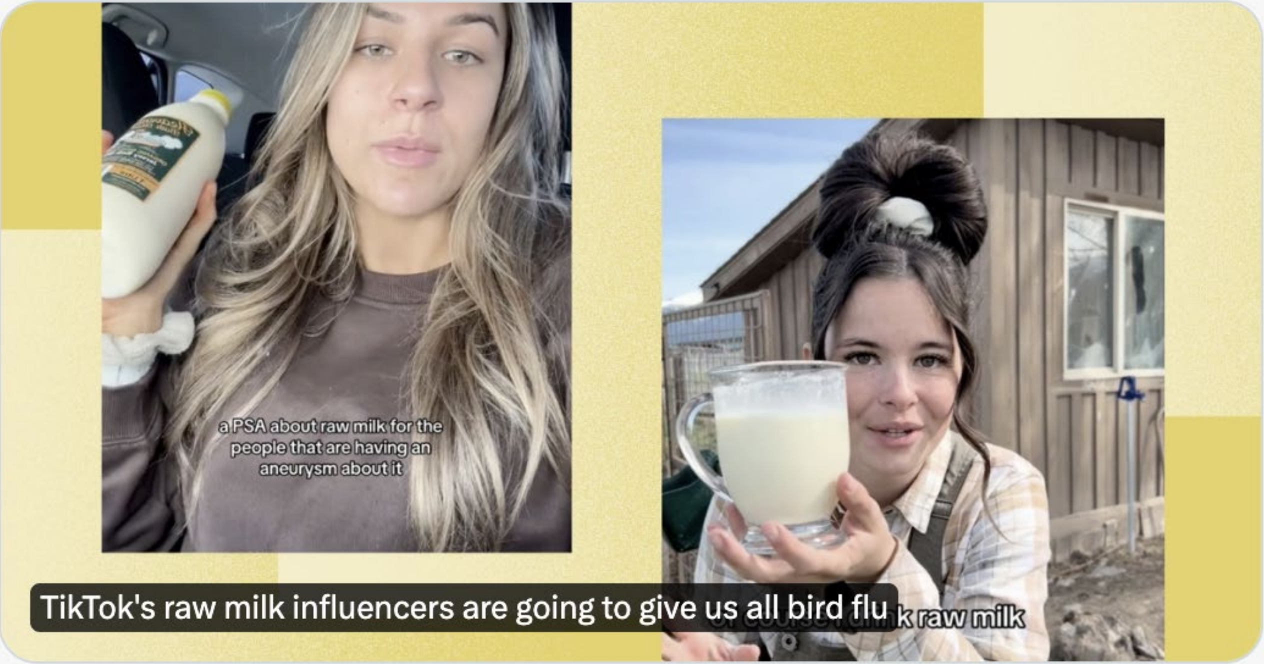
VanKonRab @VanKonRa
@laralogan @RSBNetwo
@SkyNews @OANN

The “**virus**” is now suppc
please research where al
you’ve got the megaphor

VanKonRab @Van
Thread with questions
DOWNS didn’t work so

Hmm. What do we kno
“grazers”) AND H5N1 (‘
Show more

Mother Jones @MotherJones · Jun 6
TikTok's **raw milk** influencers are going to give us all bird flu.



From motherjones.com

While validators don't have what they need to validate

Dr. Angela Rasmussen @angie_rasmussen ·

5. It would be nice to have reassurances that @
@USDA_APHIS are on top of this. However, this
with no supporting data, characteristic of the c
unclear why all the relevant data has not been s

1 32 243

Helen Branswell 🇨🇦 @HelenBranswell · Apr 23

Unknown

1. So much today on the #H5N1 #birdflu story! Just coming up for air. @US_FDA has found genetic evidence of the **virus** in commercial **milk**, but so far it sounds like killed **virus**. More info on where they found it/how prevalent it was would be useful.

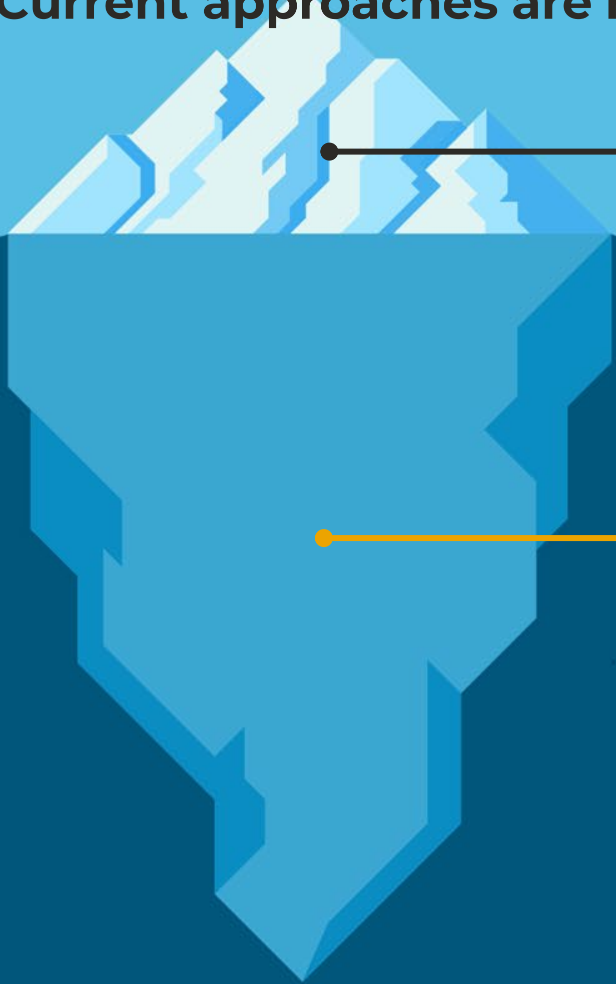
From statnews.com

19 225 529 55K

Meanwhile, e.g. in farmworker communities, quality information often...

- lacks appropriate language & cultural cues
- is designed solely for high-speed access
- is behind a paywall
- is not in the language spoken by the information seeker
- is not present in places where people spend their time consuming information
- is not designed for people with varying levels of literacies
- is delivered by messengers people trust only a little/ not at all
- is easily weaponized by bad actors who want to confuse & manipulate

Current approaches are not where the people are.



Misinformation & conspiracies
Overfocus on this top 20%

People's concerns, questions & confusion
Big opportunities for building trust and communicating effectively are in the lower 80% of the information ecosystem

Current approaches not made for participatory information ecosystems

To Be Trusted With Innovation, Give Me a Voice

Percent who say this is **important** to earning or keeping their trust in each institution to be good managers of change, showing the top 3 actions

GLOBAL 28

Across institutions, listening is a top 3 trust-building action

Business	%
Keep innovations affordable	84
Communicate pluses and minuses	83
Hear our concerns, let us ask questions	**82**

NGOs	%
Aid the vulnerable	79
Hear our concerns, let us ask questions	**78**
Help people keep up	78

Government	%
Hear our concerns, let us ask questions	**82**
Communicate pluses and minuses	80
Institute safeguards	80

Media	%
Hear our concerns, let us ask questions	**81**
Communicate pluses and minuses	81
Investigate innovations	80

Source: Edelman Trust Barometer 2024

We need to create a new evidence base for effective responses in this changed landscape

Invest in behavioral sciences, digital humanities and computational social science research and evaluation on:

- ➔ Barriers to changing outdated communications practices.
- ➔ Information inequities & access challenges for high-risk populations.
- ➔ The role of online and offline relationships (instead of messages) in trust-building.
- ➔ How health information consumption and sensemaking are changing alongside new technologies.
- ➔ How people are groomed into increasingly non-scientific belief frames over time (online & offline).
- ➔ What is working and not as we test new approaches, e.g. Infodemic management.

There are no silver bullets. Readiness means...

- Building coalitions of partners and infrastructures of trust before a crisis. (E.g. NIH CEAL Alliance)

- Training the public health workforce AND its partners in updated communications practices and infodemic management.

- Making communications and countermeasure demand part of the preparedness and response framework & including those leaders in high-level decision making.

  → **Making the shift from a message-based framework to an infrastructure-based framework.**

Thank you!

INFORMATION
FUTURES LAB

stefanie_friedhoff@brown.edu
@stef_friedhoff

Learn more at:
sites.brown.edu/informationfutures

Twitter:
@ifl_brown

LinkedIn:
https://www.linkedin.com/company/information-futures-lab

Looking left: Prevention of pandemics through the prevention of spillover

NASEM HPAI workshop October 2024

© Photo: Michael Furtman

© Photo: Peter Hudson

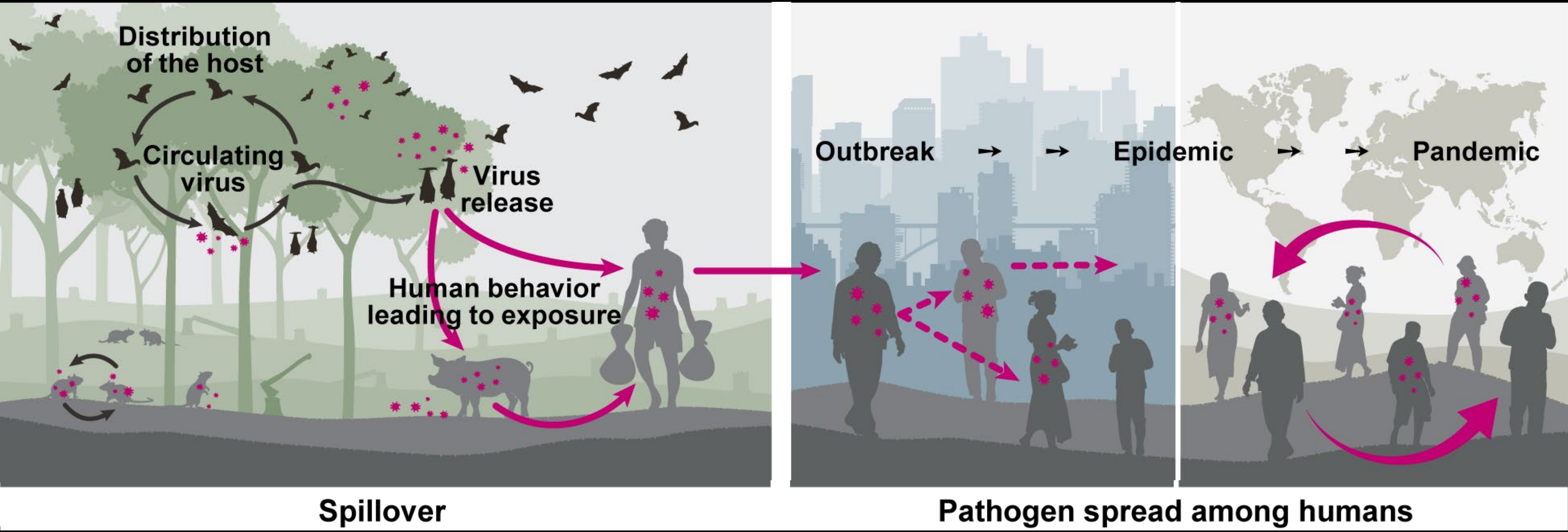
Raina Plowright

Rudolf J. and Katharine L. Steffen Professor

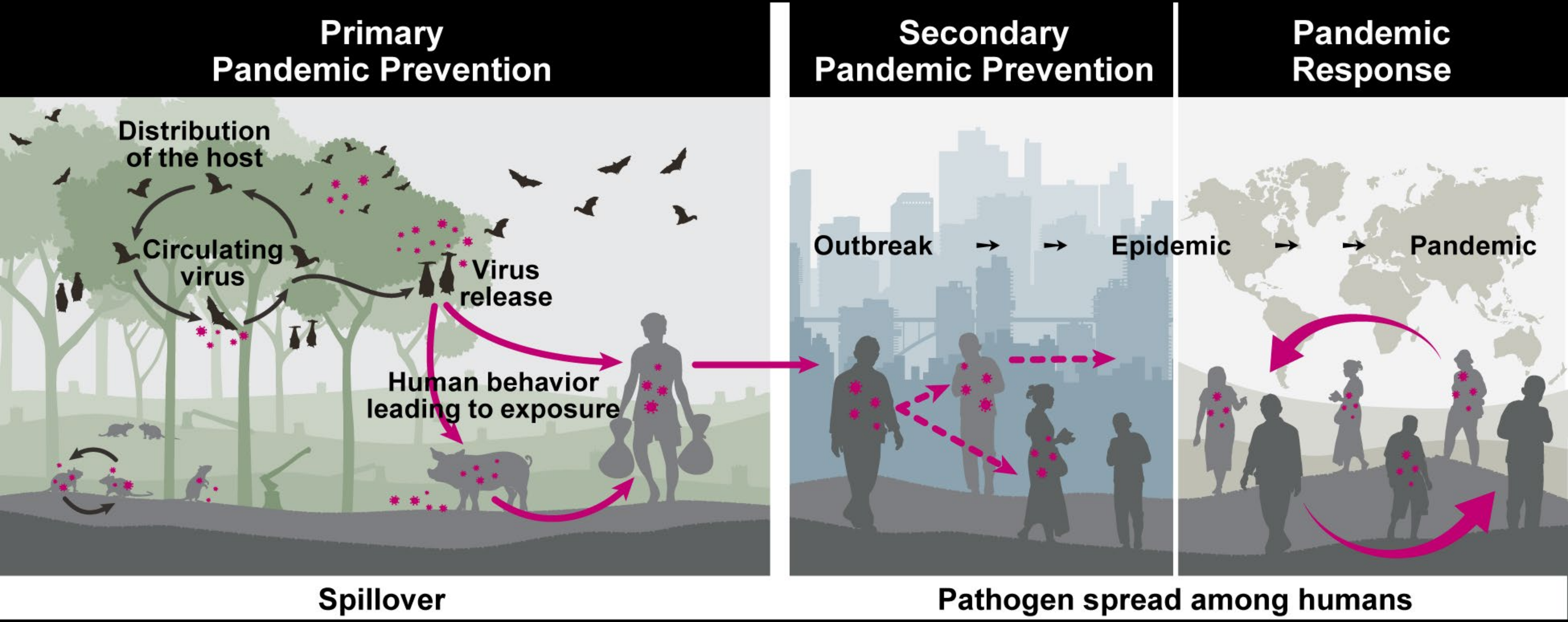
Department of Public and Ecosystem Health, Cornell University

Cornell Atkinson Scholar, Cornell Atkinson Scholar Center for Sustainability

Stages of a Pandemic: A series of unfortunate events



Plowright et al. 2024 Nature Communications



Plowright et al. 2024 Nature Communications

THE LANCET

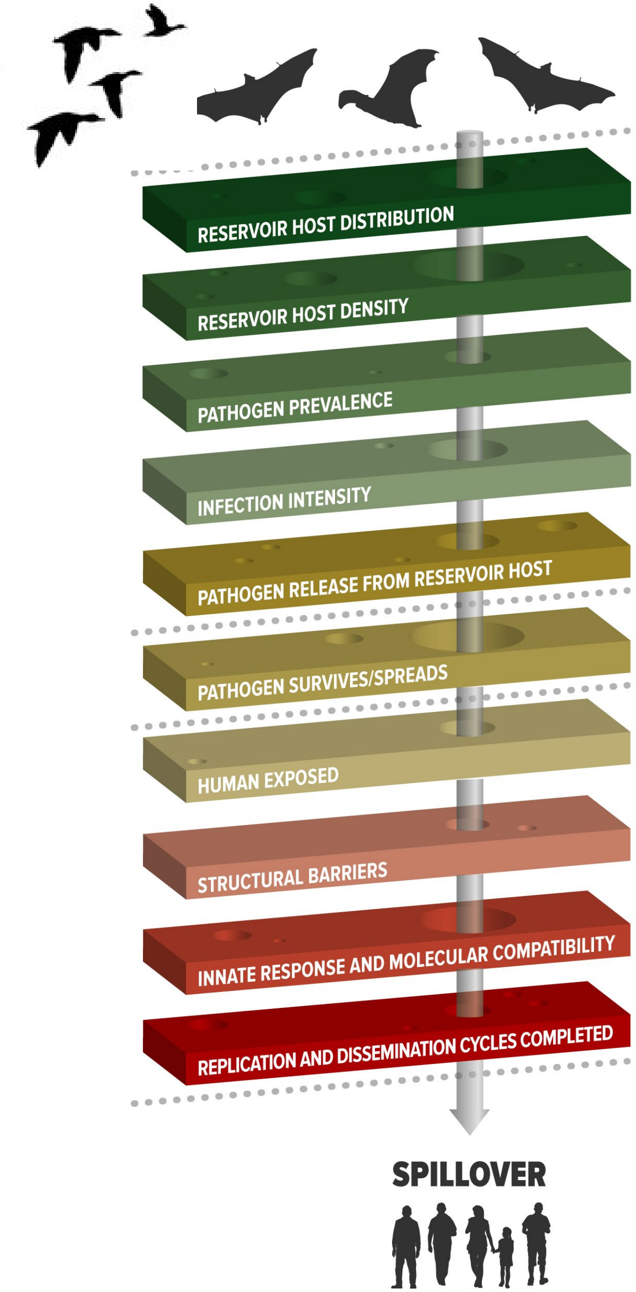
The *Lancet*–PPATS Commission on Prevention of Viral Spillover: reducing the risk of pandemics through primary prevention

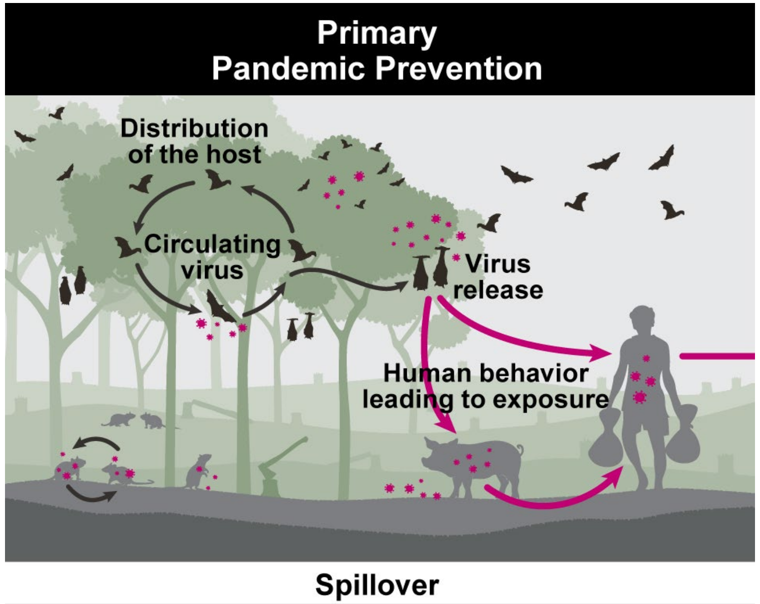
Neil M Vora • Latiffah Hassan • Raina K Plowright • Richard Horton • Sonila Cook • Nigel Sizer • et al.


© Photo: Michael Furtman


© Photo: Peter Hudson

Requisite factors for spillover:

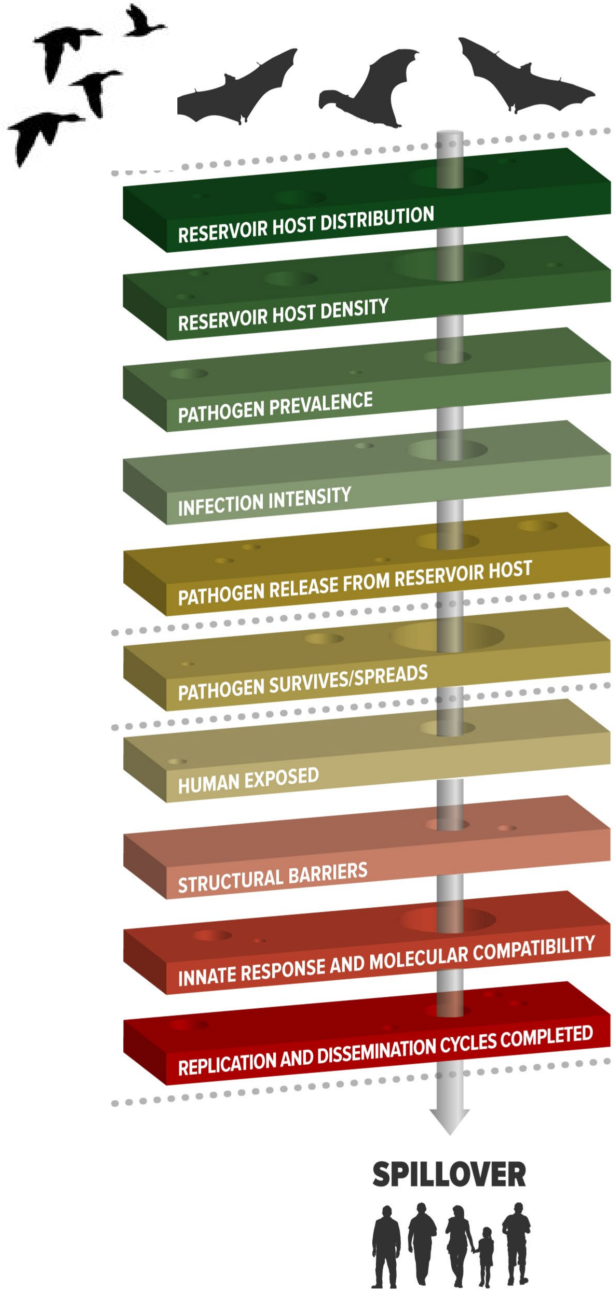




Plowright et al. 2017 *Nature Reviews Microbiology*

NATURE REVIEWS | MICROBIOLOGY

Requisite factors for spillover:

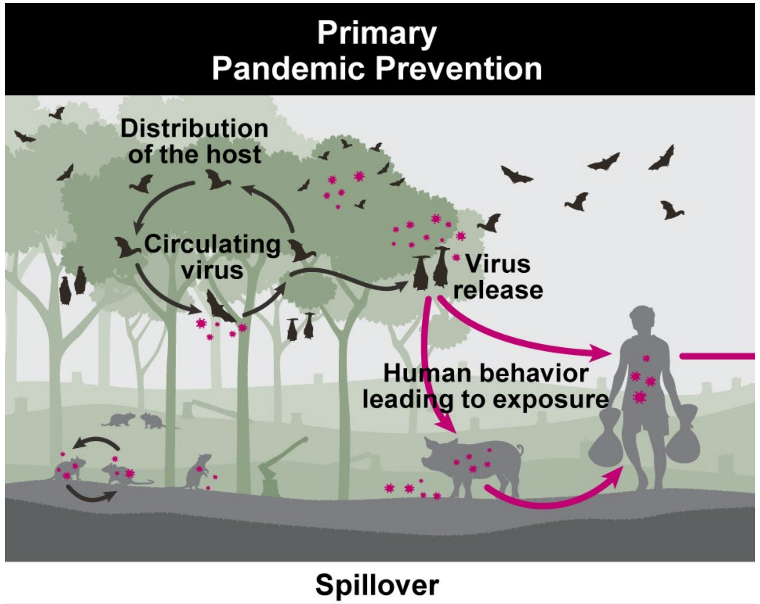


Host distribution

Pathogen Infection & shedding & survival

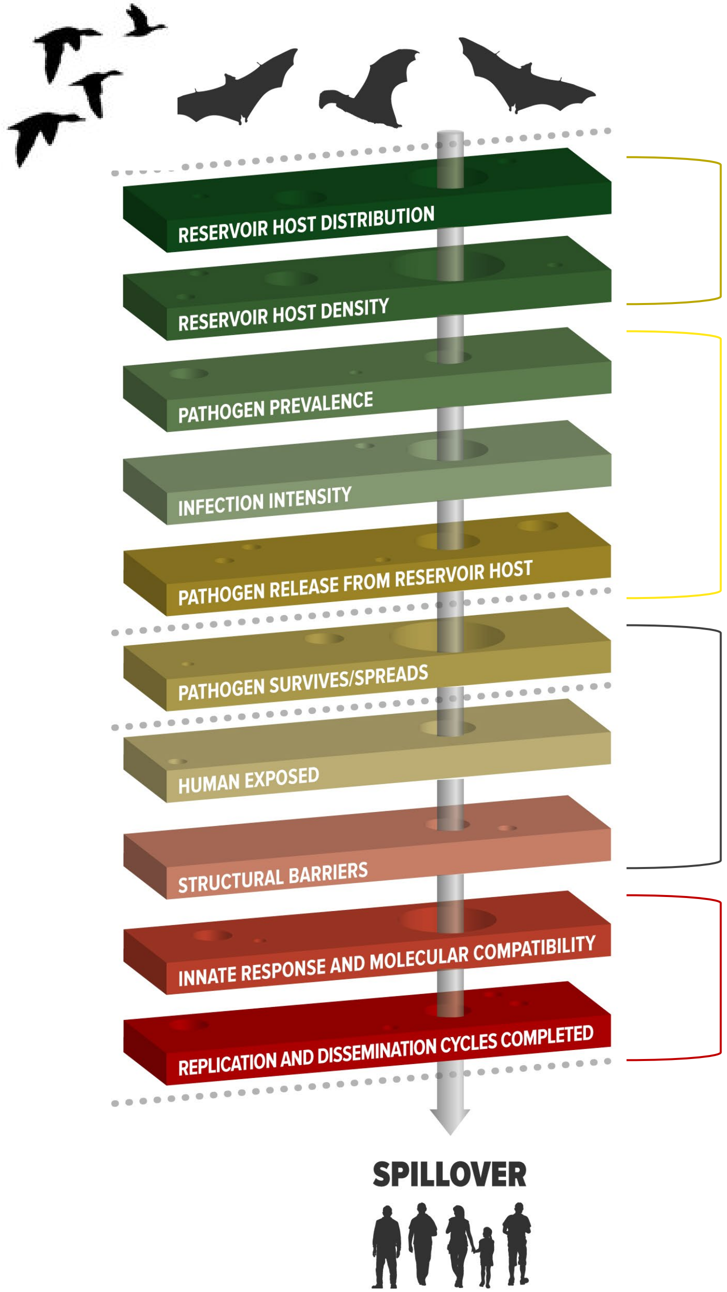
Behaviors that lead to exposure

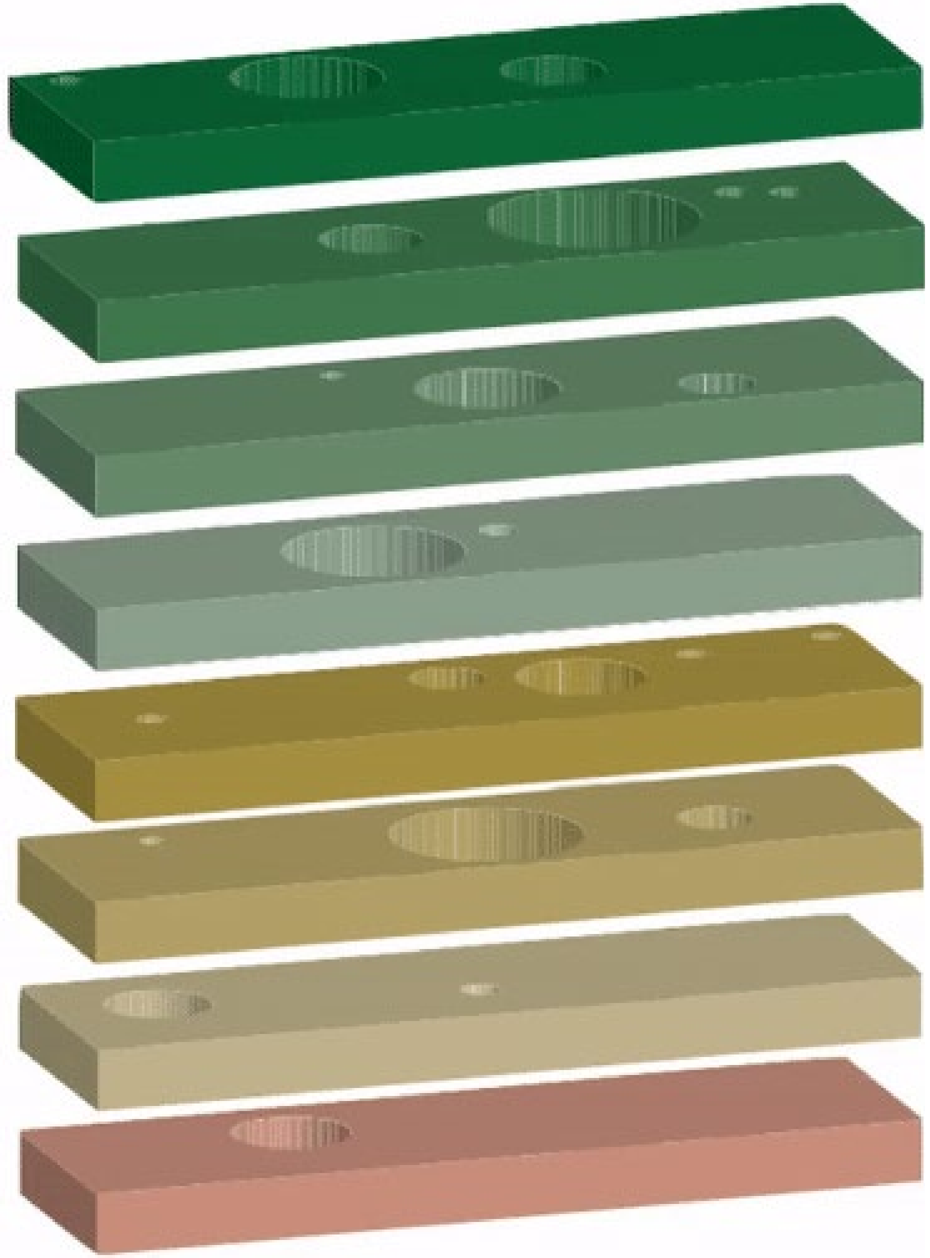
Compatibility of pathogen with recipient host



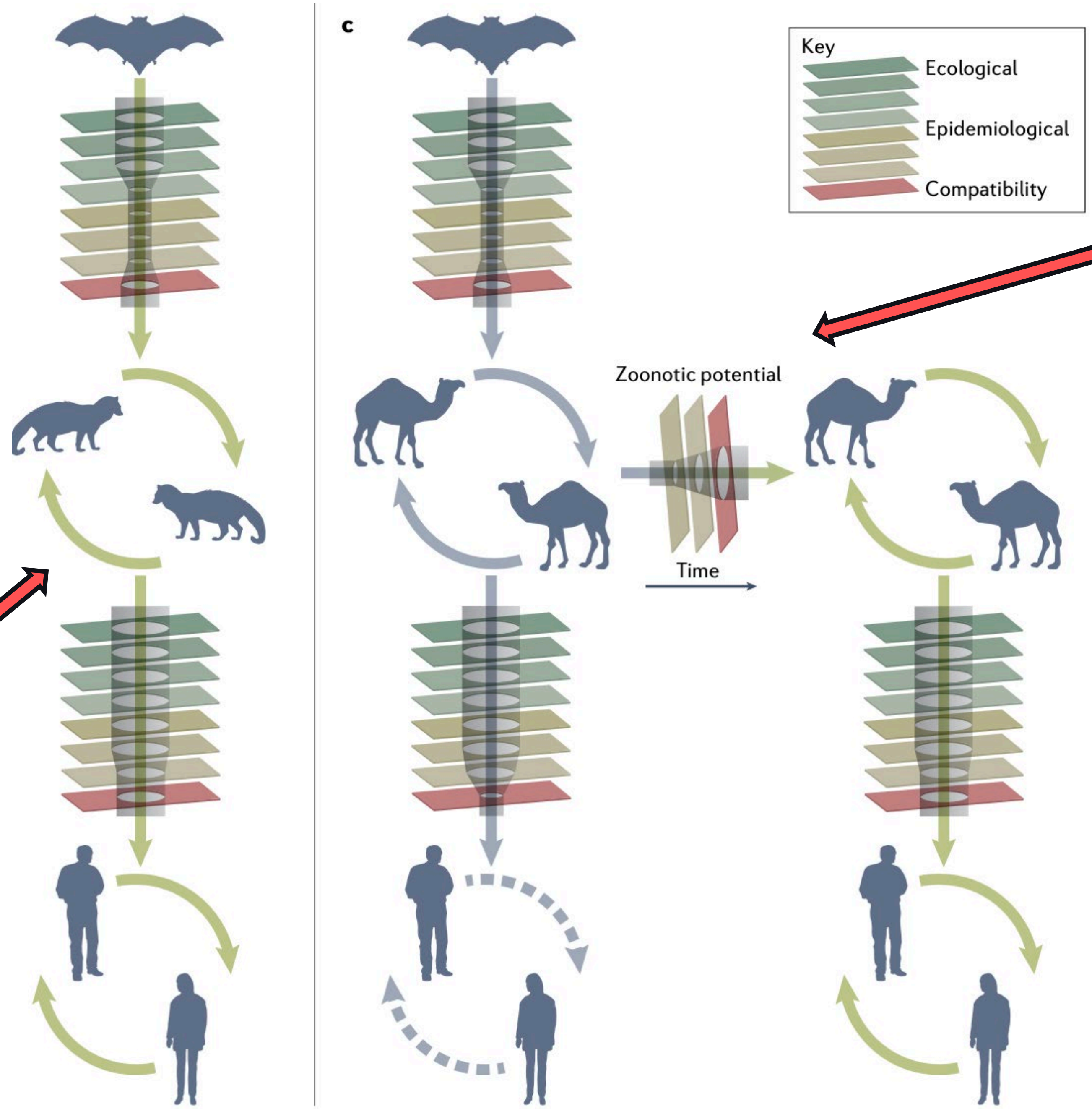
NATURE REVIEWS | MICROBIOLOGY

Plowright et al. 2017 *Nature Reviews Microbiology*





Plowright et al. 2017 *Nature Reviews Microbiology*

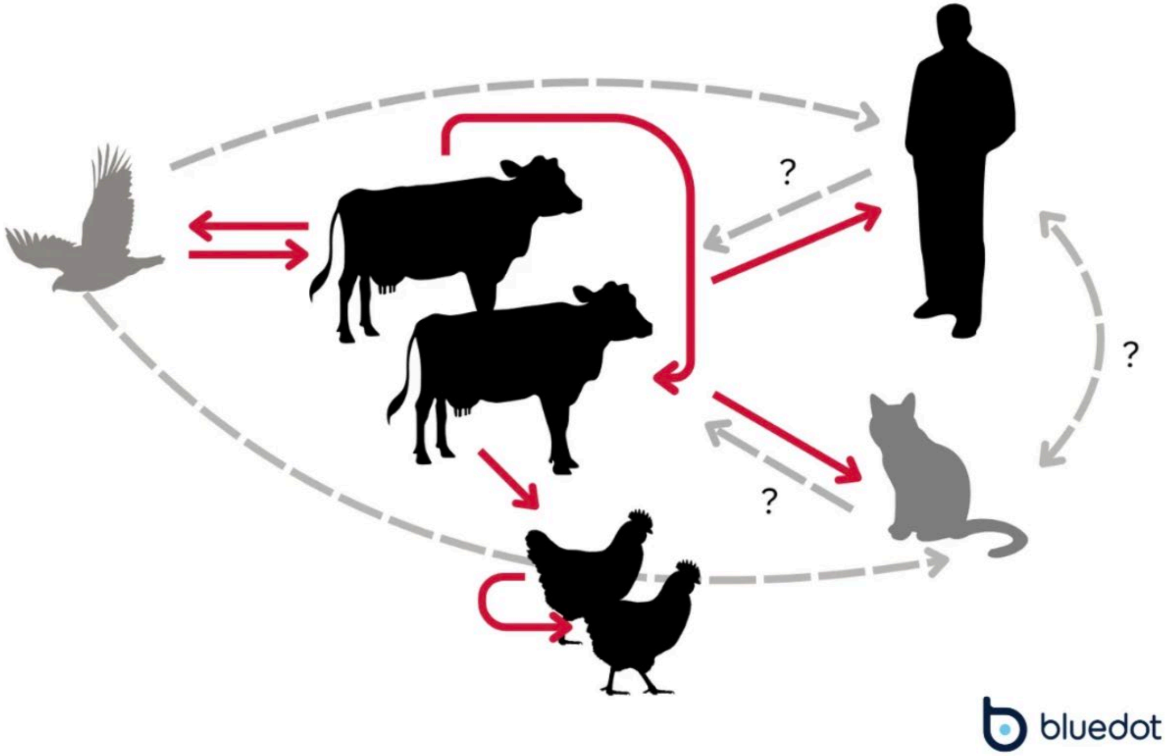


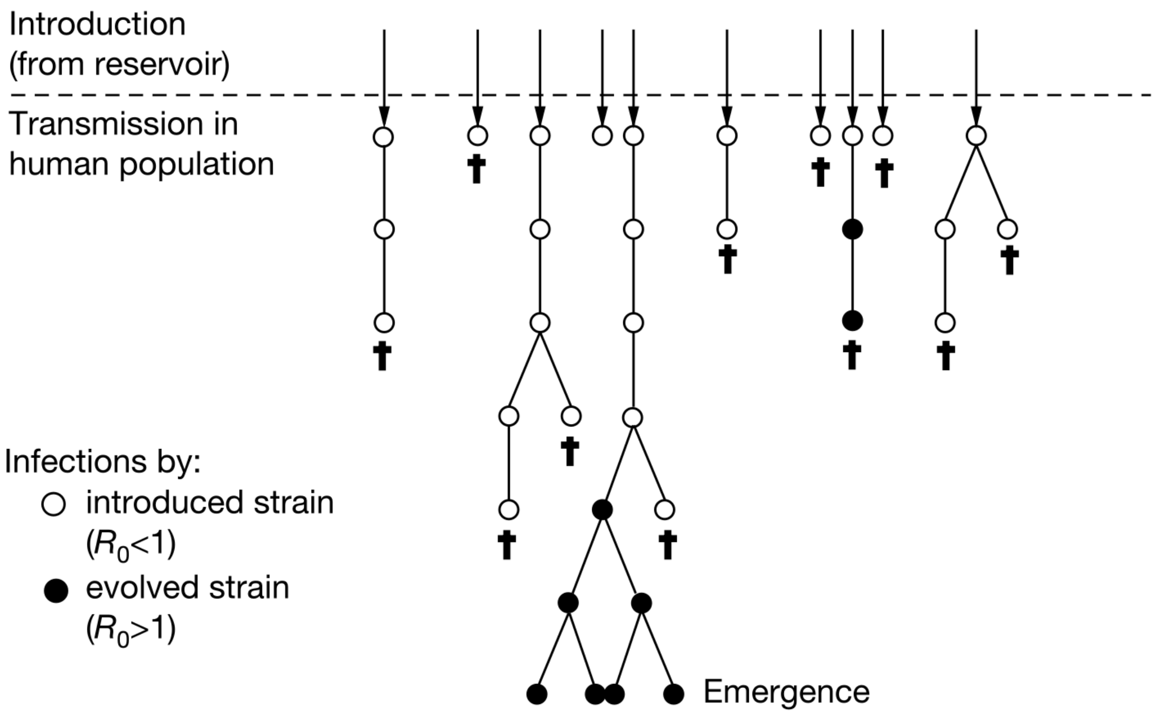
Virus evolves in bridging host to become supercritical in humans

Bridging host amplifies the virus, shedding high doses in proximity to humans

Ruiz-Aravena et al. 2021
Nature Reviews Micro

Chains of transmission and cross-species transmission events = opportunities for evolution





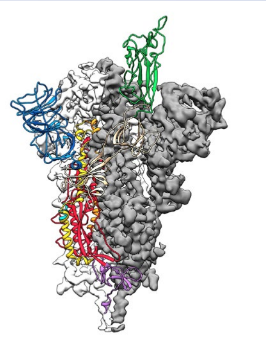
Source: https://bluedot.global/why-organizations-should-start-preparing-for-bird-flu-now/

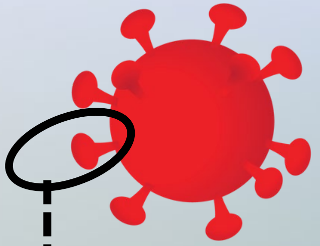
Antia et a. 2003 Nature

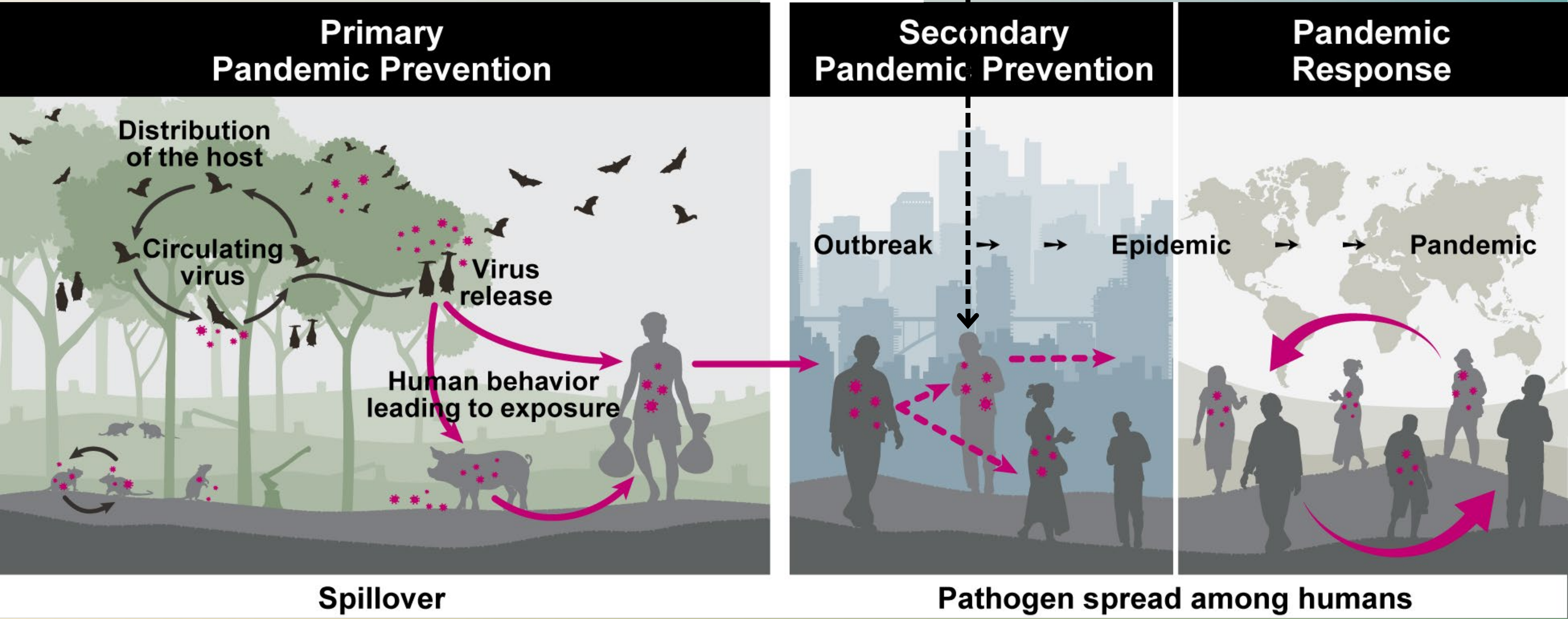
Can we prevent spillover at its source?

Photo: © Fer Arce

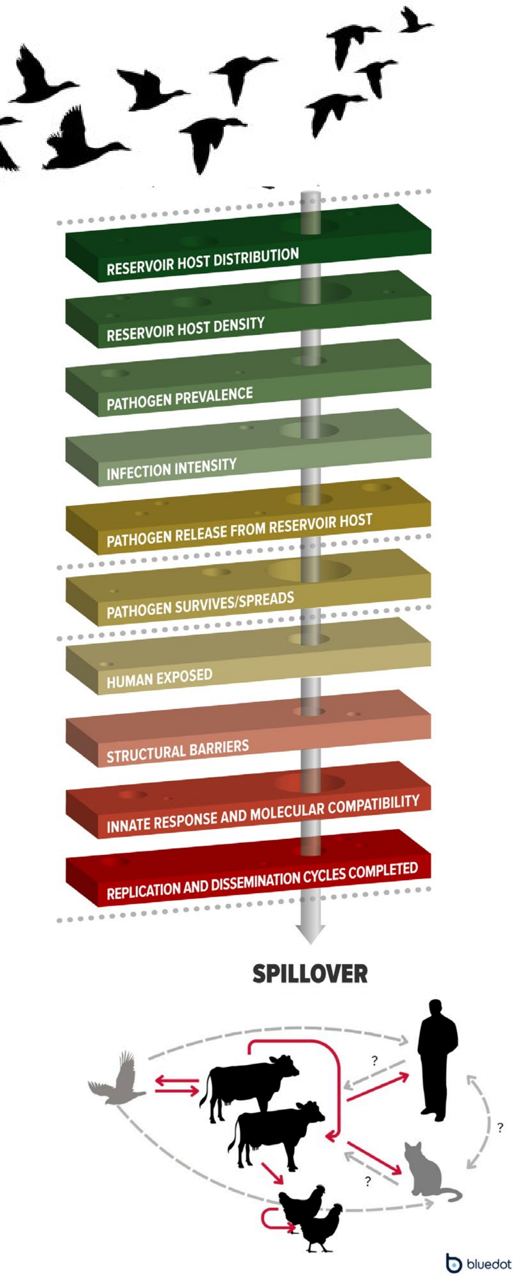
Until we invest in understanding spillover it will be a pipe dream







https://www.niaid.nih.gov/sites/default/files/prefusion%20spike.jpg

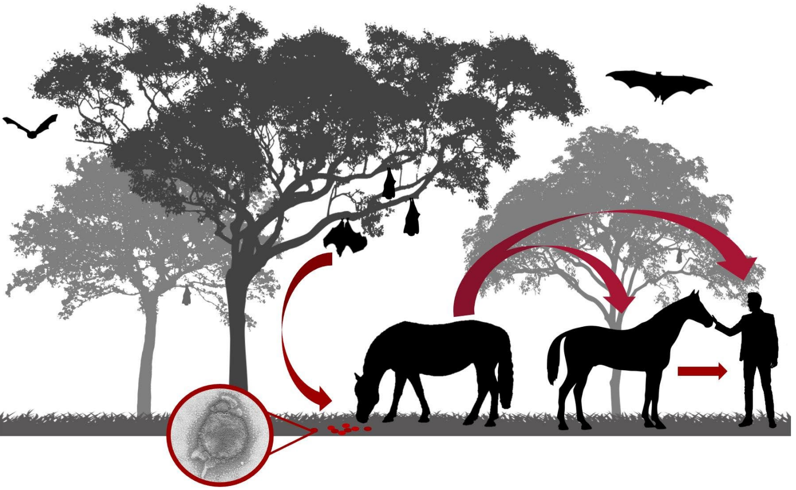


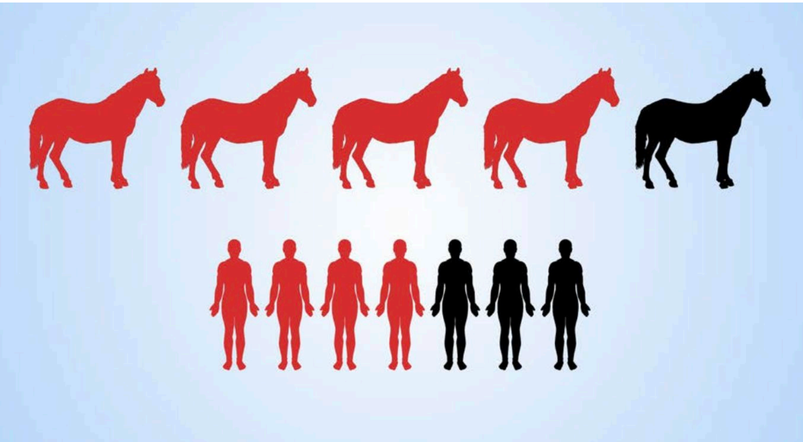
Missing research investments:

1. Investigate spillovers with a transdisciplinary One Health approach (immediately, because conditions that aligned are fleeting)

Online Coursera on One Health investigation of spillovers and outbreaks to be released in 2025 (led by Emily Gurley at Hopkins)

Hendra virus: transmission from fruit bats to horses, then humans in Eastern Australia

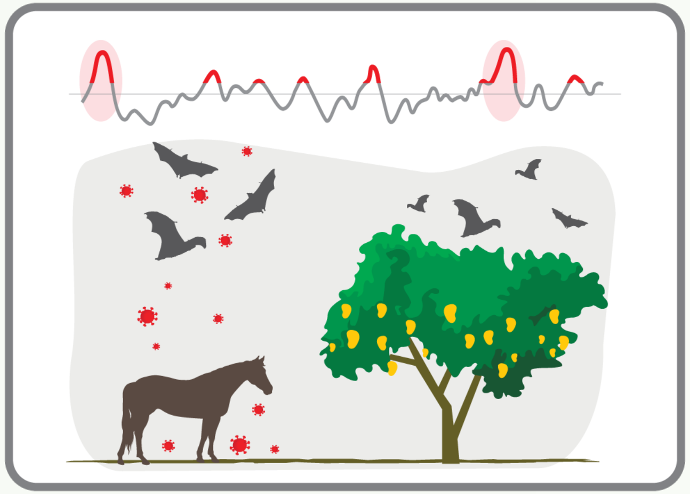


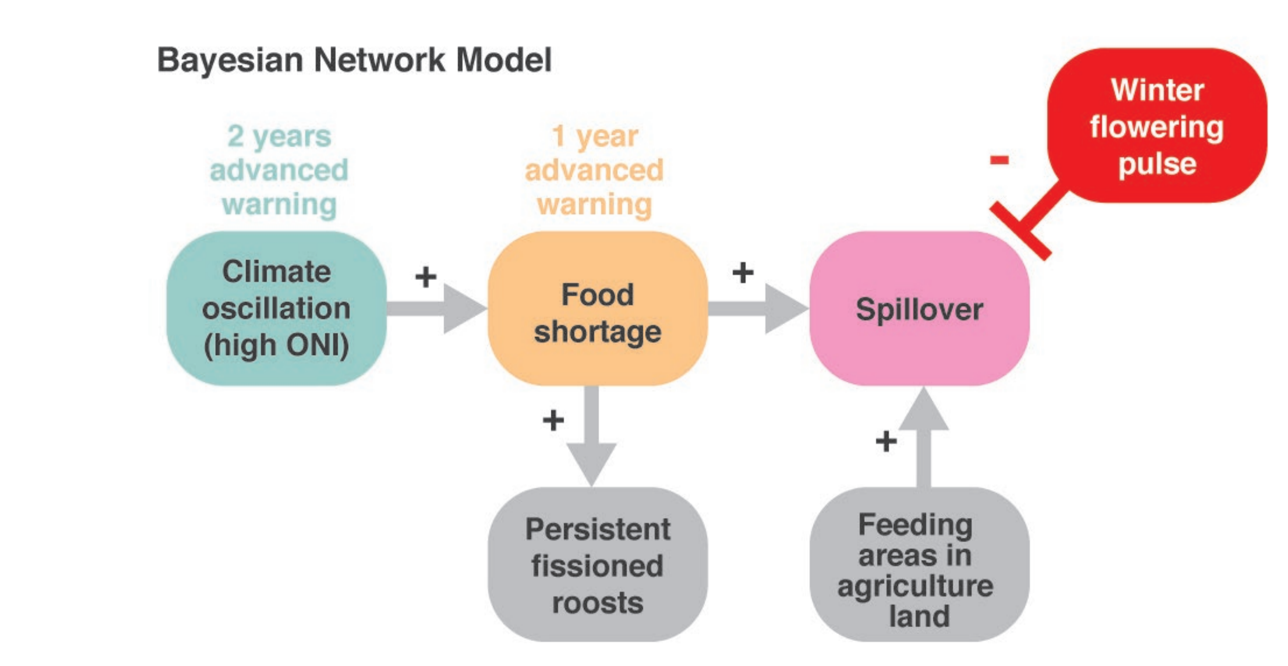


Spillover investigations: bats on affected horse properties were eating starvation avoidance foods


Photo: Doug Gimsey

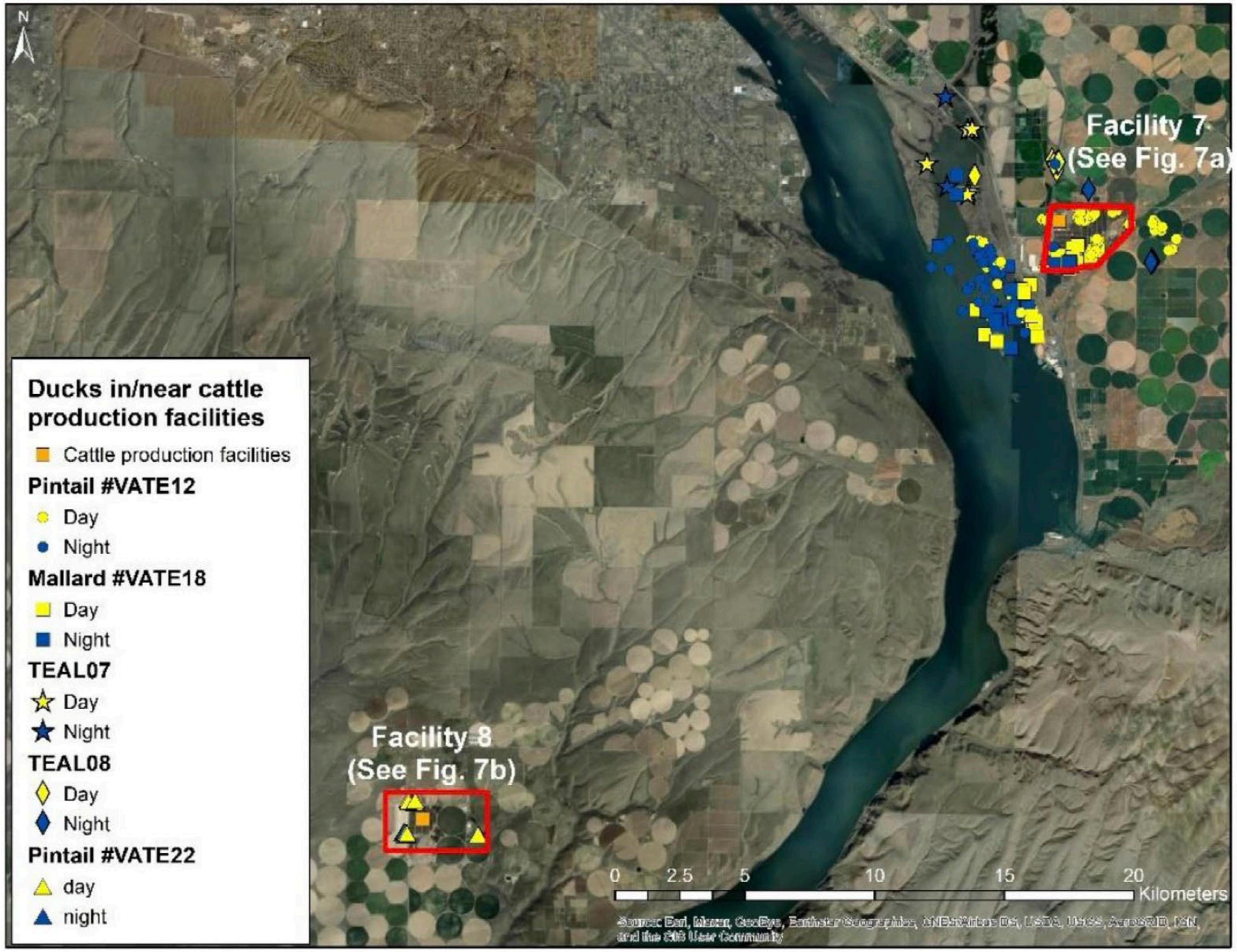

Peggy Eby





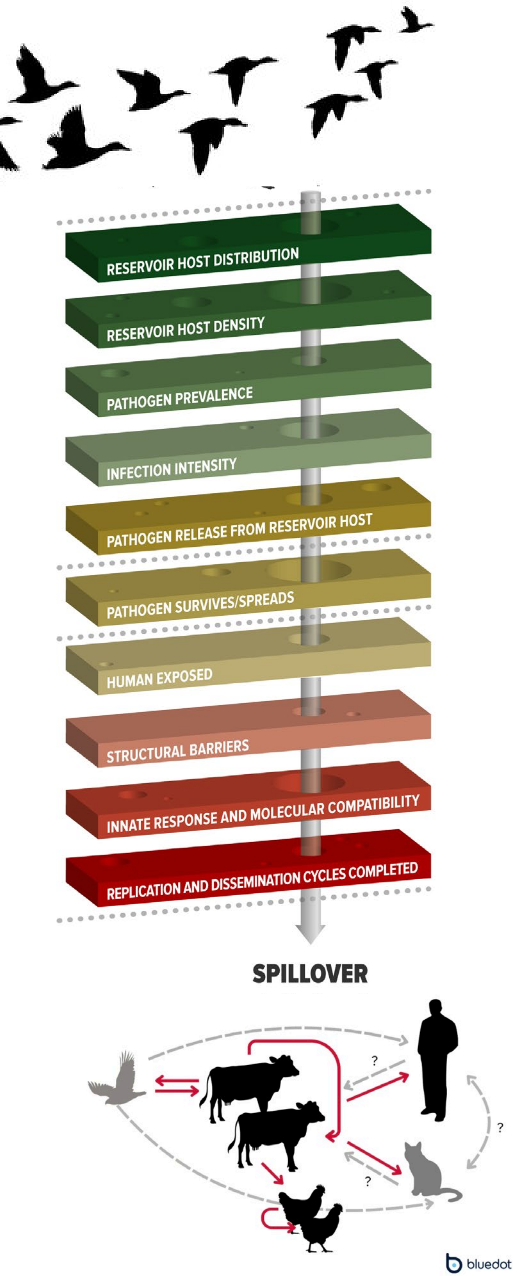
Eby et al. 2023 Nature

Ducks using cattle facilities in areas where wetlands have been destroyed



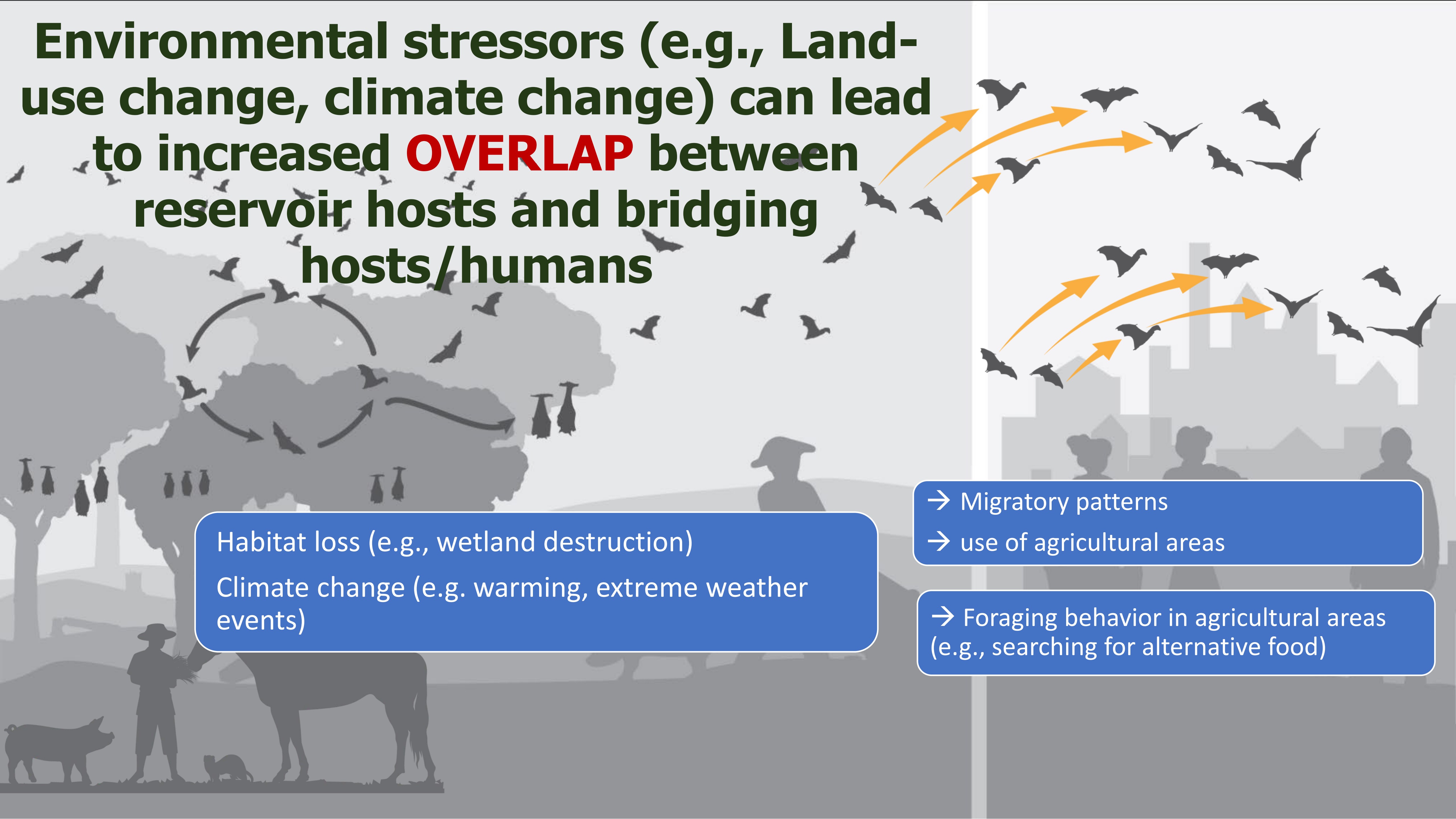
- Are we investigating the role of natural habitat in determining foraging distribution and behavior of migratory birds?

McDuie et al. 2021 Transboundary & Emerging Diseases

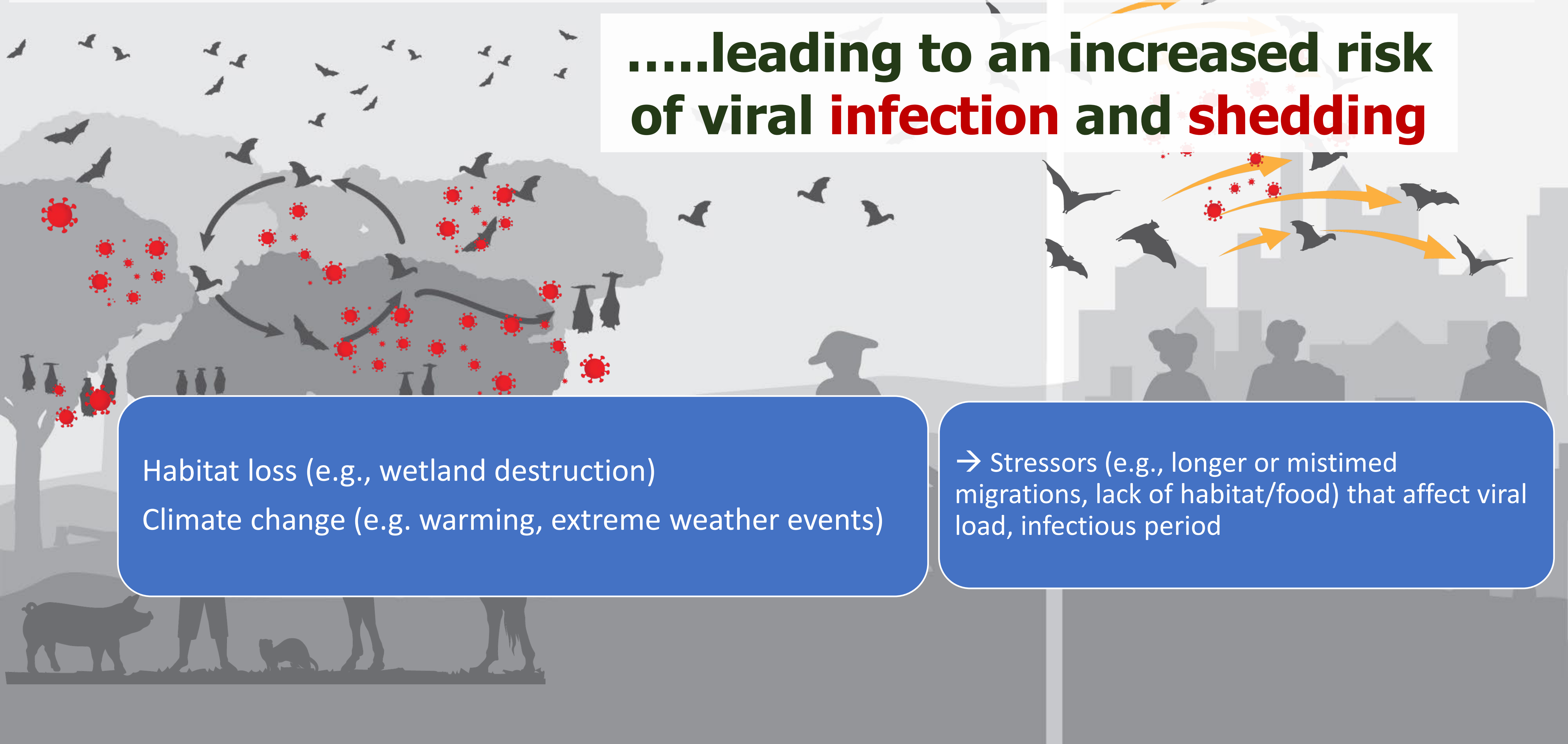


Missing research investments:

1. **Investigate spillovers** with a transdisciplinary One Health approach
2. **Investigate reservoir host ecology** (long-term, multi-scale studies)


Environmental stressors (e.g., Land-use change, climate change) can lead to increased OVERLAP between reservoir hosts and bridging hosts/humans
Habitat loss (e.g., wetland destruction)
Climate change (e.g. warming, extreme weather events)
→ Migratory patterns
→ use of agricultural areas
→ Foraging behavior in agricultural areas (e.g., searching for alternative food)

Environmental stressors can lead to increased **stress** and decreased **energy** available…

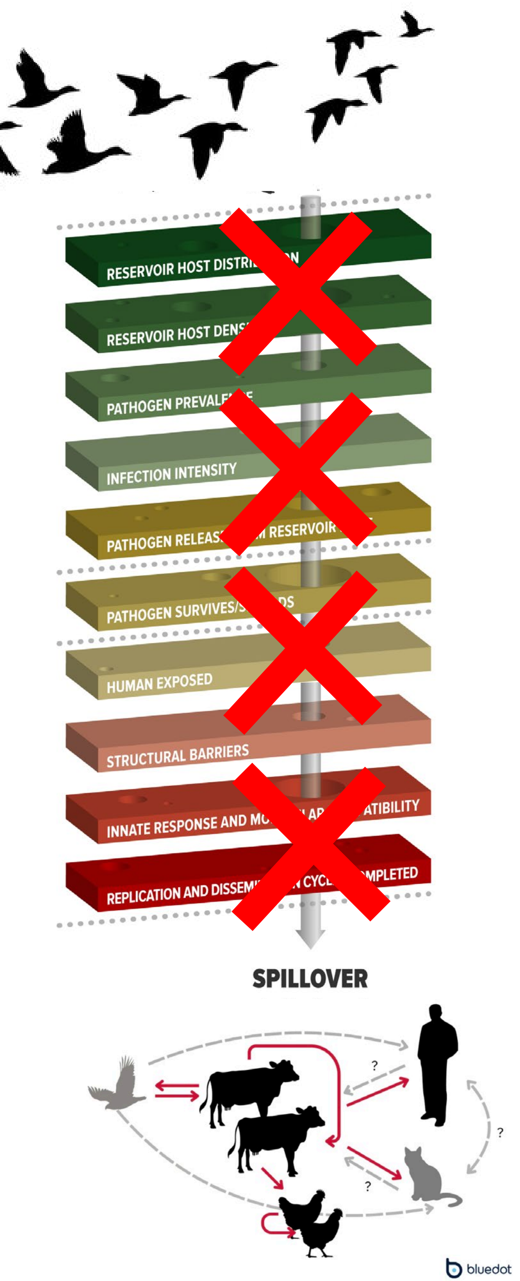


…..leading to an increased risk of viral **infection** and **shedding**

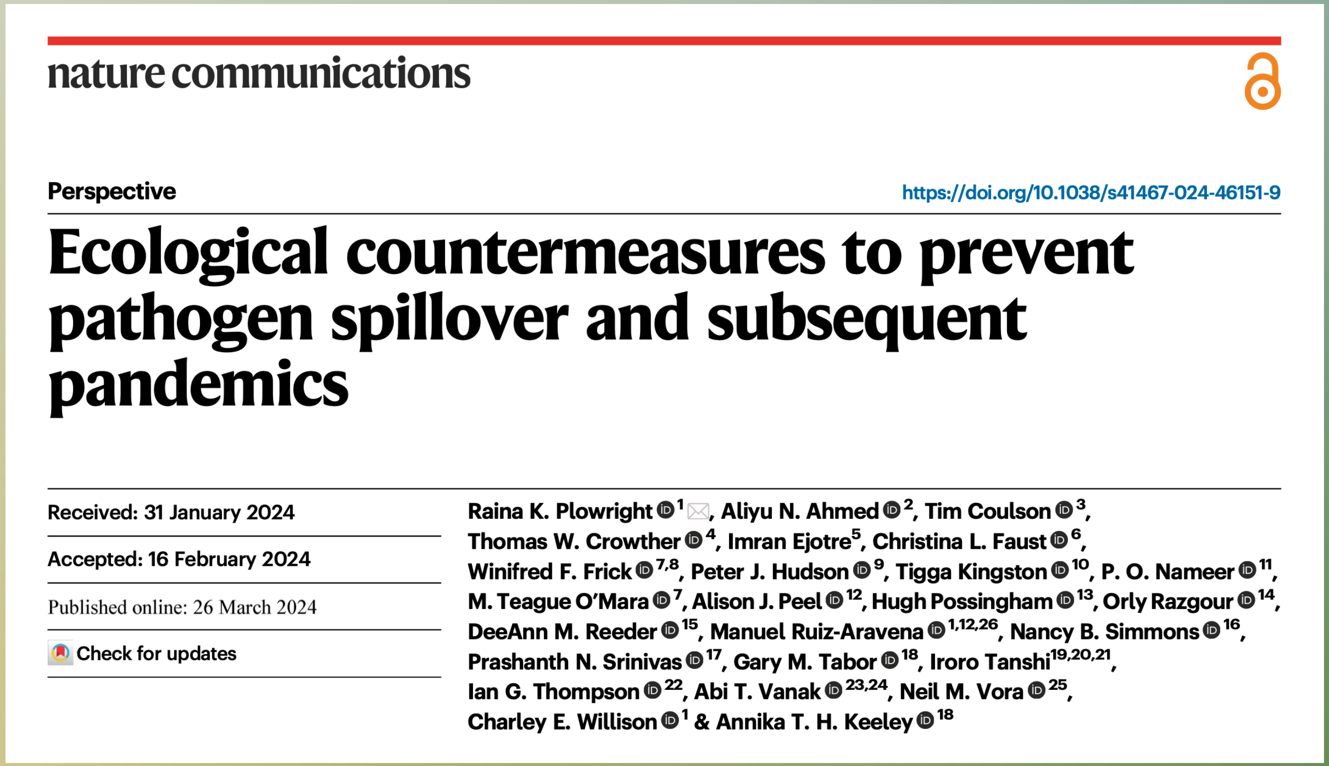
Habitat loss (e.g., wetland destruction)

Climate change (e.g. warming, extreme weather events)

→ Stressors (e.g., longer or mistimed migrations, lack of habitat/food) that affect viral load, infectious period



Understanding how spillover happens and what drives it leads to new solutions that can be combined with traditional approaches to prevent and respond to pandemics


nature communications

Perspective
https://doi.org/10.1038/s41467-024-46151-9

Ecological countermeasures to prevent pathogen spillover and subsequent pandemics

Received: 31 January 2024
Accepted: 16 February 2024
Published online: 26 March 2024
Check for updates

Raina K. Plowright[1], Aliyu N. Ahmed[2], Tim Coulson[3], Thomas W. Crowther[4], Imran Ejotre[5], Christina L. Faust[6], Winifred F. Frick[7,8], Peter J. Hudson[9], Tigga Kingston[10], P. O. Nameer[11], M. Teague O'Mara[7], Alison J. Peel[12], Hugh Possingham[13], Orly Razgour[14], DeeAnn M. Reeder[15], Manuel Ruiz-Aravena[1,12,26], Nancy B. Simmons[16], Prashanth N. Srinivas[17], Gary M. Tabor[18], Iroro Tanshi[19,20,21], Ian G. Thompson[22], Abi T. Vanak[23,24], Neil M. Vora[25], Charley E. Willison[1] & Annika T. H. Keeley[18]

Thank You

JOURNAL OF CLINICAL MICROBIOLOGY, May 1991, p. 985–989
0095-1137/91/050985-05$02.00/0

Vol. 29, No. 5

Isolation of *Escherichia coli* Serotype O157:H7 and Other Shiga-Like-Toxin-Producing *E. coli* from Dairy Cattle

J. G. WELLS,[1*] L. D. SHIPMAN,[2] K. D. GREENE,[1] E. G. SOWERS,[1] J. H. GREEN,[1] D. N. CAMERON,[1] F. P. DOWNES,[3] M. L. MARTIN,[4] P. M. GRIFFIN,[1] S. M. OSTROFF,[5] M. E. POTTER,[1] R. V. TAUXE,[1] AND I. K. WACHSMUTH[1]

Division of Bacterial Diseases[1] and Division of Viral Diseases,[5] Center for Infectious Diseases, and Division of Birth Defects and Developmental Disabilities, Center for Environment Health and Injury Control,[4] Centers for Disease Control, Atlanta, Georgia 30333; Veterinary Services, U.S. Department of Agriculture, Harrisburg, Pennsylvania 17110[2]; and Michigan Department of Public Health, Lansing, Michigan 48909[3]

Received 16 August 1990/Accepted 1 February 1991

We examined 1,266 fecal specimens from healthy cattle during the investigations of two sporadic cases of hemolytic uremic syndrome associated with raw milk consumption and an outbreak of gastroenteritis and hemolytic uremic syndrome caused by *Escherichia coli* serotype O157:H7. We collected specimens from heifers, calves, and adult cows on 22 farms, in a stockyard, and in a packing house. We also collected 3 raw hamburger specimens from a restaurant and 23 raw milk samples from two farms. All specimens were examined for *E. coli* O157:H7 by using sorbitol-MacConkey agar, H immobilization, O157 agglutination, and tissue culture cytotoxicity. *E. coli* O157:H7 was isolated from 16 heifers or calves and 1 adult cow on 22 farms, 1 stockyard calf, 2 beef specimens, and 1 raw milk sample. Selected fecal specimens were also examined for the presence of other Shiga-like-toxin-producing *E. coli* (SLTEC) by testing polymyxin B extracts of colony sweeps and then testing individual colonies for toxin production. SLTEC other than O157 was isolated from 8 of 10 farms investigated and from the stockyard; 8% of adult cows and 19% of heifers and calves were positive for SLTEC. Several animals were positive for SLTEC by colony sweep only. This investigation demonstrates that dairy cattle are a reservoir of *E. coli* O157:H7 and other SLTEC.

Escherichia coli serotype O157:H7, which produces Shiga-like toxin (SLT), also known as verocytotoxin, is a known cause of hemorrhagic colitis and hemolytic uremic syndrome (HUS). It is capable of causing the full spectrum of disease, ranging from asymptomatic carriage to HUS and thrombotic thrombocytopenic purpura (11). Consumption of raw milk and ground beef has been linked epidemiologically with several outbreaks of disease caused by *E. coli* O157:H7 (3, 12, 25, 28), and the outbreak strain has been recovered from implicated beef products in two outbreaks (12, 28). In 1986, we isolated *E. coli* O157:H7 from the feces of young cattle on dairy farms associated with two cases of HUS associated with raw milk consumption (18). During a milk-borne outbreak of gastroenteritis and HUS caused by *E. coli* O157:H7 in Canada, the organism was recovered from the feces of patients and from the feces of young cattle in dairy herds associated with the outbreak (3). Other SLT-producing *E. coli* (SLTEC) isolates have also been associated with dairy cattle (5a, 22). Although *E. coli* O157:H7 has been cultured from a variety of retail meat products (7), dairy cattle, a source of both raw milk and beef products, are a likely reservoir. We explored the possible role of dairy cattle in SLTEC-associated disease during the epidemic investigation of an outbreak of hemorrhagic colitis, HUS, and thrombotic thrombocytopenic purpura associated with beef consumption in Washington State (25) and a more detailed investigation conducted of the dairy farms associated with the two sporadic cases of HUS associated with raw milk consumption in Wisconsin (18).

* Corresponding author.

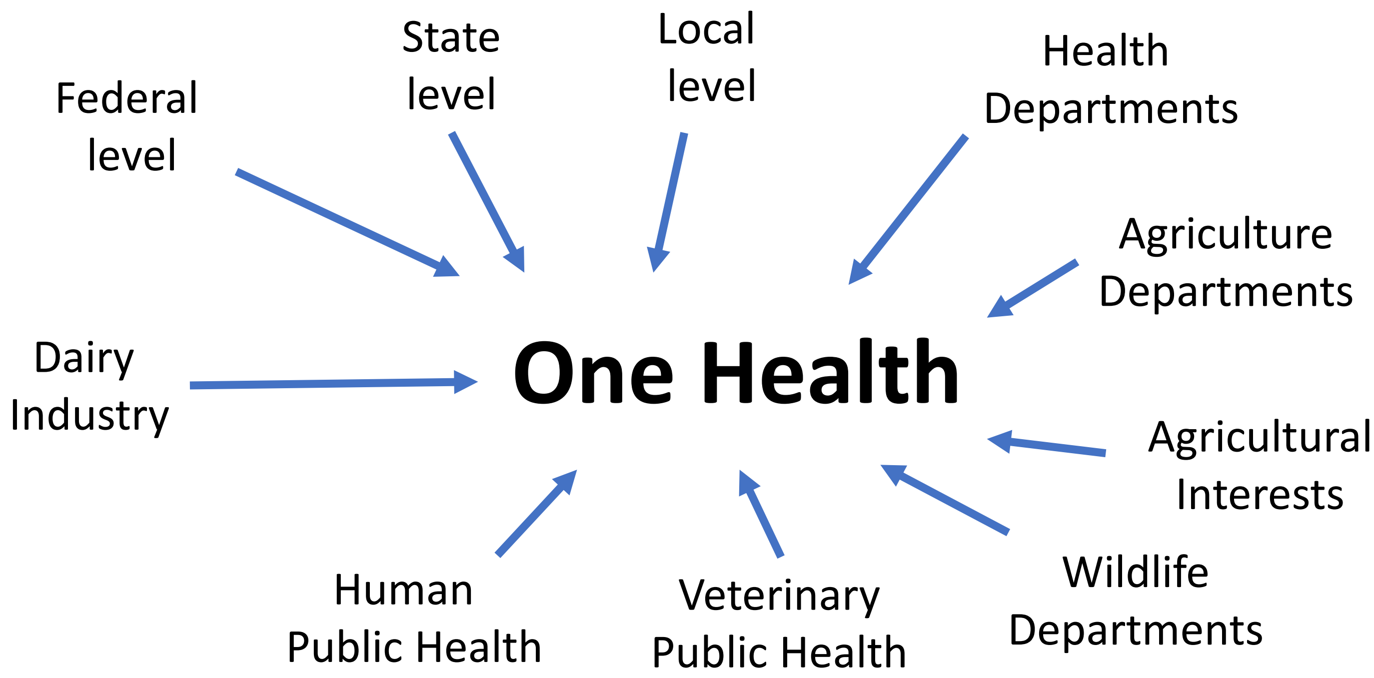
MATERIALS AND METHODS

We examined 1,266 fecal specimens from healthy dairy cattle during the two investigations. Animals younger than 4 months were classified as calves, those from ages 4 to 24 months were classified as heifers, and those older than 24 months were classified as adults. In the Wisconsin investigation, fecal specimens were collected from 438 adult cows and 262 heifers and calves from the 2 farms with which the two HUS cases were associated, a dairy farm adjacent to those farms, 10 control dairy farms in the area, and a stockyard that received cattle from that region. Specimens obtained from the two case farms were collected during two visits, 3 weeks apart. Specimens obtained from the adjacent farm, control farms, and stockyard were collected during the second visit. Twenty-three raw milk specimens were also collected from the two case farms during the second visit. In the Washington State outbreak, specimens were collected from 224 adult cows and 342 heifers and calves on nine farms (eight in southwest Washington, one in Oregon) from which the implicated meat could have originated and from the packing house that processed the meat from those farms. Three suspect raw hamburger specimens were also examined. In both investigations, additional specimens were collected up to 50 days after the first sampling from animals that were initially positive for *E. coli* serotype O157 to determine the length of excretion. In Wisconsin, 108 heifers and calves from two of the farms and the stockyard were examined 1 year later; with the exception of one heifer that was initially positive and tested again, samples were not previously obtained from any of the animals.

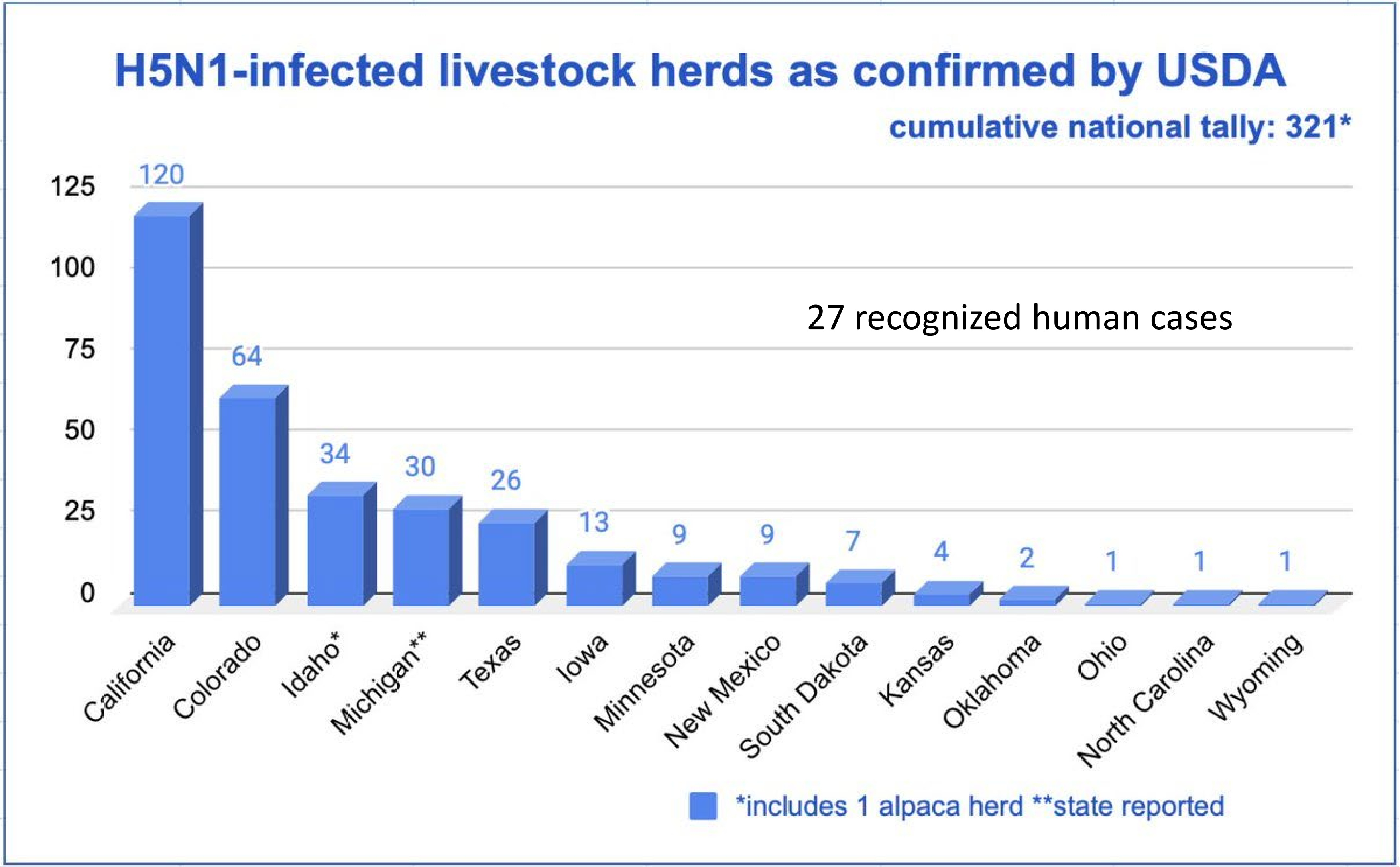
Swabs from stool specimens were placed in the medium described by Cary and Blair (4) and held at −70°C until examination. The stool swabs collected from 566 animals during the Washington State investigation and specimens

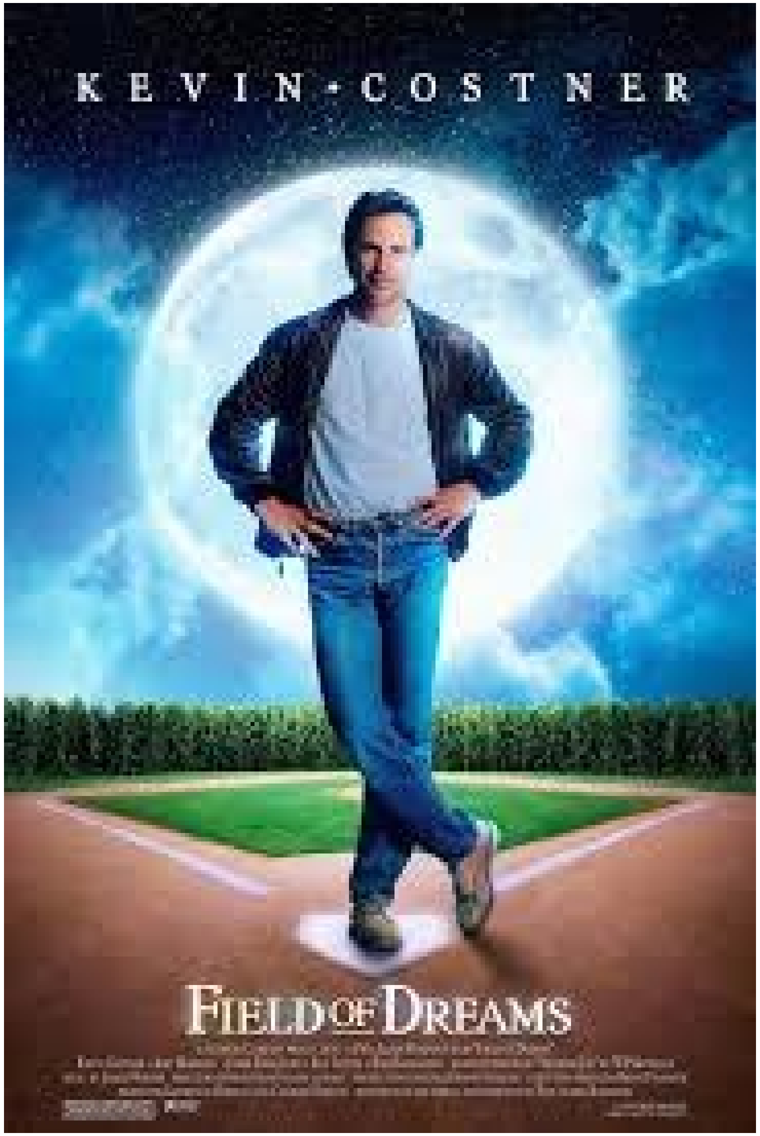
Potential Explanations for Limited Cooperation

- Dairy community does not feel this is as great a threat as we do
  - Transient impact on dairy cattle and herds
  - Illness among workers mild to moderate
- Financial concerns
- Distrust of/antagonism towards authority
  - Especially post-Covid
- Misinformation



- With HPAI H5N1, suboptimal cooperation can result in "**no health**"
- Some notable exceptions to the rule, e.g. Michigan
- But one health needs to be the rule, rather than the exception


H5N1-infected livestock herds as confirmed by USDA
cumulative national tally: 321*
27 recognized human cases
125
100
75
50
25
0
120
64
34
30
26
13
9
9
7
4
2
1
1
1
California
Colorado
Idaho*
Michigan**
Texas
Iowa
Minnesota
New Mexico
South Dakota
Kansas
Oklahoma
Ohio
North Carolina
Wyoming
*includes 1 alpaca herd **state reported



“If we build it,
they will come.”

Gaps in National H5N1 Priorities Implementation Research

- Only reference under human health component:
  - *Evaluate strategies to increase uptake of possible health interventions such as diagnosis, treatments and vaccines*
- Implementation research will require studies:
  - Identify reasons for non-cooperation
  - Strategies to promote cooperation
  - Evaluation of these strategies
  - Refinement as needed

Gaps in National H5N1 Priorities
Animal Health

- Potential reinfection in cows and other mammals
  - How much herd immunity is needed to protect a dairy herd?
  - Will previously infected cows need to be vaccinated?
- Companion animals (e.g. cats, ferrets):
  - Exposure to raw pet foods
  - Exposure to raw milk
  - Risk to humans

Gaps in National H5N1 Priorities
Human Health

- Surveillance for conjunctivitis in addition to ILI and ARI
- Vaccine:
  - *Research universal and supra-seasonal vaccines that incorporate broadly conserved immunogens into existing seasonal vaccine to mitigate impact during the time needed to develop and deploy a matched vaccine*
  - Quadrivalent seasonal vaccine now trivalent
  - Add H5 antigen into seasonal vaccine
    - Assess immunogenicity and safety
    - Potential trials in hi-risk individuals