Major enhancement of U.S. swine industry biosecurity: How on-farm biosecurity, pig and vehicle movement may explain between-farm disease dissemination?

CBTS Distinguished Speaker Series

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NC STATE UNIVERSITY
COLLEGE OF VETERINARY MEDICINE

Table of content

What we do!

1. Studying routes of between-farm disease transmission *main goal* in the targeting control strategies to minimize the spread of disease.

2. Emphasis on the *role of farm-level biosecurity* on disease transmission.

Motivation

National Bio and Agro-Defense

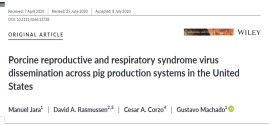
DHS FACT SHEET

on National Security Memorandum-16 on Strengthening the Security and Resilience of United States Food and Agr

On November 10, President Biden signed National Security Memorandum-16 (NSM-16) on Strengthening the Security and Resilience of United States Food and Agriculture. The NSM assigns key roles to the U.S. Department of Homeland Security (DHS) related to overall strategic guidance and enhancing national unity of effort. DHS, in coordination with the U.S. Department of Agriculture, the U.S. Department of Health and Human Services, the U.S. Department of ....

- Enhanced protection of food and agriculture critical infrastructure and associated supply chains;
- Mitigation and defense against the introduction of high consequence pests and animal or plant diseases;
- Strengthened agro-defense, food defense, and food protection efforts; and
- Improved intelligence gathering, data analysis, and information sharing.

Previous research swine disease spread



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What do we know about farm-to-farm pig disease transmission?

1. Approximately 80 % of between-farm transmission (swine diseases) are ”driven” by the movement of animals. [4, 7, 6, 5].

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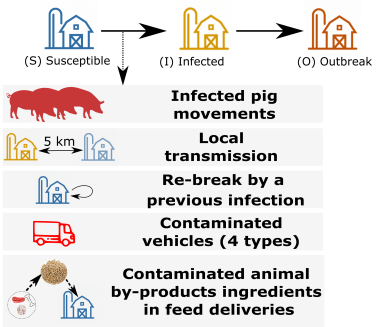
   - The contribution of other routes remains mainly unknown... e.g., vehicles.
   - **The contribution of on-farm biosecurity in reducing the force of transmission remains a major gap.**

Major modes of between-farm transmission

Transmission is driven by contact and time.



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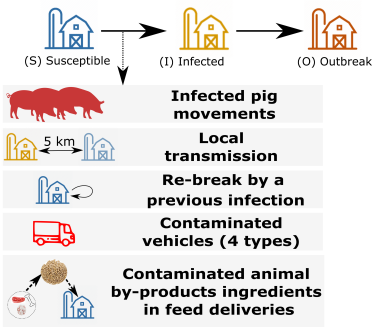

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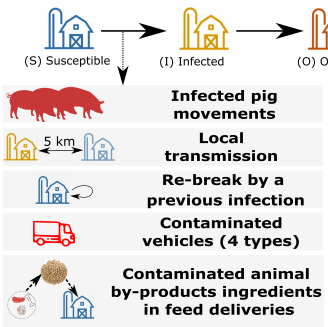

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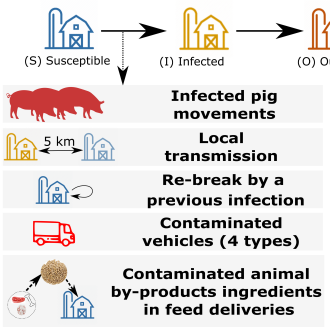

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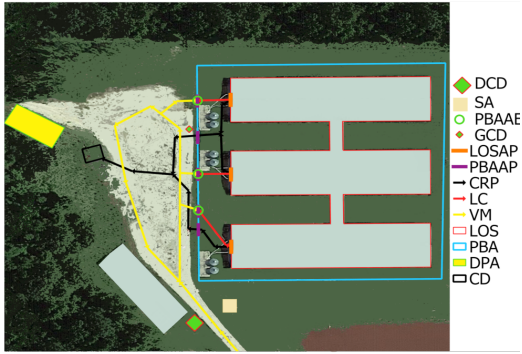
- On-farm biosecurity (directly manageable???).

On-farm biosecurity



Legend	Symbol	Legend	Symbol
LOSAE (LOS Animal Emergency)		PBAAP (PBA Access Point)	
SE (Site Entry)		LOSAP (LOS Access Point)	
PBAAE (PBA Access Entry, animals only)		CRP (Carcasses Removal Pathways)	
DCD (Designated Cleaning and Disinfection vehicle station)		VM (Vehicle Movements)	
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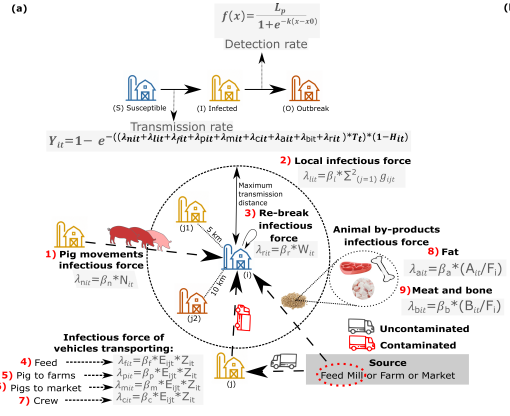
ADU (Dumpster for dead animals)		LOS (Line of Separation)	
TD (Trash Dumpster)		DPA (Designated Parking Area)	
SA (Supply drop-off Area)		CD (Carcasses Disposal location/ADU box)	

Methods

How can test/simulate for the effectiveness of such countermeasures?



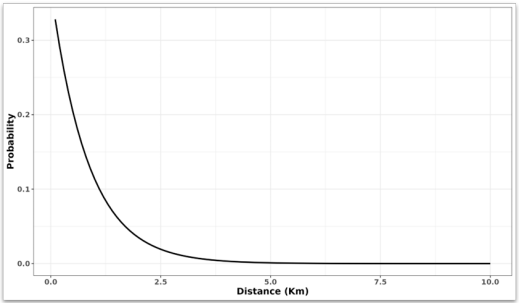
(b) Model parameters

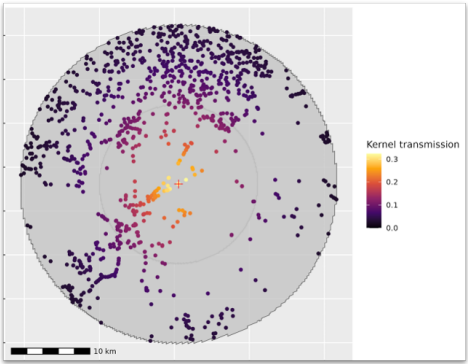
- β_n = Transmission rate of between farm pig movements
- β_l = Local transmission rate
- β_r = Re-break rate
- β_f = Transmission rate of between farm movements of vehicles transporting feed
- β_p = Transmission rate of between farm movements of vehicles transporting pig to farm
- β_m = Transmission rate of between farm movements of vehicles transporting pig to market
- β_c = transmission rate of between farm movements of vehicles transporting crew to farms
- β_a = Fat in the delivered feed rate
- β_b = Meat and bone in the delivered feed rate
- N = Number of asymptomatic and infected farms that sent pigs to "i"
- g = Gravity model with barrier effect
- E = Edge weight
- Z = Time vehicle stay on the farm
- A = Amount of fat in the meal
- B = Amount of meat and bone in the meal
- F = Pig population in the farm
- W = Re-break probability based on the time after last outbreak
- T = Monthly seasonality index
- H = Biosecurity index
- L = Detection probability
- x0 = Average time detection
- x = Time post virus introduction
- k = Logistic growth rate

PigSpread [2, 1, 3, 4]

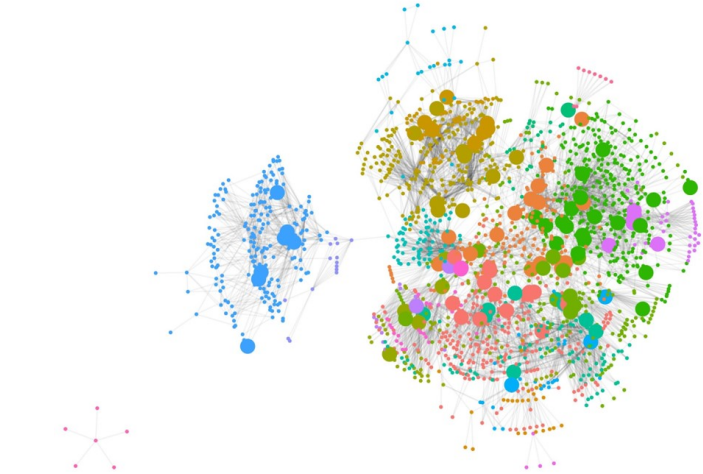
Methods

1. Local transmission–farm-to-farm proximity, *most intriguing questions!!?*



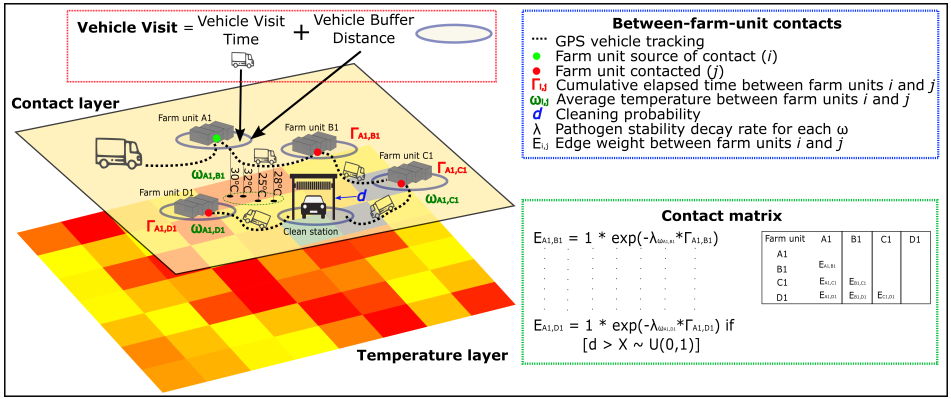


2. Between-farm animal movements also remain to be fully understood



2 years of pig network

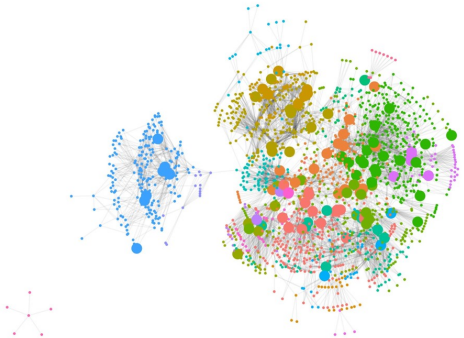
3. Vehicle networks (GPS data) how we are utilizing it



Results

What we found?

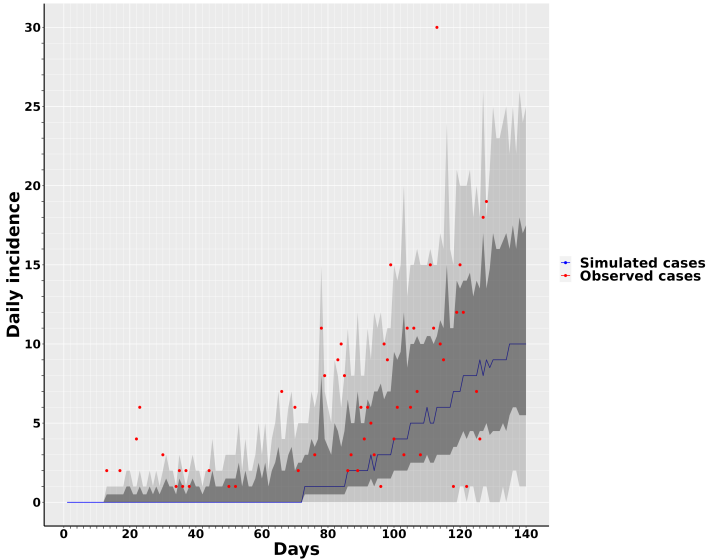
Transportation vehicles vs. between-farm animal movement



Pigs

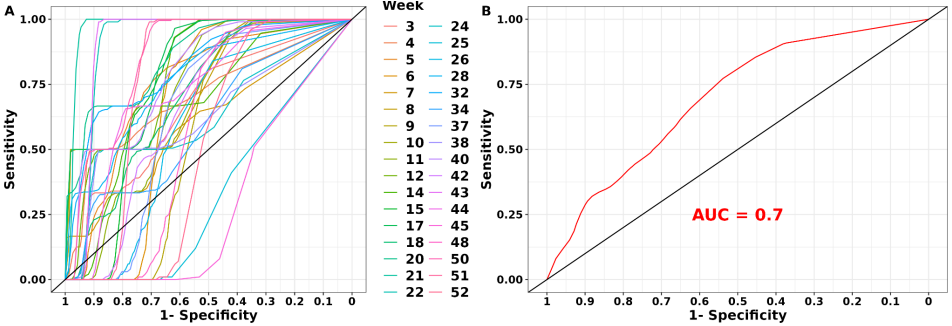
Trucks (100 x more connected)

PigSpread model performance



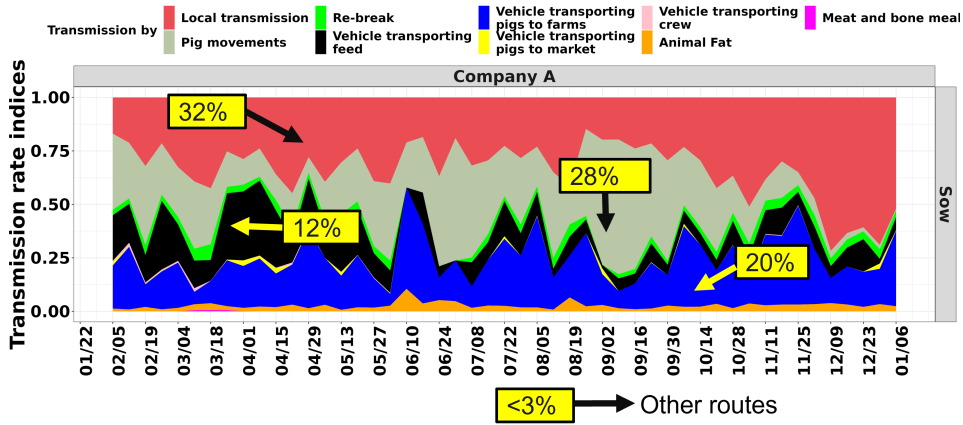
PigSpread: good at making predictions?

The average sensitivity and specificity for the weekly forecasts (PRRSV).



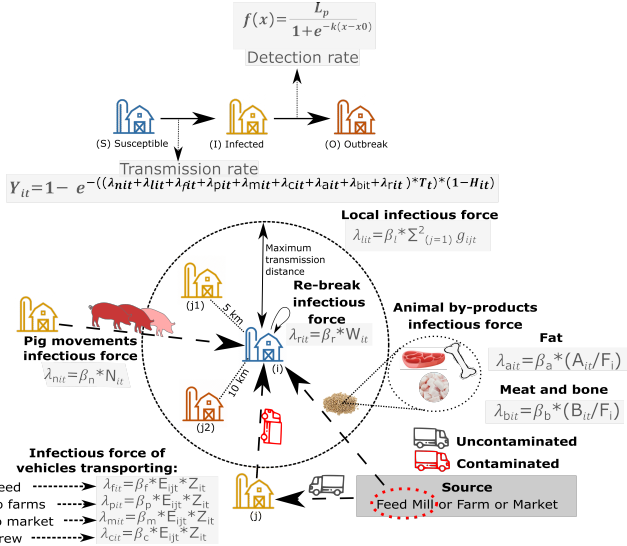
PigSpread: contribution of each route

Percentage contribution of transmission routes (PRRSV).



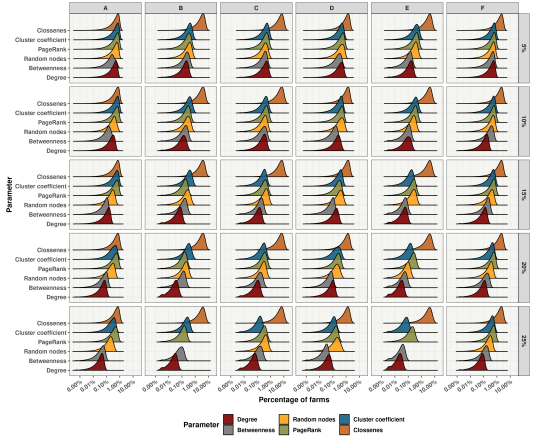
Interventions

Farm level model with countermeasures via PigSpread 2.0



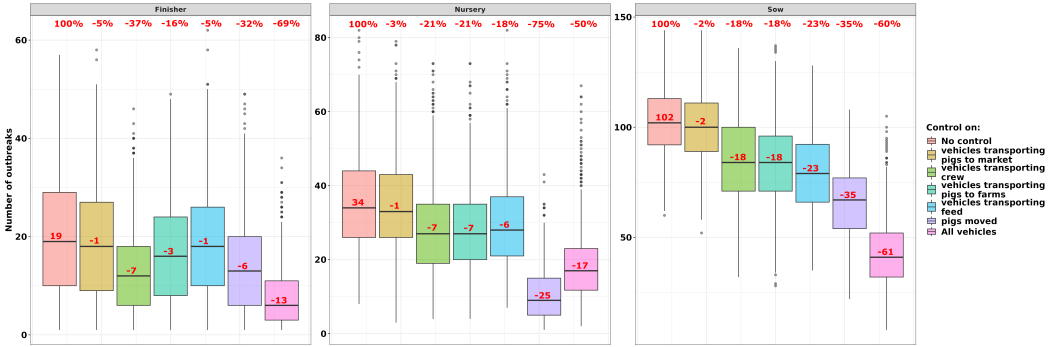
Epidemics on evolving premise-to-premise networks

Targeting 15% to 25% of premises ranked by degree and betweenness was the most effective at reducing outgoing contact chains (epidemic size).



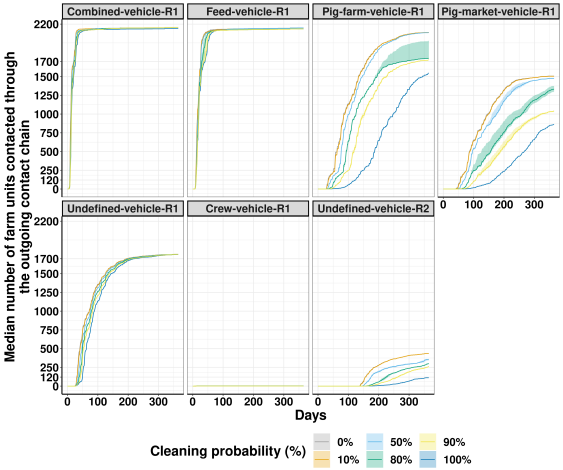
PRRSV spread reduction by re-routing trucks based in outbreaks

What happen if we block transportation vehicles from going from infected to susceptible farms(PRRSV)?



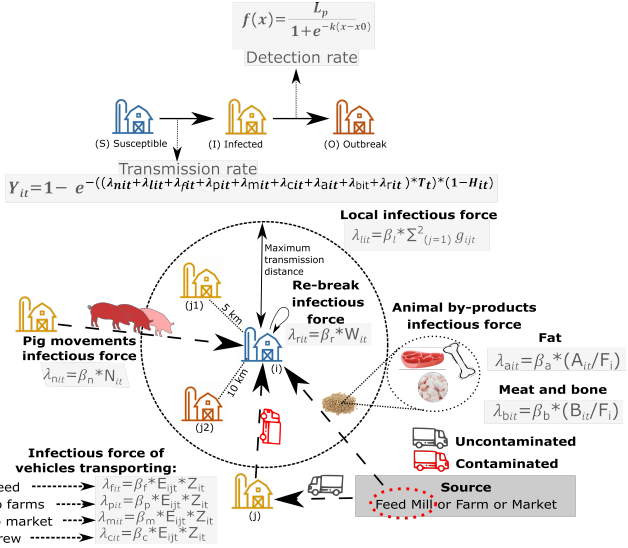
Between-farm vehicle movement and cleaning and disinfection

Not event 100% cleaning and disinfection seems to be sufficient.



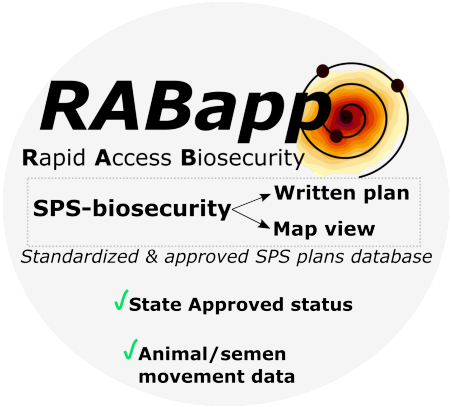
Major on-farm biosecurity contributions

Farm level model with countermeasures via PigSpread 2.0



RABapp™ core

The Rapid Access Biosecurity app (RABapp™) is a web-based tool for enhancing on-farm biosecurity preparedness and contact tracing across the U.S. swine industry, available 24/7.



What makes an SPS plan?

Within RABapp™, a completed Secure Pork Supply plan for a single site display all 169 biosecurity features as both a written description (left) and a visual map of the premises (right).

Written plan

Pirate Pork Farm Enhanced Biosecurity Plan for FAD Prevention in North Carolina

Date Created: 3/5/2021

This Biosecurity Plan is based off of the Secure Pork Supply (SPS) Self-Assessment Checklist for Enhanced Pork Production Biosecurity: Animals Raised Indoors, [August 2017] and was developed using guidance from the SPS Information Manual for Enhanced Biosecurity: Animals Raised Indoors. All documents are available at www.securepork.org. In the Plan below, all items have been implemented except those indicated which will be implemented prior to requesting an animal movement permit.

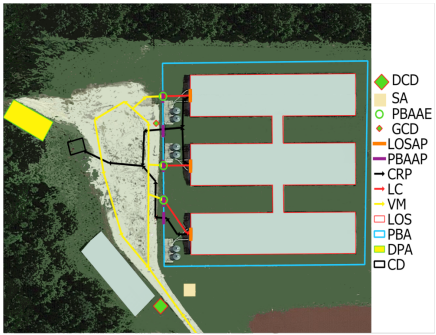
Scope of Biosecurity Plan

- National Premises Identification Number (PIN): 00XYZ12 Nursery
- Premises Address: 2468 Go Bulls Rd Durham, NC 28341
- Premises GPS Coordinates: 32.127481, -64.951797
- Animals* on primary premises: Swine and 2800
- Other business operations on premises? Yes
- If yes, what? Hay
- Secondary premises** locations:
  - Will be provided to Responsible Regulatory Officials if this premises is located in an FAD Control Area
  - *Work with your State Animal Health Official to determine if separate PINs are needed for all of your associated premises.

*Animals that are susceptible to FMD include cattle, pigs, sheep, goats, and elk. For biosecurity guidance for dairy cattle and beef cattle, see www.securemilksupply.org and www.securebeef.org.
**Work with your State Animal Health Official to determine if separate PINs are needed for all of your associated premises. When a premises becomes infected, all premises with the same PIN number will be considered to be infected.

+

Map view of the site



Standardized map view

The Rapid Access Biosecurity (RABapp™)

The RABapp™ team has been developed based SPS plans guide + partnership with SAHOs and swine industry.

1. A protocol/electronic audit for cataloging, reviewing, and approving biosecurity plans for all 169 fields on an SPS on-farm biosecurity plan [1].

[1] SPS Plan for Continuity of Business template/guide

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4. Disease transmission command center for PRRSV (✔), PEDV (✔), ASF (✔) [ongoing CSF and FMD].

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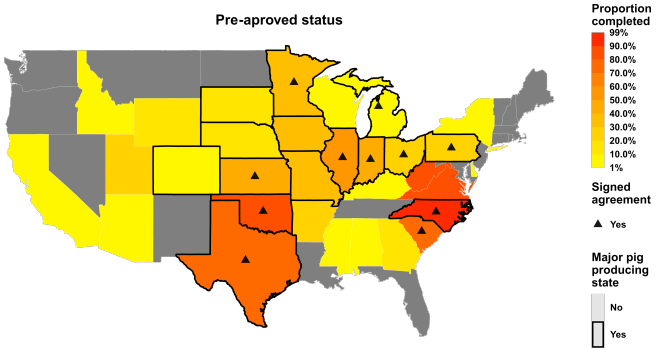
RABapp™ in numbers

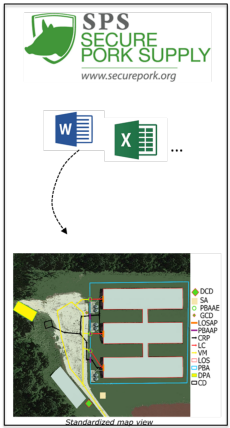
1. Total number of companies (large), mid-size, and clinics= 52 with CDAs.
2. Department of Agriculture (SAHOs) = 16 with CDAs.
3. More than 10,000 on-farm biosecurity plans.



RABapp™ big picture

Swine industry

- **Veterinarians**
- **Managers**
- **Producers**



What RABapp team does?

RABapp
Rapid Access Biosecurity
NC STATE UNIVERSITY

State animal health office (SAHO)

How will each state use this information during an FAD outbreak?

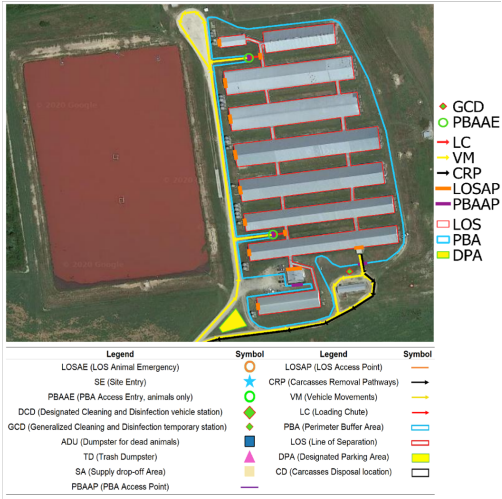
1. How quickly can you figure out which farms has an **APPROVED plan, view plans**?
2. How quickly can we find contacts? **Trace-back 30 days + forward**

Would you allows pigs from other states **X** if you question their SPS plan (permits)?

RABapp™ (electronic audit)

From this

To this



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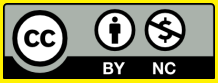
Thanks for listening

Questions?



References

[1] Jason A Galvis, Cesar A Corzo, and Gustavo Machado. “Modelling and assessing additional transmission routes for porcine reproductive and respiratory syndrome virus: Vehicle movements and feed ingredients”. In: *Transboundary and Emerging Diseases* (2022).

[2] Jason A Galvis et al. “Modeling between-farm transmission dynamics of porcine epidemic diarrhea virus: characterizing the dominant transmission routes”. In: *arXiv preprint arXiv:2201.04983* (2022).

References ii

[3] Jason A Galvis et al. “Modelling the transmission and vaccination strategy for porcine reproductive and respiratory syndrome virus”. In: *Transboundary and Emerging Diseases* (2021).

[4] Jason A Galvis et al. “The between-farm transmission dynamics of porcine epidemic diarrhoea virus: A short-term forecast modelling comparison and the effectiveness of control strategies”. In: *Transboundary and Emerging Diseases* (2021). DOI: *10.1111/tbed.13997*.

[5] Tariq Halasa et al. “Simulation of transmission and persistence of African swine fever in wild boar in Denmark”. In: *Preventive veterinary medicine* 167 (2019), pp. 68–79.

References iii

[6] Manuel Jara et al. “Porcine reproductive and respiratory syndrome virus dissemination across pig production systems in the United States”. In: *Transboundary and Emerging Diseases* 68.2 (2021), pp. 667–683. DOI: *10.1111/tbed.13728*.

[7] **Machado, Gustavo** et al. “Quantifying the dynamics of pig movements improves targeted disease surveillance and control plans”. In: *Transboundary and Emerging Diseases* (2020). ISSN: 1865-1674. DOI: *10.1111/tbed.13841*.

PigSpread model performance