PRRSV: Risk factors, knowledge gaps and management strategies for prevention and control

Leman China Conference

October 20-22, 2023

Porcine reproductive and respiratory syndrome

- A brief history
- 1987:
  - Mystery Swine Disease
- Virus isolation:
  - 1991: Netherlands (Lelystad virus)
  - 1992: United States (Swine Infertility and Reproductive Syndrome virus, ATTC VR 2332)
- Economic losses
  - US $664 million annually[1]

1. Holtkamp DJ, Kliebenstein JB, Neumann EJ, et al. Assessment of the economic impact of porcine reproductive and respiratory syndrome virus on United States pork producers. *J Swine Health Prod.* 2013

31 years since the isolation of PRRSV

- 1997
  - Wills, Zimmerman, et al.
    - Transmission of PRRSV by direct, close, or indirect contact[2]
- 2009
  - Dee et al.
    - Evidence of long distance airborne transport of porcine reproductive and respiratory syndrome virus and *Mycoplasma hyopneumoniae*[3]

2.Wills RW, Zimmerman JJ, Swenson SL, et al. Transmission of PRRSV by direct, close, or indirect contact. *J Swine Health Prod* 1997;5(6):213-218.

3. Dee, Scott et al. "Evidence of long distance airborne transport of porcine reproductive and respiratory syndrome virus and Mycoplasma hyopneumoniae." *Veterinary research* vol. 40,4 (2009)

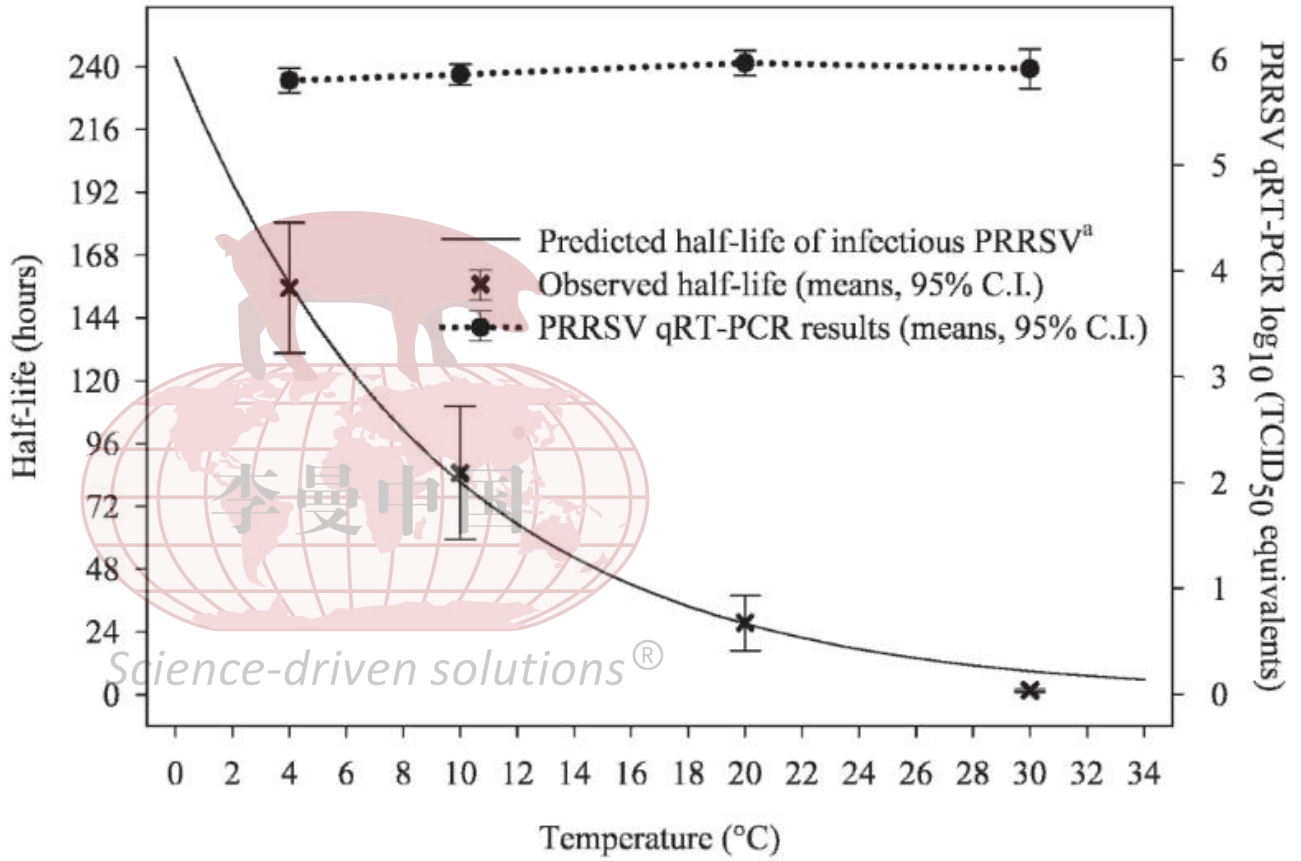
31 years since the isolation of PRRSV

- 2002
  - Dee et al.
    - Mechanical transmission[4]

4. Dee S, Deen J, Rossow K, Wiese C, Otake S, Joo HS, Pijoan C. Mechanical transmission of porcine reproductive and respiratory syndrome virus throughout a coordinated sequence of events during cold weather. Can J Vet Res. 2002

31 years since the isolation of PRRSV

- 2010
- Jacobs et al
  - Virus stability[5]



5. Jacobs AC, Hermann JR, Muñoz-Zanzi C, et al. Stability of Porcine Reproductive and Respiratory Syndrome virus at Ambient Temperatures. *Journal of Veterinary Diagnostic Investigation*. 2010

Detection of PRRSV with air sampling

- Brito, Dee et al., 2014[5]
  - Air collection outside 4 PRRSV negative sow farms
  - Four locations- Midwest United States
  - 60 days, October 15-December 15, 2012

5. Brito B, Dee S, Wayne S, Alvarez J, Perez A. Genetic diversity of PRRS virus collected from air samples in four different regions of concentrated swine production during a high incidence season. Viruses. 2014

1.Dee S.; Otake S.; Oliveira S.; Deen J. 2009 Evidence of long distance airborne transport of porcine reproductive and respiratory syndrome virus and *Mycoplasma hyopneumoniae* Vet. Res. 40 (4) 39.

Brito et al. PRRSV detection from air samples[6]

- Four sample locations
  - 60 collection days
    - 240 air samples
- Number of neighboring farms within 10 km
  - 20 to 99
- Mean distance (km) of neighboring farms to collection point
  - 6.19 to 7.53 km
- Frequency of PRRSV PCR positive
  - 37% overall
  - 29% to 42% by location
- Mean viable virus in $\log_{10}$ $TCID_{50/mL}$ of positive samples
  - 3.8 to 5.3

5. Brito B, Dee S, Wayne S, Alvarez J, Perez A. Genetic diversity of PRRS virus collected from air samples in four different regions of concentrated swine production during a high incidence season. Viruses. 2014

Detection of PRRSV with air sampling

- Tousignant, 2015[7]
- 241 air samples, 482 hours of collection time
  - October 1-March 30, 2013
  - 10 m upwind of barns
- No air samples were positive for PRRSV by PCR

7. Tousignant, Steven. (2015) Epidemiology of PRRS virus in the United States: Monitoring, Detection in Aerosols, and Risk Factors. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/175353

Detection of PRRSV with air sampling[3]

- Within-barn air collection
  - Confirmed PRRSV positive
    - 30/30 serum PRRSV PCR positive
    - 2/2 oral fluid PRRSV PCR positive
  - 29/98 (29.6%) air samples PRRSV PCR positive during a 16 day period
- Subsequent nursery fill
  - Diagnostic and clinical description similar to described
  - Air collection 5, 10, 20 m from the PRRSV positive barn
    - 0/24 PRRSV PCR positive

7. Tousignant, Steven. (2015) Epidemiology of PRRS virus in the United States: Monitoring, Detection in Aerosols, and Risk Factors. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/175353

Survivability (days) of various PRRSV strains

PRRSV strain[a]	4°C	25°C	37°C
	Days of survival (Percent reduction)	Days of survival (Percent reduction)	Days of survival (Percent reduction)
1-8-4	35 (97.81%)	7 (99.97%)	3 (99.53%)
1-4-4 MN	35 (99.12%)	7 (99.87%)	3 (98.87%)
1-4-4 SD	35 (99.98%)	3 (99.00%)	3 (99.94%)
Lelystad	35 (98.71%)	3 (99.99%)	3 (99.99%)
VR2332	35 (99.71%)	3 (99.99%)	1 (99.99%)
1-4-2	35 (99.39%)	1 (99.96%)	1 (99.99%)
1-26-2	35 (99.99%)	1 (99.99%)	1 (99.99%)
ATP Vaccine	35 (99.99%)	1 (99.99%)	1 (99.99%)
2-5-2	35 (99.97%)	1 (99.99%)	1 (99.99%)
1-7-4	35 (98.71%)	1 (99.78%)	1 (99.98%)

a: All strains belong to PRRSV-2 except the Lelystad strain, which belongs to PRRSV-1.

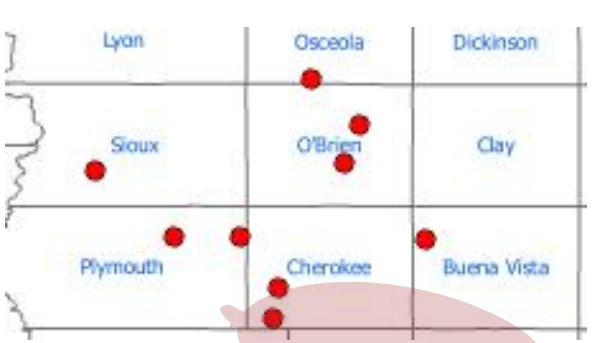
University of Minnesota Swine Disease Eradication Center. SDEC Partners Research Update, Volume 11, Issue 3 (2022)

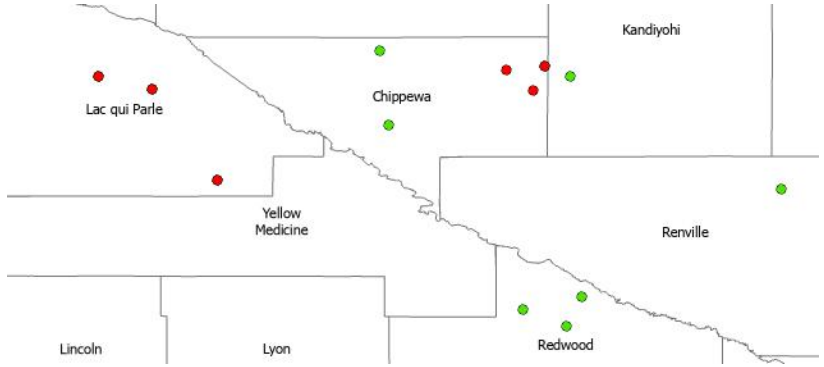
The difficulty in assigning relative risk

- "In an area where the poultry industry is dense, both in the number of birds per site and in the total number of sites, *the mechanism of spread may be obscured by the multiplicity of possible routes*." [emphasis added]

Hugh-Jones M, Allan WH, Dark FA, Harper GJ. The evidence for the airborne spread of Newcastle disease. J Hyg (Lond). 1973.

Tobler's First Law of Geography

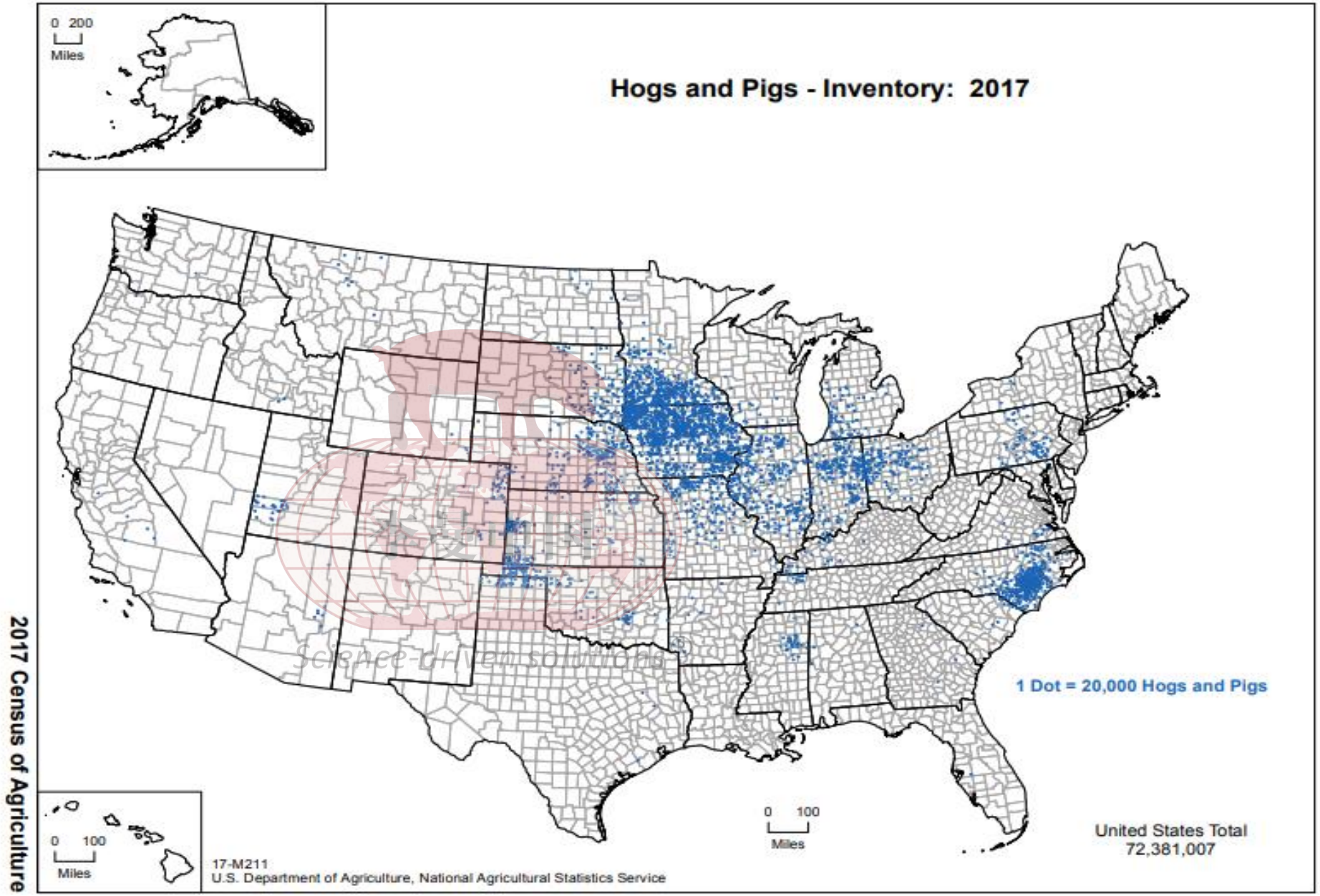




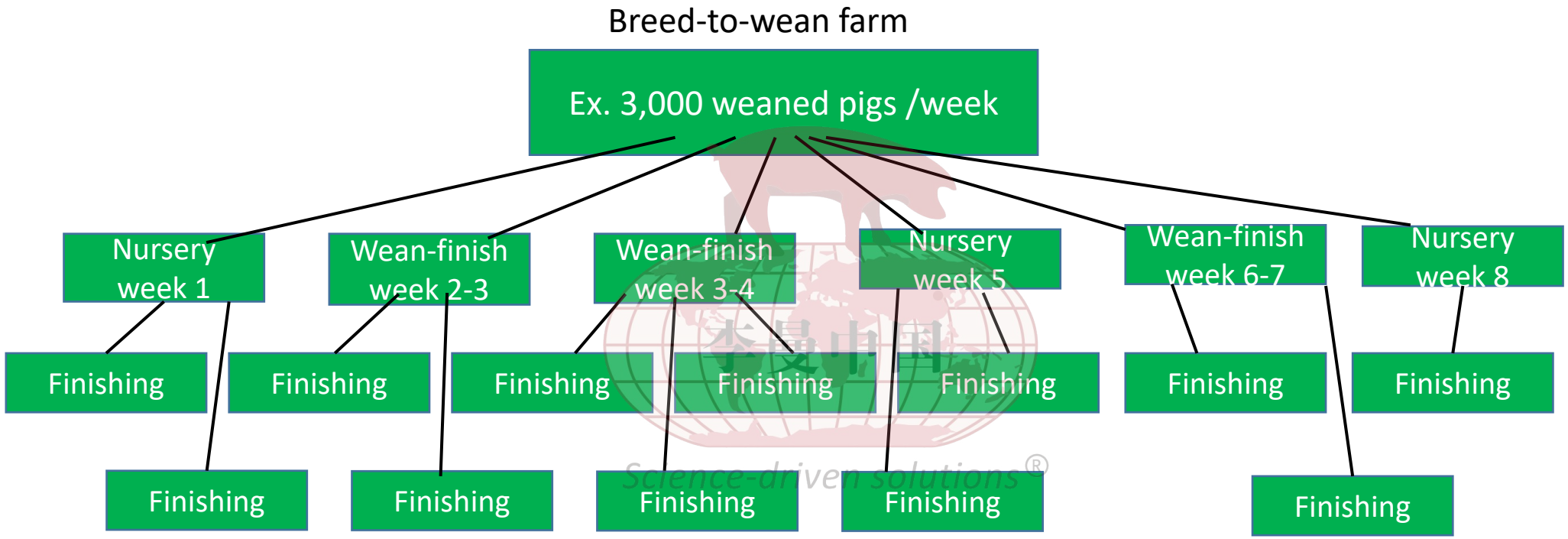
Schwartz, unpublished

Everything is related to everything else. But near things are more related than distant things. –Waldo Tobler

United States pig production- 2017 U.S. Department of Agriculture, Census of Agriculture



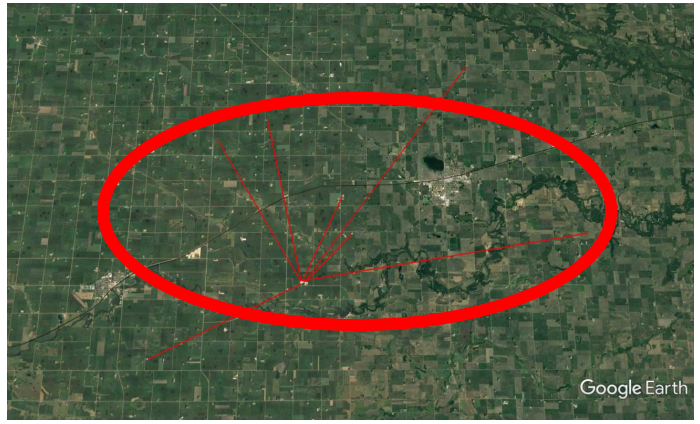
Multi-Site Production Model



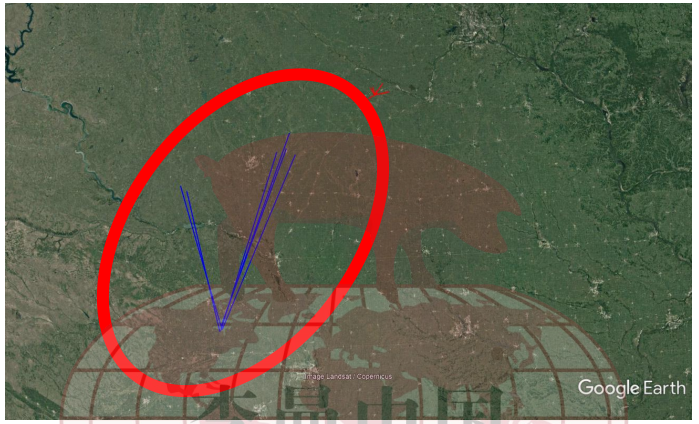
Features:

1. Weekly transport from breed-to-wean farm to nursery/wean-finish barns
2. Transport from nursery/wean-finish to finish
3. System-dependent nursery/wean-finish site capacity (2,400-8,000)
4. 12 to 20 nursery/wean-finish/finish sites for each breed-to-wean farm

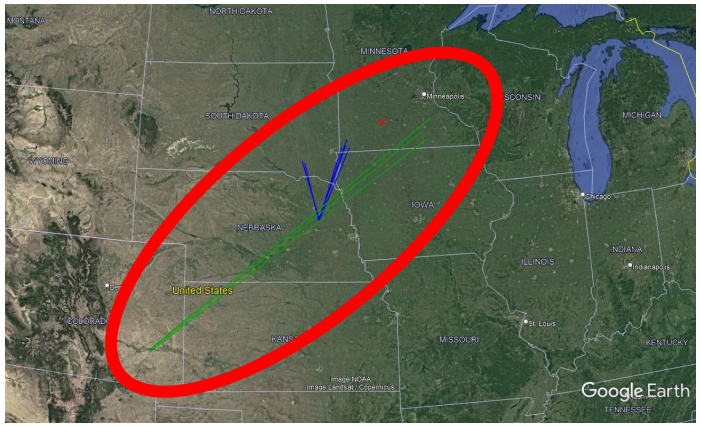
Example pig movement with multi-site production



Weaned pigs transported 1.5 to 40 miles from the breed-to-wean farm



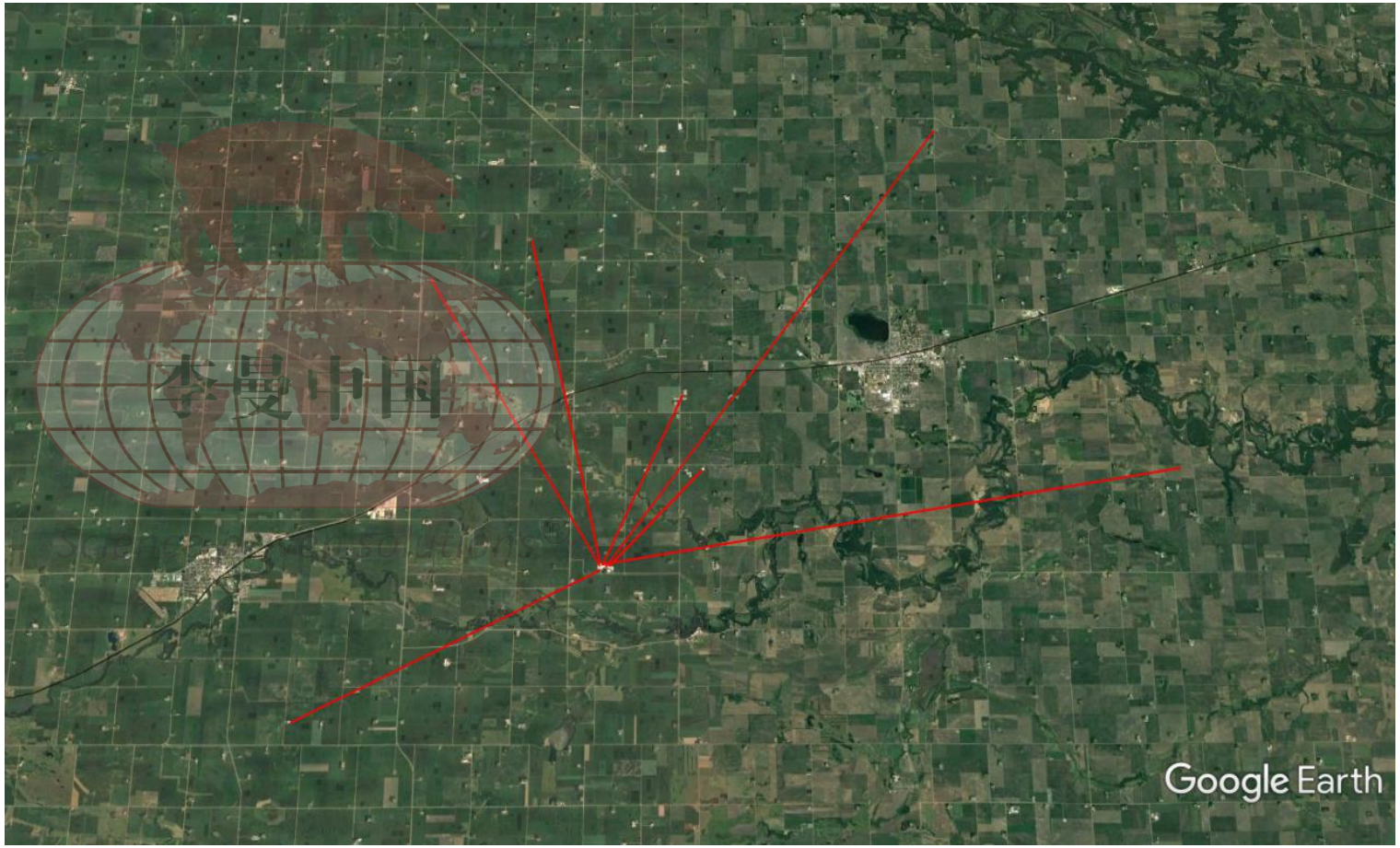
Weaned pigs transported 100-250 miles from the breed-to-wean farm



Weaned pigs transported 700-900 miles from the breed-to-wean farm

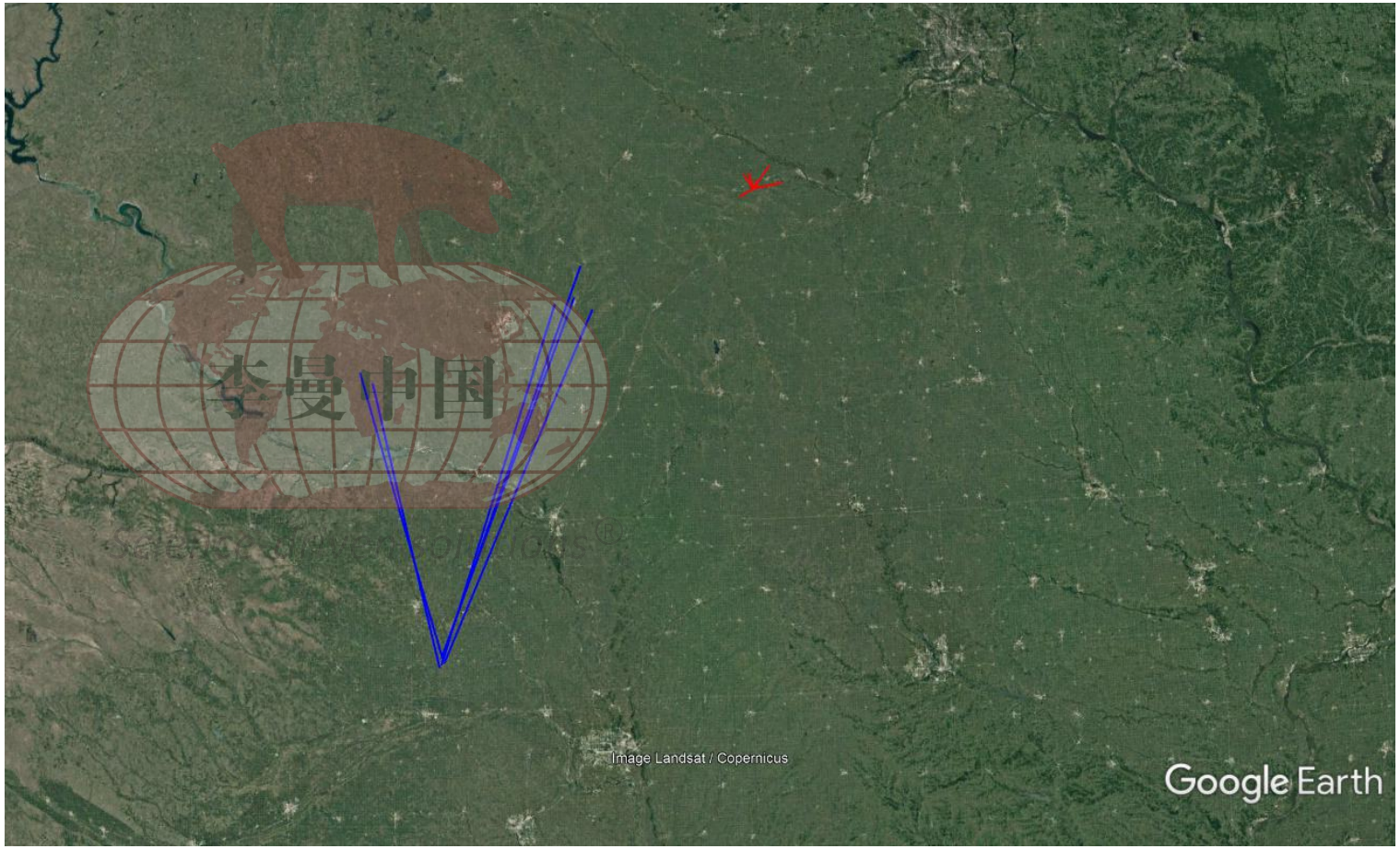
Multi-site pig production, example 1

Weaned pigs transported 4 to 50 km from the breed-to-wean farm



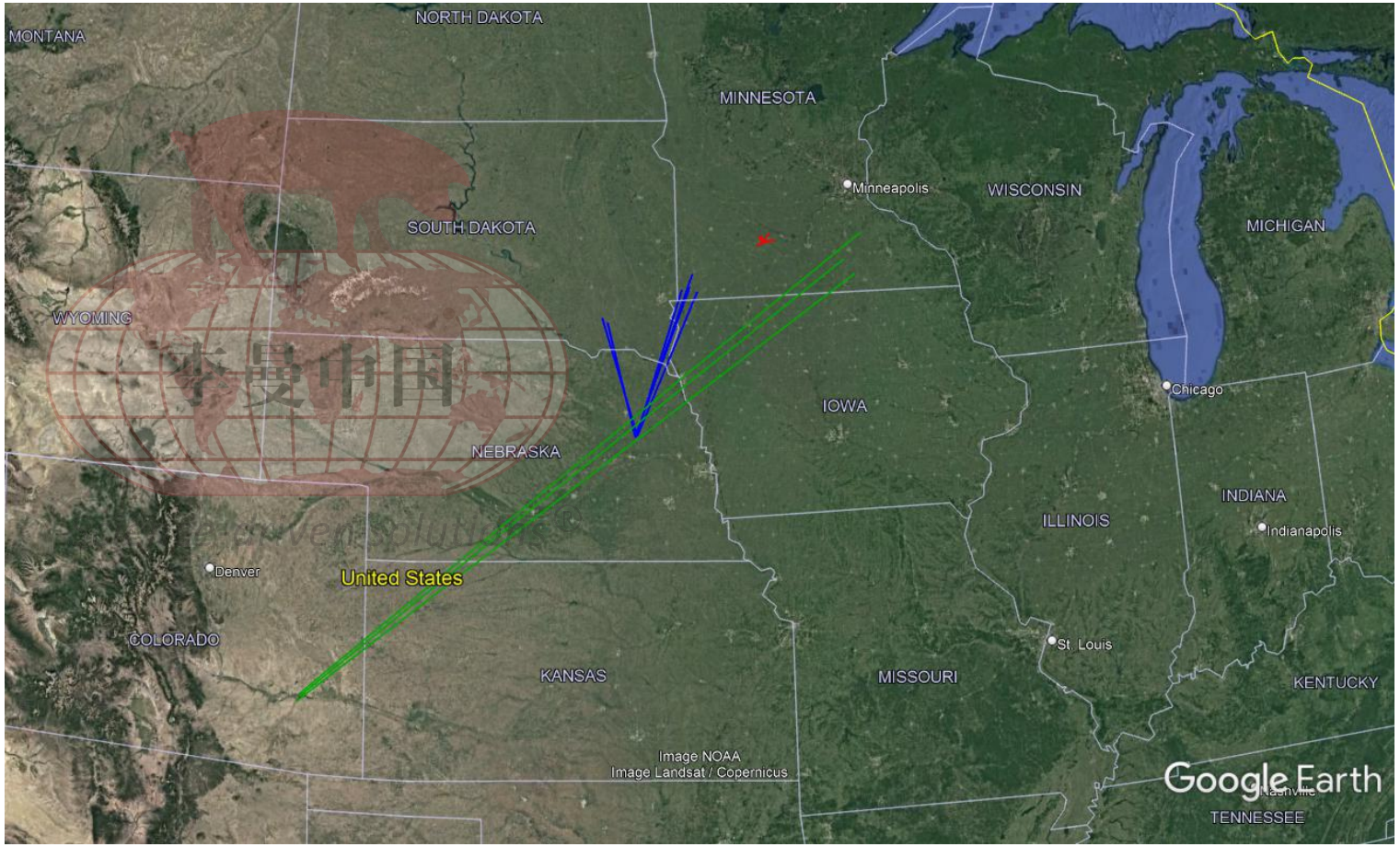
Multi-site pig production, example 2

Weaned pigs transported 250-500 km from the breed-to-wean farm

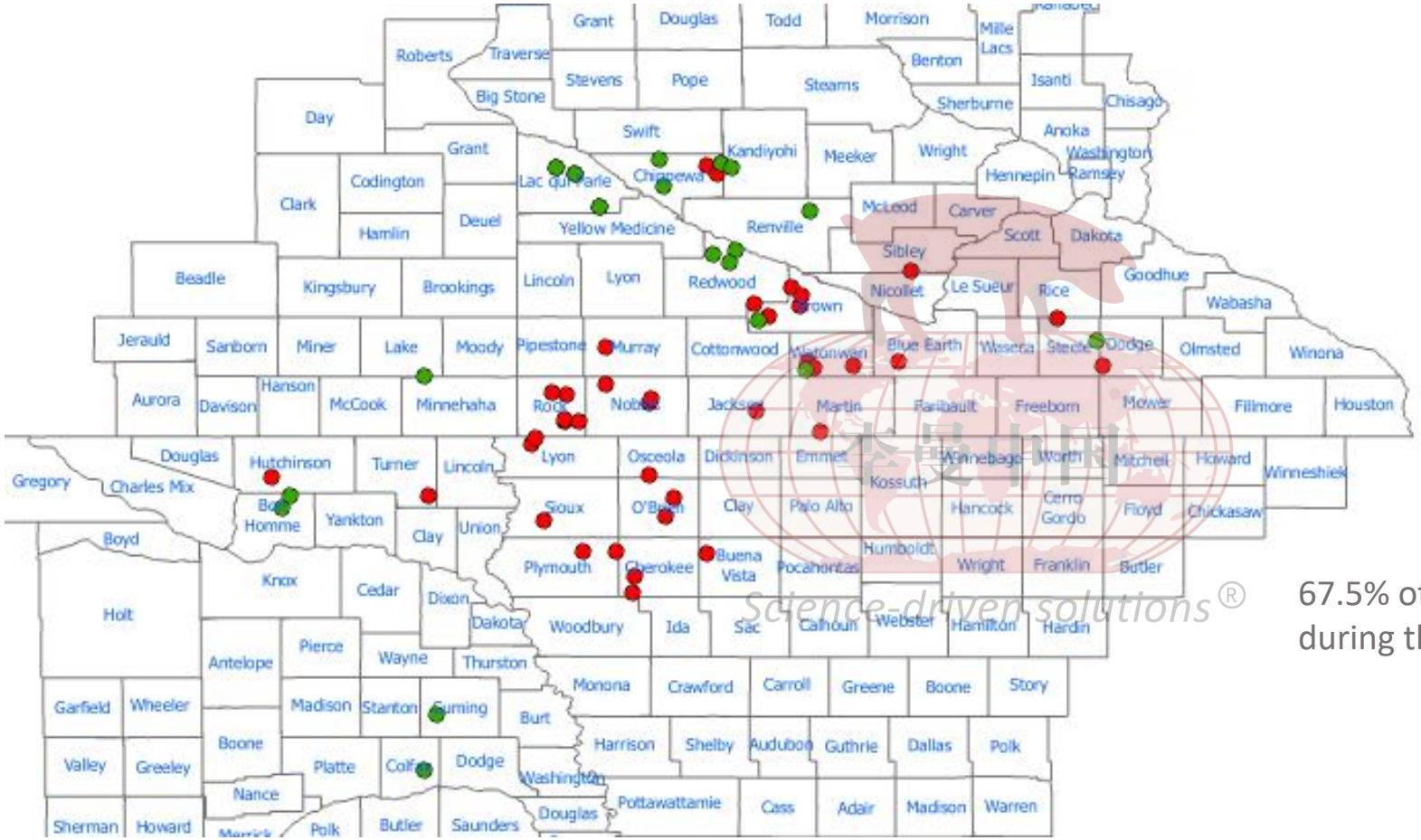


Multi-site pig production

Weaned pigs transported 1,500-2,000 km from the breed-to-wean farm



Grow-finish site PRRSV surveillance project



(n= 74)

50 POS

24 NEG

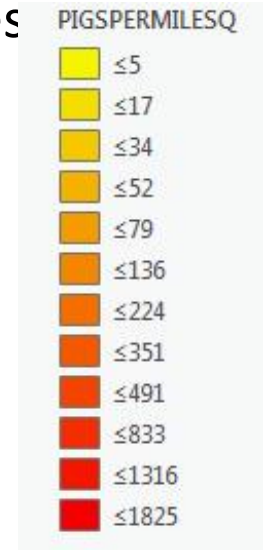
PRRS Negative Sites

PRRS Positive Sites

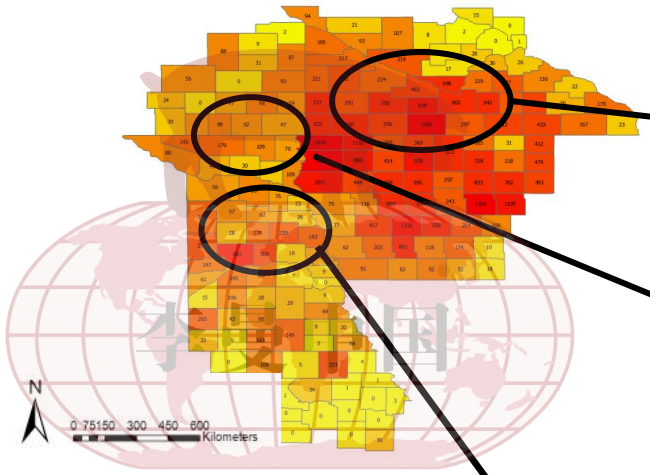
67.5% of sites convert PRRS positive during the finishing phase

Pig Density/Mile², Selected Regions in Midwest United States

- Pig Density Per Square Mile, Selected Midwest U.S. Counties



Upper Midwest U.S: MN, IA, SD, NE, KS

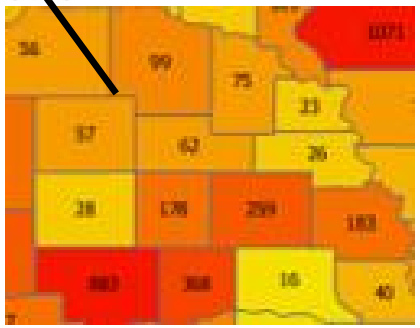


Data sources: USDA National Agriculture Statistics Service, 2017 Census of Agriculture, indexmundi.com

Southwest Minnesota

Southeast South Dakota

Northeast Nebraska



SaTScan Analysis of Low Incidence Clustering

```
Location IDs included.: 100, 104, 113, 116, 127, 143, 144, 97, 99, 102, 103, 112, 114, 115,
                        153, 154, 158
Overlap with clusters.: No Overlap
Coordinates / radius..: (45.000000 N, 95.000000 W) / 78.58 km
Gini Cluster.........: Yes
Population...........: 17
Number of cases......: 6
Expected cases.......: 11.26
Observed / expected...: 0.53
Relative risk........: 0.47
Percent cases in area.: 35.3
Log likelihood ratio..: 4.516990
P-value..............: 0.036
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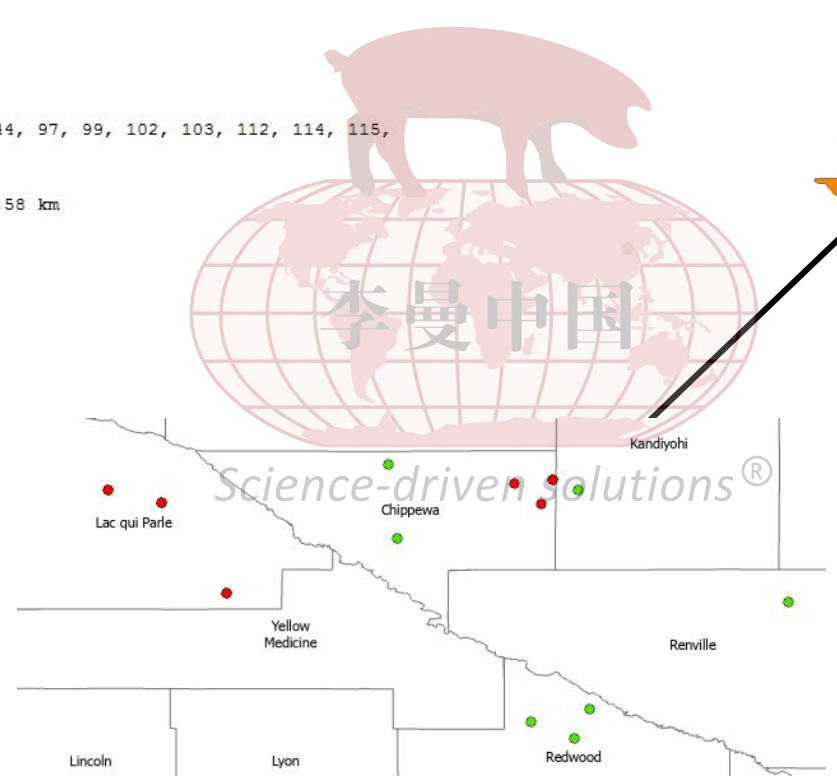
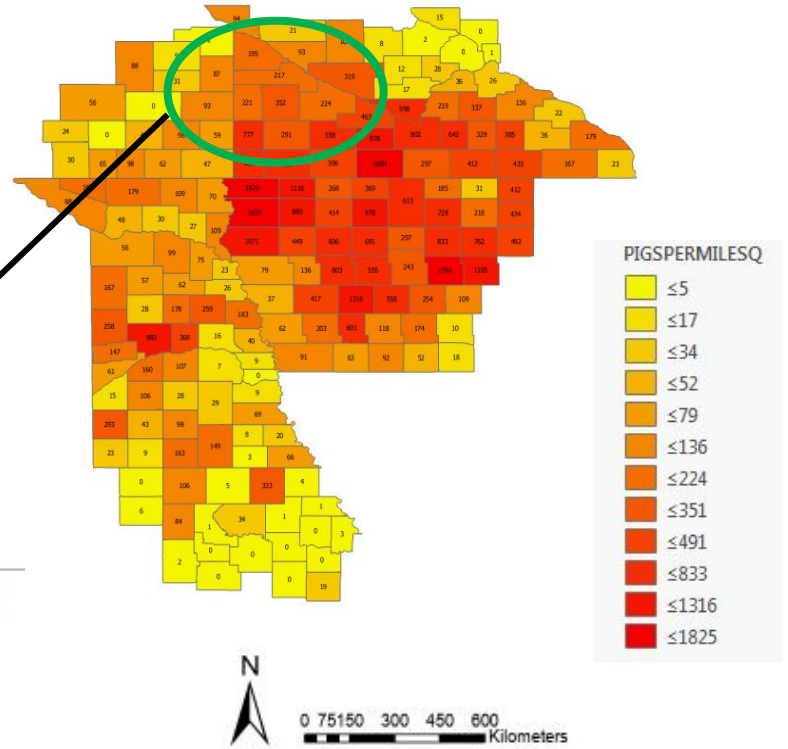
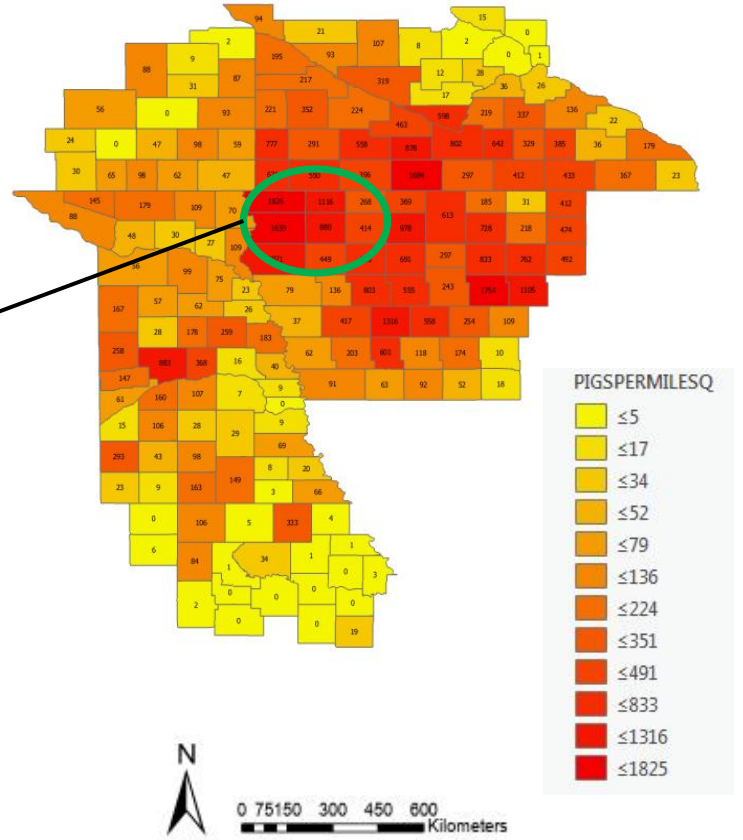




http://www.satscan.org

SaTScan Analysis of High Incidence Clustering

```
Location IDs included.: 119, 120, 125, 129, 140, 147, 148, 160, 161, 162, 98, 117, 128,
Overlap with clusters.: No Overlap
Coordinates / radius..: (43.000000 N, 96.000000 W) / 81.27 km
Gini Cluster..........: Yes
Population............: 14
Number of cases.......: 14
Expected cases........: 9.27
Observed / expected...: 1.51
Relative risk.........: 1.71
Percent cases in area.: 100.0
Log likelihood ratio..: 6.578131
P-value...............: 0.0023
```



PRRS PCR results by site and collection event

	=NEG	=POS	=SUS		
SITE(SOURCE FARM)	PRRS PCR RESULT				
WAG(B)					
HAG(A,D)					
TRE(A)					
HEN(B)					
BER(D)					
HAA(B,D)					
BRY(D)					
SCH(A)					
CUP(C)					
PRU(A)					
GOE(A)					
LOP(B,D)					
ROC(C)					
MAS(B)					
BACH(B)			May-21		
ROEL(F)					21-Apr
ROEL(F)					Feb 21
BACH(B)			Feb-21		
BIETZ(C)					
DICKE(I)					Jan-21
DICKE(I)					Jul-21

Sample Collection 1: at movement to, or start of finishing phase

Subsequent Sample Collections: every 30 days

Of suspect or positive sites, 43 percent were suspect or positive on the first collection

Chart 1 – PRRS cumulative incidence beginning July 01, 2009

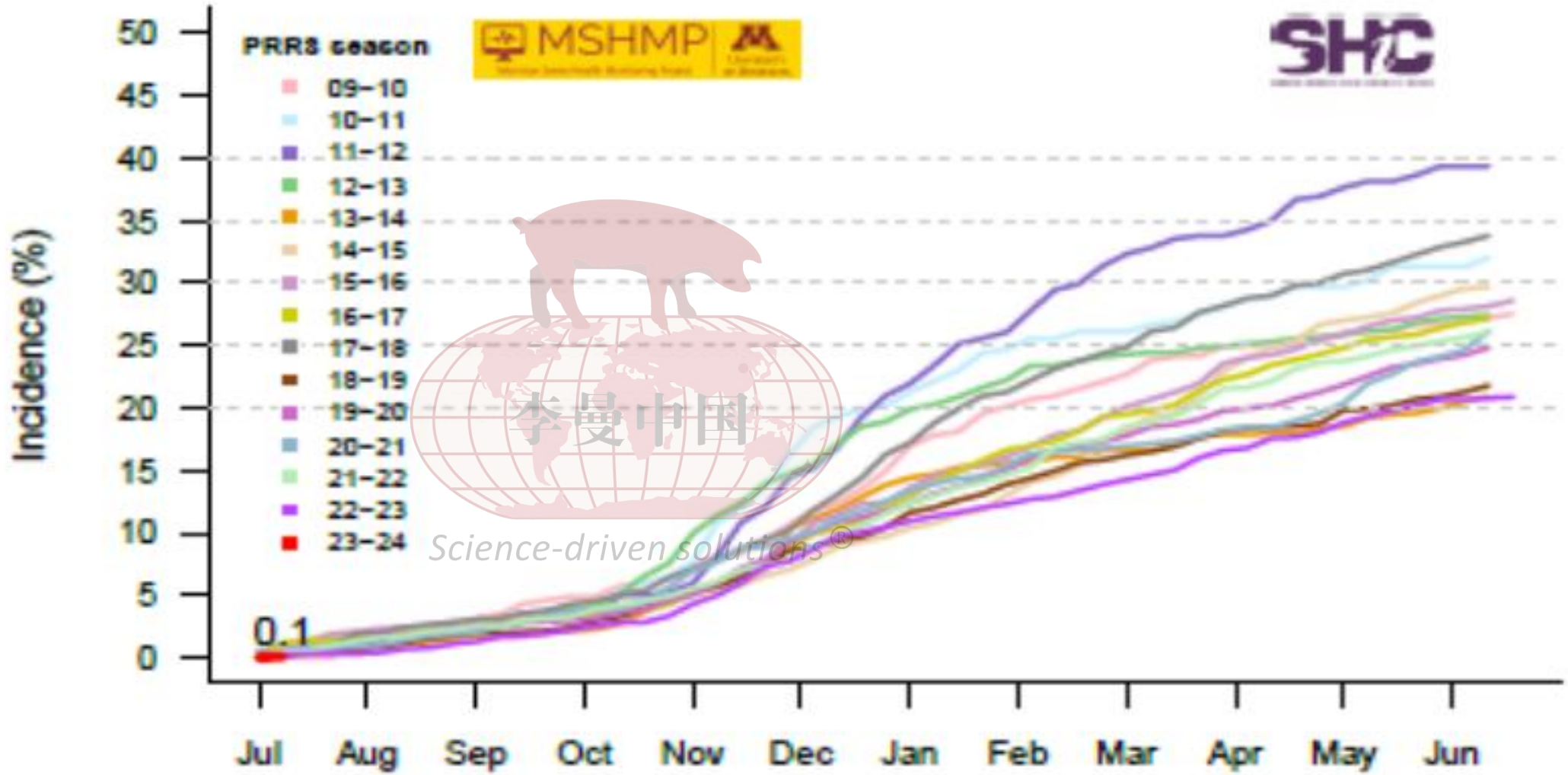
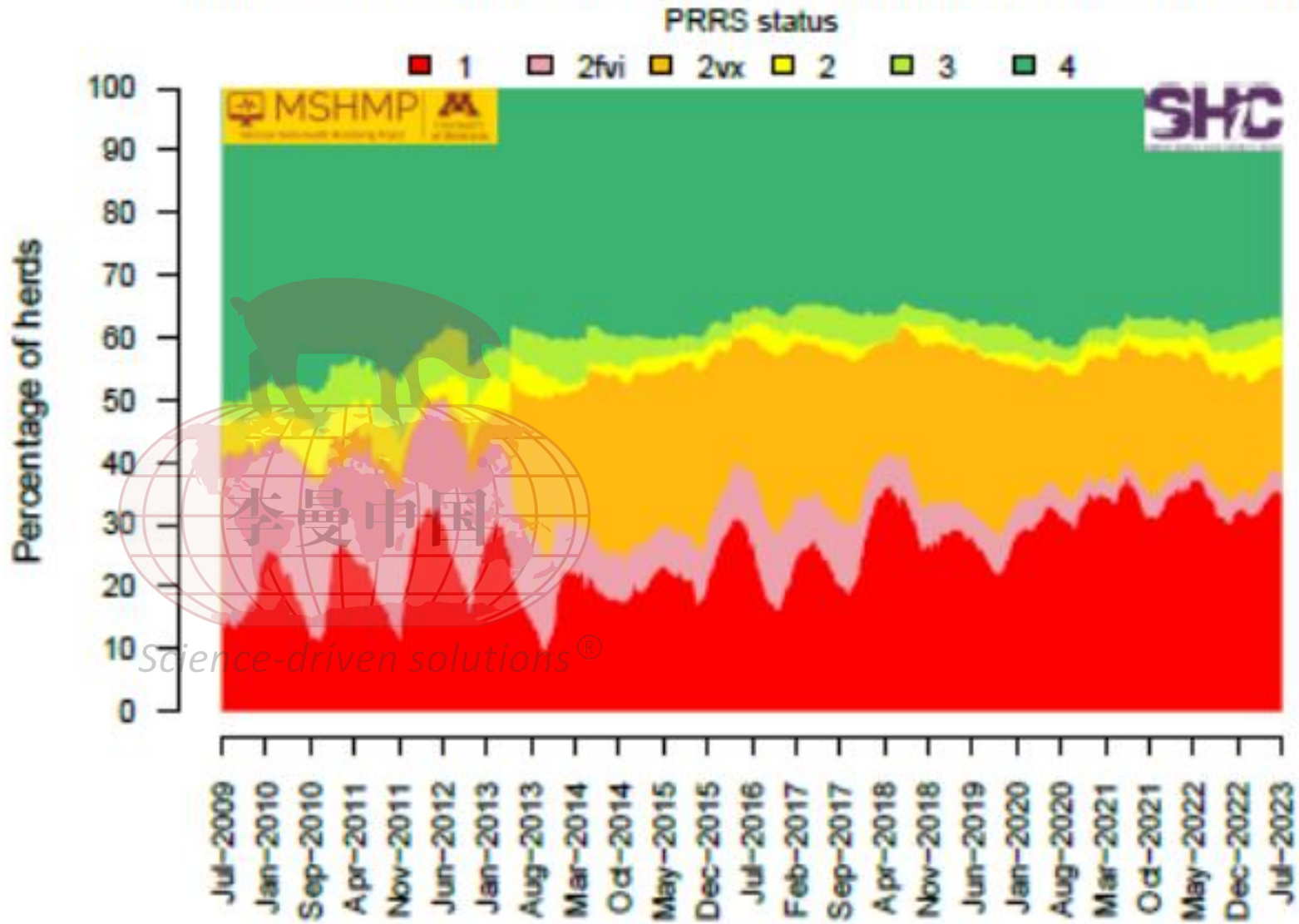


Chart 2 – PRRS prevalence of sow herd status beginning July 01, 2009



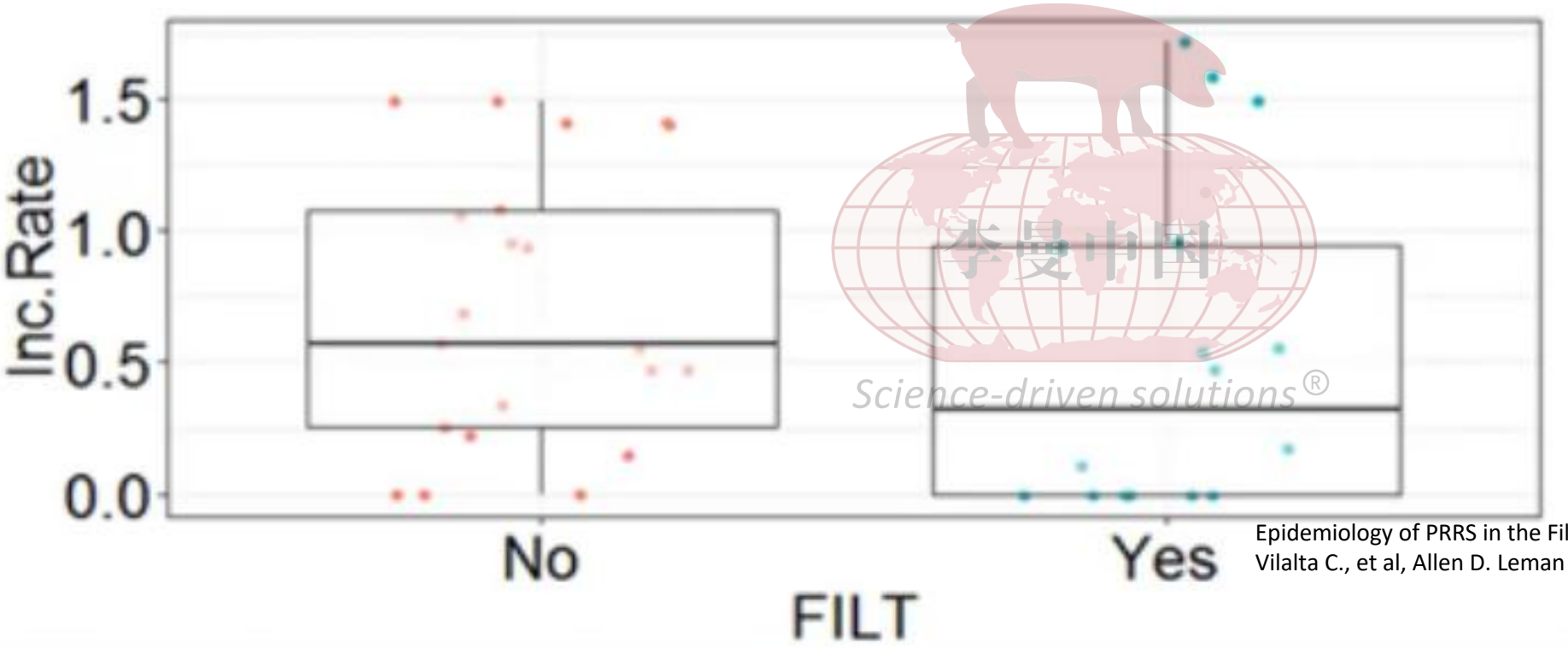
Filtered farms per state in MSHMP

STATE	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
IA	11	13	19	19	21	22	24	36	45	47
IL			3	9	9	9	10	13	13	15
MI									1	1
MN	13	20	27	39	46	54	56	57	59	59
MO			2	2	2	2	2	4	7	7
NE	1	4	7	10	10	10	12	13	14	14
OH				1	1	1	1	2	2	2
SD			1	2	3	4	8	8	10	12
WI									1	1
TOTAL	25	37	59	82	92	102	113	133	152	158

Epidemiology of PRRS in the Filtered Sow Farm Population,
Vilalta C., et al, Allen D. Leman Swine Conference 2018

Spatial comparison between filtered and non-filtered farms

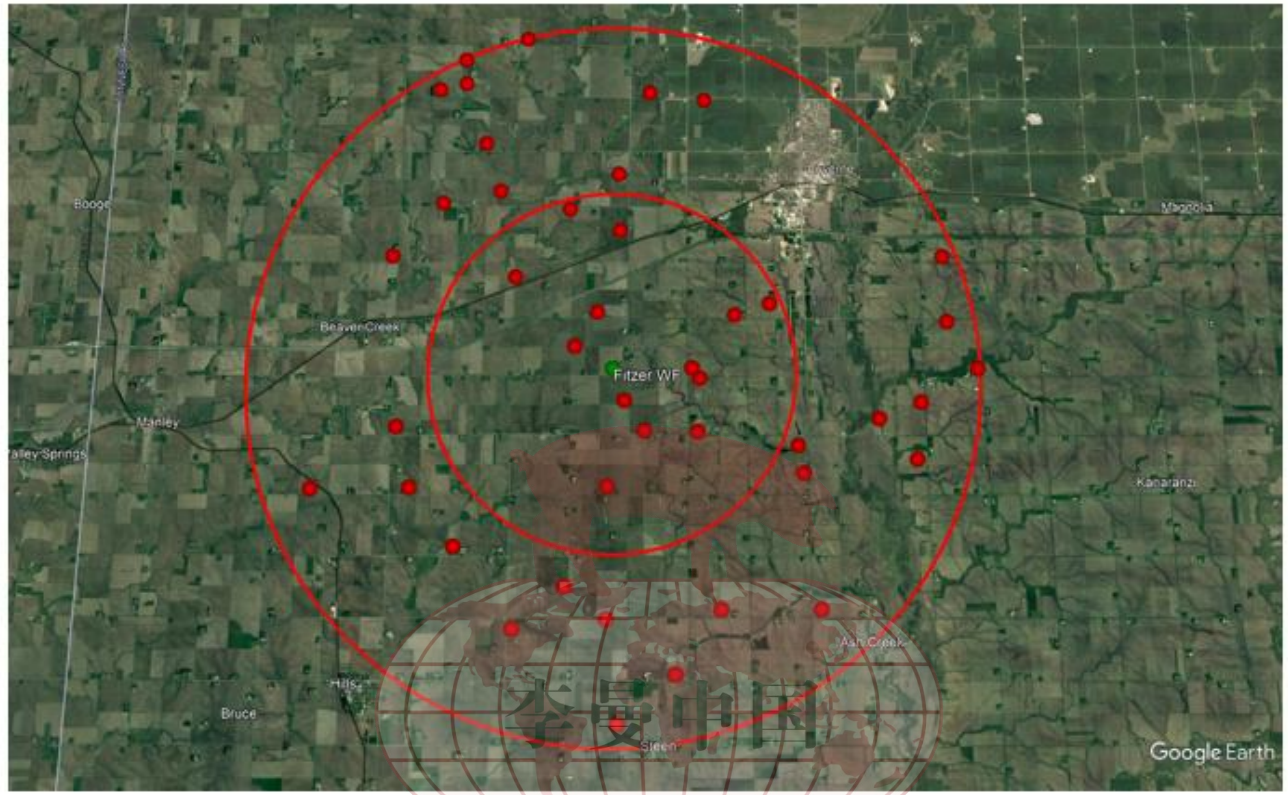
SMALL SAMPLE SIZE, NO STATISTICAL DIFERENCE!!!



Inc.Rate NO=0.5; 1 break every 2 years

Inc.Rate YES=0.34; 1 break every 3 years

Epidemiology of PRRS in the Filtered Sow Farm Population, Vilalta C., et al, Allen D. Leman Swine Conference 2018



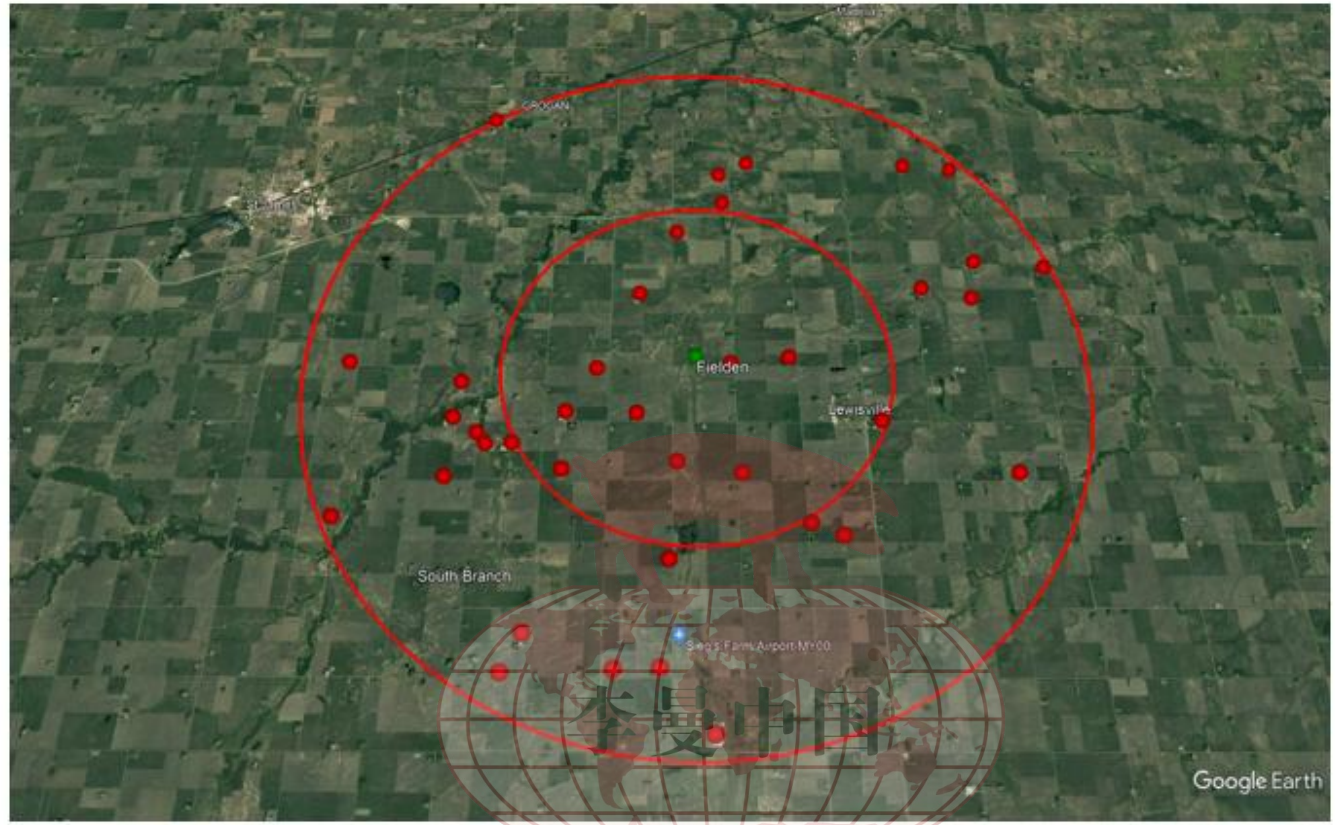
Site 2: 13 sites <= 5 km (3.1 m) radius

Ave. distance from Site 2: 2.80 km (1.74 m)

31 additional sites >= 5 km and <= 10 km

PRRSV surveillance results:

March 22, 2023: PCR NEGATIVE, 38 days in nursery phase



Site 3: 11 sites <= 5 km (3.1 m) from site

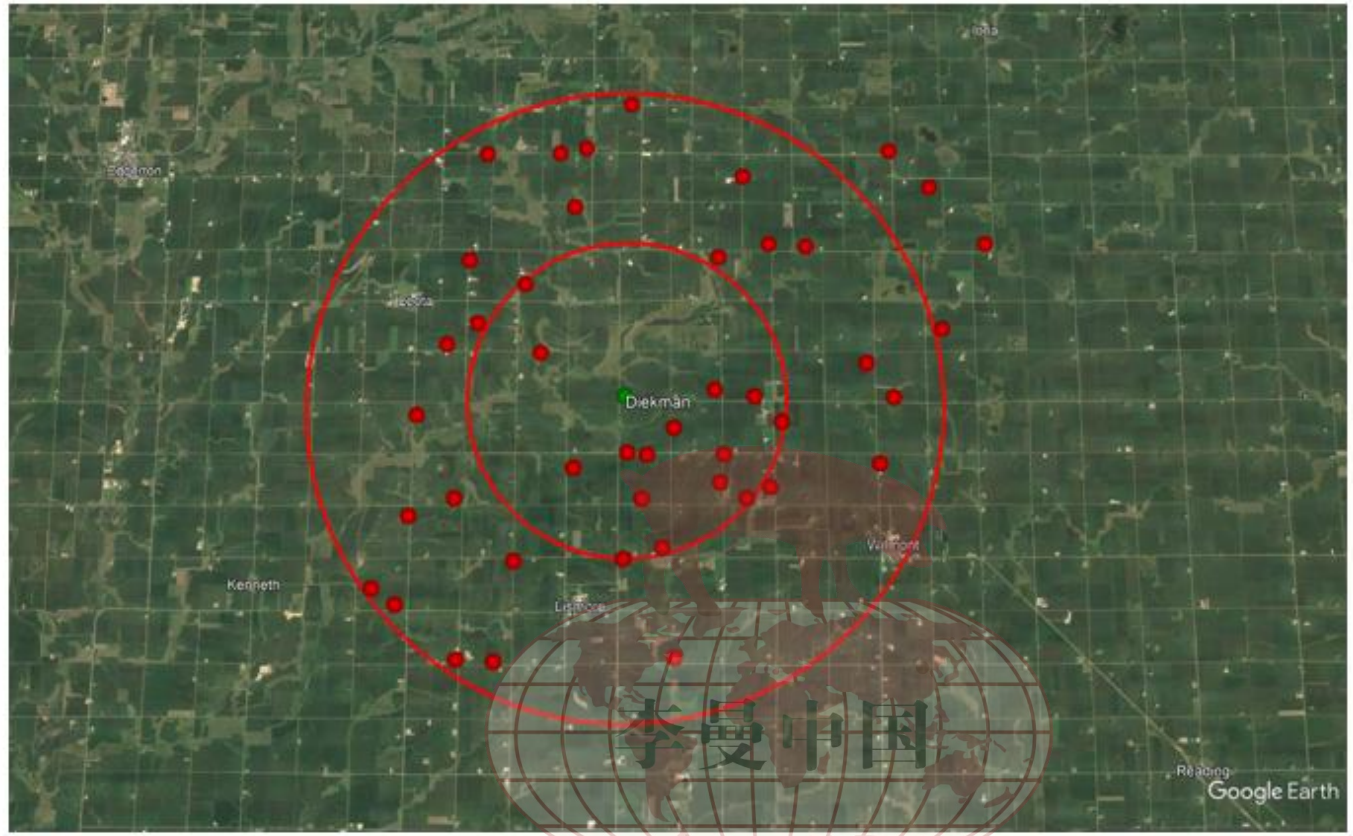
Ave. distance from Site 3: 3.09 km (1.92 m)

27 additional sites >= 5 km and <=10 km

PRRSV surveillance results:

March 9, 2023: PCR NEGATIVE, 33 days in nursery phase

March 22, 2023: PCR NEGATIVE, 42 days in nursery phase



Site 1: 14 sites <= 5 km (3.1 m) radius

Ave. distance from Site 1: 3.51 km (2.18 m)

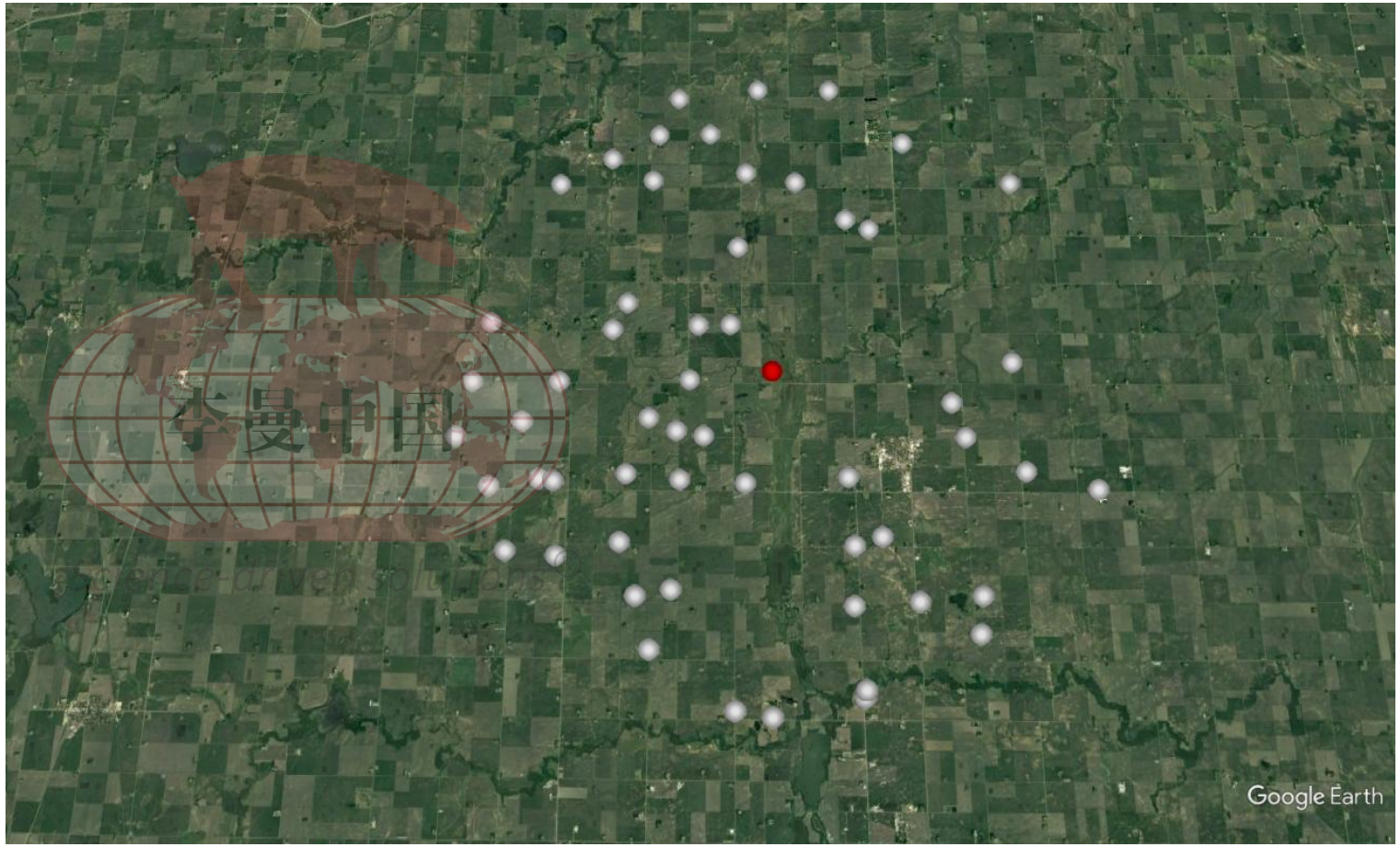
26 additional sites >= 5 km and <= 10 km radius.

PRRSV surveillance results:

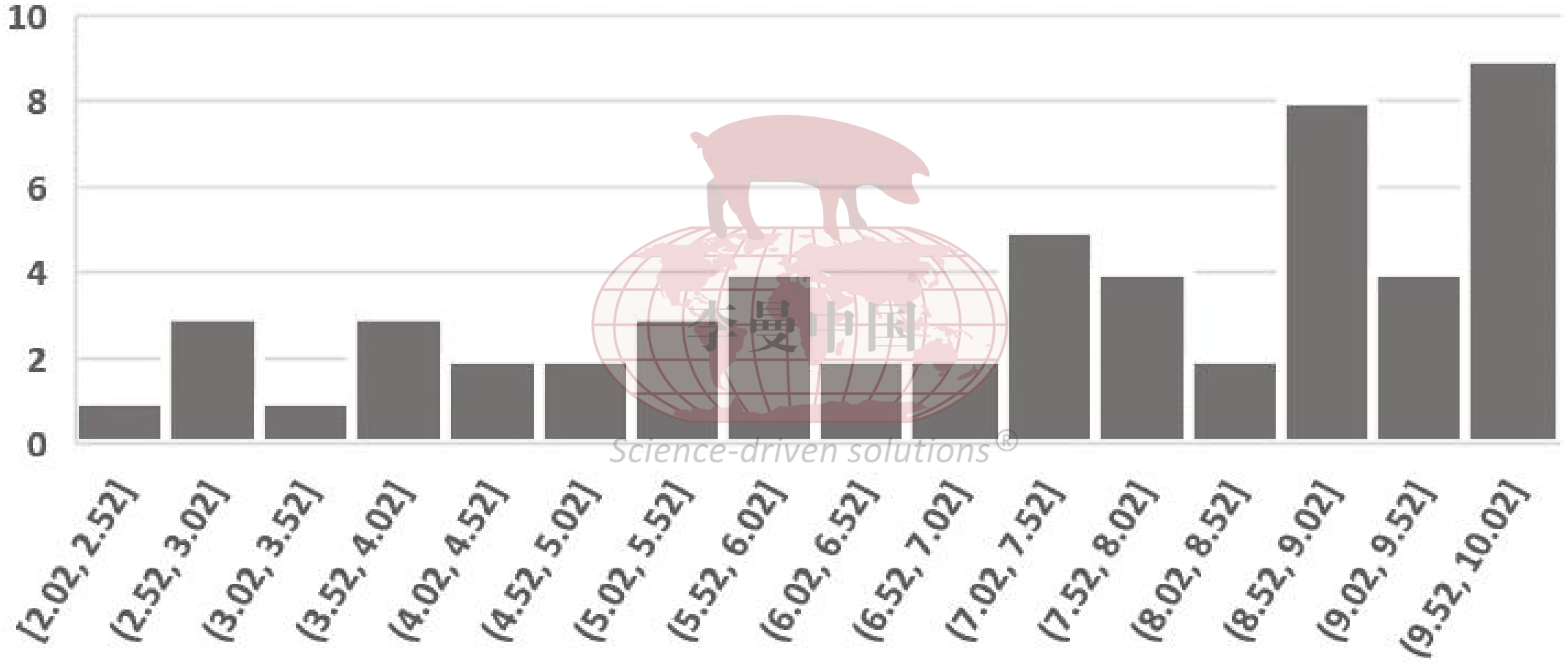
March 20, 2023: PCR NEGATIVE, 31 days in nursery phase

Breeding herd Neighboring pig sites <= 10 km

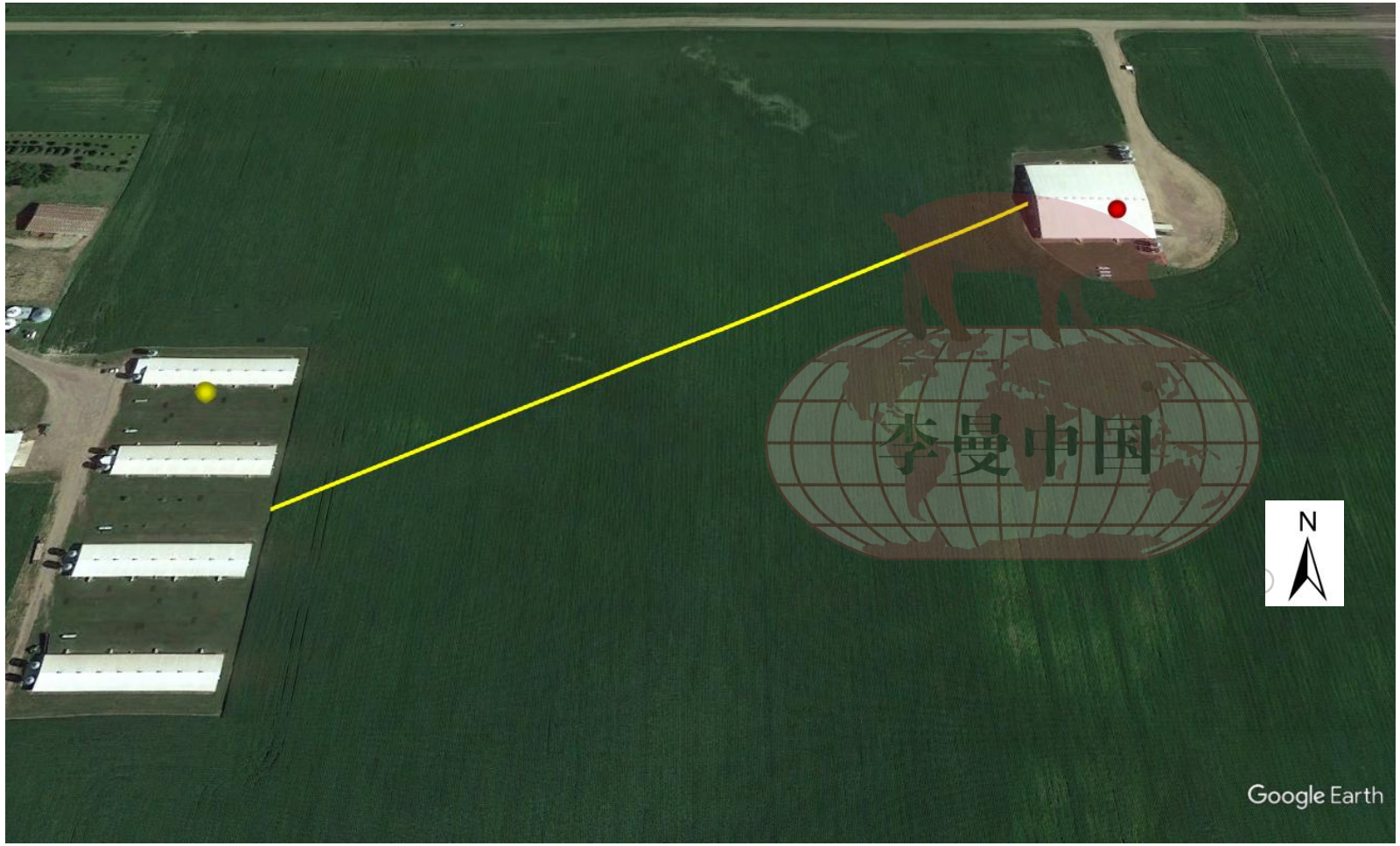
55 pig sites <= 10 km



Number of pig sites, by distance (km) from selected breeding herd



Example of non-transmission of PRRSV across a short distance



December 8-March 28, 2023
PRRSV naïve pigs placed

3,000 PRRSV-positive pigs Dec 8-Jan. 16

6,000 PRRSV-positive pigs Jan. 30-March 28

Ft. Snelling, MN weather data

Cumulative easterly winds: ~244 h
360 m from positive to negative populations

Three oral fluid collections:
Feb 21
March 2
March 28

PRRSV PCR and ELISA negative

My list of PRRSV transmission risk factors, in order of significance

- Infected, shedding pigs entered into a population of susceptible pigs
- Virus-contaminated semen used to inseminate susceptible pigs
- Trailers used in the transport of infected, shedding pigs subsequently used to transport susceptible pigs
- Personnel, equipment, supplies in contact with infected, shedding pigs subsequently in contact with susceptible pigs
- Contact with contaminated transport vehicles, rendering vehicle and subsequent contact with susceptible pigs
- Aerosolized virus over short distance, from shedding populations to susceptible populations, directly and indirectly

Specific management strategies to minimize PRRSV outbreaks in pig populations

- Locate pig production sites in low pig-dense areas
- Semen and replacement gilts confirmed PRRSV PCR negative before use or entry
- Dedicated inter-farm transport vehicles
- Washing, disinfection and controlled heating of all pig transport vehicles in contact with swine collection points, slaughter plants or other pig farms
- Minimal movement of people among farms, and only after down-time from any PRRSV site
- Equipment and supplies quarantined under controlled temperature (32°C) for 10 days before entry into a farm

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Julian Montoya

Jeff Blouin

Spencer Lucas

Joe Swerczek

Heidi Schwab

University of Minnesota SDEC

USDA

SHIC Swine Health Information Center

pork checkoff

Dr. Bob Morrison's Swine Health Monitoring Project

A Swine Health Information Center Funded Project

University of Minnesota Driven to Discover℠

College of Veterinary Medicine

Swine Disease Eradication Center

sfi Schwartz Farms