Department of Ecosystem and Public Health

Spatio-temporal patterns of Epizootic Hemorrhagic Disease (EHD) occurrence in the Continental USA (1980-2010)

Kathryn Berger, PhD
March 18 2014

Outline

- Epizootic Hemorrhagic Disease
- Manifestation
- Southeast Cooperative Wildlife Disease Study (SCWDS)
- Recent Outbreaks
- Spatio-temporal Analysis
- Gaps in Knowledge
- Targets for Surveillance
- Summary

Epizootic Hemorrhagic Disease

- Vector-borne virus of wild (and domestic) ruminants
- One of the most important diseases of deer in North America
- Vector: *Culicoides spp*. (Midges)
- Outbreaks in late summer/early autumn
- Midges hatch out of wet sand/mud
- Seasonal patterns suspected / environmental covariates
  - (e.g. drought)
- Ends after first frost kills midges
  - No animal-to-animal transmission

Image Sources: http://msuextension.org/publications/AgandNaturalResources/MT201205AG.pdf

Epizootic Hemorrhagic Disease

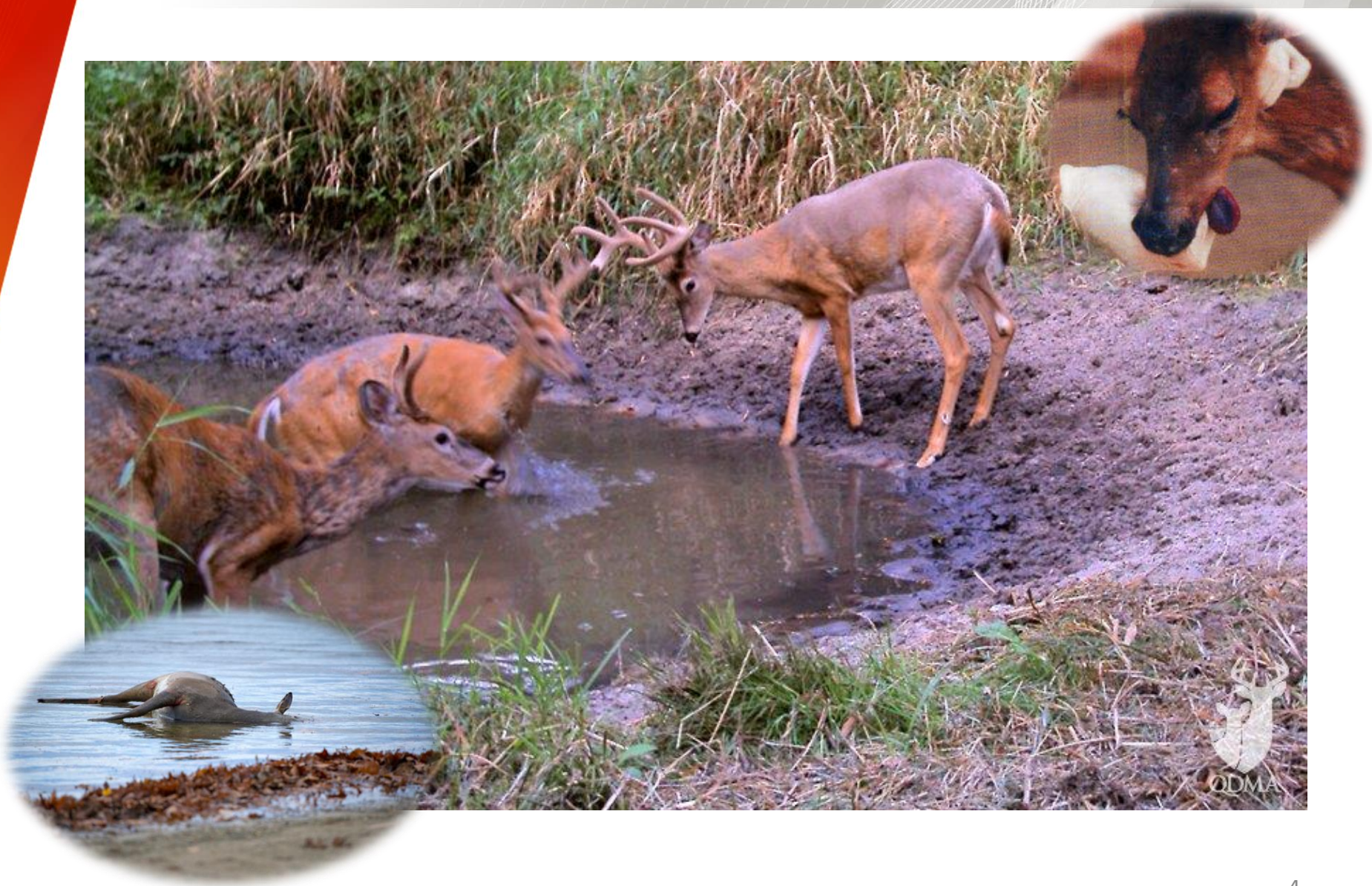


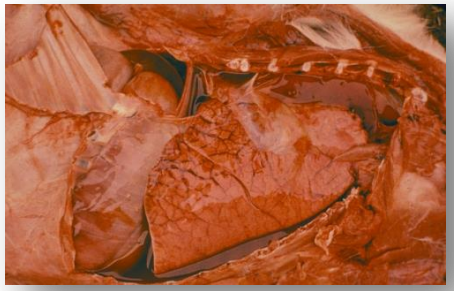
Image Sources: www.qdma.com; http://msuextension.org/publications/AgandNaturalResources/MT201205AG.pdf; and www.scwds.com

Epizootic Hemorrhagic Disease – Clinical

- **Peracute – High Mortality**

- High fever, swelling of tongue
- Die within 8-36 hours
- Sometimes few clinical signs

- **Acute (Classic EHD) – High Mortality**



- Extensive hemorrhaging
- Extensive salivation
- Ulcers on tongue, rumen

- **Chronic**

- Ill for several weeks
- Recovery
- Hoof lesions on survivors

Epizootic Hemorrhagic Disease – Clinical



- Fever, anorexia, difficulty swallowing
- Edema, hemorrhages, lesions seen on mouth and lips
  - *Lesions mimic those of Bluetongue and FMD*
- Lameness
- Abortions and stillbirths in some epidemics
- Most infections subclinical…


Image source: http://data.fao.org/

Epizootic Hemorrhagic Disease – Ecology

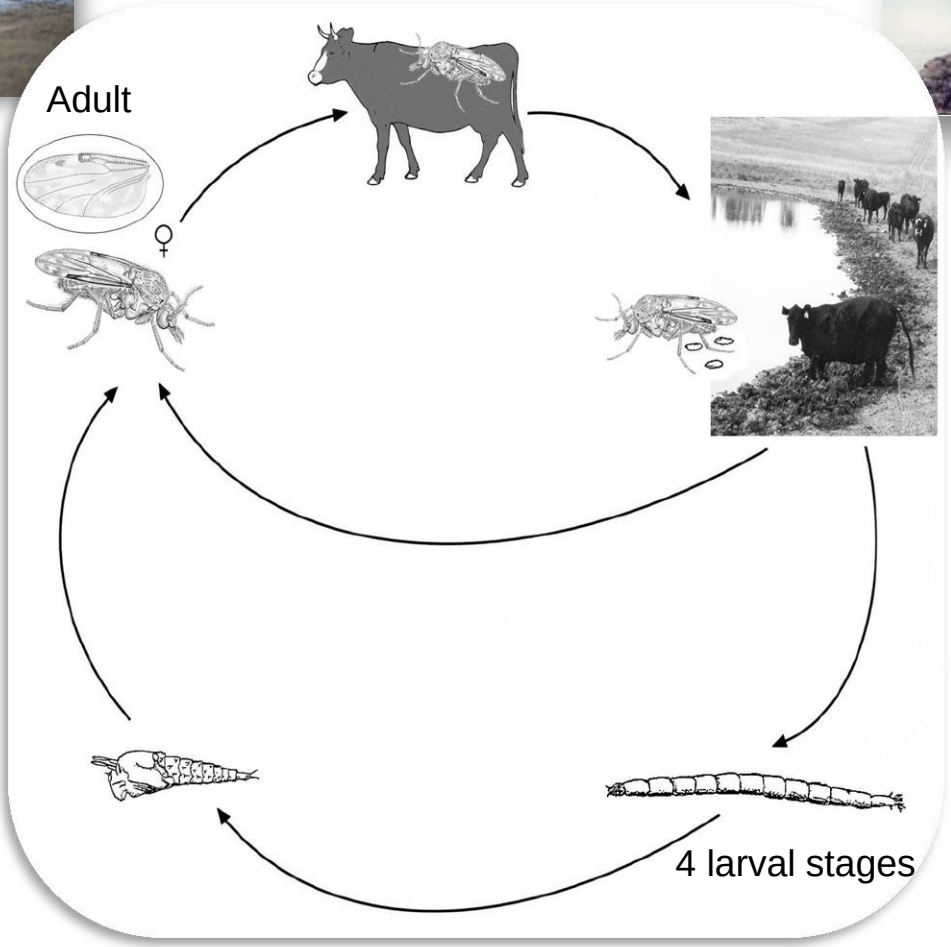


Image Source: http://msuextension.org/publications/AgandNaturalResources/MT201205AG.pdf; life cycle: Zuliani 2013

Epizootic Hemorrhagic Disease

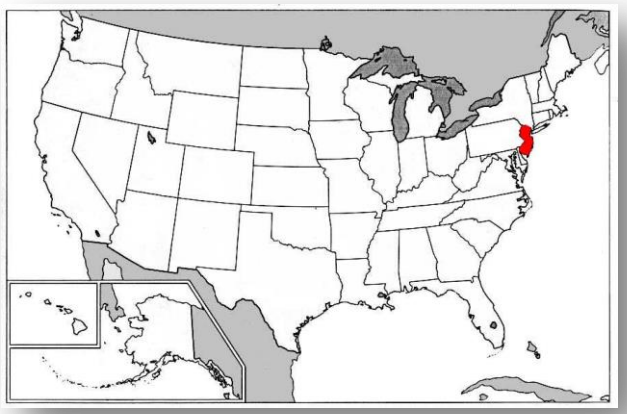
- Severity of disease varies from year to year & by geographic location
- Endemic to the southeastern USA
- Mortality as high as 90% in immunologically naïve white-tailed deer
- Not just a white-tailed deer problem
  - Pronghorn, elk, caribou, cattle, etc

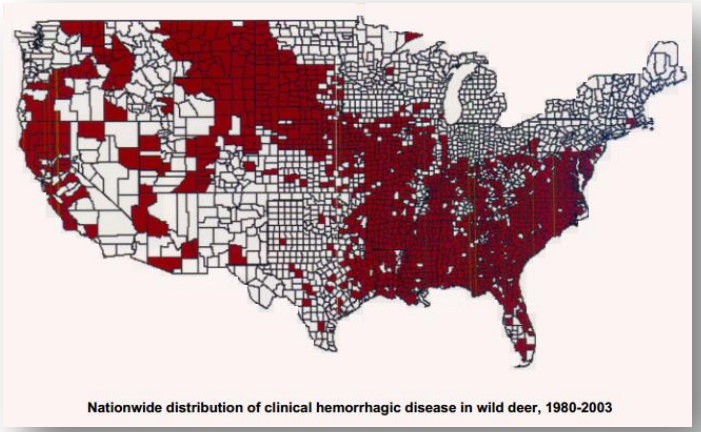
Epizootic Hemorrhagic Disease

- In **endemic areas**, a two to three year cycle (Couvillon et al.1981).
- In **epidemics areas**, a five to seven year cycle
  - Widespread US Outbreaks: 1997, 2002, 2007, 2012
- These cycles cannot be explained at this time but are likely relate to combined effects of **herd immunity** and natural or **weather**-induced fluctuation in vector populations

Epizootic Hemorrhagic Disease - History

- First isolated virus from NJ deer in 1955
  - EHDV 1 and 2 are endemic in the United States
  - EHDV 2 has been identified in Canada
- EHD History in Western Canada
  - South-eastern Alberta (1962)
  - Okanagan Valley (1987, 1988, 1999)
  - South-western Saskatchewan (1986-87)
- EHDV 6 has been isolated in several USA states (2006-ongoing)





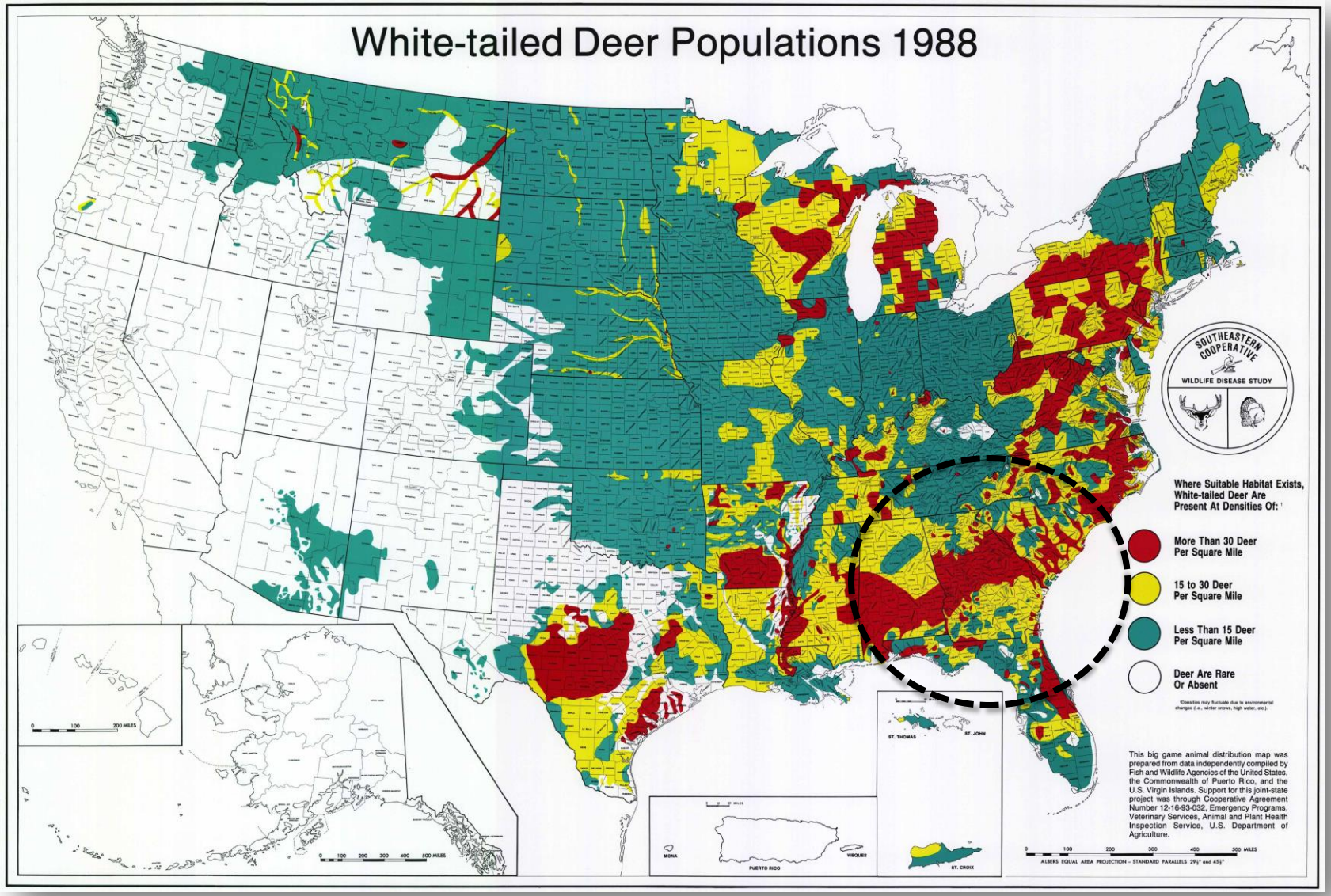
Southeastern Cooperative Wildlife Disease Study (SCWDS)

SCWDS

- Southeastern Cooperative Wildlife Disease Study (SCWDS)
  - Unofficial reference lab for whole country
- Surveys wildlife agencies (not domestic/captive) within each state
- Four survey criteria for EHD distribution
  - Mortality during EHD season
  - Hoof lesions: a good estimate of morbidity (survivors)
    - Seen mostly in southeastern USA (endemic areas)
  - Diagnostically compatible with EHD
  - Virus confirmation

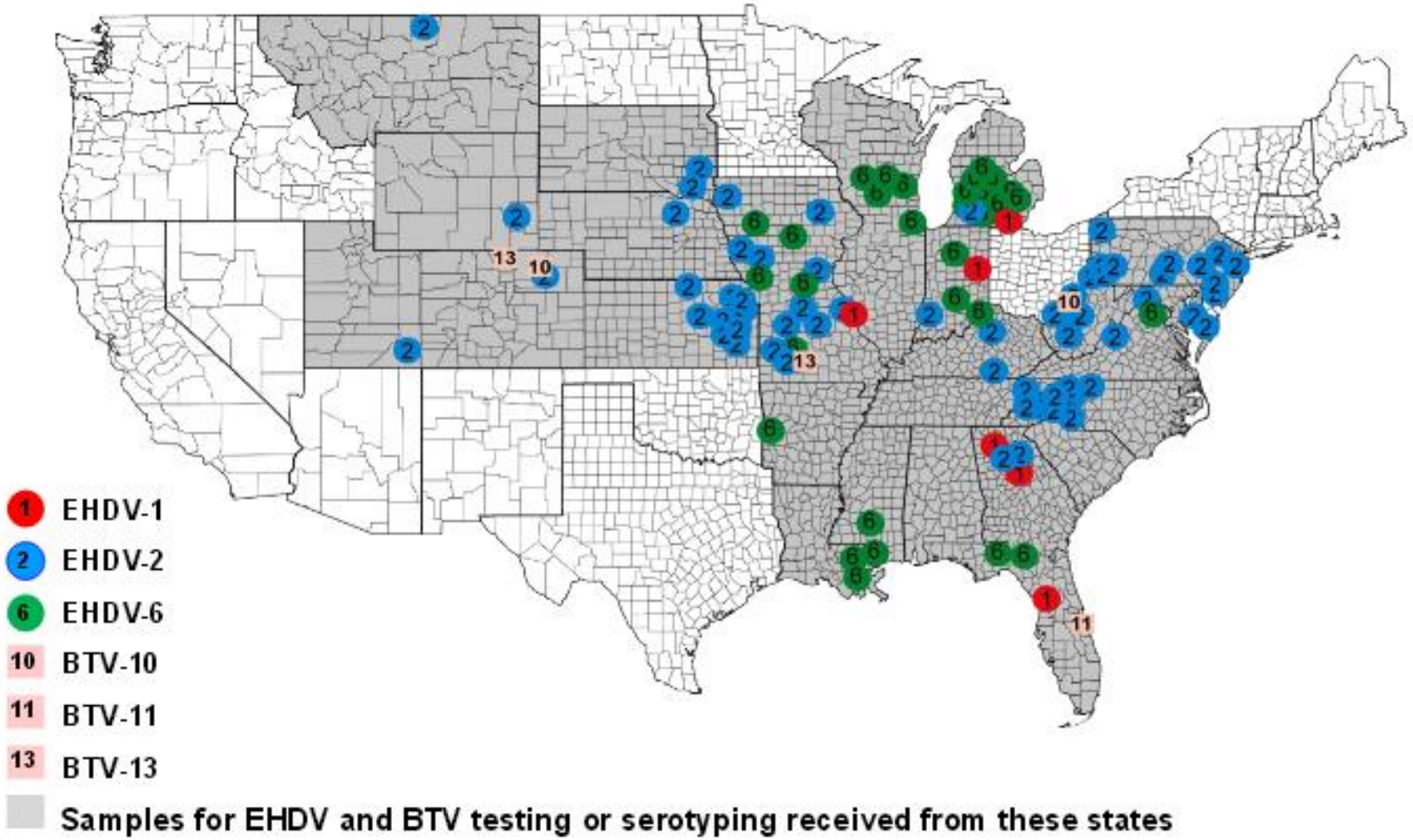
UNIVERSITY OF CALGARY

SCWDS



Southeastern Cooperative Wildlife Disease Study (SCWDS)

SCWDS



Southeastern Cooperative Wildlife Disease Study (SCWDS) newsletter, 2012

Recent Outbreaks

2013

The Bismarck Tribune

34°
Overcast
Weekly Forecast

News | Sports | Opinion | Obituaries | Bakken | Community | Lifestyles | Entertainment

Home / News / Bismarck-Mandan News

EHD confirmed in some cattle herds

Recommend 6 | Tweet | +1 0 | Share 2 | Print | Email

October 09, 2013 5:47 pm

pecially those in the
ic hemorrhagic
ed in cattle in severa

Tri-State NEIGHBOR

36°
Broken Clouds
Weekly Forecast

Tri-State News | Features | Recipes | Country Living | Weather | Calendars | Subscribe

Home / Tri-State News / Regional

EHD reported in Iowa cattle herds

Recommend 6 | Tweet 1 | +1 2 | Share | Print | Email

September 27, 2013 4:43 pm | (0) Comments

DES MOINES, Iowa – The Iowa Department of Agriculture and Land Stewardship said that 14 cattle herds, primarily in eastern Iowa, have had animals contract the epizootic hemorrhagic disease (EHD) virus.

EHD is a virus that is spread by biting midges

WVDL
Wisconsin Veterinary Diagnostic Lab

HOME | ABOUT WVDL + | DIAGNOSTIC AIDS + | SUBMISSION GUIDELINES + | CLIENT POR

Epizootic Hemorrhagic Disease (EHD) confirmed in Wisconsin cattle

MADISON –Animal health officials are urging cattle farmers to take preventive measures against Epizootic Hemorrhagic Disease (EHD) in cattle in light of two recent confirmed illnesses. The Wisconsin State Veterinarian encourages the use of insect control to eliminate biting midges and black flies, which are common carriers of the disease that primarily affects deer, but can also infect cattle and other ruminants.

"We already have reports of EHD in Wisconsin cattle, and until we have a hard freeze to kill the midges and flies, the virus will continue to be a threat to our cattle population," said Dr. Paul

Recent Outbreaks

- Recently EHD has become an (re?) emerging disease in cattle
- Added to OIE list of notifiable diseases in May 2008
  - Following outbreaks in 4 Mediterranean countries
- Can reduce milk production
- Abortions/still births
- Problem: Clinically indistinguishable from FMD

Recent Outbreaks

2013 ProMED Reports

Recent Outbreaks

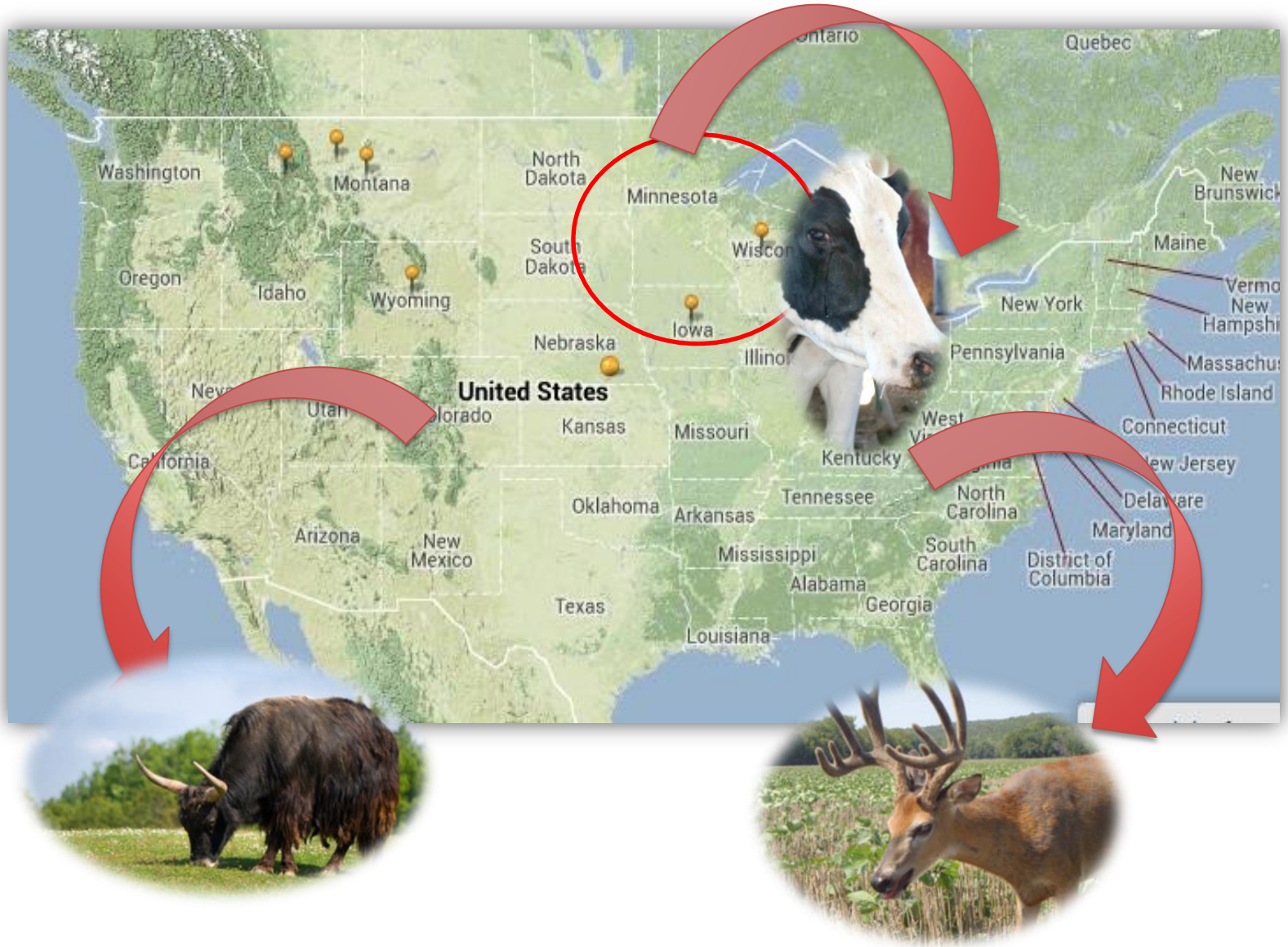
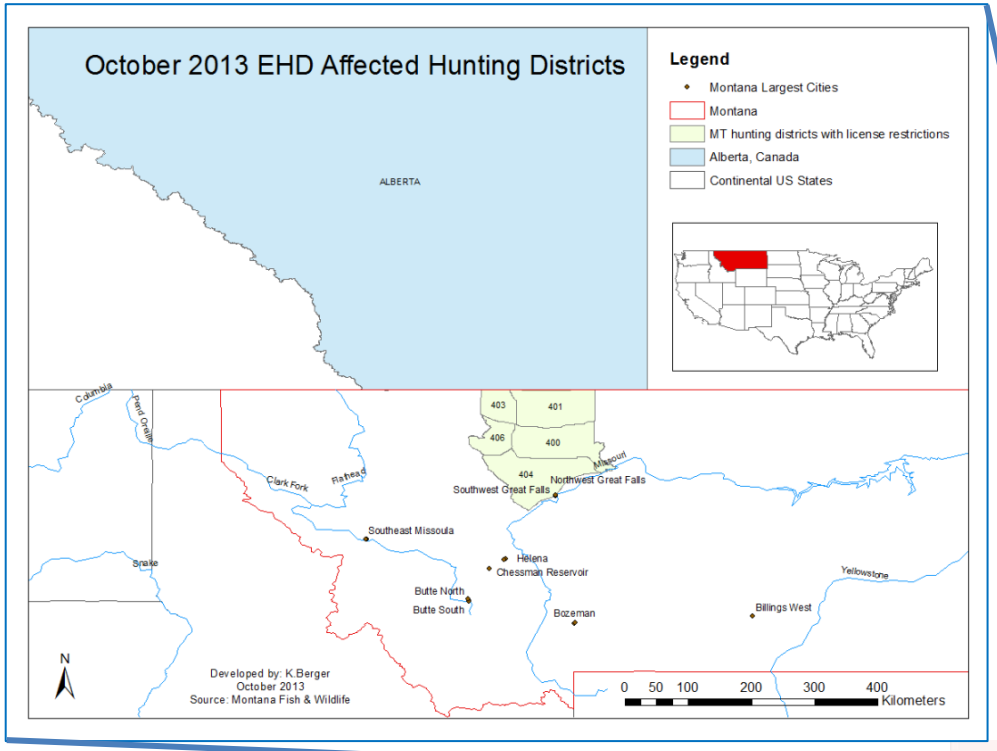


Image Source: Yak http://csu-cvmbs.colostate.edu/Pages/first-case-of-epizootic-hemorrhagic-disease-in-colorado-yaks.aspx; Deer: http://news.wildlife.org/featured/tracking-a-deer-killer/;

Recent Outbreaks

What about Canada?

Recent Outbreaks

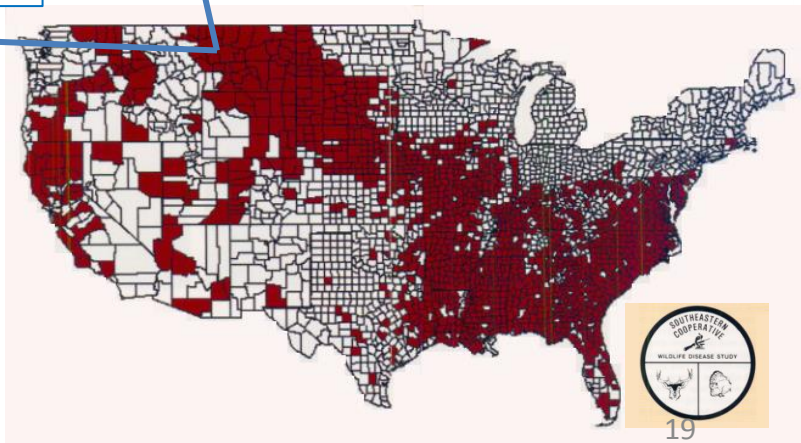


AUTUMN 2013

- Missoula, MT: First episode west of the Continental Divide in Montana.
- What about Alberta?

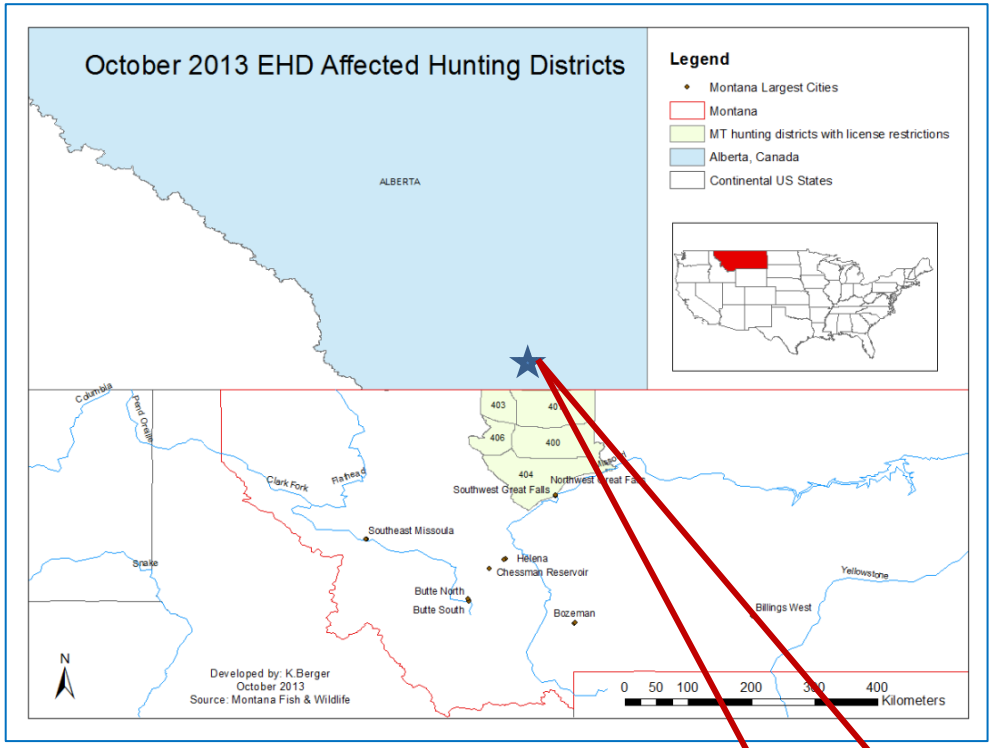
Historically:

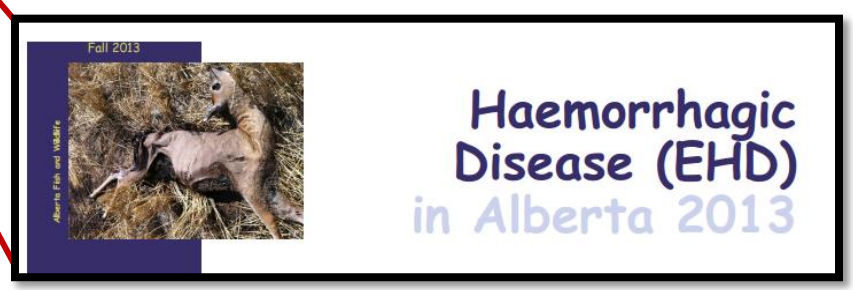
- Sporadic episodes in southwestern Canada
- Okanagan region of BC (1987)



Nationwide distribution of clinical hemorrhagic disease in wild deer, 1980-2003

Recent Outbreaks





September 2013 Outbreak

- Foremost, AB about 30 km north of USA border on September 16 2013

Vector Ecology Group Objectives

Vector distribution modeling

Model the vector distribution at the edge of its range (MT + AB)

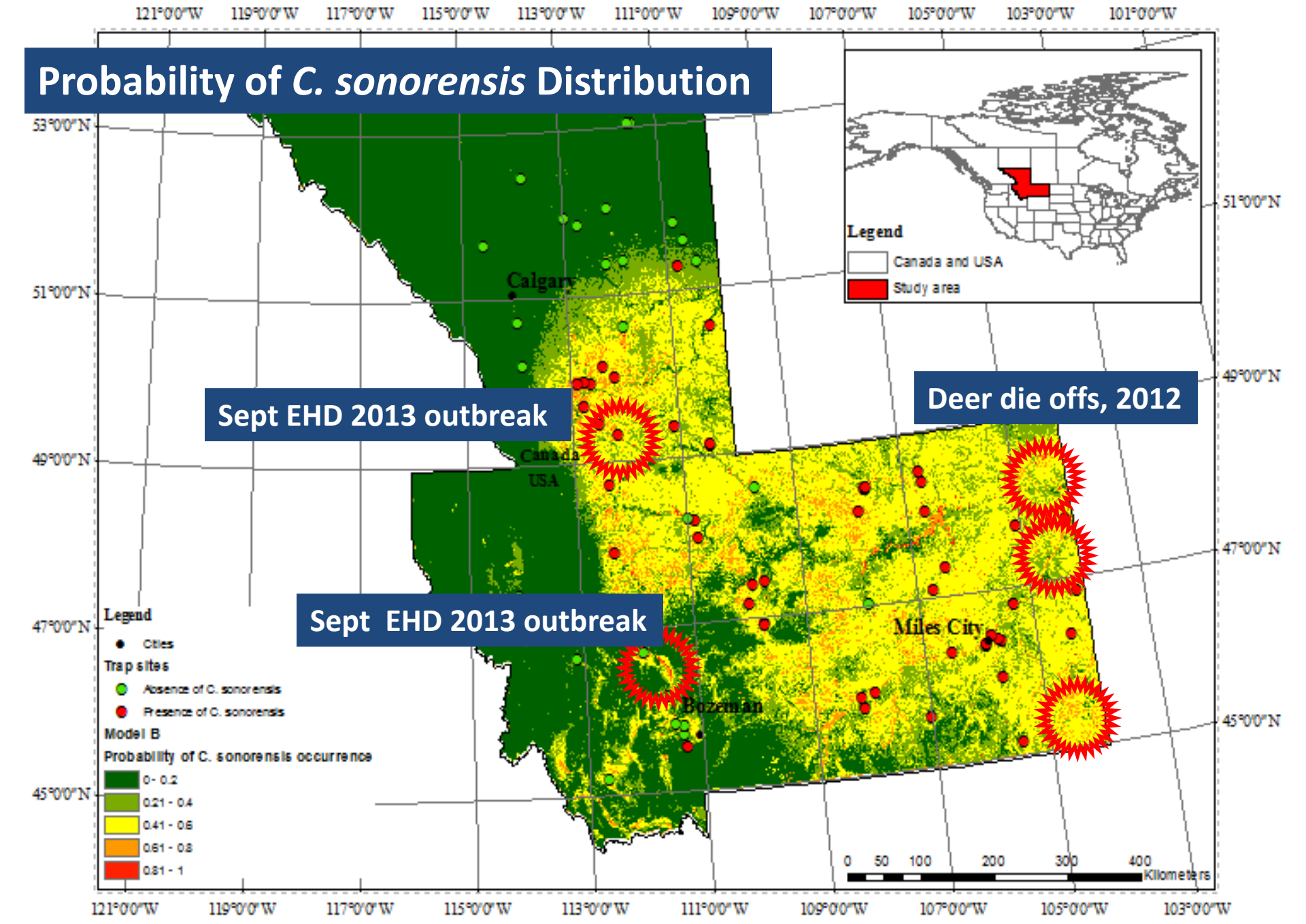
Project the trend of occurrence across AB in the next 50 years

Disease distribution modeling

Detect the Spatio-temporal patterns of EHD outbreaks (USA)

Model the factors affecting EHD outbreaks

Project the trend and predict the patterns of invasion



Outbreaks overlaid onto current distribution map for *C. sonorensis* developed by A. Zuliani (2013)

Spatio-temporal Analysis

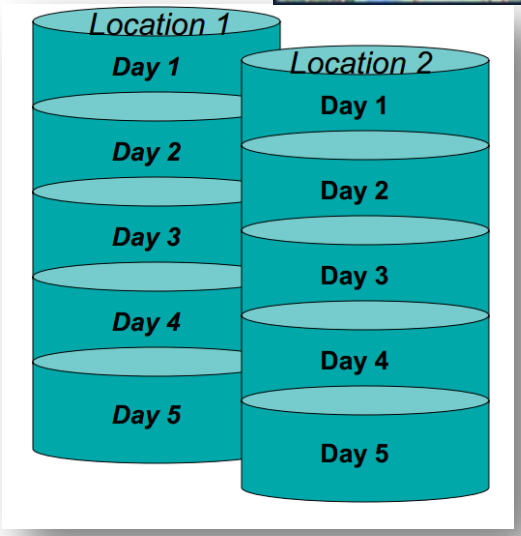
- Collaboration with the United States Department of Agriculture (USDA)
- Thirty year dataset (1981-2010)
- All events georeferenced; county centroids
- Used to identify spatio-temporal distribution of EHD occurrence, at county level

Spatio-temporal Analysis

- Cluster Detection
- SaTScan Space-Time Permutation Model
- No pre-selection bias
- Uses moving circular window
- High prevalence clusters identified
- Used successfully in development of early warning system for other vector-borne diseases

SaTScan™

Software for the spatial, temporal, and space-time scan statistics



Adapted from: Marilyn O'Hara (Univ. of Illinois) "An Introduction to SatScan" lecture slides; SaTScan logo (www.satscan.org)

Spatio-temporal Analysis

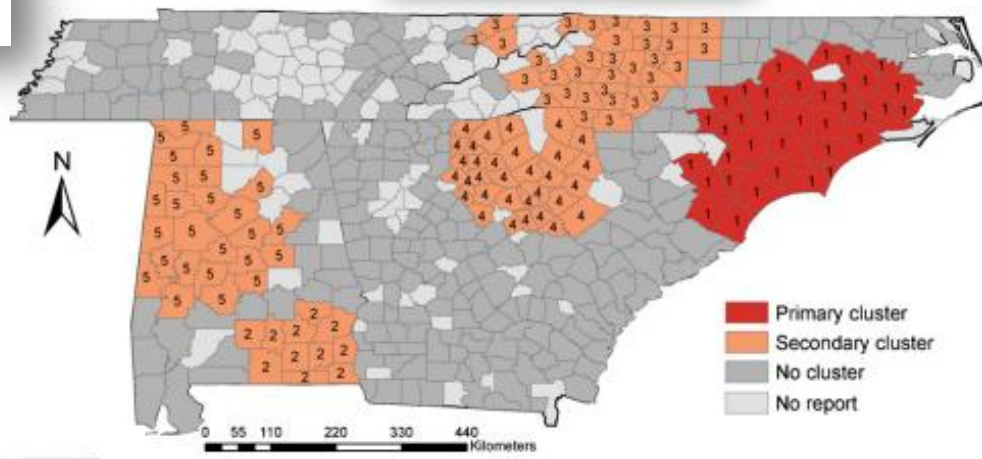
Preventive Veterinary Medicine

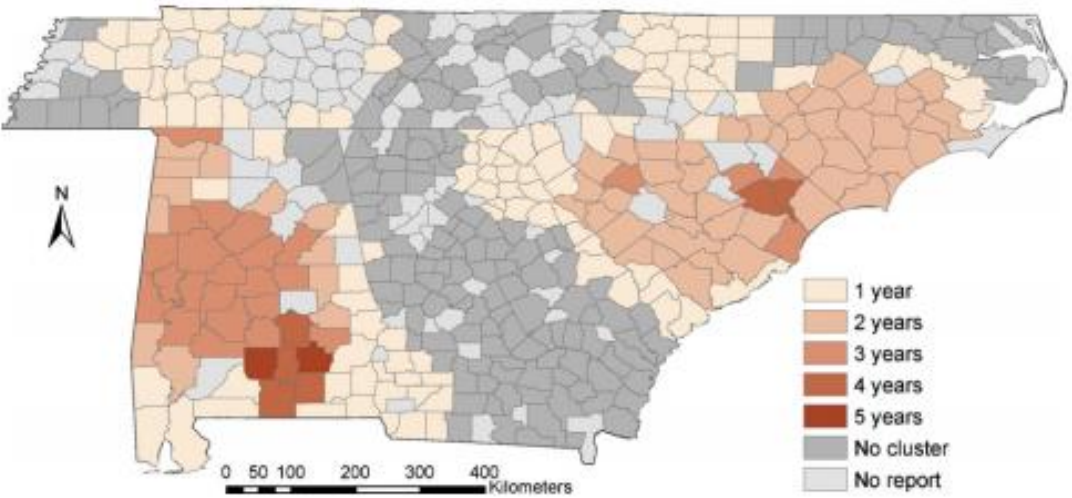
journal homepage: www.elsevier.com/locate/prevetmed

Spatial and spatial–temporal clustering analysis of hemorrhagic disease in white-tailed deer in the southeastern USA: 1980–2003

Bo Xu[a,*], Marguerite Madden[b], David E. Stallknecht[c], Thomas W. Hodler[d], Kathleen C. Parker[d]

SaTScan™
Software for the spatial, temporal, and space-time scan statistics

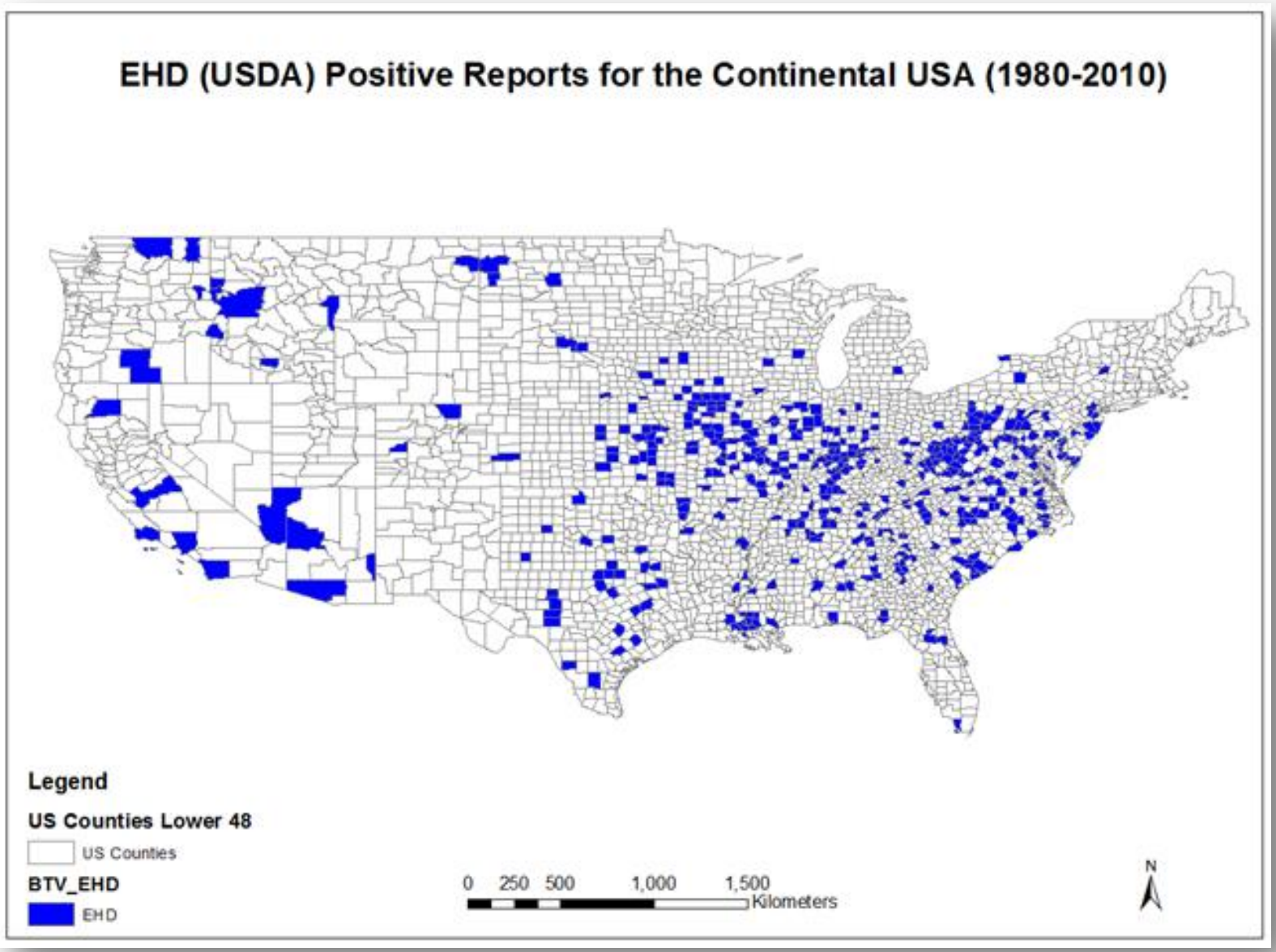




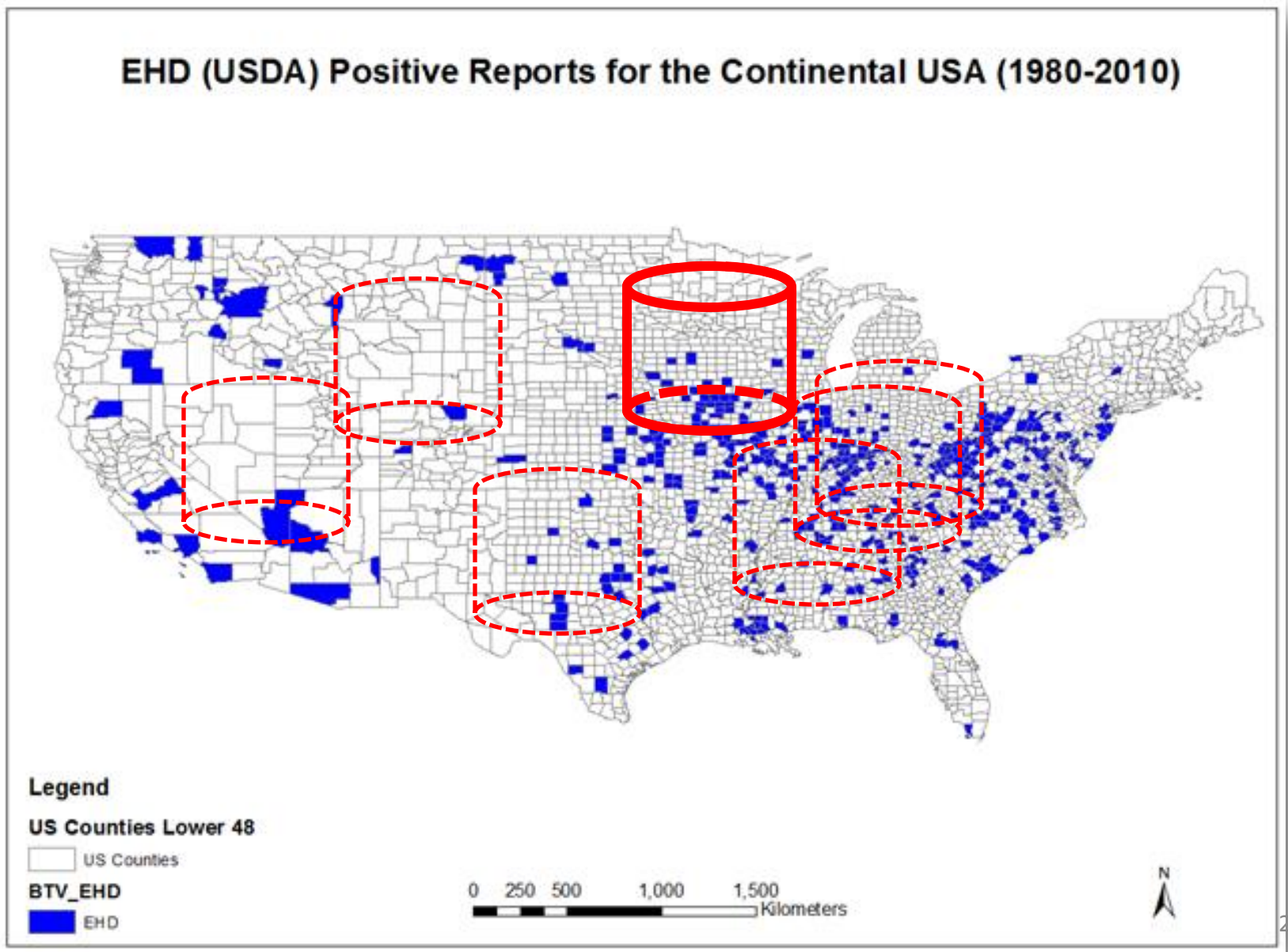
Spatio-temporal Analysis

- EHD Collection dates: aggregated by month
- Probability model: space-time permutation
- Scan for areas with: high rates
- Circular window
- Maximum spatial cluster size (1%, 5%, 7% 10%)
  - Literature (Xu et al. 2012; Sugumaran et al. 2009)
- Maximum temporal cluster size (4 mos, 9mos, 12mos)

Spatio-temporal Analysis

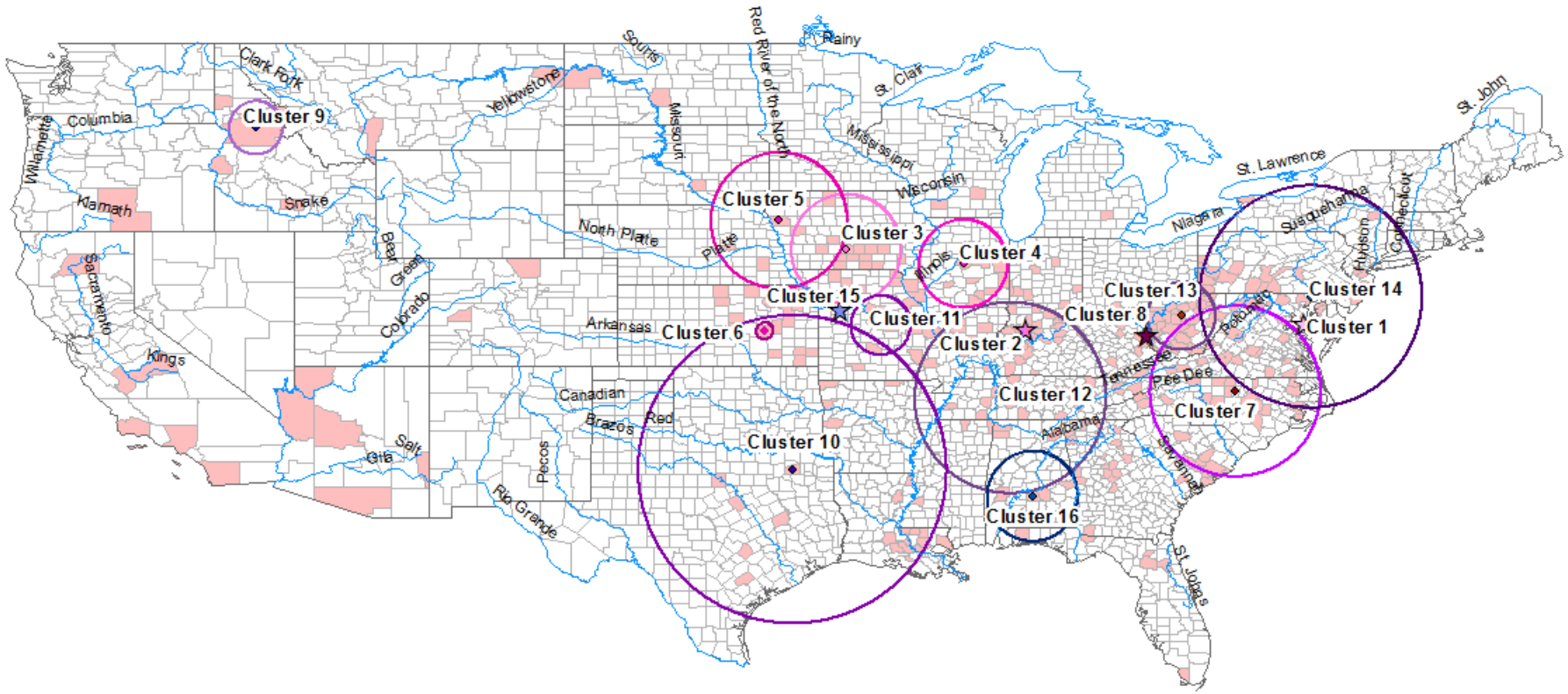


Spatio-temporal Analysis



EHD Spatio-Temporal Clusters (1980-2010)

EHD clusters identified using Kulldorff's spatial scan statistic (SaTScan) from USDA EHD records for 1980-2010, displayed in temporal order
Earliest clusters displayed in lighter rings, darker rings identify more recent clusters
Stars signify a cluster based on multiple reports from the same county
(Note: EHD positive counties from records where county and collection date were available, n= 646)



Legend

- Continental US States
- US Counties
- EHD positive counties

N

Developed by: K.Berger
October 2013
Source: USDA EHD database

Kilometers
0 250 500 1,000 1,500

UNIVERSITY OF CALGARY

Spatio-temporal Analysis

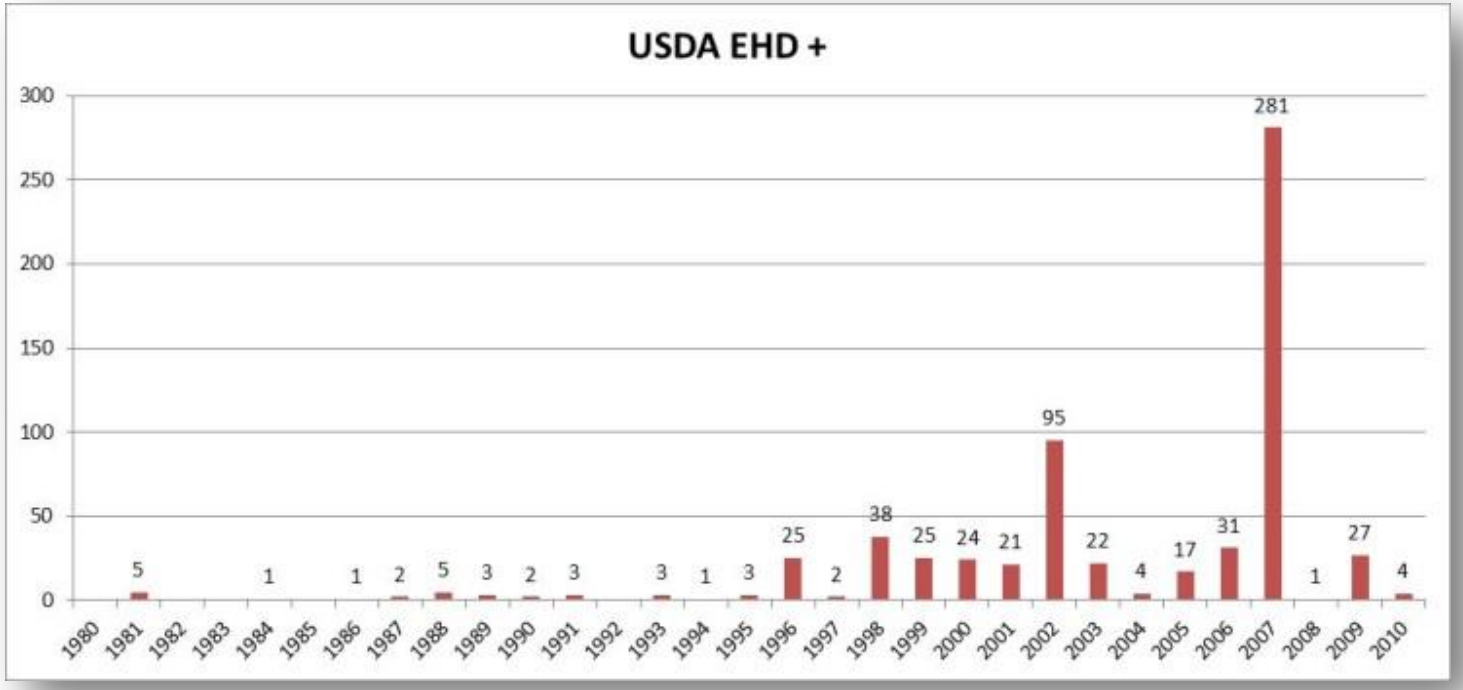
Cluster	Year	January	February	March	April	May	June	July	August	September	October	November	December
	1980												
1	1981								3	2			
	1982												
	1983												
	1984									1			
	1985												
	1986								1				
	1987									2			
	1988									2	3		
	1989								1	2			
	1990								1	1			
	1991		1							1	1		
	1992												
	1993								1	1	1		
	1994									1			
	1995									2	1		
2	1996								1	8	15	1	
	1997	2											
3;4	1998							1	1	9	23	4	
5	1999								2	8	15		
6	2000							1	8	10	4	1	
	2001								4	13	4		
7;8	2002							2	20	43	29	1	
9	2003								7	6	9		
	2004								2	1		1	
10;11	2005							1	3	10	3		
	2006			1					7	13	9		1
12;13;14	2007				1		1	4	97	134	40	4	
	2008										1		
15;16	2009							2	7	10	8		
	2010	1							2	1			

a significant cluster, identified by SaTScan (Cluster # displayed in table is signifcant clusters put in temporal order - this will correlate with SaTScan mapped output

"background" EHD positive counties, not identified as part of a significant cluster by SaTScan

Spatio-temporal Analysis

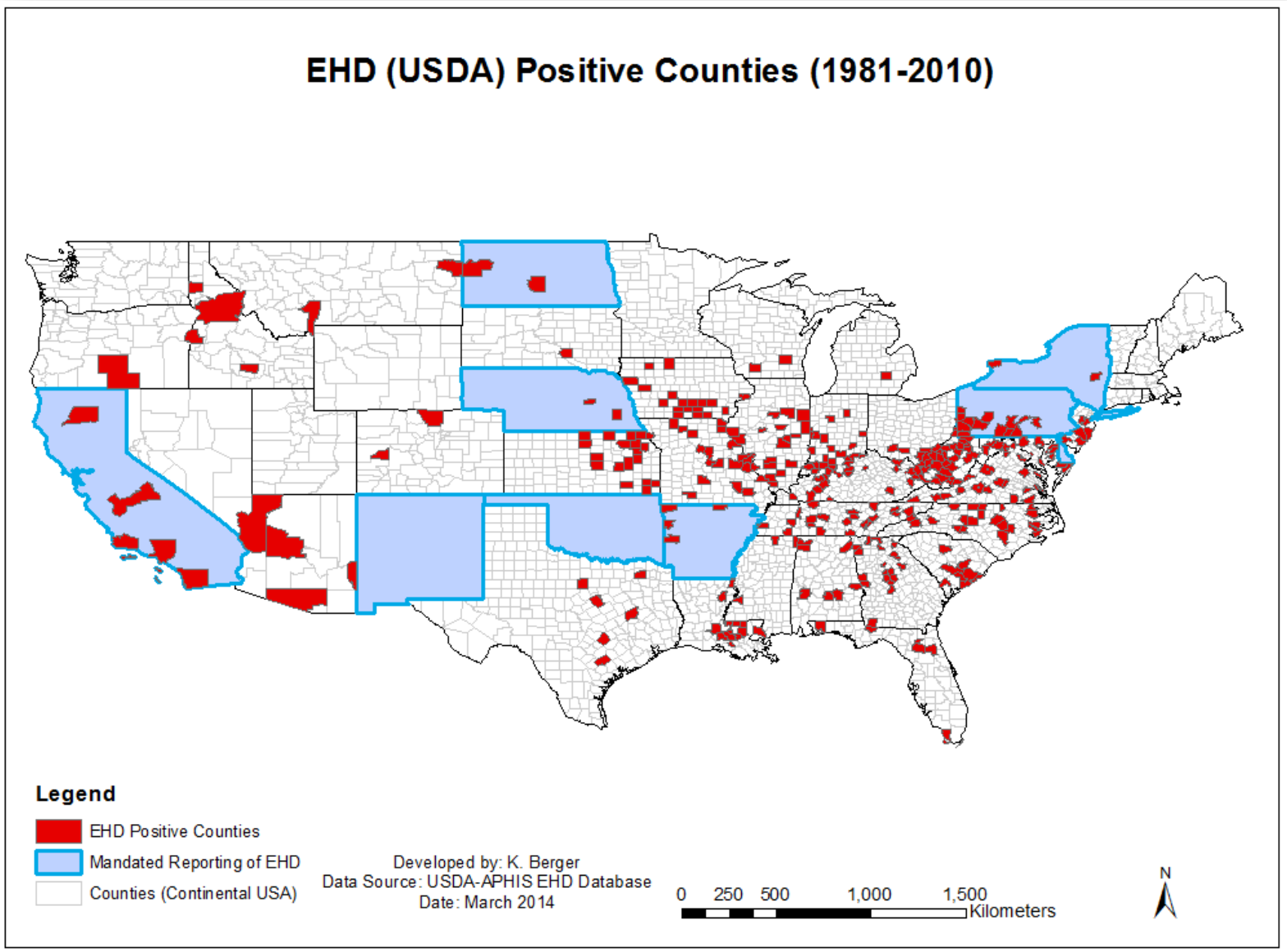
- Cluster analysis provides a better understanding of the spatio-temporal distribution of EHD in the USA
- But limitations...



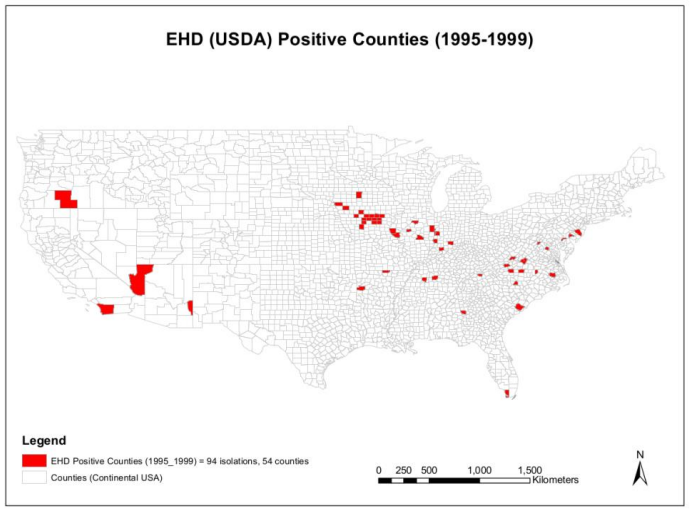
Gaps in knowledge

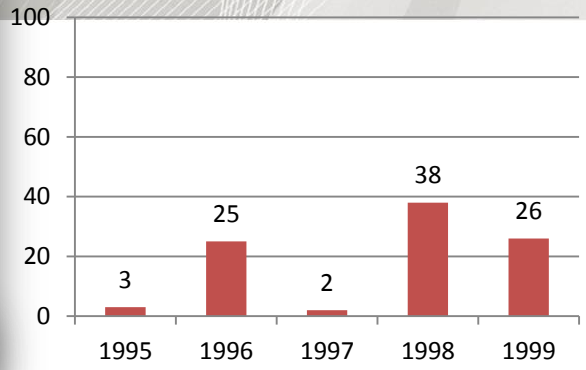
- Reporting bias within the database
  - Emails sent to 48 states within the continental USA
  - 34 (70.83%) states responded
  - Of those that responded: Only 10 states (29.41%) report EHD directly to USDA - APHIS
  - 3 of those 10 states only report cases of domestic/captive animals directly to USDA and cases in not wildlife
  - 1 of those 10 states only reported if an exotic serotype (i.e. not EHDV 1, 2, or 6)

Gaps in knowledge

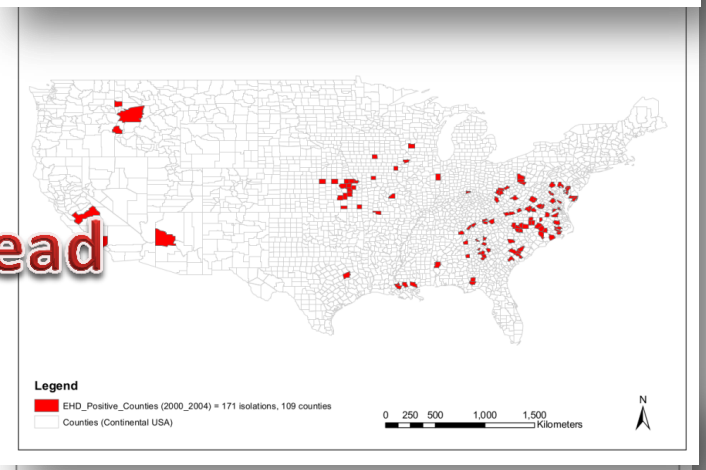


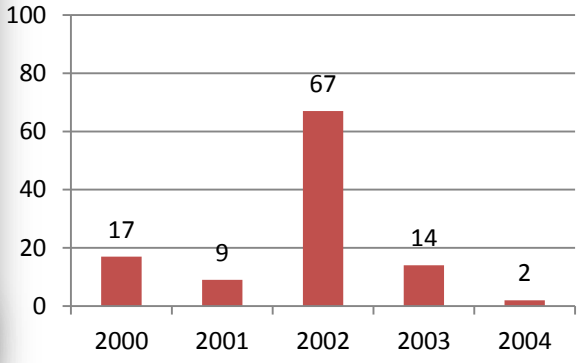
Gaps in knowledge



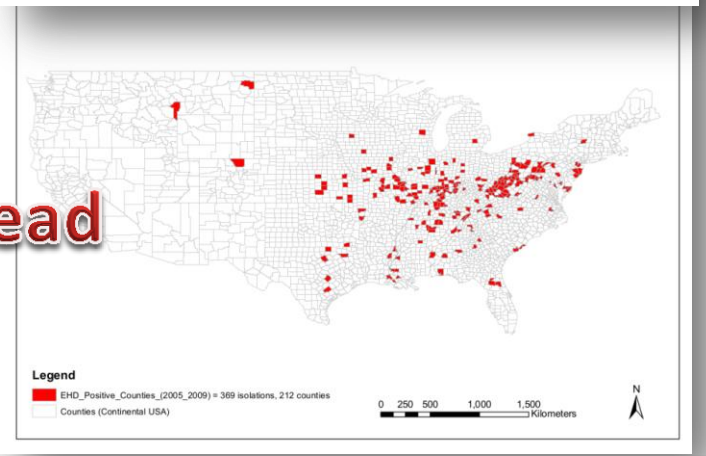


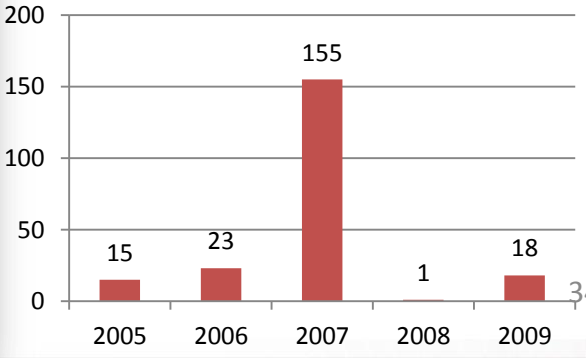
2002 Widespread Outbreak



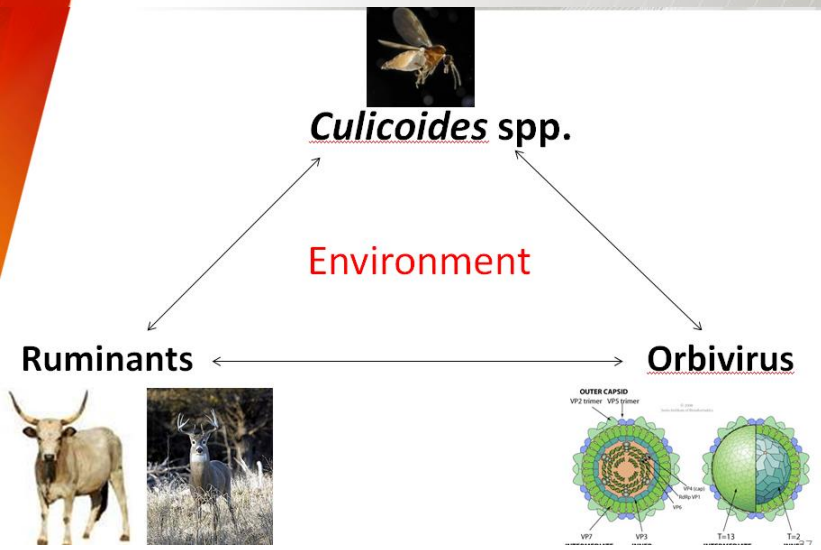


2007 Widespread Outbreak





Targets for Surveillance



Modeling is key

Disease surveillance and prevention (inform policy);
Disease invasion **under climate change scenarios**; a **multidisciplinary** process!

Data quality!

For active surveillance, data collection needs to be '**designed**' for modeling vectors AND disease **together**

Targets for Surveillance

- Next steps…
- Integrate new data into the USDA EHD dB
- Expert knowledge/data
- Factors affecting EHD outbreaks
  - County based, spatially weighted GLMM (Log. Regr. For repeated measures) for presence only (positive county) data
  - Incorporate reporting bias
- Project trends under climate change scenarios into southern Alberta
- Suggestions…?

Summary

- Epizootic Hemorrhagic Disease
- Recent Outbreaks
- Spatio-temporal Analysis
  - But limitations…
- Gaps in Knowledge
- Targets for Surveillance

- Needs:
- Strategic entomological sampling
- Interdisciplinary approach

Acknowledgments

- **UCVM Vector Ecology Group**
  - Dr. Susan Cork, Dr. Alessandro Massolo, Anna Zuliani
- **EHD Data (USDA)**
  - Dr. Jerry Frier, Dr. Ken Linthicum
- ***C. sonorensis* Data**
  - T. Lysysk (Alberta Research Center, Lethbridge)
  - G. Johnson (Univ. of Montana)
- **Additional Expert Knowledge**
  - Dr. David Stallknecht (SCWDS, Univ. of Georgia)

Funded by

UNIVERSITY OF CALGARY

Any Questions?