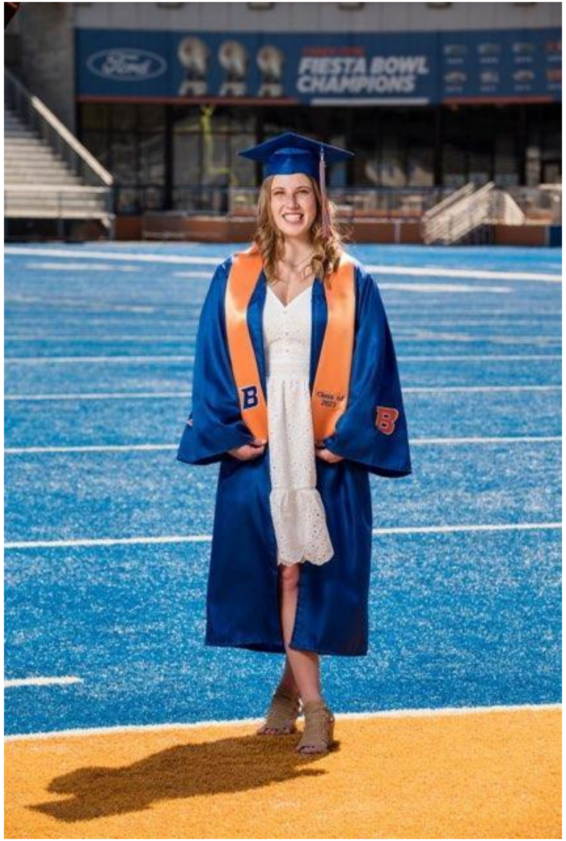
Wastewater Monitoring for West Nile Virus Trends in Kansas

McKenzie Ghrist
Master of Public Health
Infectious Disease and Zoonoses

About Me

- Hometown: Boise, Idaho
- Undergrad at Boise State University
  - Bachelor of Science: Public Health, General emphasis
  - Minor: Addiction Studies
- Internship in Buffalo, NY summer of 2022
  - Studied cancer patients' use of cannabis
- Current Position: Graduate Teacher/Research Assistant
- Wanted to be an Epidemiologist since I was 12 years old
- Fun Fact: I was born with Pulmonary Atresia (half a heart)



Outline

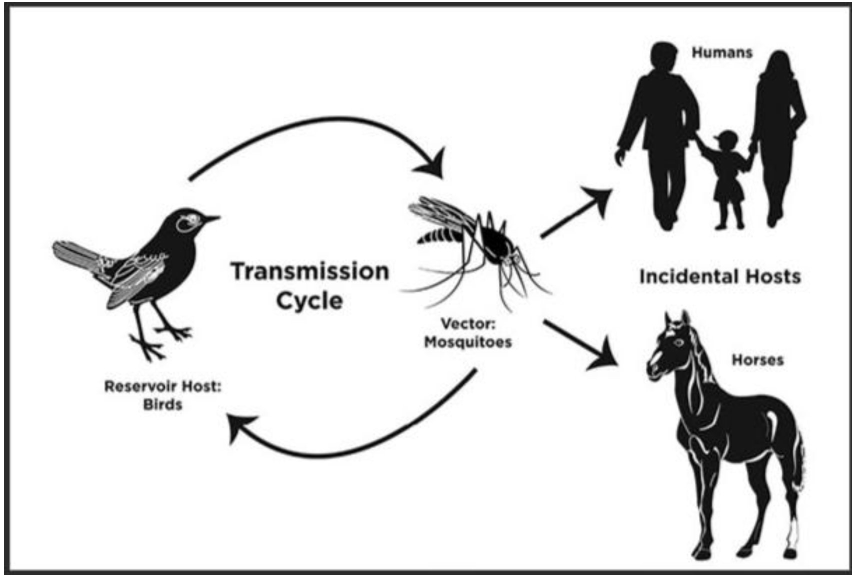
- Applied Practice Experience (APE) Site
- Background and Purpose
- Learning Objectives
- APE Products
- Limitations & Next Steps
- Competencies
  - MPH Foundational Competencies
  - Emphasis Area Competencies
- Conclusion
- Acknowledgements

APE Site

- Kansas Department of Health and Environment (KDHE)
  - Mission: “protect and improve the health and environment of all Kansans.”
  - Location: Topeka, KS
- APE Dates: June 9, 2025 – July 25, 2025
- Informatics and Molecular Epidemiology Program
  - Dr. John Anderson, PhD
  - Christopher Carter, MPH
- Infectious Disease Epidemiology and Response
  - Dr. Erin Petro, DVM, MPH, DACVPM

West Nile Virus (WNV)

- First discovered in 1930’s
- First identified in the United States (1999)
- Spread through *Culex* mosquitoes
- 70-80% = asymptomatic
  - 19% = mild flu-like symptoms
  - 1% or less = severe symptoms



Turner, 2020

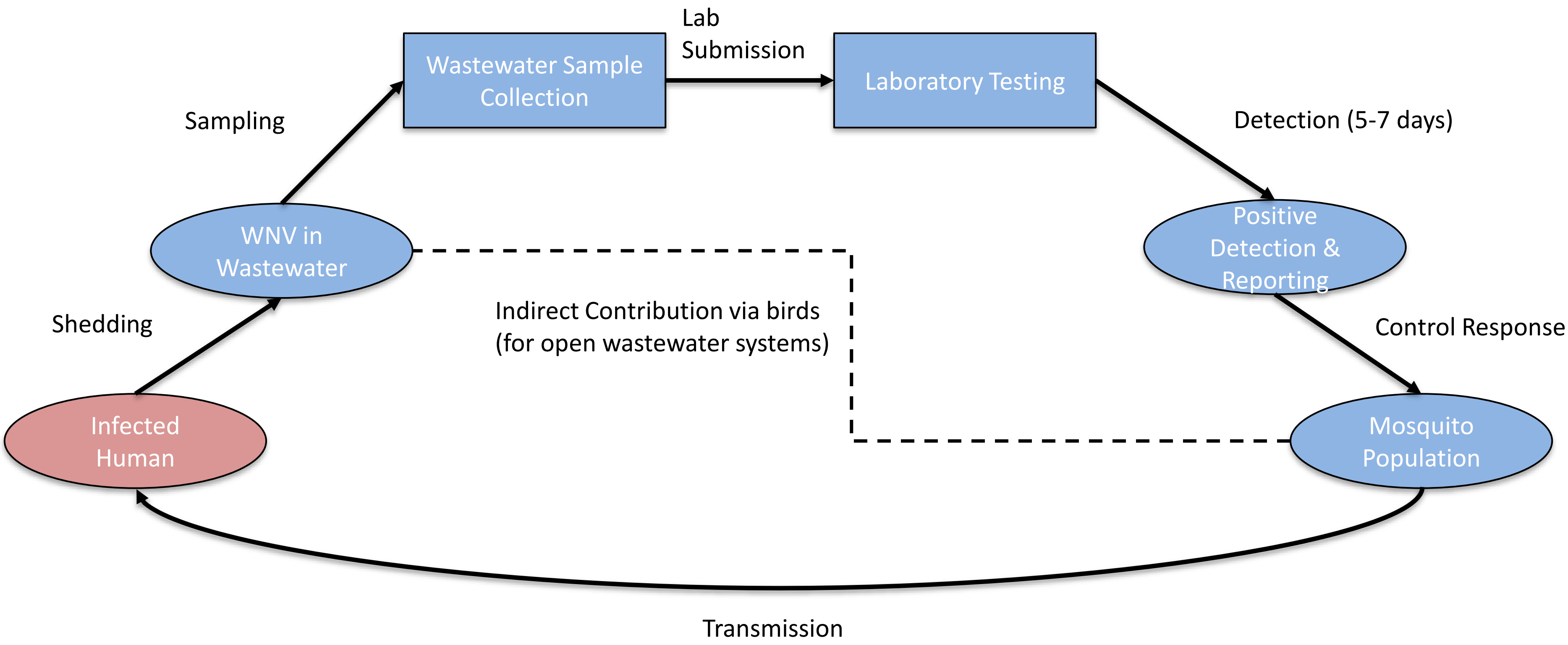
(CDC, 2021; Gorris et al., 2021; Kuhn et al., 2025; Vazquez-Prokopec et al., 2010)

Wastewater Monitoring

- Widespread tool at the start of 2020
  - CDC implemented the National Wastewater Surveillance System (Sep. 2020)
  - Monitoring for SARS-CoV-2 virus, influenza A & B virus, measles virus, etc.
- Cost effective
  - Saves $10.5-$18.5 million compared to clinical diagnostic surveillance
- Possible use for arboviruses
  - Dengue, Yellow Fever, West Nile Virus, etc.

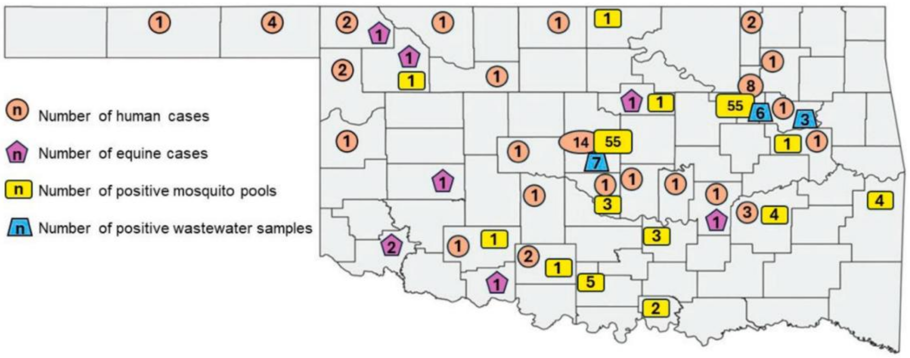
(NWSS, 2025; Diamond et al., 2022; Lee et al., 2022; Sanjak et al., 2024; Singer et al., 2023)

Wastewater Surveillance System



Oklahoma Study

- **Goal:** develop and establish a long-term wastewater monitoring tool for WNV
- Samples collected from 16 counties
- Acquired human, horse, and mosquito data
- WNV detected in 3 counties
  - Represents ~1.6 million people
  - Not detected in 5 rural counties
- Wastewater results aligned with human cases
  - Aligned with mosquito data



(Kuhn et al., 2025)

Purpose

- WNV is endemic in the United States
  - Endemic in Kansas
- Possibly underreported
  - Due to the 70-80% asymptomatic cases
- Goal: Strengthen surveillance systems for WNV and provide public health with an in-depth understanding of human WNV trends.

(CDC, 2025; KDHE, 2025)

Learning Objectives

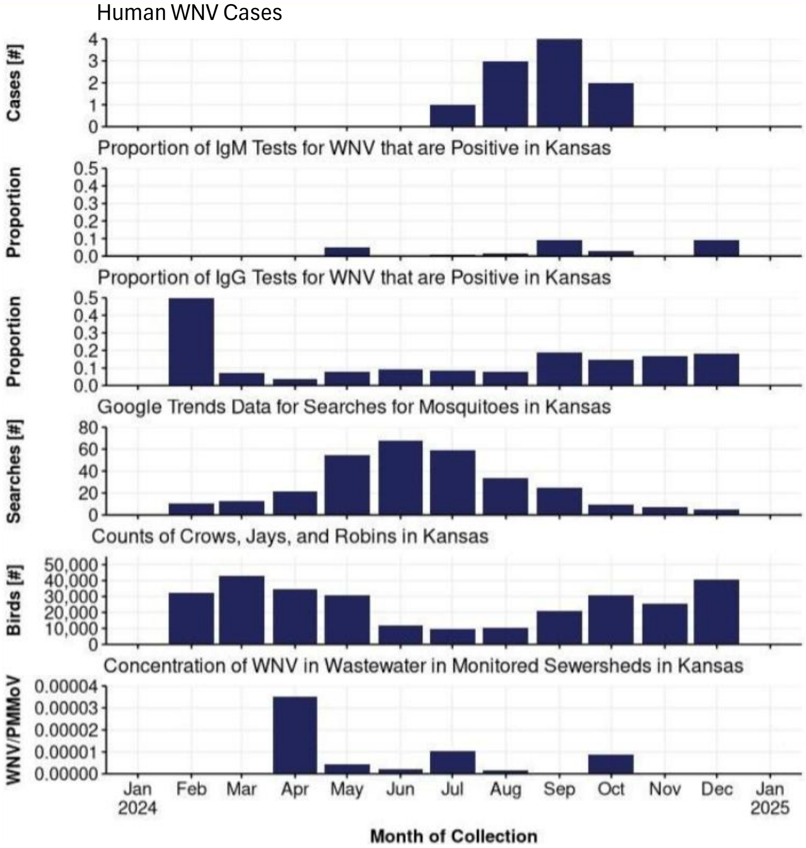
Statistical Analysis:

- KPSS Test: Stationary
- Time-series Cross-correlation
- ARIMA modeling
  - AIC & RMSE values
- Ljung-Box portmanteau
  - Non-significant result = good

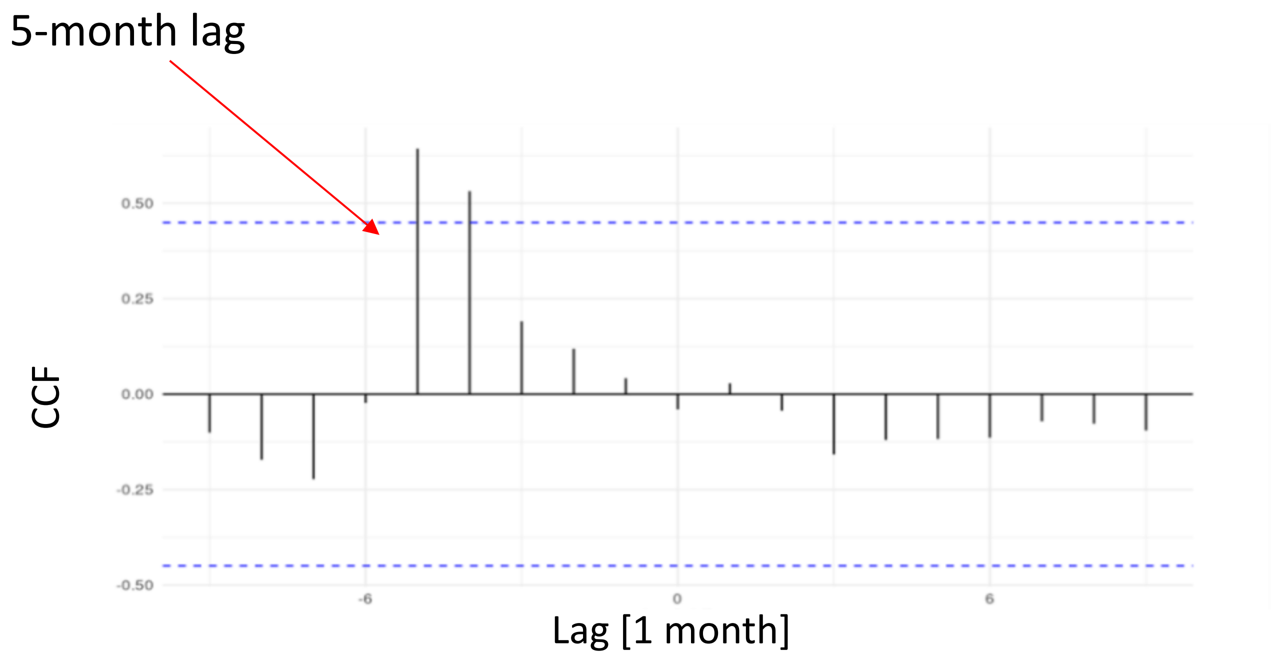
Geographical Information Systems (GIS) Analysis:

- Collected Boundary Shapefiles
- Created Point Feature Class
- Incidence Rate of Reported WNV human cases
- Mean Center & Standard Distance
- Average Nearest Neighbor
- Spatial Autocorrelation (Global Moran’s I)

Data Overview

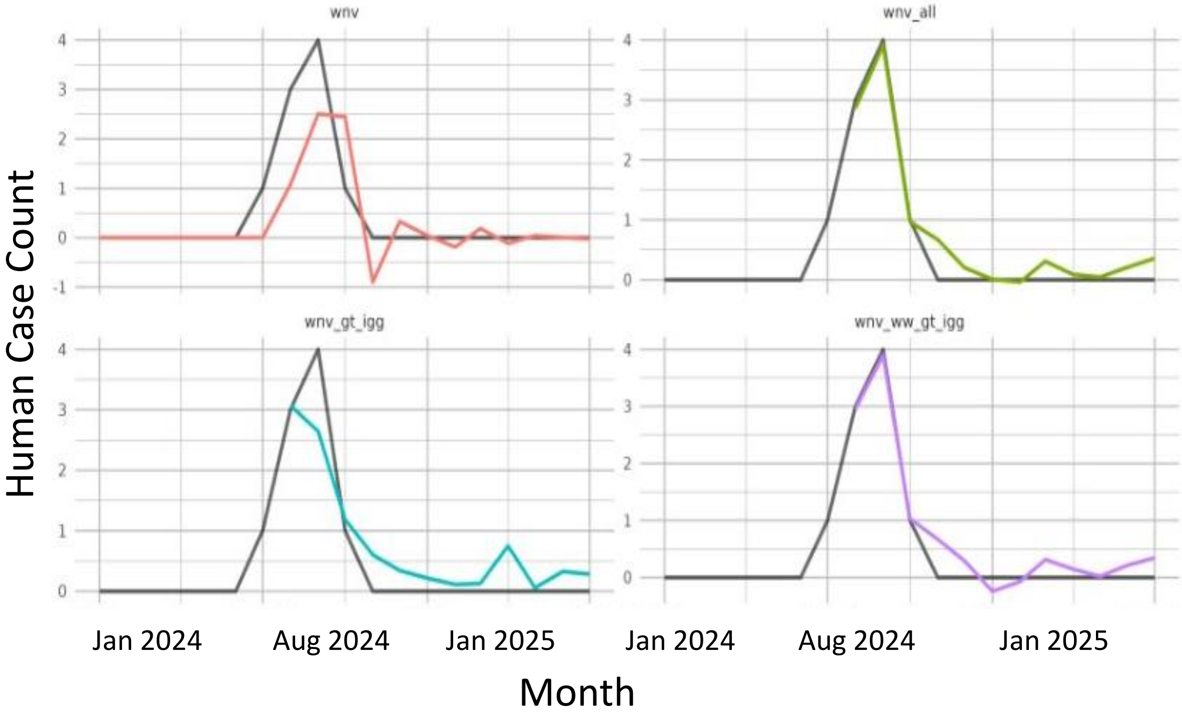


Time-Series Cross-Correlation



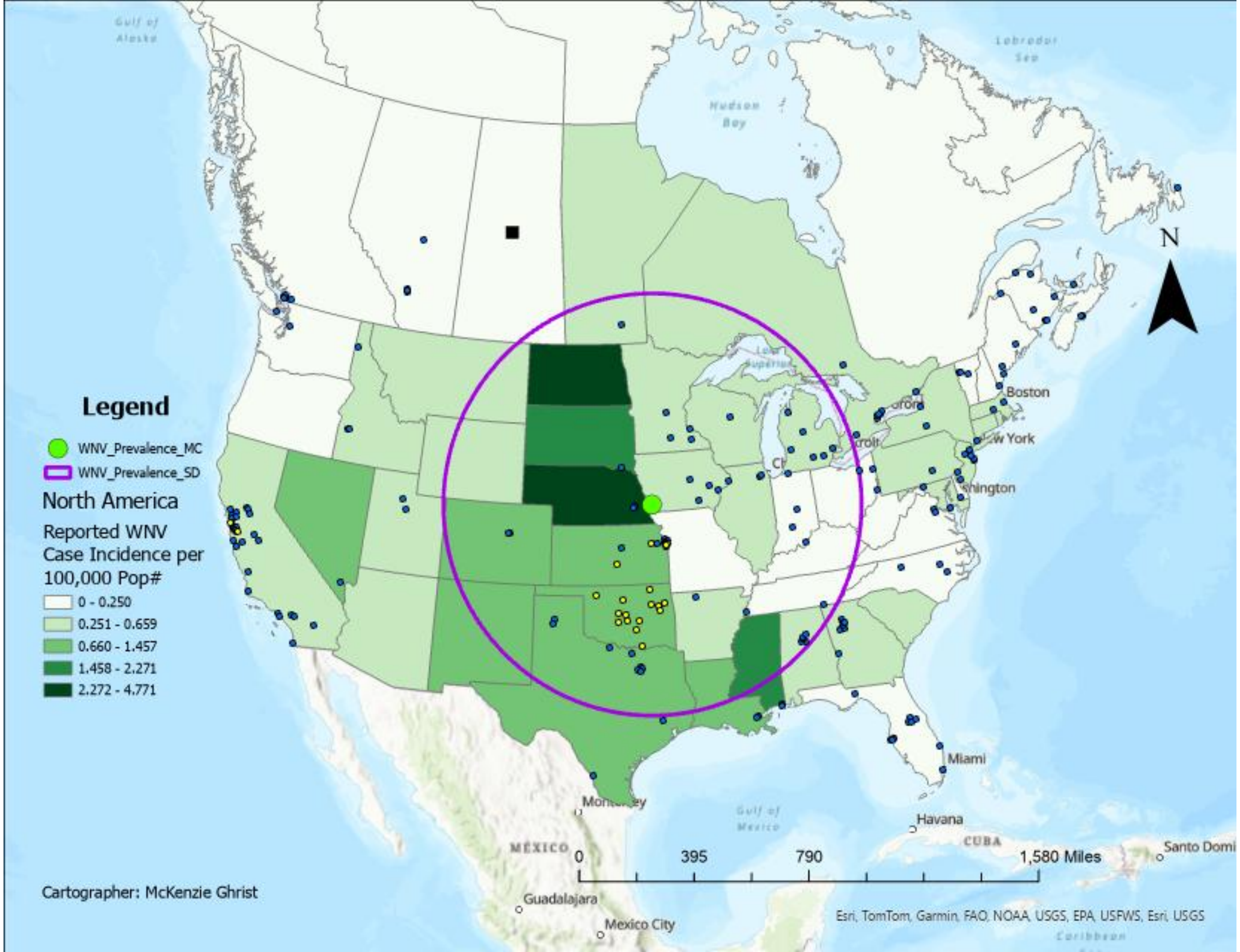
CCF plot for wastewater WNV detection data against human WNV cases

ARIMA Models

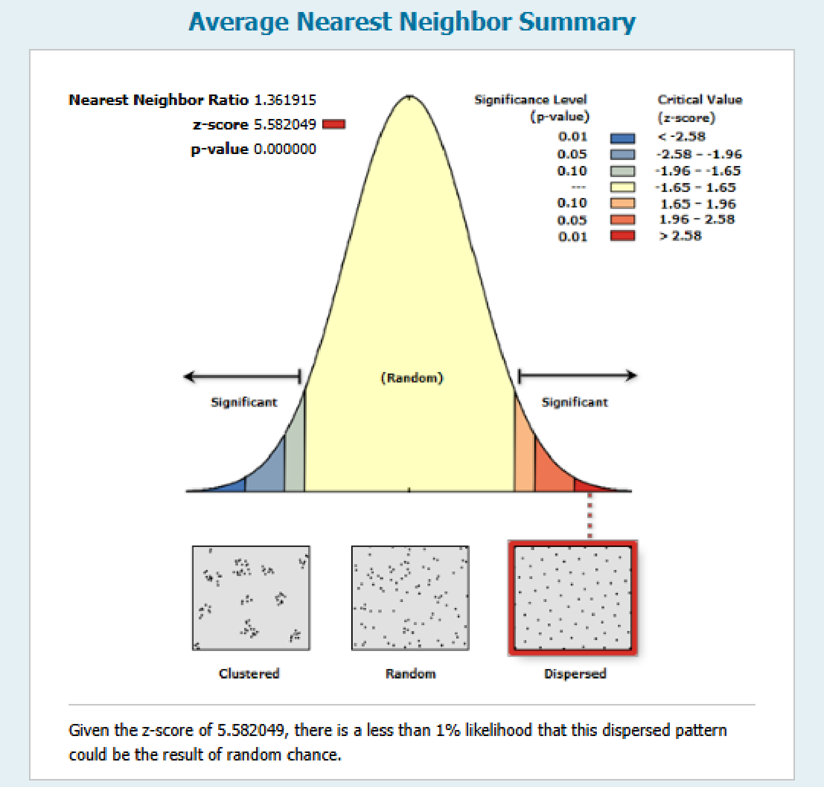


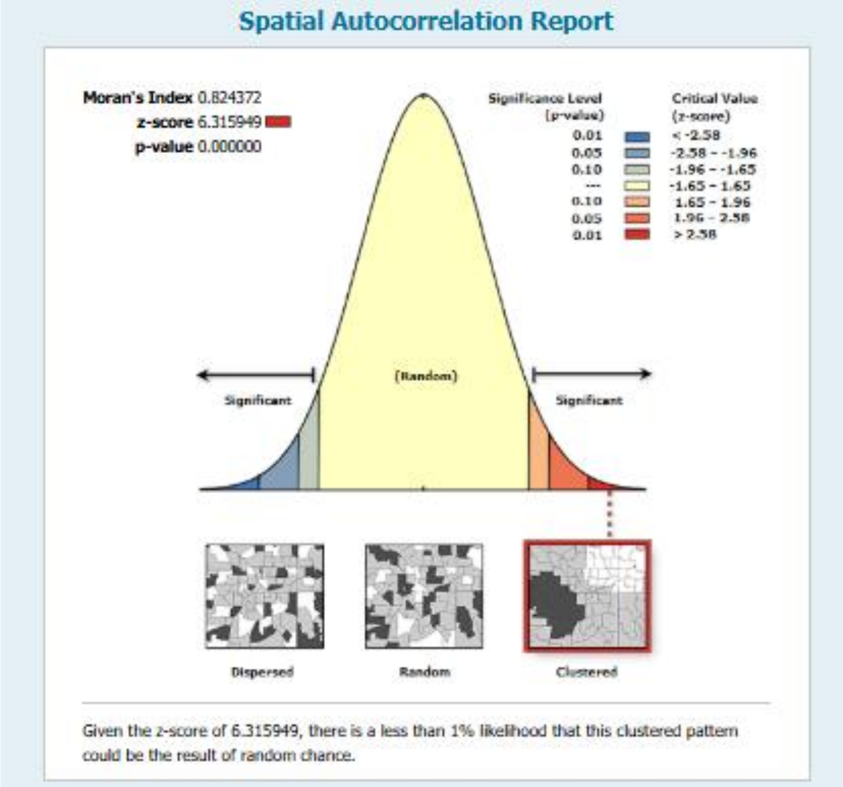
Best fit-model = **"wnv_ww_gt_igg"**
- AIC = 14.9
- RMSE = 0.273

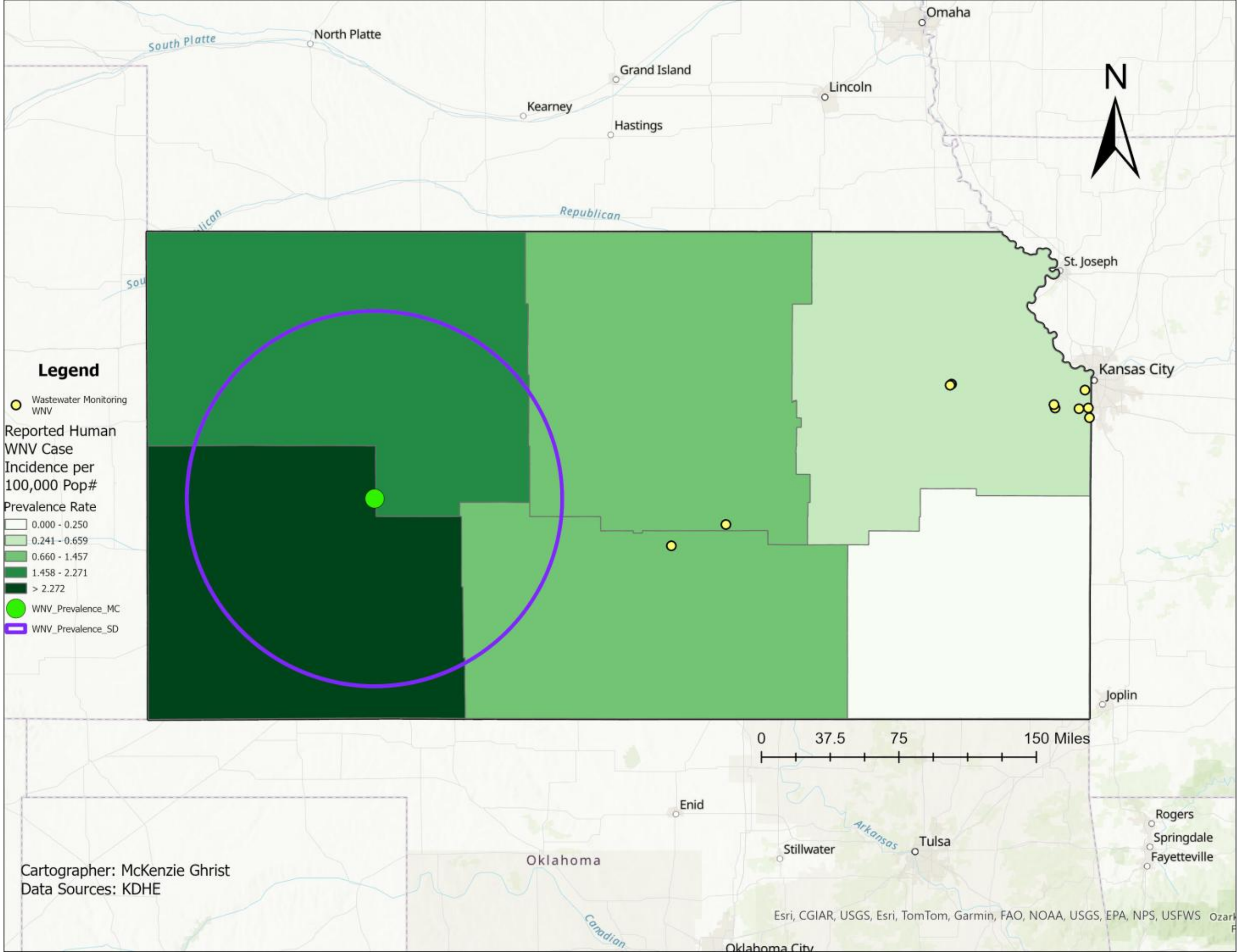
Worst fit-model = **"wnv_gt_igg"**
- AIC = 26.8
- RMSE = 0.515


Legend
WNV_Prevalence_MC
WNV_Prevalence_SD
North America
Reported WNV Case Incidence per 100,000 Pop#
0 - 0.250
0.251 - 0.659
0.660 - 1.457
1.458 - 2.271
2.272 - 4.771
Gulf of Alaska
Labrador Sea
Hudson Bay
Boston
New York
Washington
Miami
Havana
CUBA
Santo Domi
Gulf of Mexico
MÉXICO
Monterrey
Guadalajara
Mexico City
0
395
790
1,580 Miles
N
Cartographer: McKenzie Ghrist
Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS, Esri, USGS

Spatial Analysis Report – U.S. & Canada

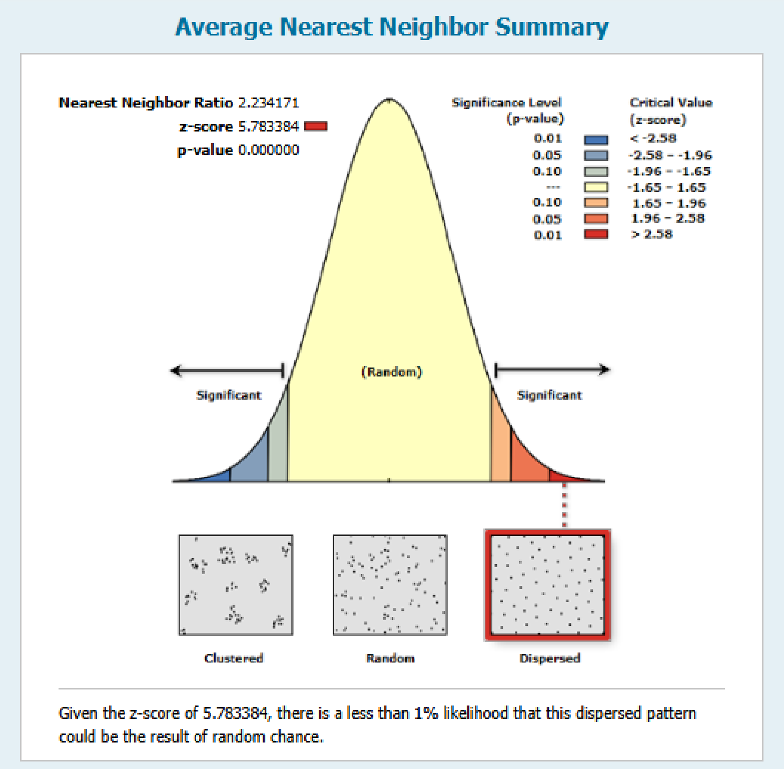


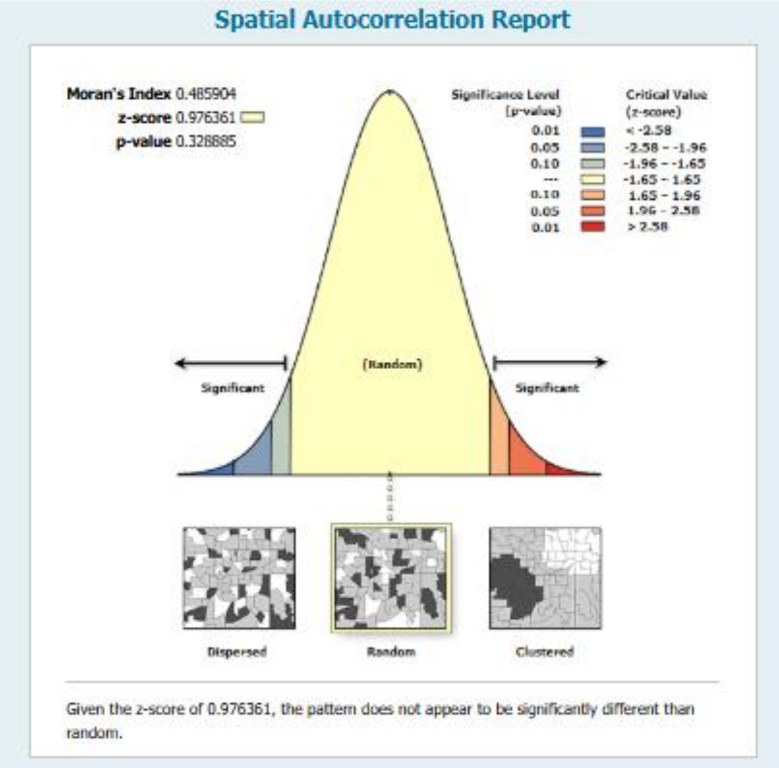




Omaha
North Platte
South Platte
Grand Island
Lincoln
Kearney
Hastings
Republican
St. Joseph
Kansas City
Joplin
N
Legend
Wastewater Monitoring WNV
Reported Human WNV Case Incidence per 100,000 Pop#
Prevalence Rate
0.000 - 0.250
0.241 - 0.659
0.660 - 1.457
1.458 - 2.271
> 2.272
WNV_Prevalence_MC
WNV_Prevalence_SD
0
37.5
75
150 Miles
Enid
Arkansas
Tulsa
Stillwater
Oklahoma
Rogers
Springdale
Fayetteville
Canadian
Oklahoma City
Cartographer: McKenzie Ghrist
Data Sources: KDHE
Esri, CGIAR, USGS, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, USFWS

Spatial Analysis Report - Kansas





Limitations & Next Steps

- Lacking multiple years/seasons of data
- Harvey County doesn't regularly send wastewater samples
  - Southcentral region of KS
- No wastewater monitoring sites in western KS
- Limited direct comparison of wastewater monitoring
- Non-stationary data for the ARIMA analysis

MPH Foundational Competencies

Competency	Coursework	ILE
1: Apply epidemiological methods to the breadth of settings and situations in public health practice	MPH 701; MPH 754; DMP 854; STAT 705; GEOG 508	I applied spatial and statistical epidemiological methods to analyze the potential implementation of wastewater monitoring for public health officials understanding of human WNV trends in KS.
19: Communicate audience-appropriate public health content, both in writing and through oral presentation	DMP 815	I communicated the wastewater WNV detection results to other public health professionals through an oral presentation for public health officials and a literature review to communicate previous research on the application of wastewater for WNV.

Emphasis Area Competencies

Competency	Coursework	ILE
1: Pathogens/pathogenic mechanisms	BIOL 687	It was important to understand human WNV shedding rates and the WNV transmission cycle to evaluate human WNV trends and the potential application of wastewater monitoring.
2: Host response to pathogens/immunology	DMP 850	Incorporated serological data (IgG and IgM tests) to analyze population-level immune response in relation to wastewater WNV detection data.
3: Environmental/ecological influences	MPH 701; MPH 802; DMP 850	Integrated bird sighting data (crows, blue jays, and robins) to explore WNV surveillance methods.
4: Disease Surveillance	MPH 754; DMP 854	I designed multiple surveillance datasets to understand human WNV trends.
5: Disease Vectors	BIOL 687; MPH 702; DMP 710	I incorporated *Culex* mosquito research on biology, ecology, geographic distribution, host-feeding patterns, and WNV transmission ability.

Conclusion

- Initial insight into wastewater monitoring for WNV
  - Demonstrate potential WNV application for wastewater
- Important to consider limitations
- Incorporate wastewater monitoring in western Kansas
- Continue this study after multiple years/seasons of data

Acknowledgements

Committee Members:

- Dr. Ellyn Mulcahy, PhD, MPH
- Dr. Margaret Kincaid, PhD
- Dr. Shawn Hutchinson, PhD, GISP

MPH Team:

- Plern Kongsamut

KDHE Employees

- Dr. John Anderson, PhD
- Dr. Erin Petro, DVM, MPH, DACVPM
- Chris Carter, MPH
- Infectious Disease Epidemiology & Response Team
- Informatics and Molecular Epidemiology Team

HRSA Scholarship

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Thank You To My Family & Friends

KANSAS STATE
UNIVERSITY

Questions

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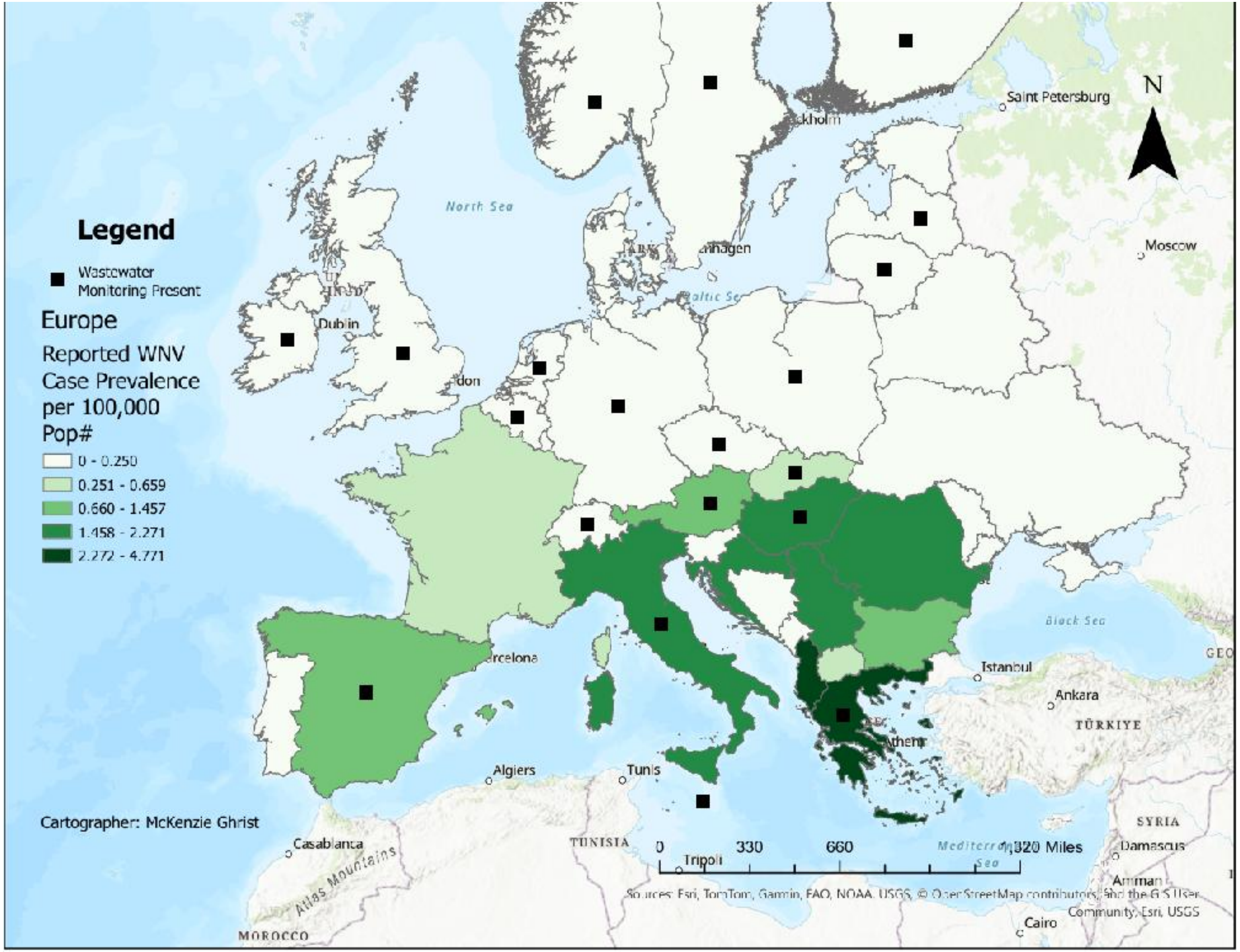
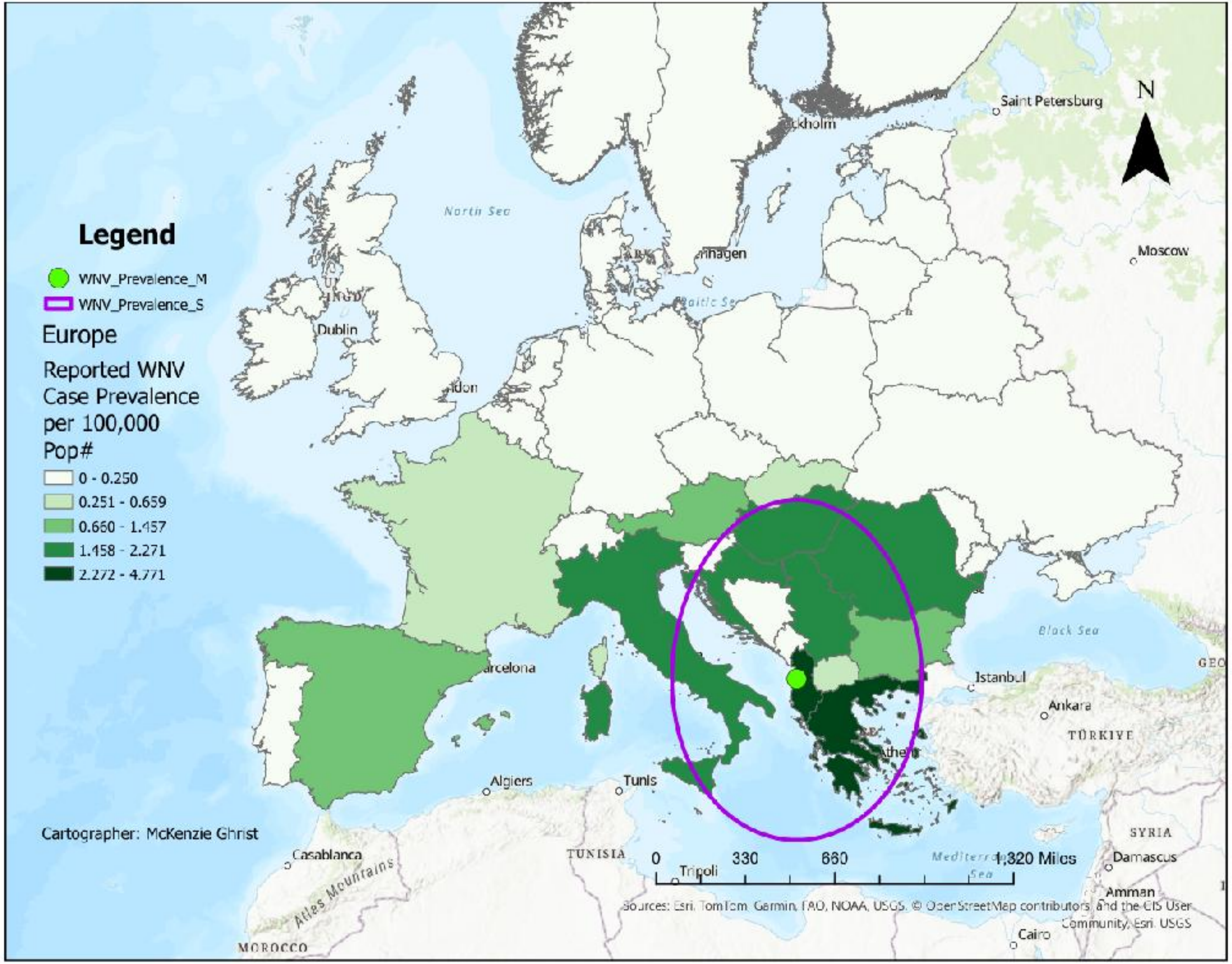


Legend
Wastewater Monitoring Present
Europe
Reported WNV Case Prevalence per 100,000 Pop#
0 - 0.250
0.251 - 0.659
0.660 - 1.457
1.458 - 2.271
2.272 - 4.771
Cartographer: McKenzie Ghrist
N
North Sea
Saint Petersburg
Moscow
Dublin
Black Sea
Istanbul
Ankara
TÜRKIYE
Algiers
Tunis
TUNISIA
Casablanca
Atlas Mountains
MOROCCO
Tripoli
Damascus
SYRIA
Amman
Cairo
0 330 660 1,320 Miles
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS


Legend
WNV_Prevalence_M
WNV_Prevalence_S
Europe
Reported WNV Case Prevalence per 100,000 Pop#
0 - 0.250
0.251 - 0.659
0.660 - 1.457
1.458 - 2.271
2.272 - 4.771
Cartographer: McKenzie Ghrist
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North Sea
Baltic Sea
Black Sea
Saint Petersburg
Moscow
Dublin
Istanbul
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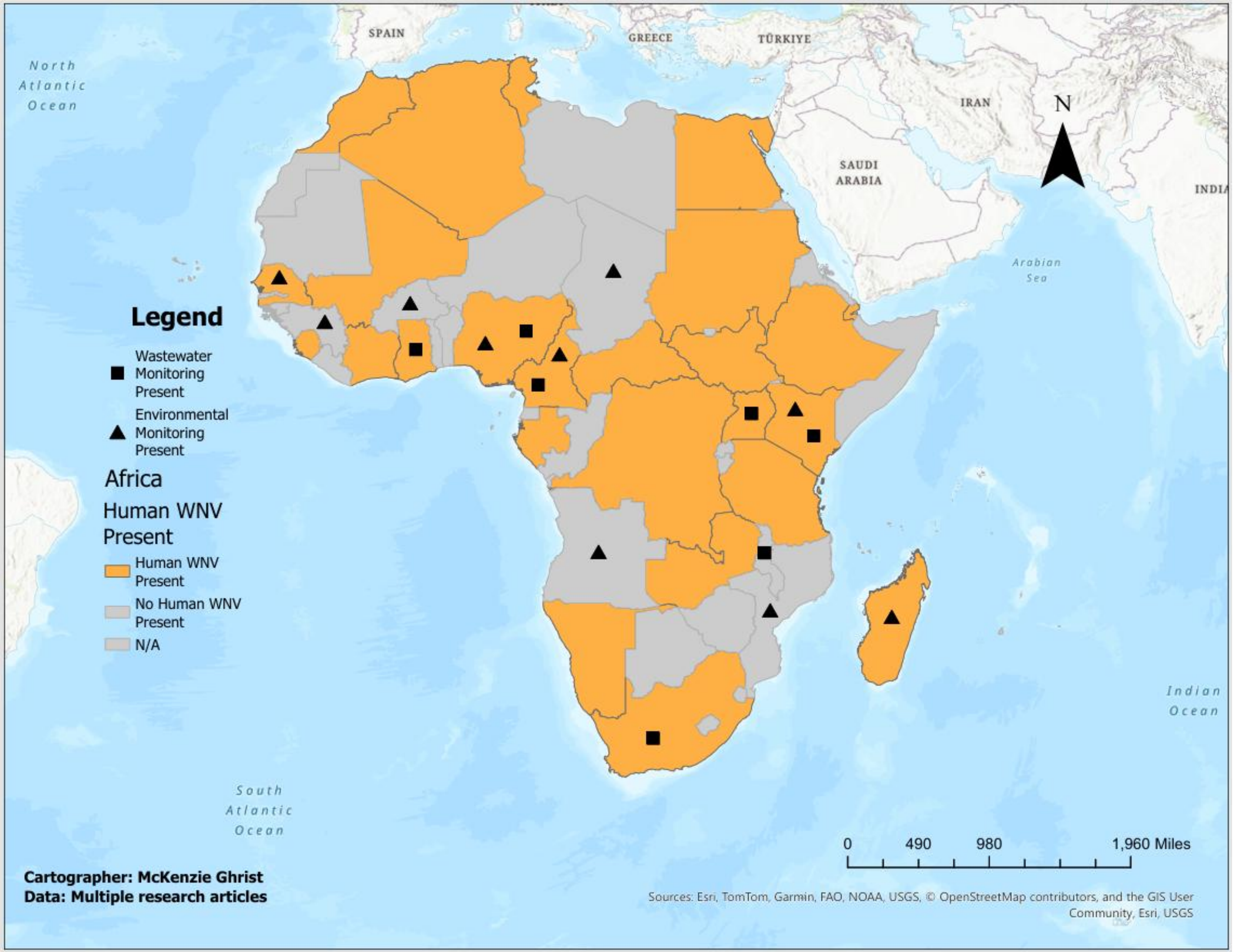
TÜRKIYE
Algiers
Tunis
TUNISIA
Tripoli
Casablanca
Atlas Mountains
MOROCCO
SYRIA
Damascus
Amman
Cairo
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS



SPAIN
GREECE
TÜRKIYE
IRAN
SAUDI ARABIA
INDIA
North Atlantic Ocean
Arabian Sea
Indian Ocean
South Atlantic Ocean
N
Legend
Wastewater Monitoring Present
Environmental Monitoring Present
Africa
Human WNV Present
Human WNV Present
No Human WNV Present
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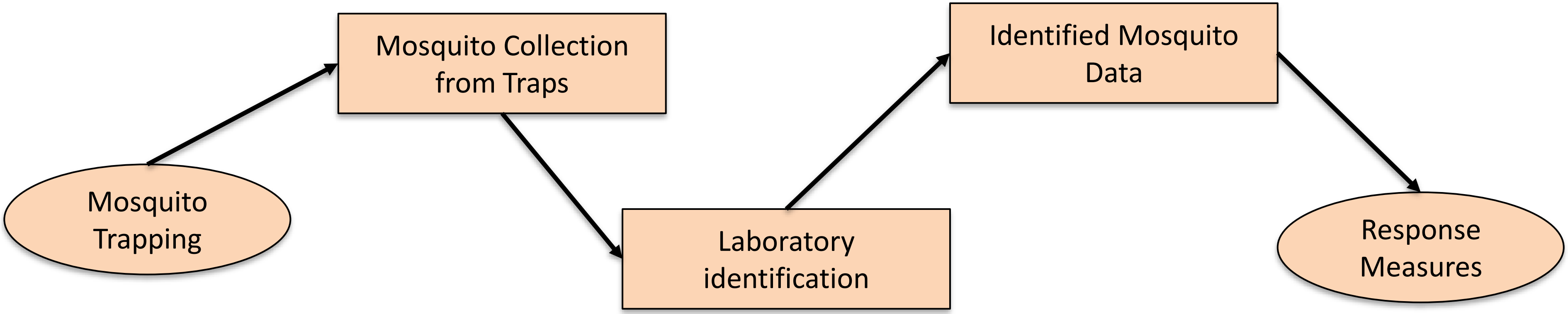
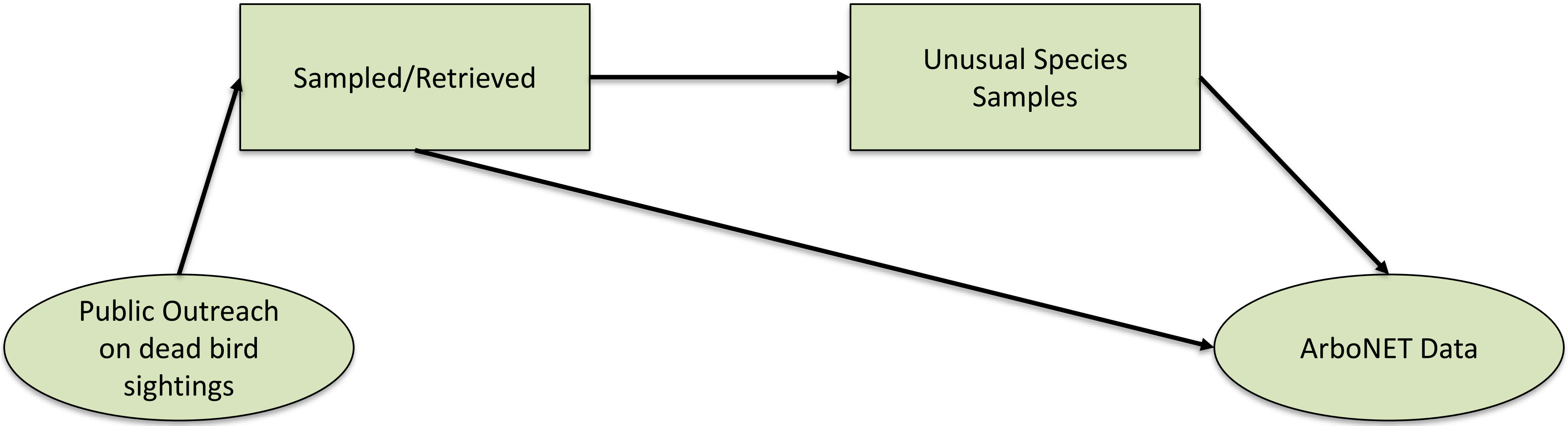
490
980
1,960 Miles
Cartographer: McKenzie Ghrist
Data: Multiple research articles
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS


Legend
Wastewater Monitoring Present
Environemtnal Monitoring Present
Asia
Human WNV Present
Human WNV Present
No Human WNV Present
N/A
Cartographer: McKenzie Ghrist
Data: Multiple research articles
0 500 1,000 2,000 Miles
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS
N
Norwegian Sea
SWEDEN
FINLAND
POLAND
GERMANY
UKRAINE
FRANCE
ITALY
GREECE
ALGERIA
LIBYA
EGYPT
Sahara Desert
NIGER
CHAD
SUDAN
NIGERIA
ETHIOPIA
DR CONGO
TANZANIA
ANGOLA
ZAMBIA
NAMIBIA
Arabian Sea
Sea of Okhotsk
INDONESIA
Coral Sea

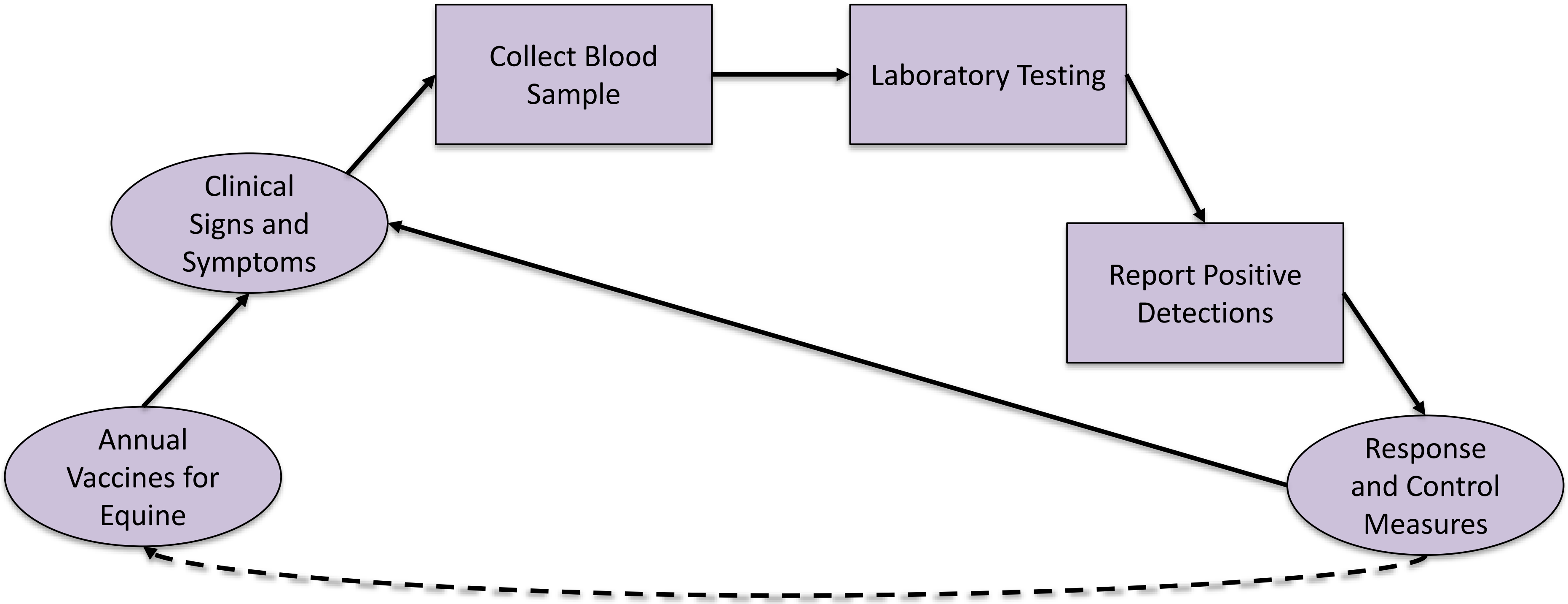
Mosquito Surveillance



Bird Surveillance

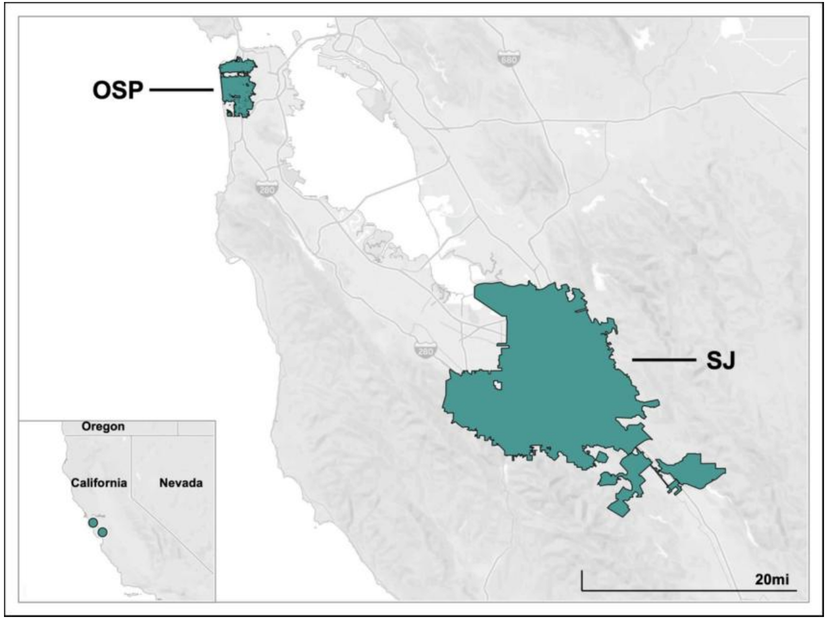


Human/Equine Surveillance



San Francisco Bay Area, California Study

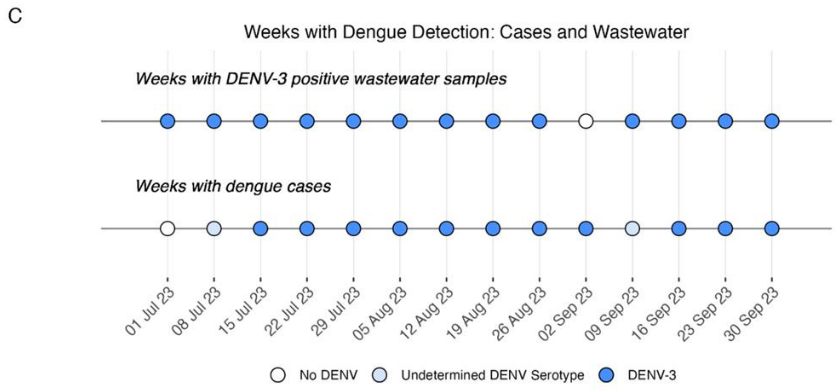
- 2 wastewater facilities involved
  - 45.6 miles apart
  - Collected samples from February 2021 to April 2023
  - Multiple viruses tested, including WNV
- WNV was not detected at all
- All other viruses were detected



(Boehm, et al., 2023; Google maps, n.d.)

Miami, Florida Study

- 3 wastewater facilities in Miami-Dade County
  - Represents ~95% of the county
  - Tested for Dengue serotypes 1-4
- Acquired weekly arbovirus reports
  - Human Dengue cases
  - Mosquito surveillance
- Dengue serotype 3 detected
  - Aligned with human cases
  - Did not align with mosquito surveillance



(Wolfe et al., 2023)

Wastewater Monitoring Sites

- Blue River Main Treatment Facility (Johnson County)
- Indian Middle Treatment Facility (Johnson County
- Mill Creek Regional Treatment Facility (Johnson County)
- Mission Main Treatment Plant (Johnson County)
- Turkey Creek Treatment Plant (Johnson County)
- Tomahawk Creek (Johnson County)
- Hutchinson Wastewater Treatment Facility (Reno County)
- North Topeka Wastewater Treatment Facility (Shawnee County)
- Oakland Wastewater Treatment Facility (Shawnee County)
- Newton Wastewater Treatment Facility (Harvey County)