Master of Public Health Culminating Experience: A Master's Report Presentation

Jessica Bradford

January 14th, 2014

EXAMINING *CULEX TARSALIS* (DIPTERA: CULICIDAE) POPULATION CHANGES WITH SATELLITE VEGETATION INDEX DATA

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Background

- Arboviruses
- Rift Valley Fever
- *Culex tarsalis*
- Normalized Difference VegetationIndex (NDVI)

Image from https://www.carstickers.com/proddetail.php?prod=8717

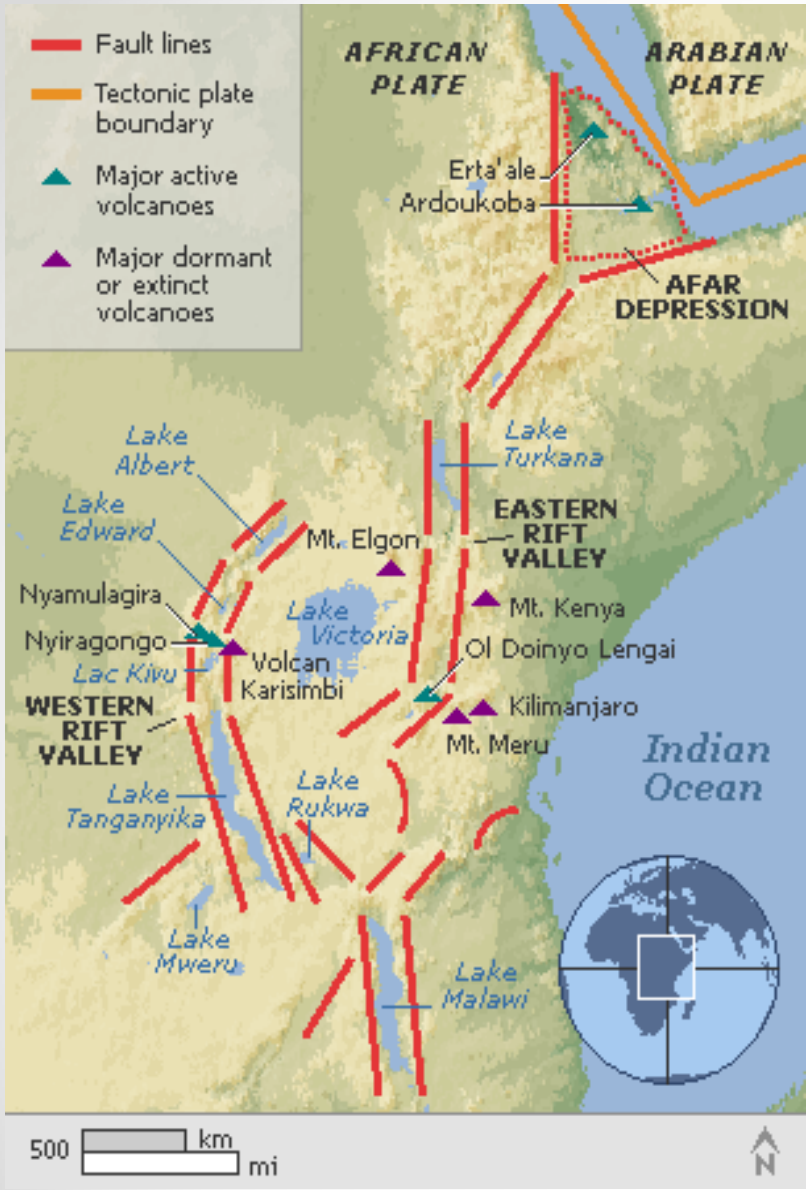
Arboviruses

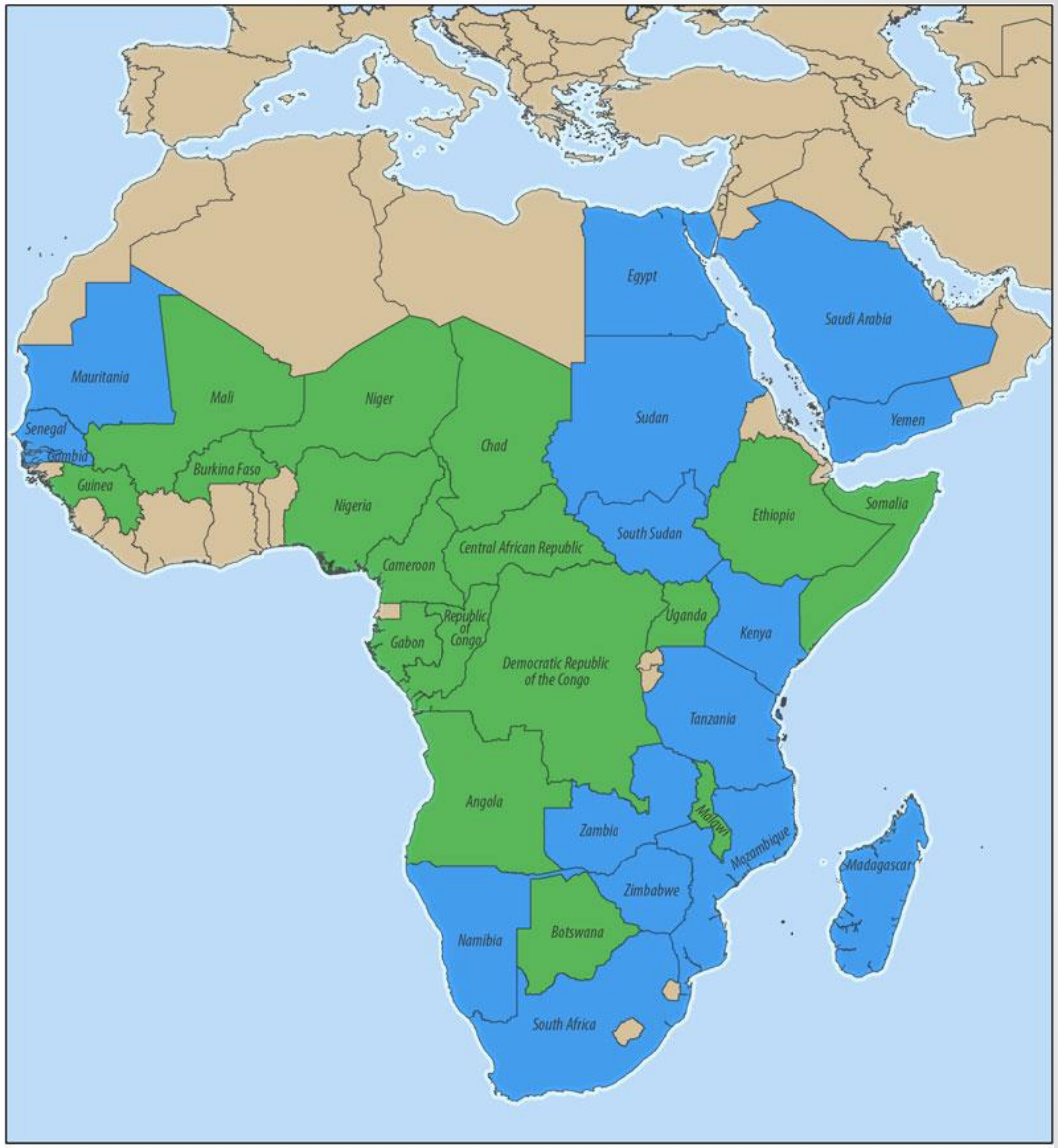
- Arboviruses in the United States
  - West Nile virus (WNV): leading cause of domestically acquired arboviral disease in people
  - Other arboviruses cause seasonal outbreaks and sporadic cases
  - Majority of arboviruses infections are asymptomatic
- Foreign arboviruses
  - Rift Valley fever (RVF) virus
- Disease surveillance, vector control and public education
- References: Center for Disease Control and Prevention, 2013c; Dar, 2013; Gubler, 2002

Rift Valley Fever

- Viral disease of domesticated animals and humans
- Significant economic losses and trade reductions: disease and abortion in domesticated animals
- Livestock outbreaks increase contact between diseased animals and humans
- No vaccines are currently available for human use. Limited vaccine use in animals.

- References: Center for Disease Control and Prevention, 2013a





RIFT VALLEY FEVER DISTRIBUTION MAP

- Countries reporting endemic disease and substantial outbreaks of RVF
- Countries reporting few cases, periodic isolation of virus, or serologic evidence of RVF infection
- RVF status unknown

N W E S

0 250 500 1,000 Miles

Rift Valley Fever

- Incubation period of 2-6 days
- Human cases:
  - Asymptomatic or a mild illness
  - Ocular disease, blurred and decreased vision
  - Encephalitis
  - Hemorrhagic fever
- Overall human mortality rate: 1%

- References: Center for Disease Control and Prevention, 2013a

Rift Valley Fever

- Affects sheep, cattle, goats, buffalo, camels, monkeys, gray squirrels
- Primary amplifying hosts: sheep and cattle
- Viremia without disease: adult cats, dogs, horses and some monkeys
- Incubation: 12 hours to 3 days
- Reference: Rift Valley Fever, 2006

Rift Valley Fever

- Lambs: biphasic fever, anorexia, lympahdenopathy, weakness, hemorrhagic diarrhea, abdominal pain, death
- Calves: fever, anorexia, depression and death
- Adults: abortion
  - Sheep: fever, weakness, melena, vomiting, nasal discharge
  - Cattle: fever, anorexia, weakness, excessive salivation, fetid diarrhea, icterus
- Post-mortem: hepatic necrosis, petechial and ecchymotic hemorrhages
- Livestock mortality rates: 10-20% in adults and 70-100% in young

- References: Rift Valley Fever, 2006; Center for Disease Control and Prevention, 2013a

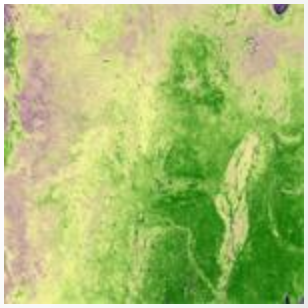
Culex tarsalis

- Transmits: West Nile virus, Western Equine Encephalomyelitis virus, St. Louis Encephalitis virus and, in vitro, Rift Valley Fever virus
- Studies examining populations of *Culex spp.* and NDVI are few:
  - *Culex spp.* may not always track NDVI data because habitat includes artificial bodies of water with human activity
  - Good correlation between both *Aedes* and *Culex spp.* populations in RVF endemic regions in Africa
- Strong relationship between NDVI and populations of other mosquito species, such as *Anopheles spp*. (Diptera: Culicidae)
- More research is needed to determine if *Culex spp.* population dynamics are related to NDVI in additional regions

- References: Turell et al., 2010; Reisen et al., 1993; Reisen et al., 2003; Gargan et al., 1988; Britch et al., 2008; Linthicum et al, 1987, 1990; Dambach et al., 2012; Liu and Chen, 2006; Rueda et al., 2010

Normalized Difference Vegetation Index (NDVI)

- Satellite imagery to measure and monitor plant growth, vegetative cover, and biomass production
- Linked to temperature, rainfall, and plant productivity
- Unit-less but numerically ranges from -1 to 1
  - ≥0.5 = dense vegetation
  - ≤0 = no vegetation



- References: Department of the Interior, 2010; University of Reading, 2002; Britch et al., 2008; Chuang et al., 2012; Liu et al., 2006; Shililu et al., 2003; Gleiser et al., 1997; Apiwathnasorn et al., 2006

NDVI

- NDVI anomaly value: the time-specific numerical difference of the measure compared to the long term average
  - Used to examine the deviation of NDVI from the long term mean
- Potentially be used to develop advanced warning systems for droughts, famines and mosquito population changes
- Because mosquito populations have been correlated to rainfall and/or temperature, many studies have examined the relationship between specific mosquito populations and NDVI

- References: Department of the Interior, 2010; University of Reading, 2002; Britch et al., 2008; Chuang et al., 2012; Liu et al., 2006; Shililu et al., 2003; Gleiser et al., 1997; Apiwathnasorn et al., 2006

Objective

- To examine *Cx. tarsalis* population change in Fort Riley, Kansas, in relation to the time of year and patterns of change in NDVI

- May be useful in predicting future changes in *Cx. tarsalis* populations in order to develop and evaluate vector population control methods
  - Limit transmission of potential emerging diseases to humans and susceptible wildlife or livestock

Materials and Methods

- Mosquito population surveillance data:
  - U.S. Army preventive medicine teams at Fort Riley
  - Number and position of traps varied by year but some trap locations were constant over all of the years
  - Identification of species and sex

- Female mosquitoes per trap-night index for each week and month of the study

- Data was collected by month for 1995-2000 and by week for 2001-2011 from NASA Goddard Space Flight Center

- References: Lester and Pike, 2003; Masuoka et al., 2009; Chuang et al. 2011; Cleckner et al., 2011

Materials and Methods

- Mosquito trap data are typically not normally distributed
  - log-transformation ln (x+1), where x was the number of female *Cx. tarsalis* collected by one trap in one night
- Analyzed using linear regression via STATA 12.1
- Monthly: at the simultaneous dates and lagging one month behind
- Weekly: at the simultaneous dates and a two-week and a four-week lag
- Only May through October was analyzed

Results and Discussion

Figure 1: Monthly Comparison of Mosquitoes/Trap Night to NDVI

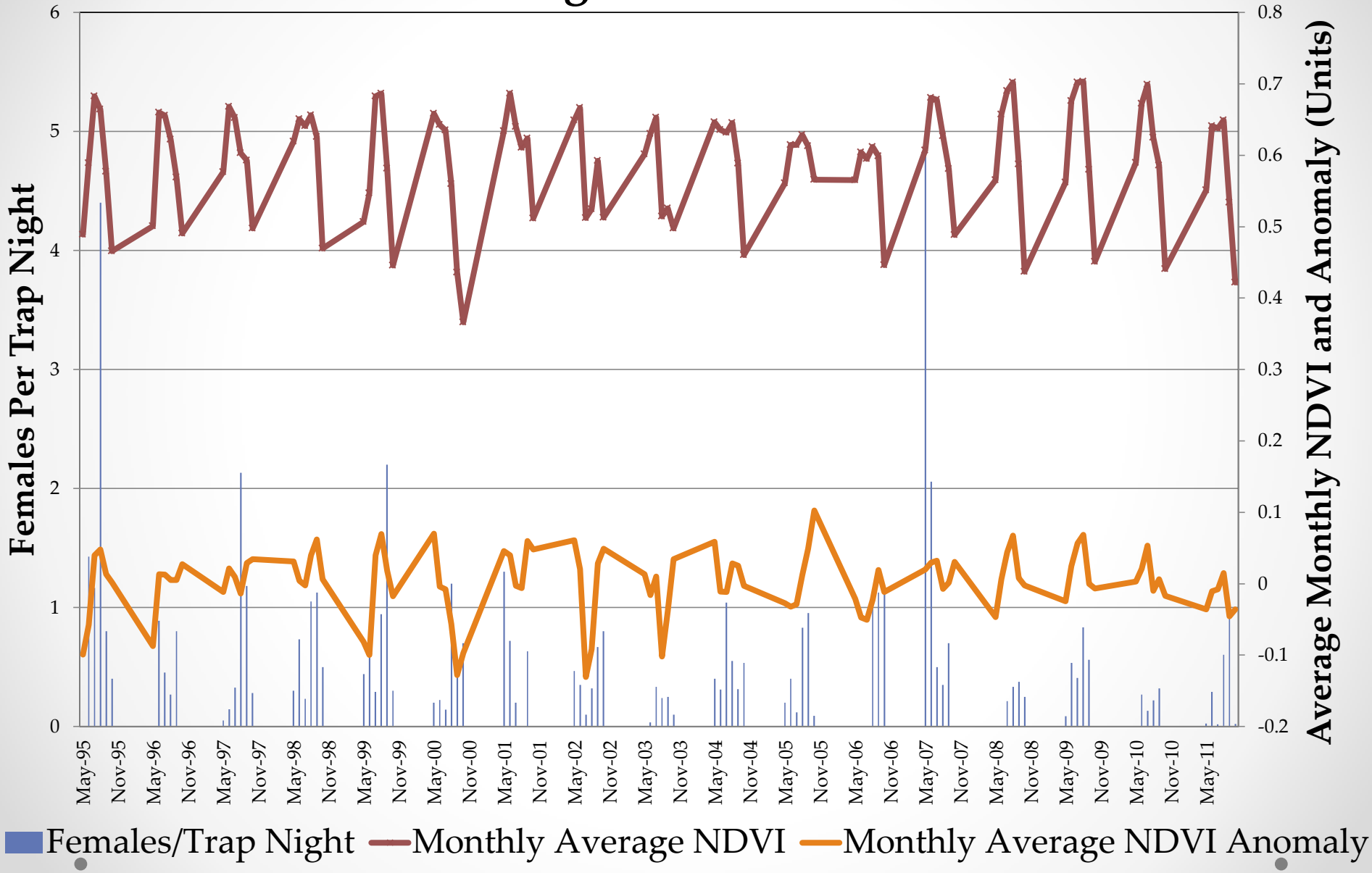
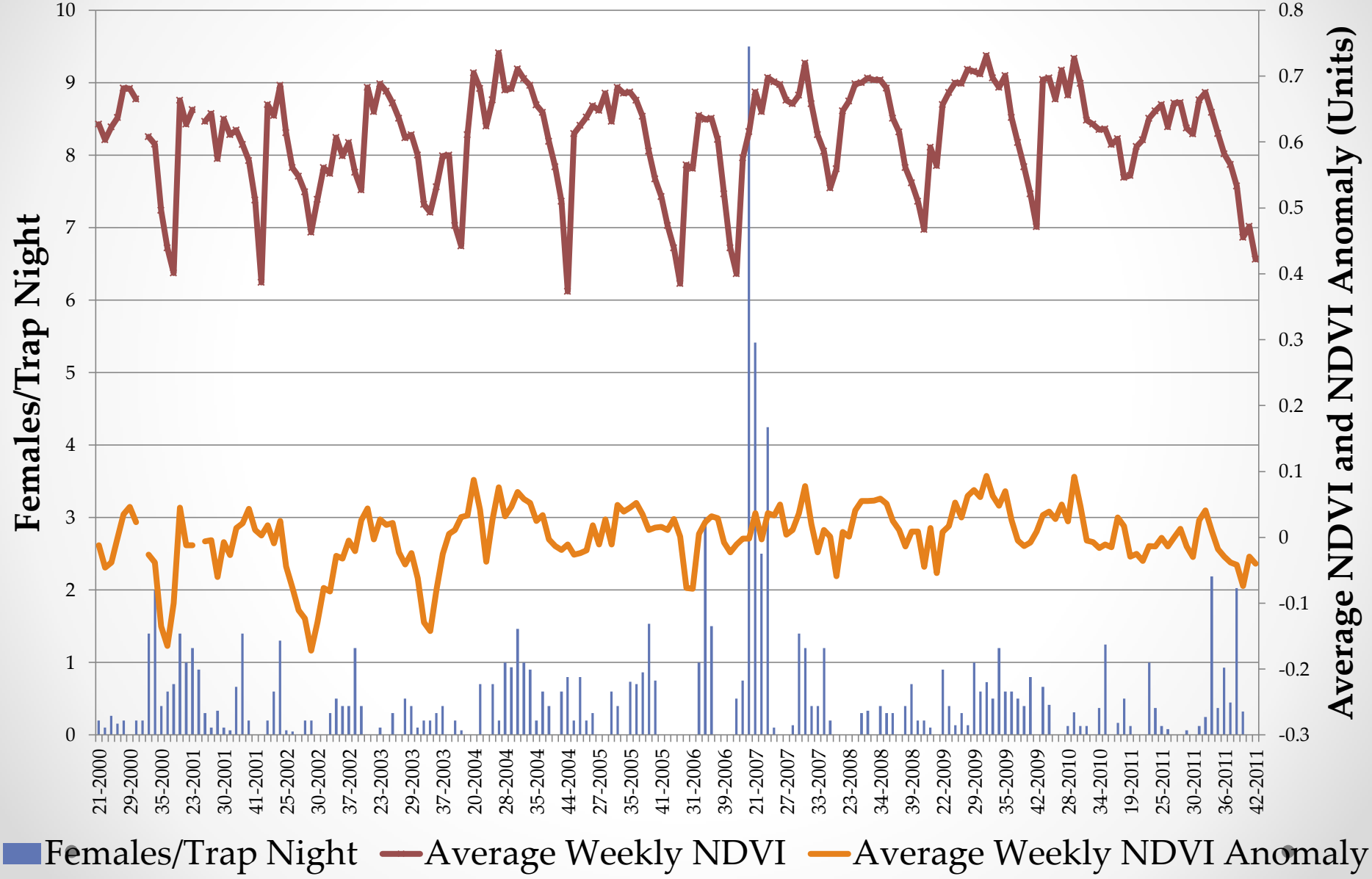


Figure 2: Weekly Comparison of Mosquitoes/Trap Night to NDVI



Analysis of the Natural log of mosq/TN for the Average Monthly Data Set		
Time	**Analysis**	**Results**
Simultaneous	Avg NDVI anomaly	No relationship ($p=0.107$)
	Year and month of year	Significant relationship ($p<0.05$)
One Month Lag	Avg NDVI anomaly	No relationship ($p=0.356$)
	Year and month of year	Significant relationship ($p<0.05$)

Analysis of the Natural log of mosq/TN for the Average Weekly Data Set		
Time	**Analysis**	**Results**
Simultaneous	NDVI anomaly	p=0.058 – positive coefficient
	Year and week of year	Significant ($p<0.05$)
Two Week Time Lag	NDVI anomaly	p=0.054 – negative coefficient
	Year and week of year	Significant ($p<0.05$)
Four Week Time Lag	NDVI anomaly	No significant difference (p=0.604)
	Year and month of year	Year: significant ($p<0.05$) Week: not significant (p=0.052)

Summary of Results and Discussion

- The year 2007 was always statistically higher than 2000 (in the weekly analysis)
- No relationship between the ln of the mosq/TN and NDVI anomaly for the monthly averages but trended toward significance for the weekly averages
- Results approached significance for the ln of the weekly mosq/TN as it tended to increase with NDVI anomaly ($p=0.058$) and tended to decrease with the two-week lag of NDVI anomaly ($p=0.054$)

Discussion

- The NDVI Anomaly values with both a two week and a four week lag had negative coefficients
  - Model lag is not representative of the true relationship
  - The high NDVI is just predictive of regressing subsequent movement of the NDVI toward the long term mean

- The relationship between weather, NDVI and mosquito populations is complex and further investigation is needed

Discussion

- The results are in contrast to research performed with mosquito population data from several U.S. military installations that found:

  "*the NDVI signal may actually be visible late in the previous month or early in the current month and so be useful operationally as a warning regarding potential mosquito-borne disease activity*" (Britch et al., 2008)

- Time lags between the NDVI and mosquito trap night data were intended to identify any value of NDVI as a leading indicator of mosquito numbers
  - However, Britch et al. (2008) did hypothesize that *Culex* species may not always track NDVI data because their habitat includes bodies of water associated with human activity, such as storm drains and containment ponds

Conclusions

- Mosquito-borne diseases threaten human and animal health alike
- An understanding of vector population change and vector epidemiology is crucial in minimizing these diseases and managing disease transmission
- Our resources are more efficiently used when paired with this knowledge

Conclusions

- Future studies:
  - NDVI to strike rate and with mosquito population numbers
  - Population numbers based on terrain, such as availability of shade and still water sources
  - Geographical movement and population numbers of host species

- Both host and mosquito populations are important in predicting outbreaks of disease

MPH Classes Utilized:

- Fundamental Concepts of Emerging Infectious Diseases
- Veterinary Public Health
- Veterinary Epidemiology
- Intermediate Epidemiology
- Statistical Methods for the Natural Sciences

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Acknowledgements

- Drs. Britch and Linthicum
- Dr. Scott McVey

Questions so Far?

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EDUCATING THE PUBLIC ABOUT ZOONOSES THROUGH THE RILEY COUNTY EXTENSION AGENCY: A FIELD EXPERIENCE REPORT

...

Introduction

- Case of H3N2 influenza at the Riley County Fair in 2009
- Educating the public about infectious disease and zoonoses
- Focus on diseases possibly contracted at the fair plus from household pets and food-borne illnesses
- Swine flu: initiating factor but not the keystone of the project

Project Design

- Designing and creating the source of information to be displayed to the public at the Riley County Fair

- Considerations:
  - Encouraging interactions
  - Efficient demonstration of a large amount of material
  - Education of all ages
  - Diversity
  - Attractiveness
  - Durability
  - Presented in a language understood by various ages and educational status

TRANSMISSION ROUTES OF ZOONOTIC DISE
PREVENTION OF ZOONOTIC DISEASES
Zoonotic Disease Informatio

TRANSMISSION ROUTES OF ZOONOTIC DISEASES
PREVENTION OF ZOONOTIC DISEASES
GOATS
SWINE
Zoonotic Fun Facts!
Flip the card over to see the answers and more facts about the disease!
K-STATE

Interactive Informational Board

- Purpose: to present a large amount of information in an engaging way

- Anthrax
- Avian Flu
- Baylisascaris
- Cat Scratch Disease
- Cryptosporidium
- Giardia
- Leptosporosis
- Lyme Disease
- Orf
- Plague
- Rabies
- Rocky Mountain Spotted Fever
- Roundworms
- Salmonella
- Swine Flu
- Toxoplasmosis
- Tularemia
- West Nile Virus

Interactive Informational Board

Skunks are the main reservoir of ____ in Kansas, although most US cases are from infected bats.

Children's Discovery Wheel

- Purpose: to educate children on basic zoonotic prevention facts and engage their parents in a discussion about zoonotic diseases
- The Children's Discovery Wheel was a plastic wheel that each child could spin and answer a question for a prize (a sticker or a glow-stick.)
- These questions were intended for five (5) to ten (10) year olds
- Many return visits from county fair youth participants

What is a Zoonotic Disease?
What do you do after petting animals and before eating?
What do you do if you find a baby animal outside?
What is a Zoonotic Disease?
What do you do if an animal bites you?
What do you do if an animal is acting strange?
What is a Zoonotic Disease?
What do you do if an animal bites you?
What do you do if an animal is acting strange?
What is a Zoonotic Disease?
What do you do after petting animals and before eating?
What do you do if you find a baby animal outside?

Poster Display – Transmission Routes

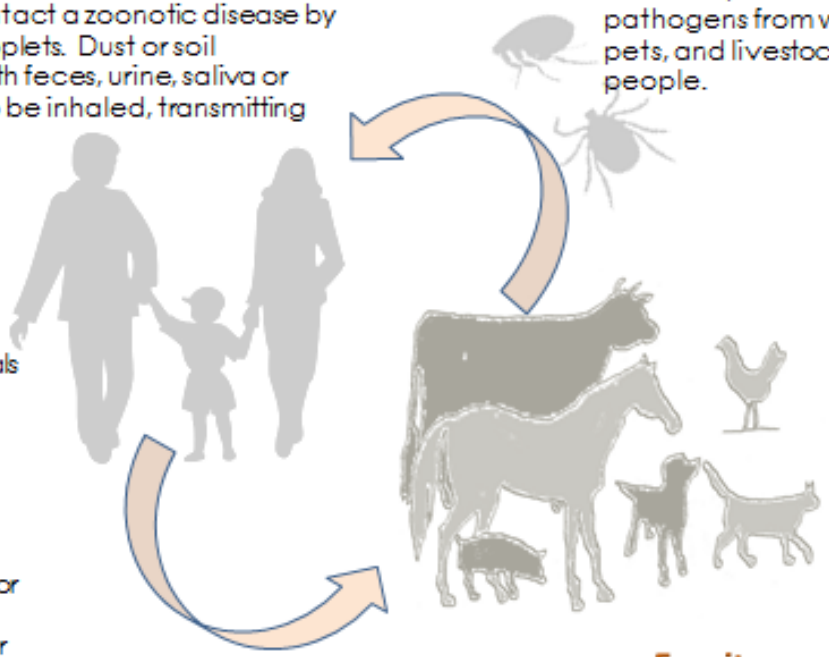
TRANSMISSION ROUTES OF ZOONOTIC DISEASES

Aerosol:

When an infected animal coughs, or sneezes, infected droplets can be passed through the air. A person can contact a zoonotic disease by inhaling these droplets. Dust or soil contaminated with feces, urine, saliva or bacteria can also be inhaled, transmitting disease.

Vectors:

Mosquitoes, fleas and ticks can pass pathogens from wildlife, pets, and livestock to people.



Oral:

Eating or drinking after handling animals or feces without washing your hands can result in transmission of pathogens. Also, consumption of contaminated food or water, such as unpasteurized milk or undercooked meat, can transmit disease.

Fomites:

Fomites are objects that have been contaminated by an infected animal. These objects can transfer a pathogen to a person.

Direct Contact:

Transmission can occur when a pathogen directly touches an open wound or mucous membrane. Bites and scratches are common causes.

DID YOU KNOW?!? Certain diseases can be passed from sick people to animals too!

Images © Riley County Extension Agency, The Sign and Design Company, and dreamstime

Poster Display – Prevention

PREVENTION OF ZOONOTIC DISEASES

From Our Animals:

- Wash hands with soap after handling any animal.
- Become familiar with common diseases in the pets and livestock you own.
- Teach children proper handling of pets and provide supervision. Teach children to wash their hands with soap after handling pets.
- Vaccinate all pets, including indoor only pets, for rabies and other diseases as directed by your veterinarian.
- Take extra precautions around any animal that is acting unusual. If the animal is a pet/livestock, seek veterinary care immediately.
- Separate any sick livestock to minimize transmission in the herd and reduce environmental contamination.
- Seek veterinary care for any sick animal.

DID YOU KNOW?!?
Children, the elderly, and immunocompromised individuals are at greater risk for contracting a zoonotic disease.

In the Kitchen:

- Promptly refrigerate or freeze perishable foods.
- Use a meat thermometer to ensure proper cooking of meat.
- Fruits and vegetables should be washed before eating, cutting or cooking.
- Raw meat, poultry, seafood, and their juices should be kept away from other foods.
- Wash hands for at least 20 seconds with warm, soapy water before and after handling raw meat, poultry, fish, shellfish, produce or eggs.

In the Outdoors:

- Do not keep, feed, or adopt wild animals as pets.
- Wear long sleeves and pants during dawn and dusk when insect activity is greatest. Use insect repellent and remove ticks promptly.
- Wear gloves when handling sick or dead wildlife.
- Cover sandboxes.
- Reduce rodent habitats around your home by removing brush, rock piles, wood piles and possible food sources.
- Properly cook game before consuming.
- Do not drink from untreated water sources, such as lakes, rivers, or streams.

FREE DISEASE AND FOOD SAFETY INFORMATION
Zoonotic Diseases of Dogs and Cats
K·STATE
Zoonotic Diseases of Exotic Pets
K·STATE
Zoonotic Diseases of Wildlife
K·STATE
Food Safety
K·STATE
Zoonotic Diseases of Large Animals
K·STATE

Informational Handouts

Pets:

- Rabies
- Toxoplasmosis
- Cat Scratch Disease

Exotic Pets:

- Salmonella
- Psittacosis
- Tularemia

Image from http://usherp.org/tag/baby-turtle-ban/

Informational Handouts

Large Animal:

- Cryptosporidium
- Orf
- Food-borne Diseases

Wildlife:

- Rabies
- Tularemia
- Baylisascaris
- Leptospirosis

Orf Image from CDC

Informational Handouts – Foodborne

- Due to public awareness this may have been the public's main interest and therefore a limited amount of information was included
- Preventative measures rather than individual food-borne illness agents
- The top five agents were listed as well as common symptoms (Centers for Disease Control and Prevention, 2013d)

Fun Facts for Kids!

- Dogs provide many services for humans, including hunting, farm work, security and assisting the blind and disabled.
- Dogs can hear sounds four times farther away than humans can hear.
- Cats sleep an average of 13-14 hours a day.
- A cat uses its whiskers to help detect objects and navigate in the dark.

For Additional Information:

- http://www.cdc.gov/24-7/cdcfastfacts/zoonotic.html
- http://www.cdc.gov/healthypets/
- http://www.kdheks.gov/epi/human_animal_health.htm

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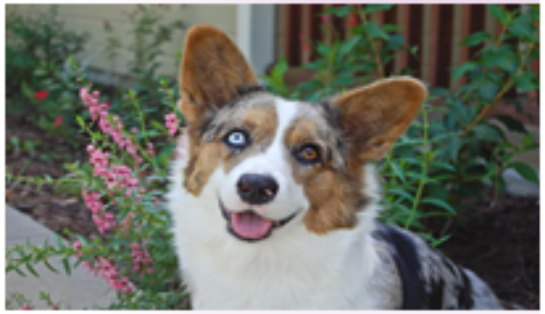
Zoonotic Diseases of Dogs and Cats

Important things to know about zoonotic diseases in your pets, symptoms to look for and prevention tips!



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Research and Extension

What is a Zoonotic Disease?

-Zoonotic diseases are diseases or infections that can be naturally transmitted from animals to humans. Some diseases can also be transmitted from humans to animals.

-The disease agents can be viruses, bacteria, fungi, parasites, or prions.

-Diseases can be contracted from pets (including exotic pets,) horses, livestock, or wildlife. Some diseases can be transmitted through food.

-This brochure will focus on a few common zoonotic diseases in dogs and cats.

Some Diseases To Know About:

Rabies:

Common pets: Any mammal, including indoor only pets

Animal Symptoms: Acts unusual, either vicious and attacks without provocation, or is dumb-acting

Human Symptoms: Initially anxiety, fever, and headache. Develops into excitableness and light or sound sensitivity. Eventually, delirium, seizures, coma and death can occur.

Toxoplasmosis:

Common pets: Cats

Animal Symptoms: Typically no symptoms

Human Symptoms: Many people have no signs. Some have flu-like signs and vision problems. Pregnant women can transmit the parasite to their child, whom may then be born with serious eye and brain damage.

Cat Scratch Disease

Common pets: Cats

Animal Symptoms: No symptoms

Human Symptoms: Mild infection at the site of bite or scratch, swollen lymph nodes, fever, headache, poor appetite. Rarely, more severe complications can occur.

Other zoonotic diseases occur. **Tell your healthcare provider about all animal contact, including any pets.**

How Do I Prevent These Diseases?

- Wash hands with soap after handling any animal.
- Become familiar with common diseases in the pets you own.
- Teach children proper handling of pets and provide supervision. Teach children to wash their hands with soap after handling pets.
- Vaccinate all pets, including indoor only pets, for rabies and other diseases as directed by your veterinarian.
- Take extra precautions around children, the elderly, or any immunocompromised individuals, as these groups are more susceptible to disease.
- Take extra precautions around any animal that is acting unusual. If the animal is a pet, seek veterinary care immediately.
- Seek veterinary care for any sick animal.
- Seek health care immediately if you suspect any zoonotic disease.

Fun Facts for Kids!

- There are around 2000 different plant types used to make food today.
- China is the world's largest producer of garlic.
- India is the world's largest producer of bananas.
- Around 8% of children and 2% of adults have some kind of food allergy; this occurs when the body's immune system incorrectly assumes a certain food protein is harmful and attacks it.
- 2/3 of the blueberries produced in the US are from Michigan and New Jersey.

For Additional Information:

- http://www.cdc.gov/24-7/cdcfastfacts/zoonotic.html
- http://www.cdc.gov/healthypets/
- http://www.kdheks.gov/epi/human_animal_health.htm

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Food Safety

Important things to know about foodborne illness, symptoms to look for and prevention tips!

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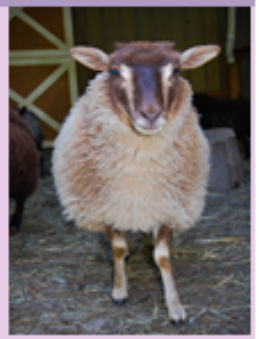
Research and Extension

What is a Foodborne Illness?



-Commonly called food poisoning, foodborne illness is any illness resulting from the consumption of contaminated food.

-Most foodborne diseases are caused by bacteria but they can also be caused by viruses or parasites.

-Foodborne illness can occur from any food, including meat and fish, fruits and vegetables. Foodborne illness may result from commercially produced food, organic food, locally grown food and any other production method.

-This brochure will focus on the top five causes of foodborne illness, symptoms and how to prevent illness.

Causes and Symptoms:

The five most common causes of foodborne illness are:

1. Norovirus
2. Salmonella (non-typhoidal)
3. Clostridium perfringens
4. Camplylobacter spp.
5. Staphylococcus aureus

Other common causes of foodborne illness include Toxoplasma gondii, E. coli, and Listeria.

Symptoms of foodborne illness include vomiting, diarrhea, abdominal pain, fever, chills. More severe signs can occur. These include weakness, blurred vision, dizziness, paralysis, headache, and tingling or numbness of the skin.

Although most cases of foodborne illness are mild, they can result in hospitalization or death.

Prevention:

- Raw and cooked perishable foods—foods that can spoil—should be refrigerated or frozen promptly. Refrigerators should be set at 40 degrees or lower and freezers should be set at 0 degrees.

- A meat thermometer should be used to ensure foods are cooked to the appropriate internal temperature:
  +145 degrees for roasts, steaks, and chops of beef, veal, pork, and lamb, followed by 3 minutes of rest time after the meat is removed from the heat source
  +160 degrees for ground beef, veal, pork, and lamb
  +165 degrees for poultry

- Fruits and vegetables should be washed under running water just before eating, cutting, or cooking. A produce brush can be used under running water to clean fruits and vegetables with firm skin.

- Raw meat, poultry, seafood, and their juices should be kept away from other foods.

- People should wash their hands for at least 20 seconds with warm, soapy water before and after handling raw meat, poultry, fish, shellfish, produce, or eggs.

Results

- Majority of time was spent with children and the Children's Discovery Wheel
  - Parents were happy that their children had some answer and many of them added on to my answers when the children did not know
- Several fair patrons were unaware of what zoonotic diseases are and stopped to discuss
  - Rabies and the various influenzas
- The Pet Handout was the most popular with approximately 50 distributed
  - At least 15 copies of all of the other handouts were taken

Results

- All of the material remained available to the public for the duration of the fair, with the exception of the Children's Discovery Wheel
- Offer this display to the other Kansas counties for use at their fairs, farm shows, and other events in which the public may interact with animals
- Project Expansion
  - Images
  - "Hot Topic" diseases
  - Something for the children to take home
- Could be used in the future to distinguish how much the public knows about public health and in what areas

Results

- Deepened my understanding of zoonotic disease and food-borne illness
- Strengthened my knowledge about how to educate both children and adults

MPH Classes Utilized:

- Veterinary Public Health
- Fundamental Concepts of Emerging Infectious Diseases
- Multidisciplinary Concepts of Food Safety and Security
- Social and Behavioral Principles of Public Health

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Acknowledgements

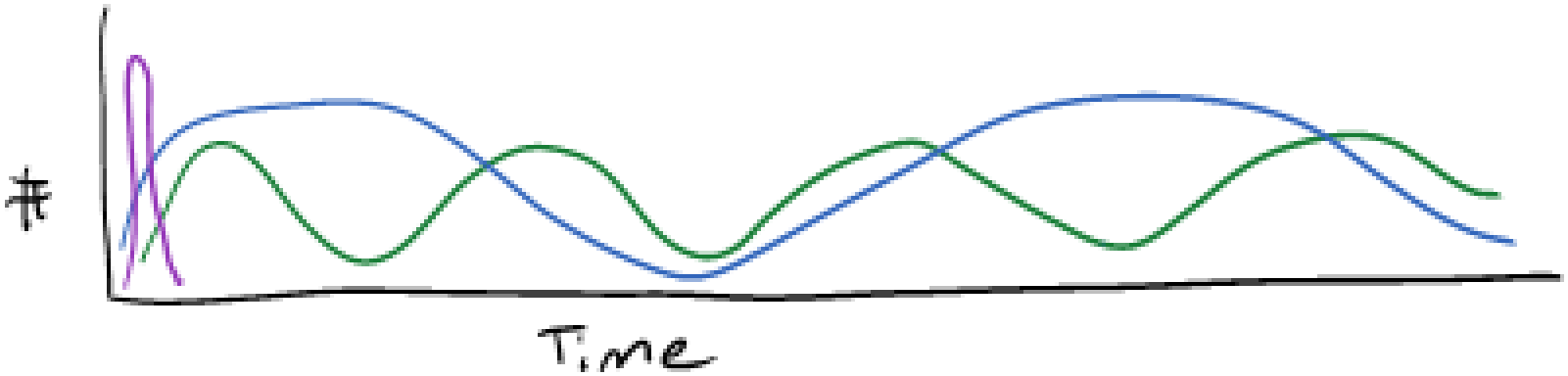
- Ginny Barnard and Riley County Extension Agency

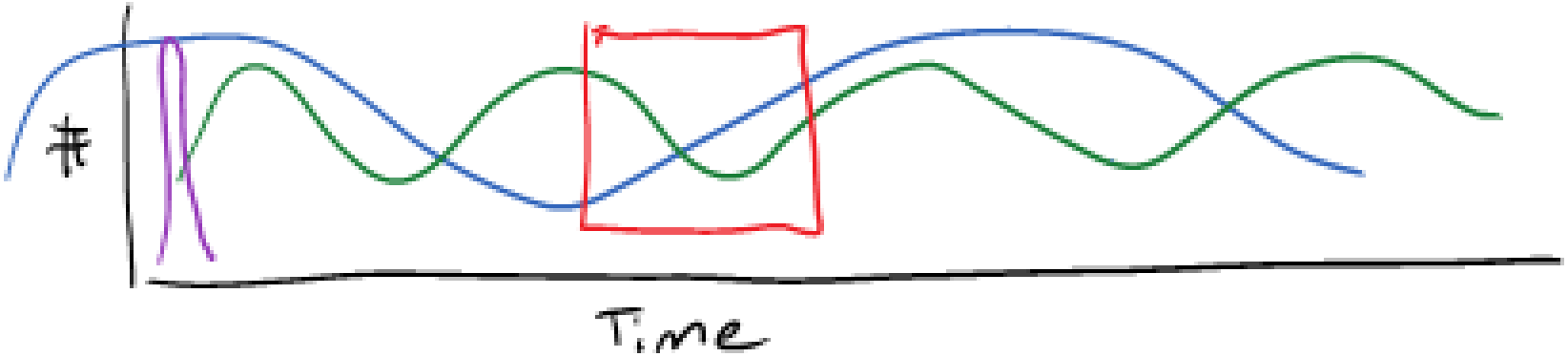
- Kellie Lewis Photography

Any Questions?

Thank you for your time and attention.

Example Data Set		
Mosq/TN	NDVI	NDVI Lag
5/1/1995	5/1/1995	
6/1/1995	6/1/1995	5/1/1995
7/1/1995	7/1/1995	6/1/1995
8/1/1995	8/1/1995	7/1/1995
9/1/1995	9/1/1995	8/1/1995
10/1/1995	10/1/1995	9/1/1995





~ = mosq/TN

~ = rain

~ = NDVI