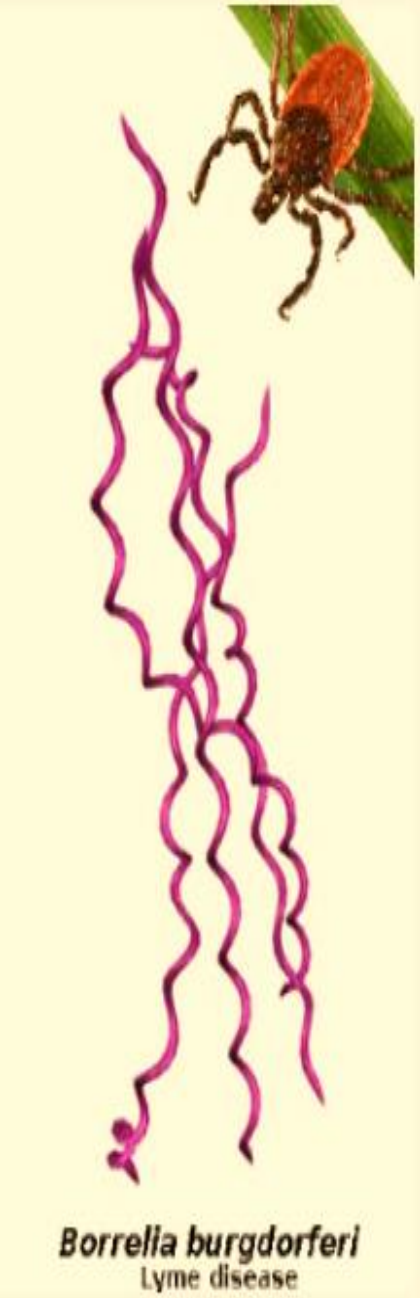


Using Geographic Information System to Identify Lyme Disease Risk Components

Wayne Frad

GEOG 596A Capstone Proposal

Penn State MGIS Program

Advisor: Dr. Alexis R. Santos

Agenda

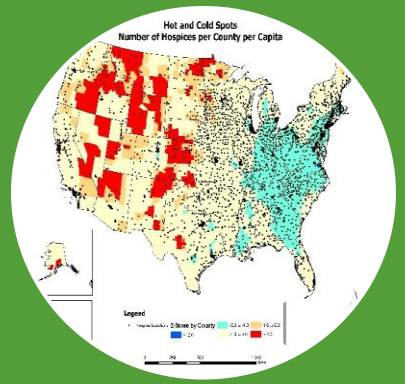
- Application of GIS in Epidemiology
- Lyme disease Facts
- Objective
- Study Area
- Sources & Methods
- Data Analysis Cluster Analysis
- Regression Models
- Analysis of Results
- Discussion of Application
- Lyme Disease Issues and Facts
- References
- Question and Comments

Practical Application of GIS in Epidemiology

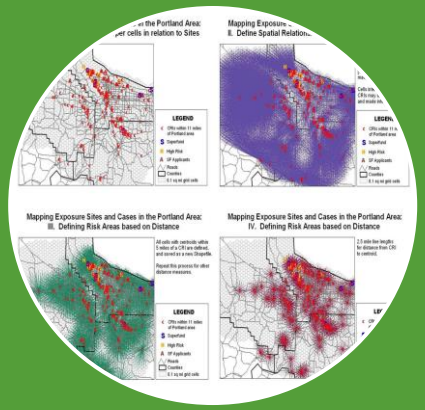
Historical Examples that Location Matters

- Hippocrates 3rd century BC physicians observed disease occurred some places and not in others
- 1854 Dr. John Snow used geospatial information to analyze cholera deaths and found clustering around water pumps in London

Spatial Data Management



Visualization

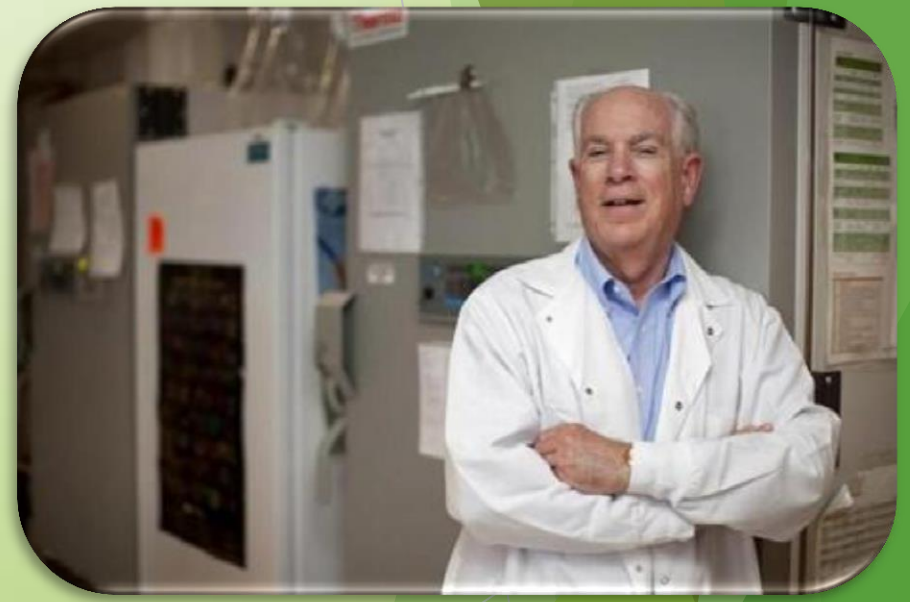


Spatial Analysis

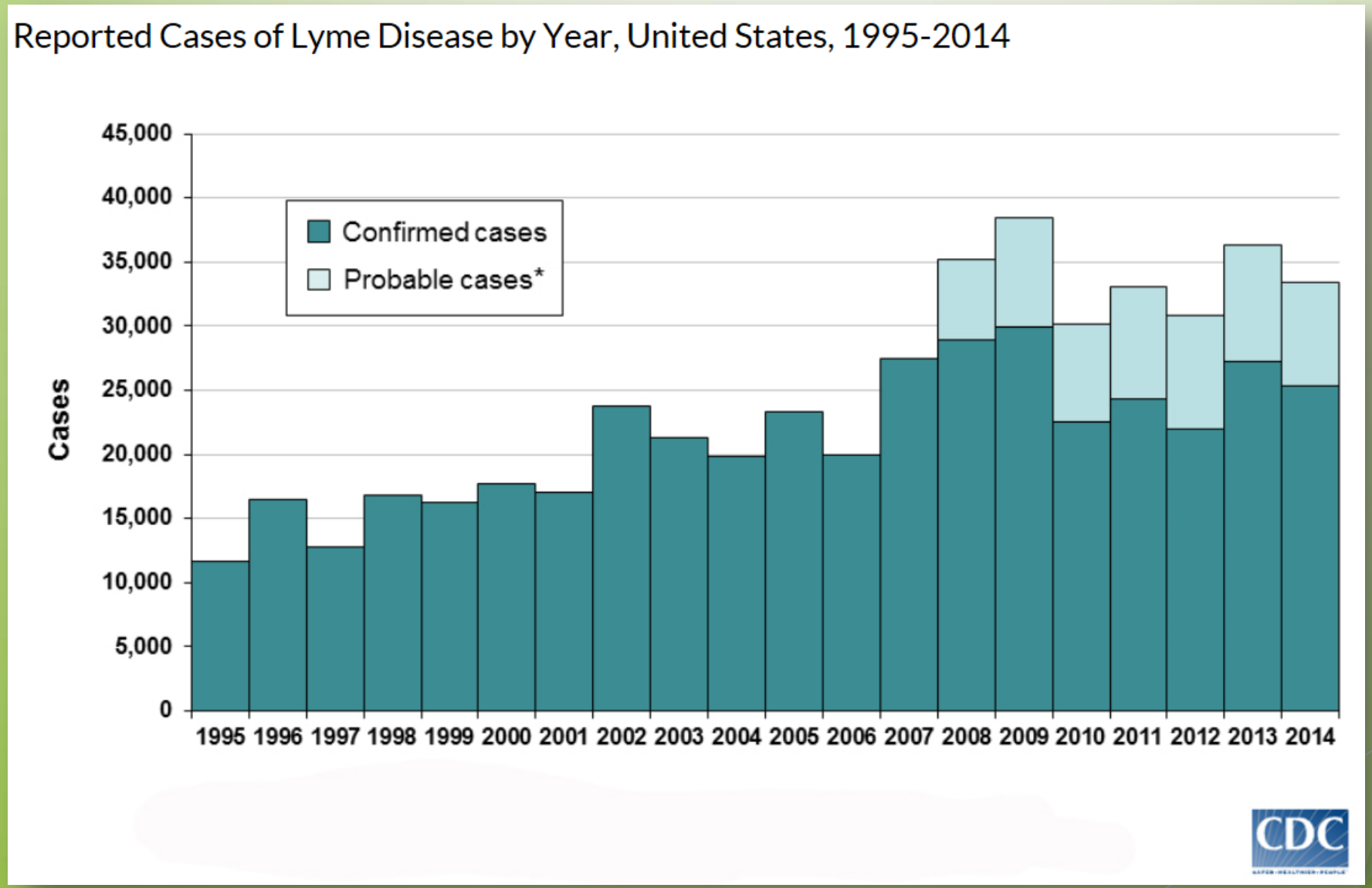
- Overlaying
- Buffer Analysis
- Location-allocation Analysis
- Exploratory Spatial Analysis
- Spatial Statistical Modeling
- Spatial Interaction Model
- Spatial Diffusion Models

Why Worry About Lyme disease?

- Lyme disease caused by Borrelia burgdorferi is the most prevalent vector-borne disease in the United States 240-300 thousand new cases a year.
- First discovered by Dr. Alan Steere in 1977.
- Spread to humans by Ixodes scapularis (deer tick or western blacklegged tick).
- Ticks get the bacterial species from the skin and blood of hosts such as White-tailed deer and other small mammals.
- Symptoms include a bull's-eye rash, fever, chills, headache, fatigue and joint pain.
- Lyme disease costs the US health care system between $712 million to 1.3 billion a year (Johns Hopkins School of Public Health, 2015).
- Long Term effect can lead to neurological diseases, meningitis, Bell's palsy, heart problems and arthritis.



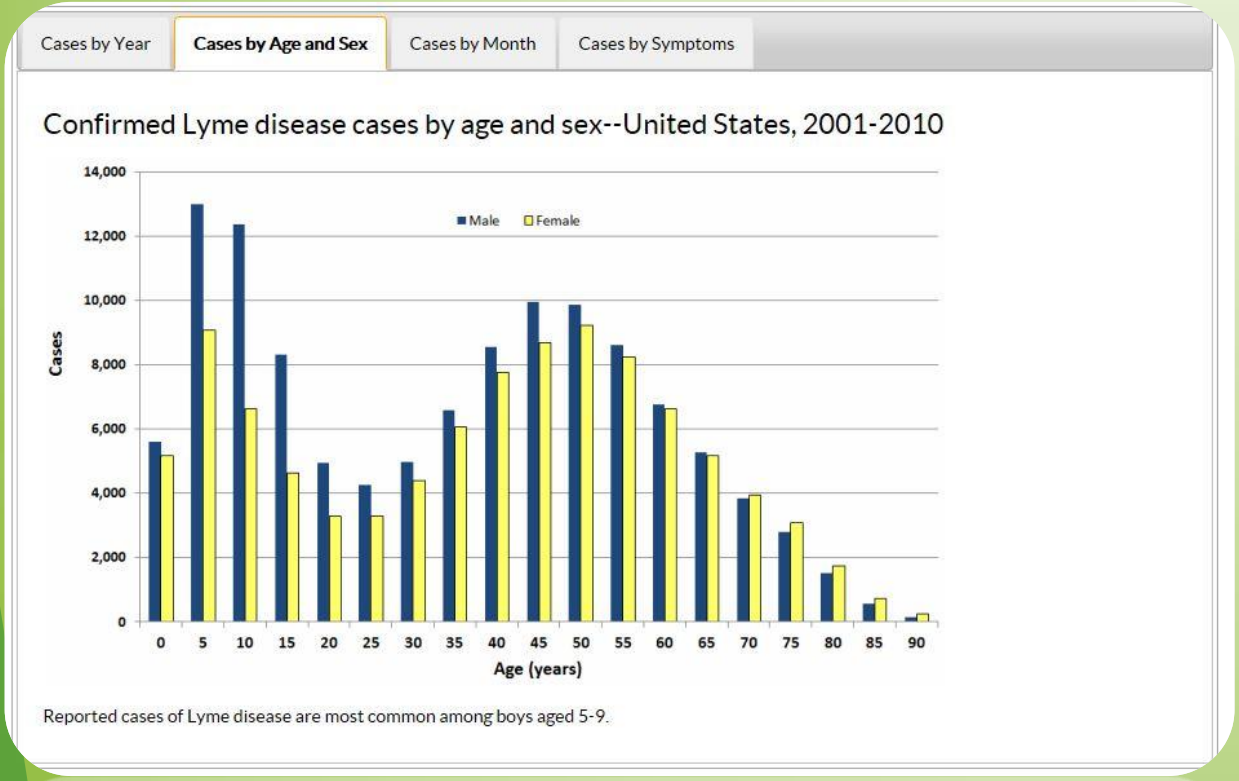
Confirmed Cases of Lyme disease in the United States 1995-2014



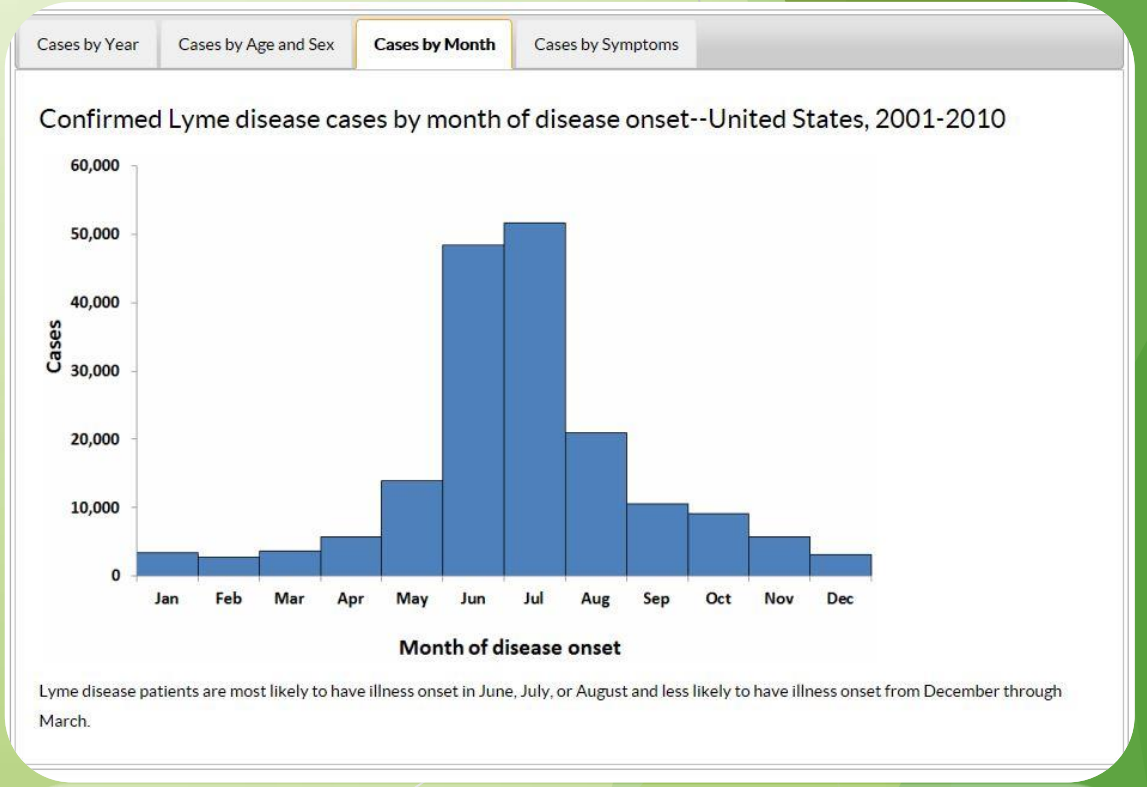
Source: Centers for Disease Control and Prevention http://www.cdc.gov/lyme/stats/index.html

Lyme Disease Facts

- Commonly infects boys Age 5-9 years



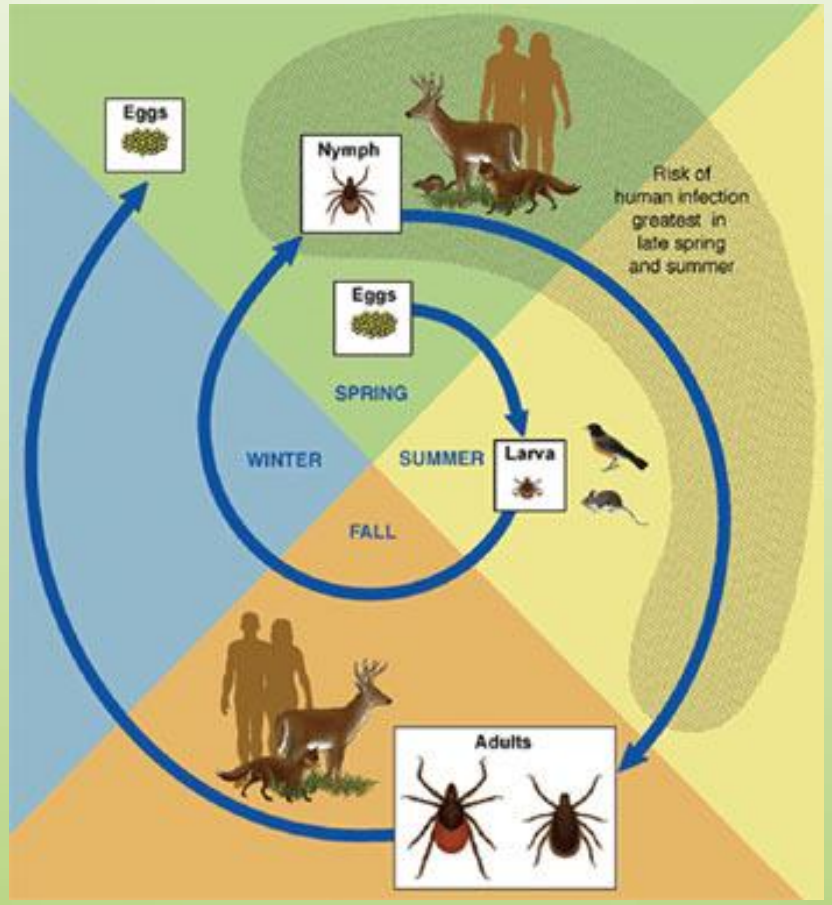
- Incidence is higher between May and August



Sources: Centers for Disease Control and Prevention http://www.cdc.gov/lyme/stats/index.html

Objective

- To Compare differences in Lyme disease cases by county in a ten year period.
- To study environmental and population factors associated with Lyme disease incidence



Environment

- Climate
- Temperature
- Soil
- Ecosystem (Forest Canopy)

Rural Housing

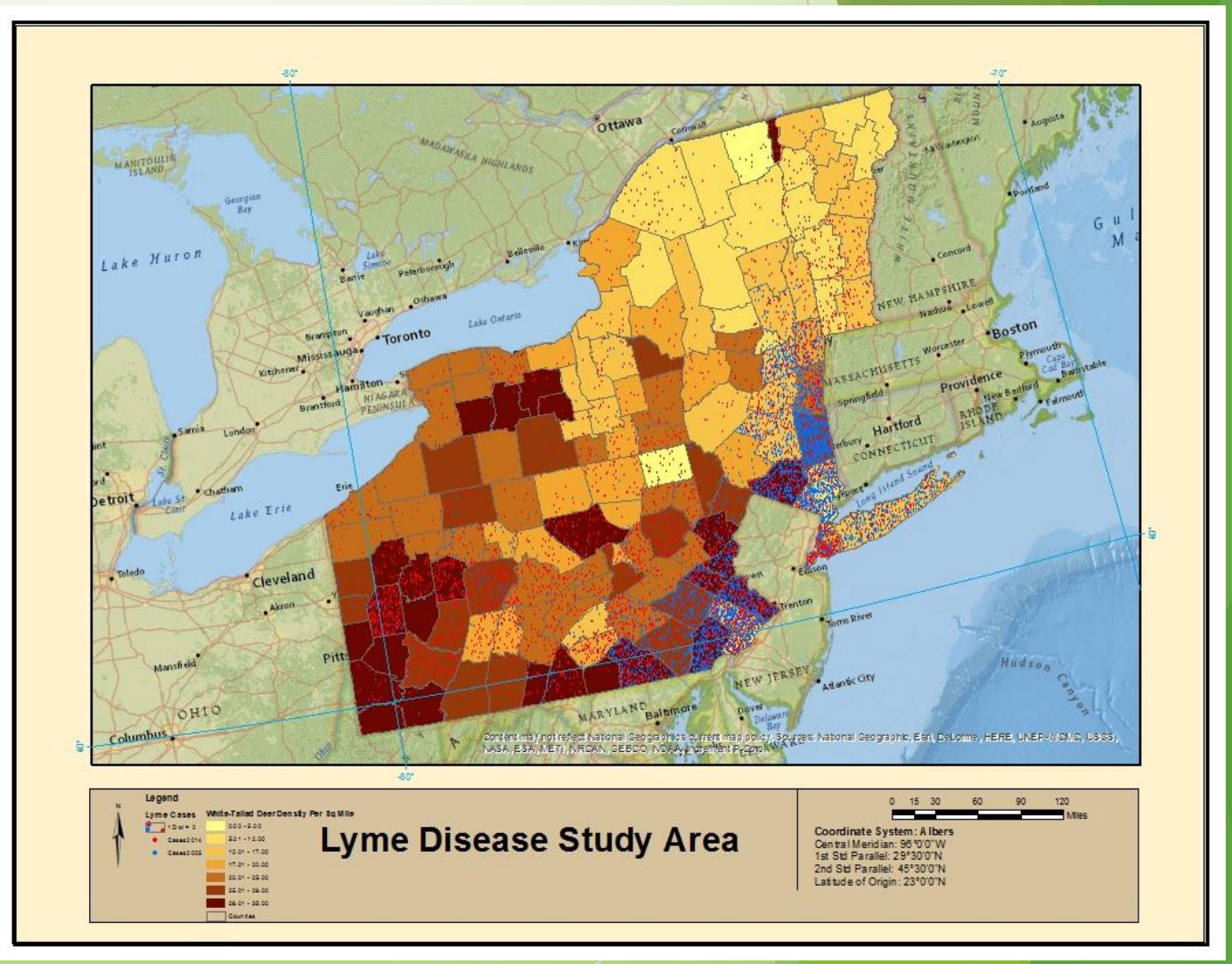
- New Housing more Rural Areas
- Interaction Forest Edges

Host Population

- Mammal Migration Patterns

Study Area

- Tristate region of New York, Vermont and Pennsylvania consisting of 143 counties
- County level analysis
- CDC Data uses home address. The assumption made that most people are near home when infected.
- States chosen have high rates of infection and have similar ecosystems lend itself to spatial observation.
- Data was over 2012-2014 Period Incidence rates.



Data Sources

Raw Count Lyme disease cases

Rural Housing and Metro Communities

Soils, Climate and Temperature Data

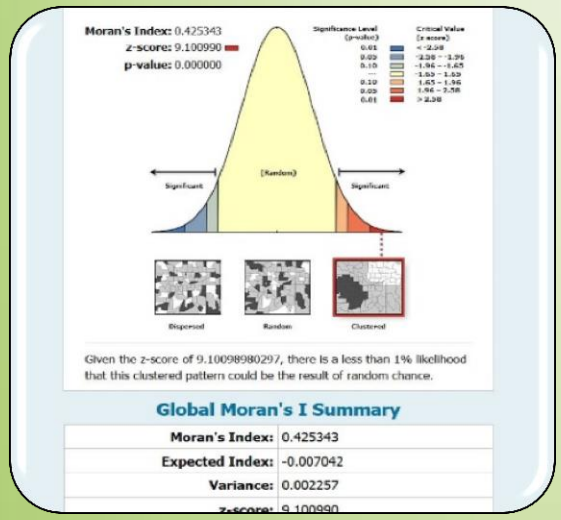
Population and County Data

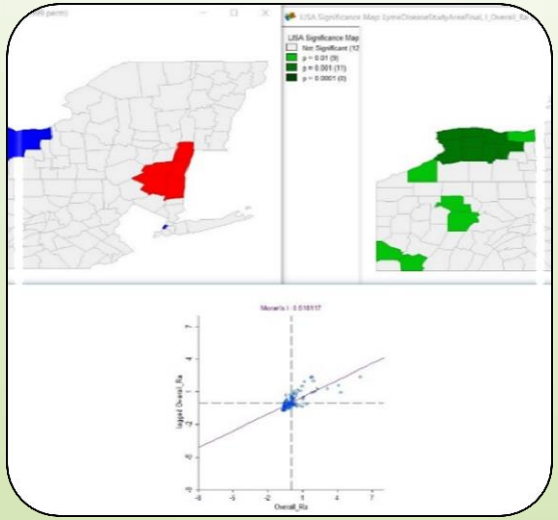
NDVI Data

Deer Density Migration Data

Statistical Analyst and Maps

Spatial Analytical Methods





Cluster Analysis

(Spatial Auto-Correlation)

- Gets Indication of Lyme disease distribution over region.
- Are Lyme disease cases are randomly distributed or is clustering observed?

Local Indicators of Spatial Association (LISA)

Analyze study area for cold or hot areas of activity

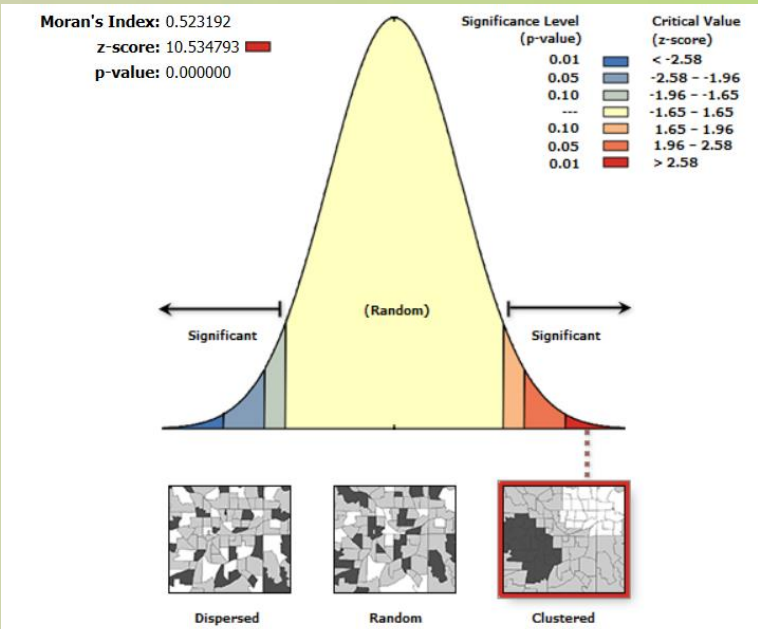
Determine relationship of points and vector polygons (County)

- High Z Score +Small P = Hot Spot
- Low Negative Z Score + Small P Value = Cold Spot

Regression Analysis (OLS + GWR)

- Effects of Multiple Independent Variables on Dependent Variable
- Defines Strength of relationship and predictive value
- Look at variables related to environment, housing and host white tailed deer populations relating to dependent variable of Lyme disease cases

Cluster Analysis Results Incidences Lyme 2012-2014 Tri State NE Study Area



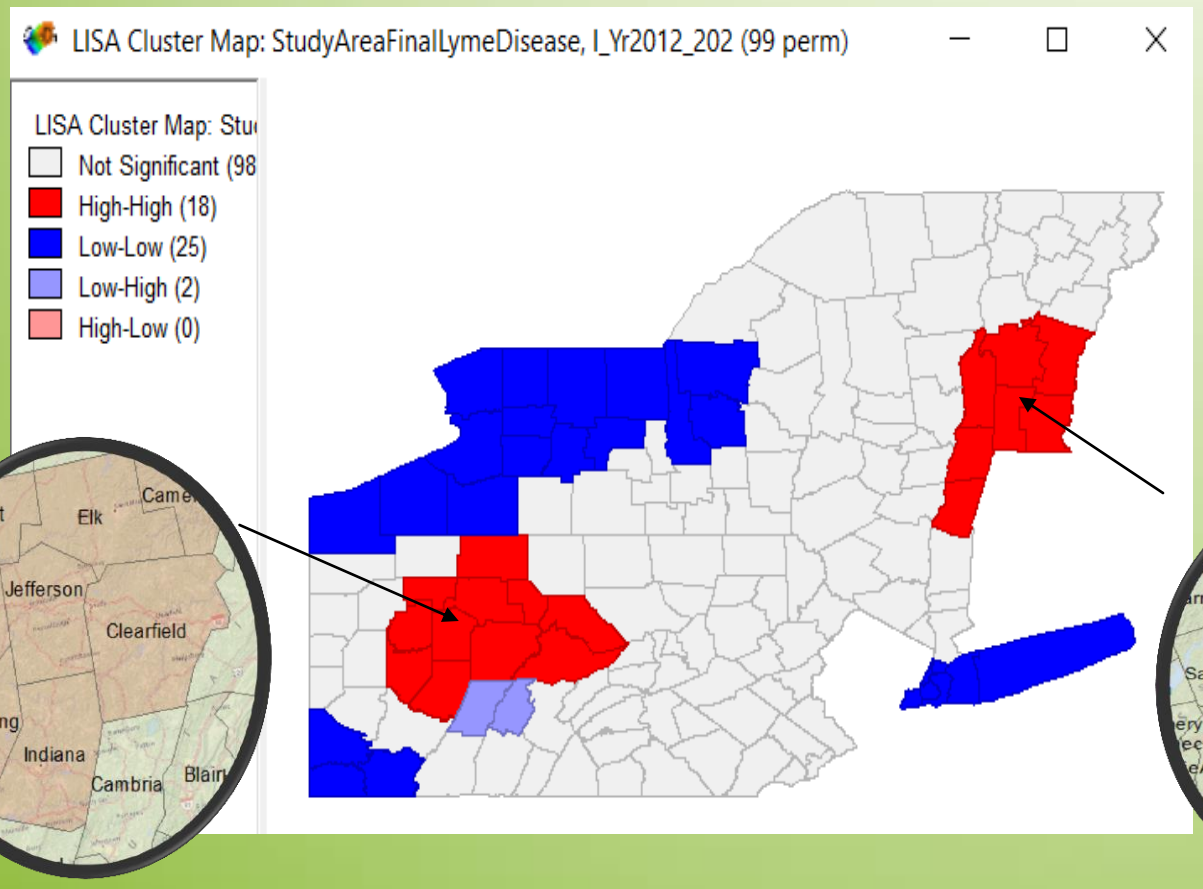
Given the z-score of 10.5347929065, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary	
Moran's Index:	0.523192
Expected Index:	-0.007042
Variance:	0.002533
z-score:	10.534793
p-value:	0.000000

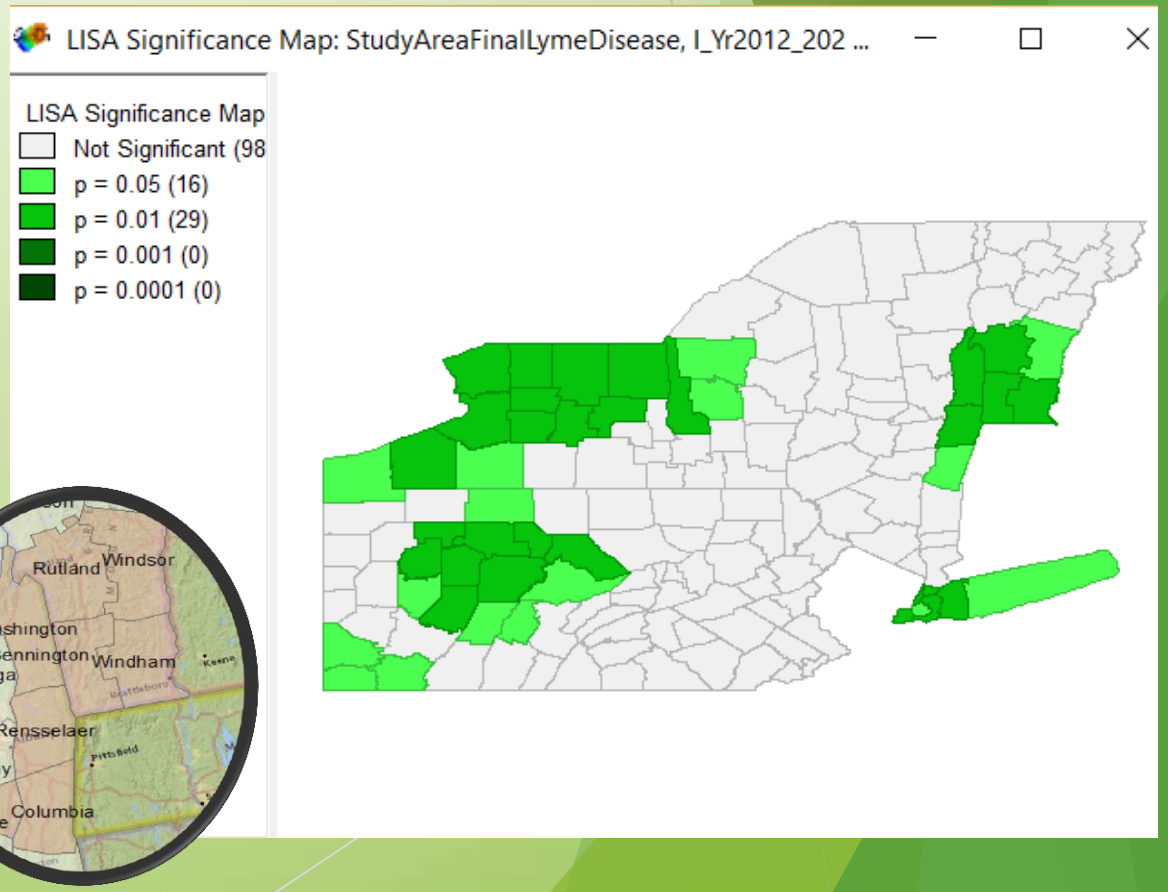
- County Level Rates.
- Method Euclidian Distance.
- Period Incidence Rates Average 2012-2014.
- Shows areas higher case counts (Clusters) that share similarity.
- Starts investigation for factors that may be creating these significant events.

Local Indicators of Spatial Association Analysis

- Evaluate areas of high and low density clustering.
- Conduct Hot Spot analysis to define areas of significance.



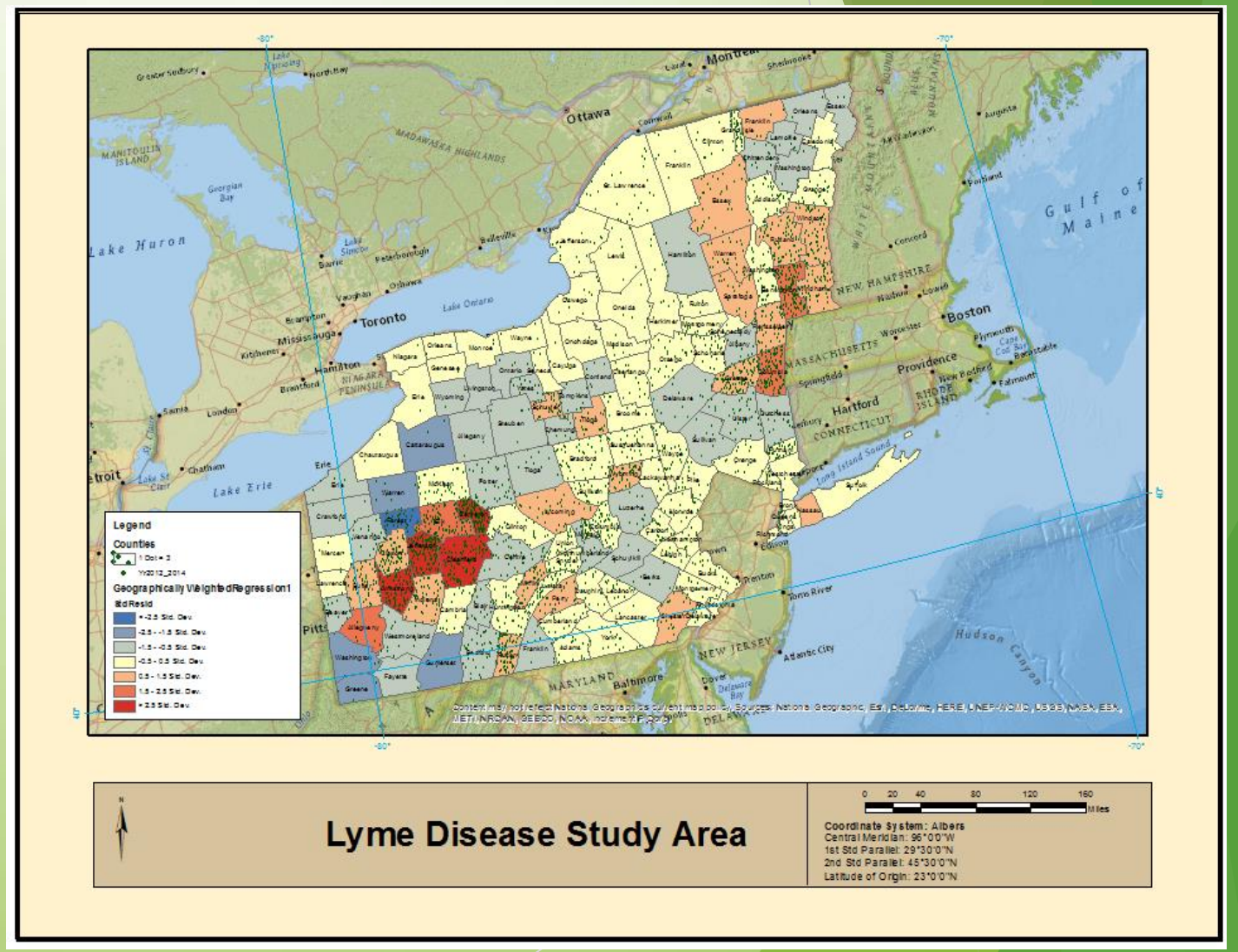
Allegheny Plateau



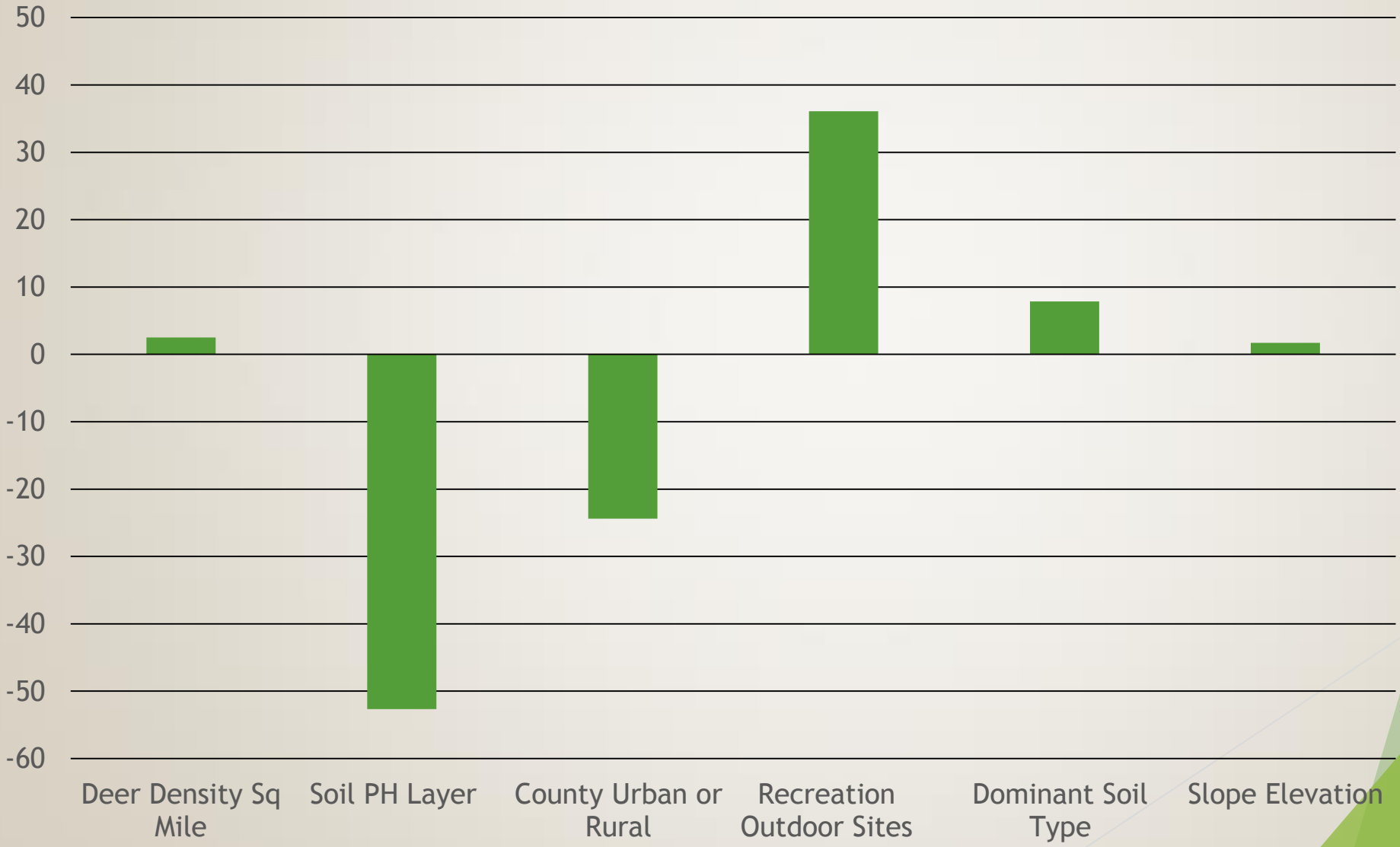
Hudson River Valley

Regression Analysis

- Urban or Rural County
- White-tailed Deer Densities
- Canopy Cover % using NDVI data
- Temperature
- Precipitation
- Relative Humidity
- Soil Analysis
- Slope/Elevation
- Housing Construction
- Watershed Percentage
- Recreation



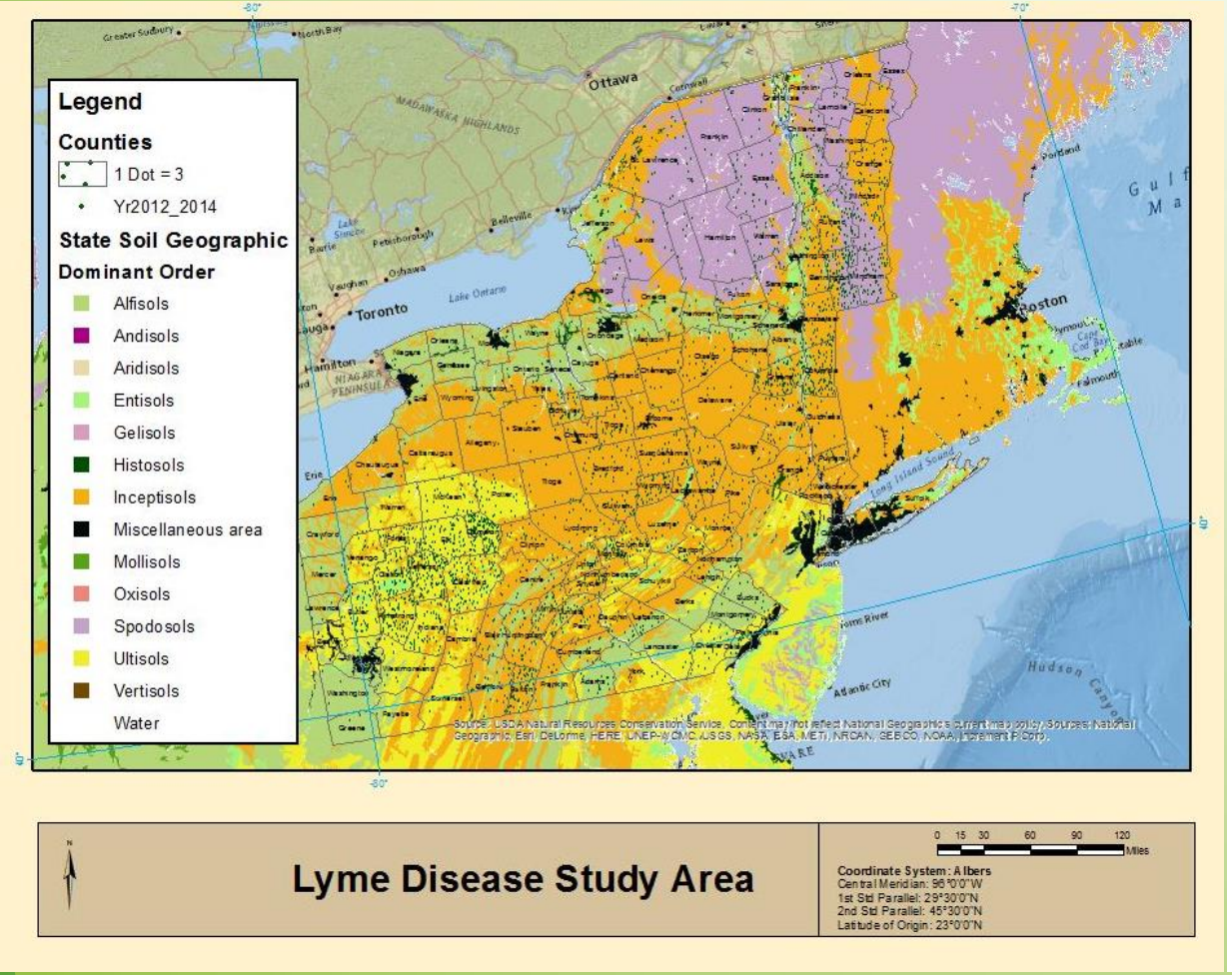
OLS Regression Coefficents (R-Square = 0.41)

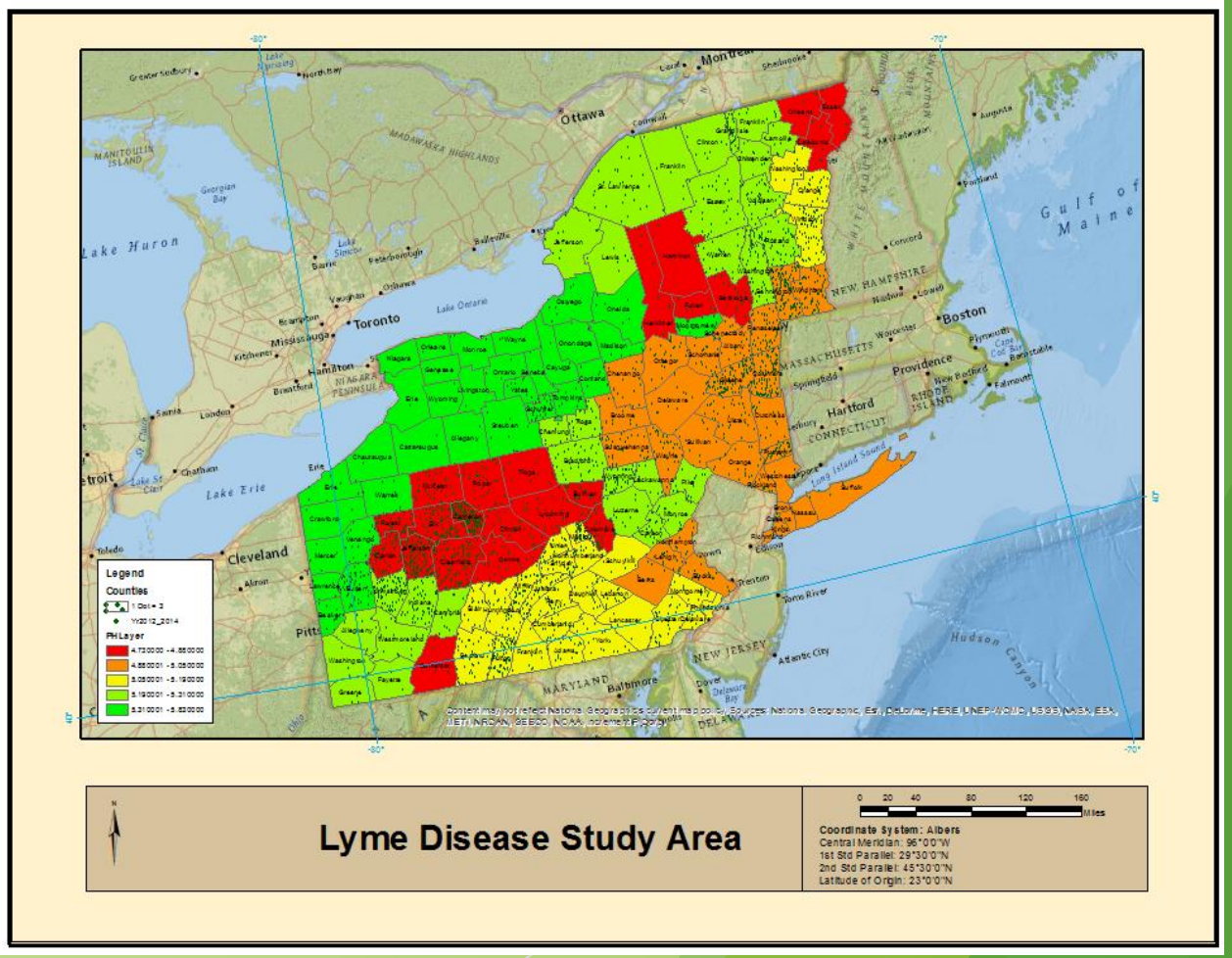


Geographically Weighted Regression Model (R-Squared 0.61)

- Deer Density was associated with higher incidence of Lyme disease
- Metropolitan Counties have lower incidence of Lyme disease
- PH of Soil higher acidity was marginally associated with lower incidence
- Spatial Component of the model capture a significant effect

Regression Analysis Soil Habitation



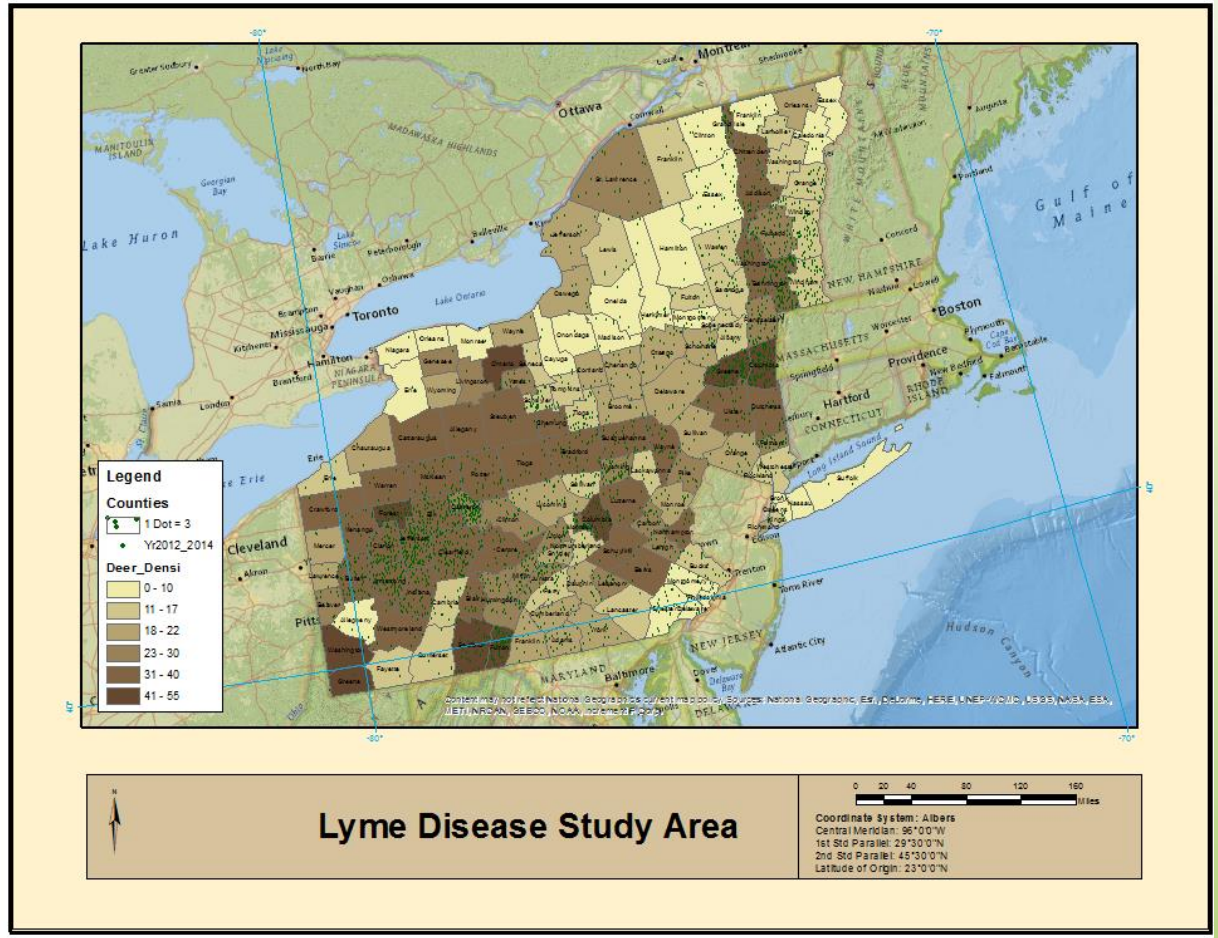


Sandy Loom Soils Ultisols & Inceptisols

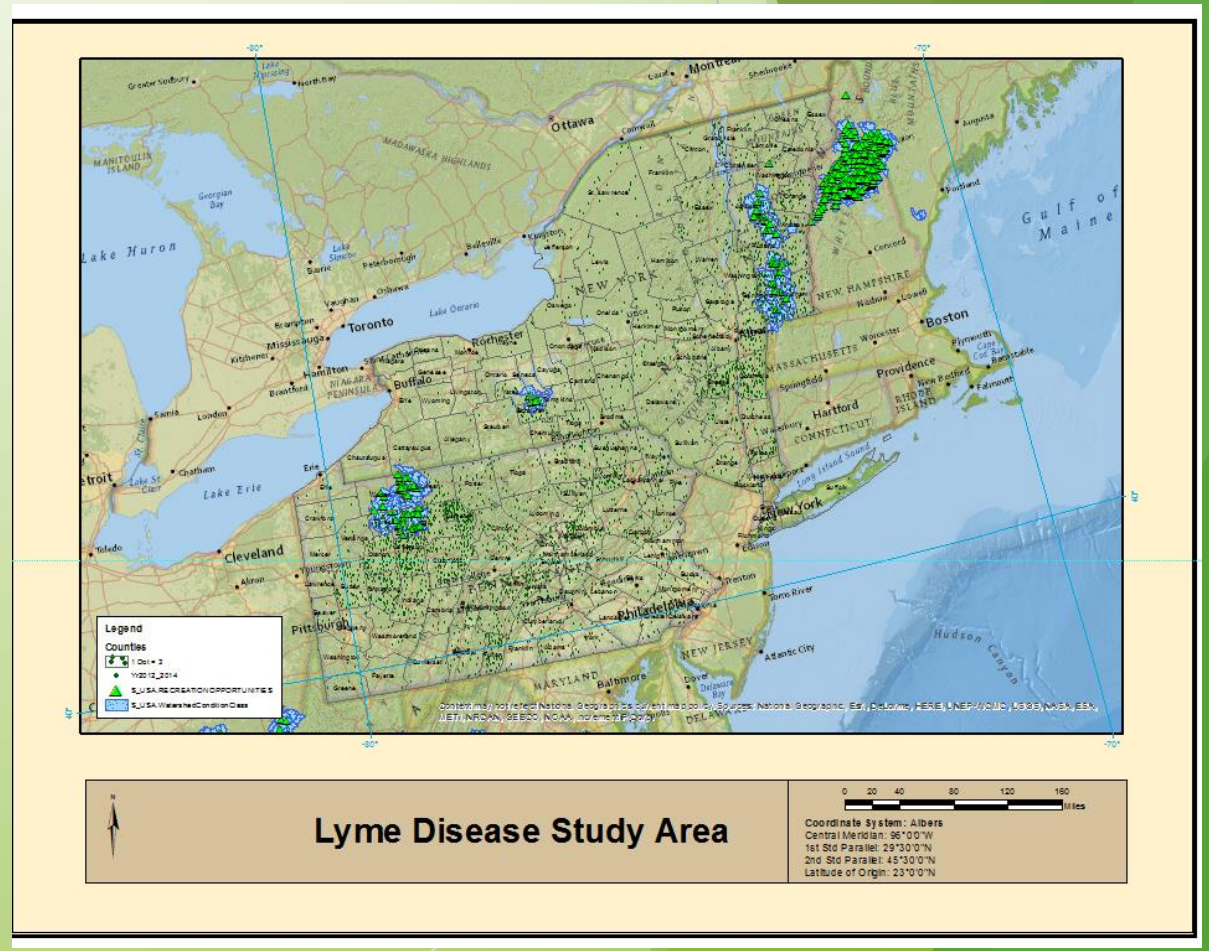
Low Acidity of Soil for Tick Populations Thrive

Regression Analysis Tick Host & Recreation

Deer Density Per Square Mile



Location of Park & Recreation and Watershed Sites



Analysis of Results

- Environmental and Human Habitat variables found to be Significant
  - Deer Density
  - Soil Composition
  - Recreational Opportunity
  - Rural County

What can be with statistically significant factors?

- Use models to map and identify future risk areas.

- Use Results to recommend warning zones to the public and public health agencies.

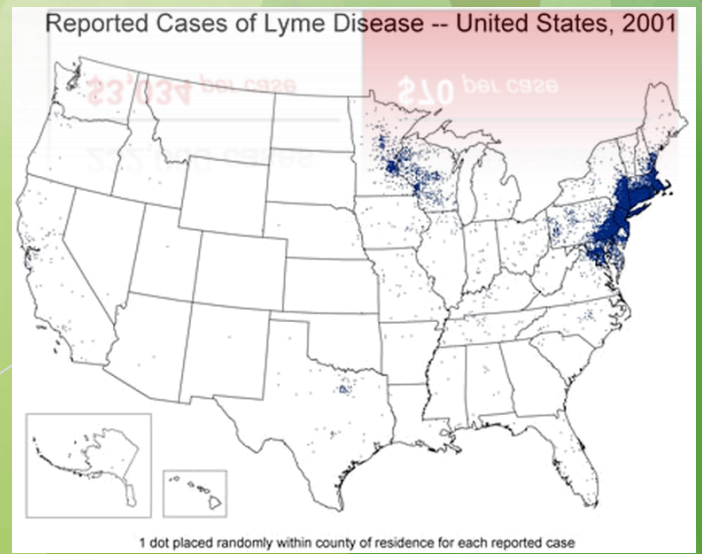
Discussion of Application

- Create web applications that outline risk areas that tie to hiking trails applications
- Create Signs in High Danger areas for tick infestation
- Zoning for housing that create rural neighborhoods in areas that put humans at risk for infections
- Use counter measures such as fungus that kill ticks or control ticks on deer populations
- Lyme disease vaccines or bait vaccinations of rodents
- Increase resources and facilities that treat Lyme disease now very few resources available for size of the epidemic

Treatment Costs and Lack of Resources

- Small Numbers of physicians diagnose and treat Lyme disease (Fear of sanctions by medical boards decrease those practice while those do treat Lyme are swamped and cannot accept new patients)
- 285 primary care physicians surveyed 2% treat Lyme and 50% don't believe chronic infection of Borrelia burgdorferi exists (MedPage Today, 2010)
- Disparity in spending gap for prevention measures for mosquito-borne and tick not related to actual cases
- Lack of agreement for standardized Lyme treatments with antibiotics
- New Laws in New York by Governor Cuomo (2015) offer hope Lyme Doctor Protection Act give medical providers the ability try alternative and new methods or use long term antibiotic regiments

HIV/AIDS $3 billion 50,000 cases **$60,000** *per case*	**WEST NILE VIRUS** $48 million 2,100 cases **$22,857** *per case*
BREAST CANCER $704 million 232,000 cases **$3,034** *per case*	**LYME DISEASE** $21 million 300,000 cases **$70** *per case*



NEW LYME DISEASE CASES IN US

CASES PER MONTH

25,000 CDC ESTIMATE

CASES PER WEEK

5,770 CDC ESTIMATE

CASES PER DAY

822 CDC ESTIMATE

CASES PER HOUR

34 CDC ESTIMATE

NO ACCURATE TESTS

THERE ARE NO TESTS AVAILABLE TO PROVE THAT THE ORGANISM IS ERADICATED OR THAT THE PATIENT IS CURED.

50% FEWER THAN 50% OF PATIENTS WITH LYME DISEASE RECALL A TICK BITE.

50% FEWER THAN 50% OF PATIENTS WITH LYME DISEASE RECALL ANY RASH.

35% THE ELISA SCREENING TEST IS UNRELIABLE.

The common Elisa test you receive at your doctor's office misses 35% of culture proven Lyme disease. Some studies indicate up to 50% of the patients tested for Lyme disease receive false negative results.

50% UP TO FIFTY PERCENT OF TICKS IN LYME-ENDEMIC AREAS ARE INFECTED.

The onset of Lyme disease symptoms can be easily mistaken for other illnesses. Once symptoms are more evident the disease may have already entered the central nervous system, and could be hard to cure.

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Questions or Comments