



National Aeronautics and Space Administration

DEVELOP National Program

Spatial Analysis of Environmental Factors Related to Lyme Disease in Alabama by Means of NASA Earth Observation Systems

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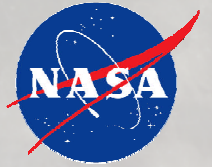
Lyme Disease

- Accounts for more than 95% of vector borne diseases in U.S.
- 27,444 cases reported to CDC in 2007
- Caused by tick bite, usually *Ixodes* species
- Causative agent – *Borrelia burgdorferi* residing in the gut of the tick



Lyme Disease: History

- 1975-clustering of children ill with possible juvenile rheumatoid arthritis seen in Lyme, Connecticut
 - History of tick bite seen
 - Antibiotics cured arthritis
- 1982-Willy Burgdorfer found spirochetes in midgut of ticks sent from Shelter Island, NY, a place with endemic Lyme disease (LD)
 - Erythema migrans produced in rabbits after bitten by ticks infected with spirochetes
- The etiologic agent was named *Borrelia burgdorferi*



Symptoms

- Erythema migrans, fever, fatigue and headache
- If left untreated, may result in long term effects: arthritis, neurocognitive difficulties or fatigue



Tick Life Cycle

Stages:

Egg



Larva

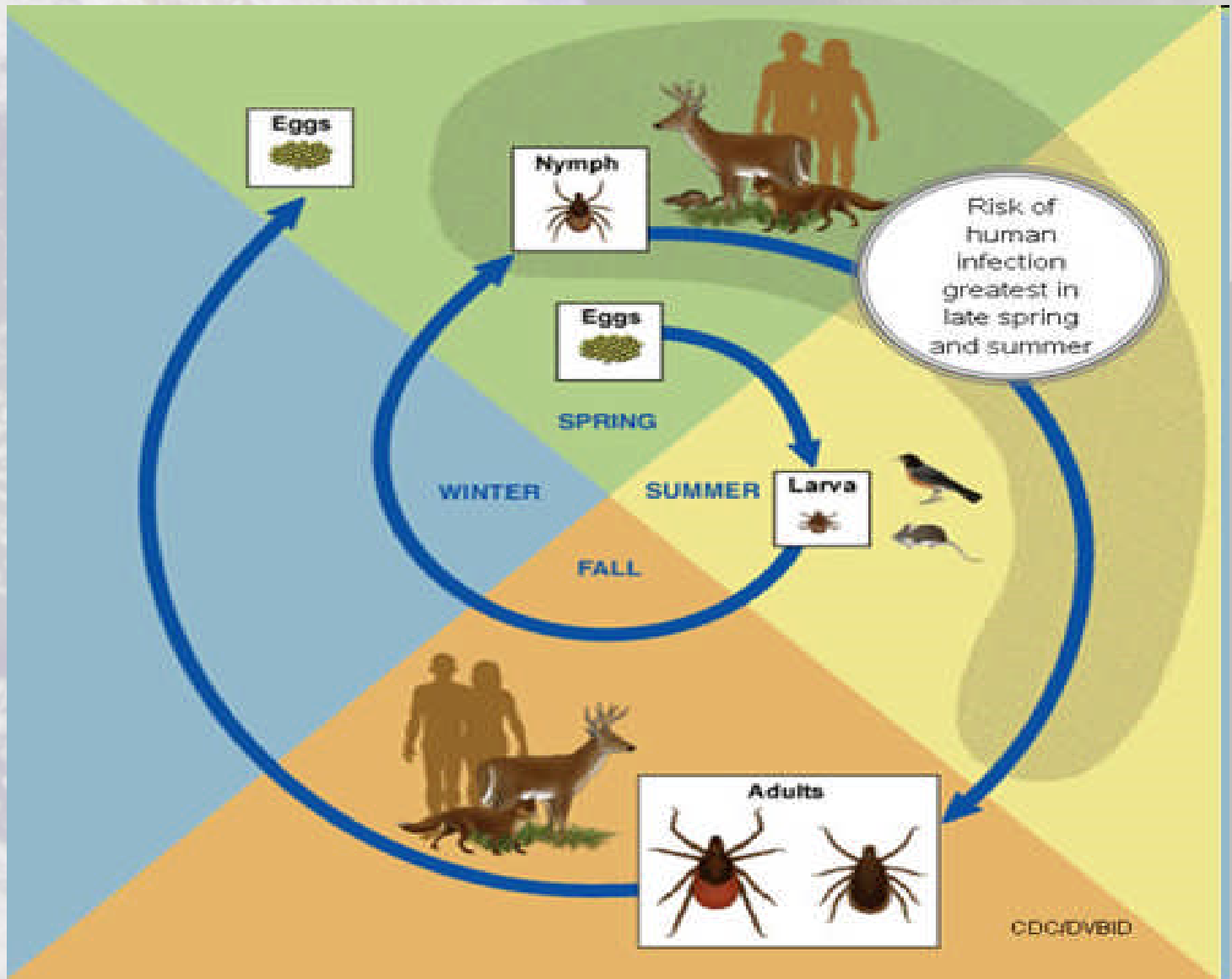


Nymph



Adult

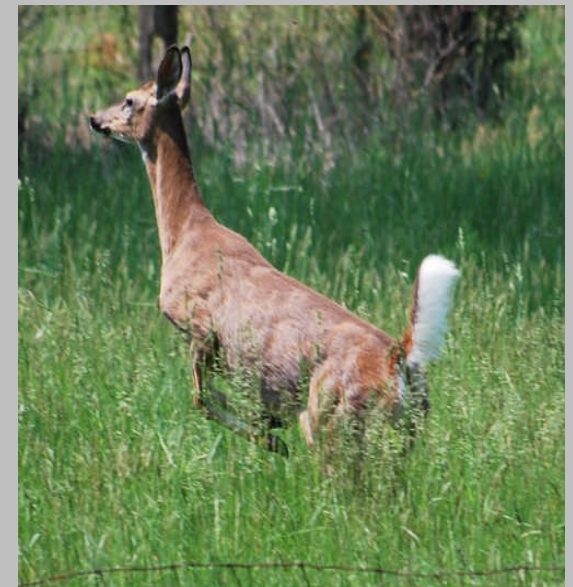
(2 years)

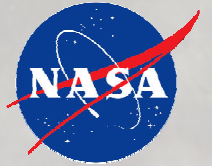




Tick Hosts

- Small mammals
 - For larval and nymphal stages
 - Nymph stage more likely to cause LD due to small size
- White-tailed deer
 - For adult stage
- Over 30 types of wild animals and many species of birds may be hosts

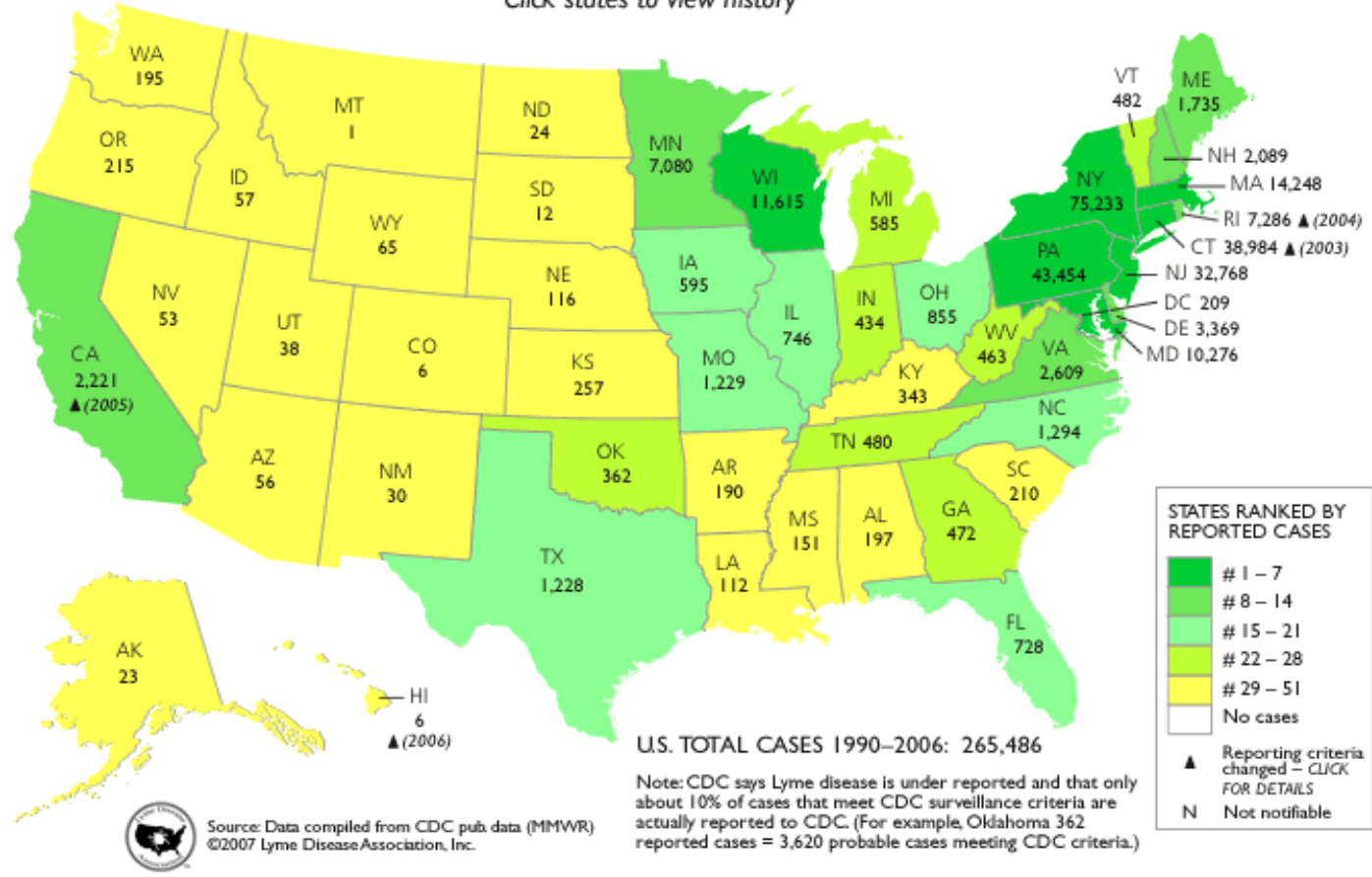




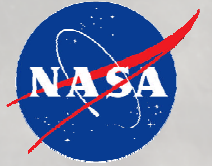
CDC Case Map

TOTAL LYME CASES REPORTED BY CDC 1990–2006

Click states to view history



It has been suggested that states with low incidence rates may have underreporting issues



Lyme Disease in Alabama

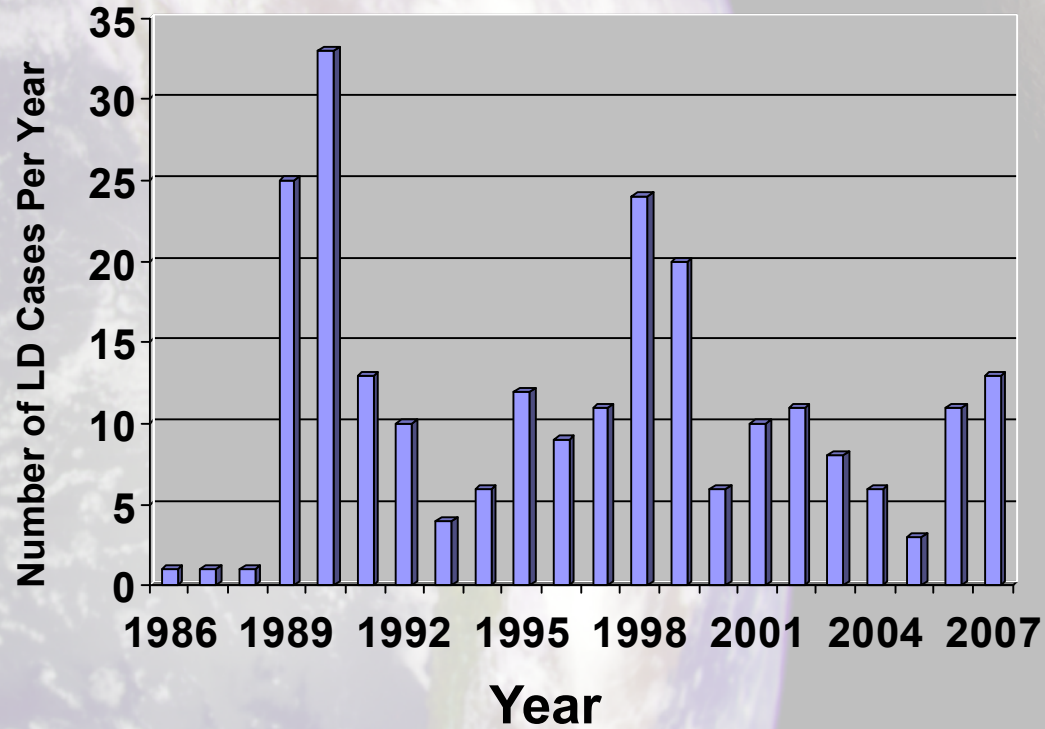


Figure 1 - Number of LD cases in Alabama per year from 1986 to 2007 reported by CDC



Project Goals

1. Demonstrate the presence of the chain of infection of Lyme disease in Alabama
 - Identify areas with environmental factors that support tick population using NASA Earth Observation Systems data in selected areas of Alabama
 - Increase community awareness of Lyme disease and recommend primary and secondary prevention strategies



Goal 1 - Methods

Reviewed studies that proposed the presence of ticks and LD in Alabama in order to investigate the presence of the chain of infection of LD in Alabama



Lyme Disease Vector

- First case of LD in Alabama was reported in 1986 by Dr. Mullen, Auburn University
- Studies conducted in 1988-89, 1989-90
- Ticks collected from 547 white-tailed deer during winter months
- *Ixodes scapularis* (black legged tick, n = 2,060) was the most common tick, *Dermacentor albipictus* (n = 1,253) > *Amblyomma americanum* (n = 315) > *Amblyomma maculatum* (n = 5)
- *I. scapularis* – adults, infested 54% of deer and 57% of total ticks collected



Association between Tick, *B. burgdorferi* and Hosts

- Study conducted in East Central AL (8 sites in Lee County)
- A total of 859 ticks were recovered using the following three methods:
 - Small mammals and reptiles were trapped and tested
 - Hunter-harvested white-tailed deer and other large mammals
 - Dragging method



Association between Tick, *B. burgdorferi* and Hosts

Host	Percentage of Black Legged Tick
Small Mammals	97.4% larval stage
White-tailed deer	81.8% adult stage

- *A. americanum* (33.4%) and *I. scapularis* (20%) accounted for 53.4% of all ticks collected
- 49.1% were examined for *B. burgdorferi* using direct and indirect fluorescent antibody assays
- 4% of *A. americanum* tested were infected
- 3% of *I. scapularis* tested were infected



Amblyomma americanum - STARI

- Patients bitten by *A. americanum* ticks ⇒ characteristic red rash
- Causative agent of Lyme disease has not been cultured from skin biopsy specimens; diagnostic serum antibodies were usually not found
- DNA amplification techniques produced *B. lonestari* sequences both from the skin of the patient and *A. americanum* tick attached to it
- Southern Tick Associated Rash Illness (STARI)



Borrelia burgdorferi



Ixodes scapularis



Nymphs and larvae prefer cotton mice - more active during late spring and summer



Adults prefer white-tailed deer - more active during winter



Project Goals

1. **Demonstrate the presence of the chain of infection in Alabama**
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Remote Sensing Methods

- Conducted literature review to identify environmental factors
- Analyzed Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and DigitalGlobe Quickbird satellite imagery from summer months
- Performed image analyses in ER Mapper 7.1



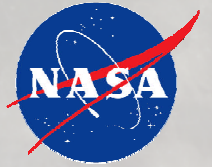
Environmental Factors for Tick Populations

- Temperature: -10 to 35°C
- Relative humidity: no lower than 80%
- Vegetation: forest cover and decaying vegetation help maintain relative humidity
- Soil characteristic: moist soil



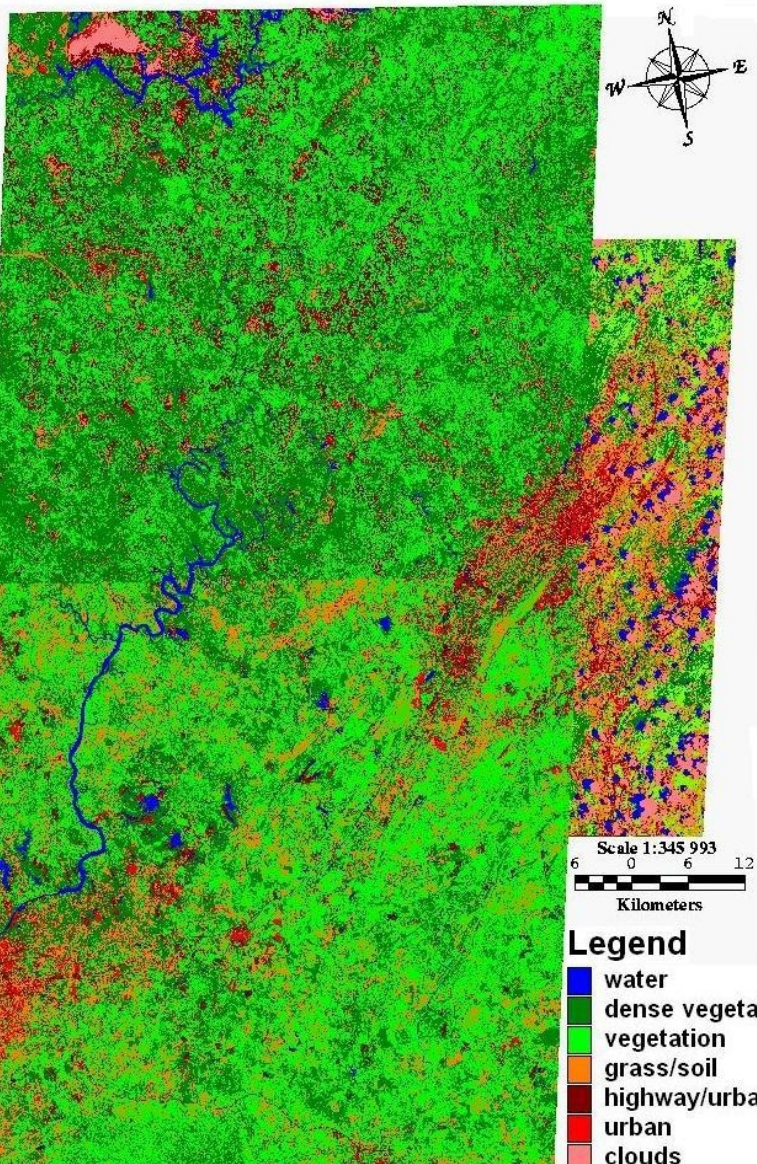
Classifications

- Iterative Self-Organizing Data (ISODATA) Analysis Technique
- Analyzes all image pixels and groups them in similar categories
- Supervised classification can be used in tandem with ground truthing to get a more detailed analysis of land cover

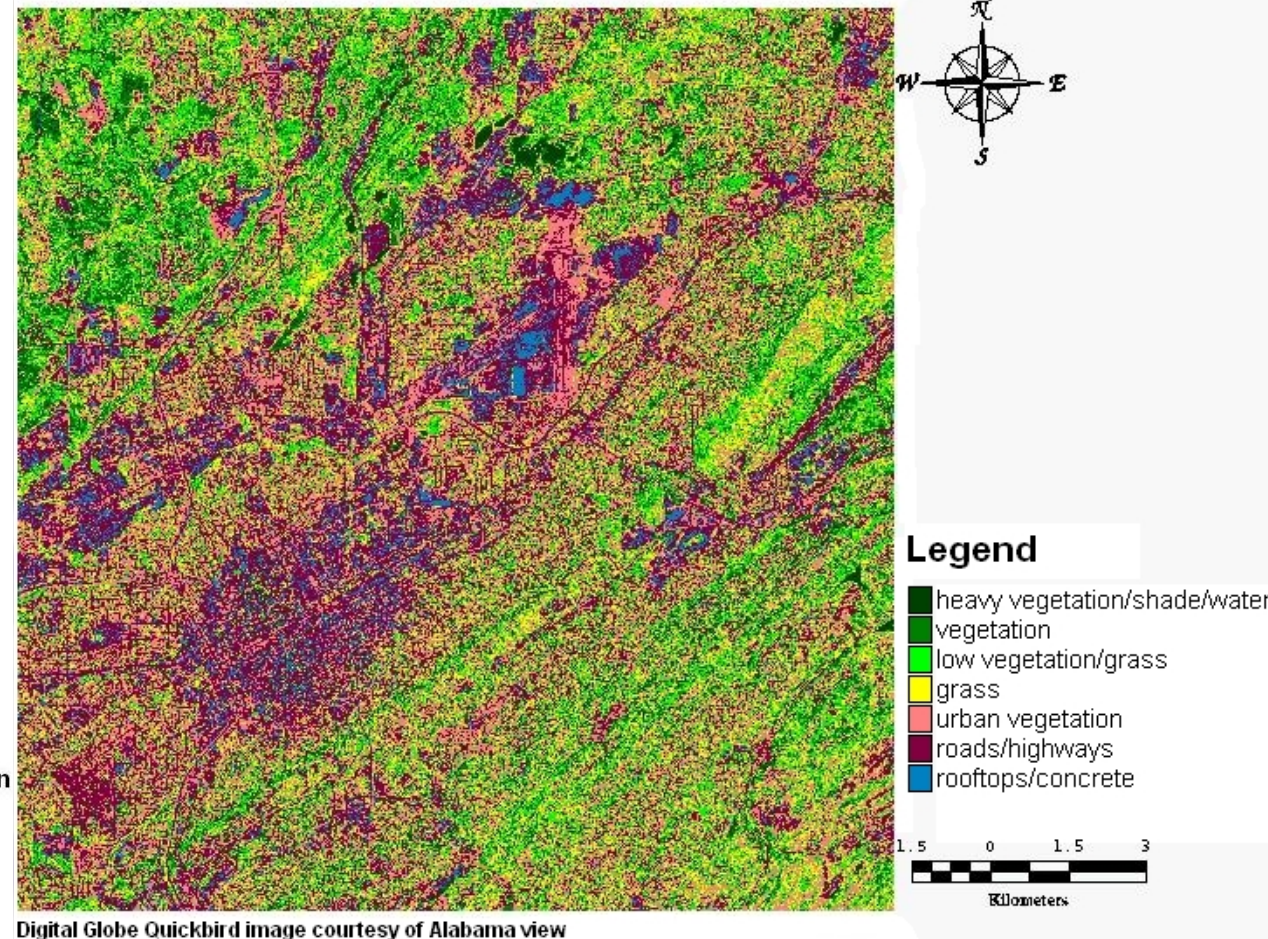


ASTER and Quickbird Land Cover Classifications

ASTER LULC classification



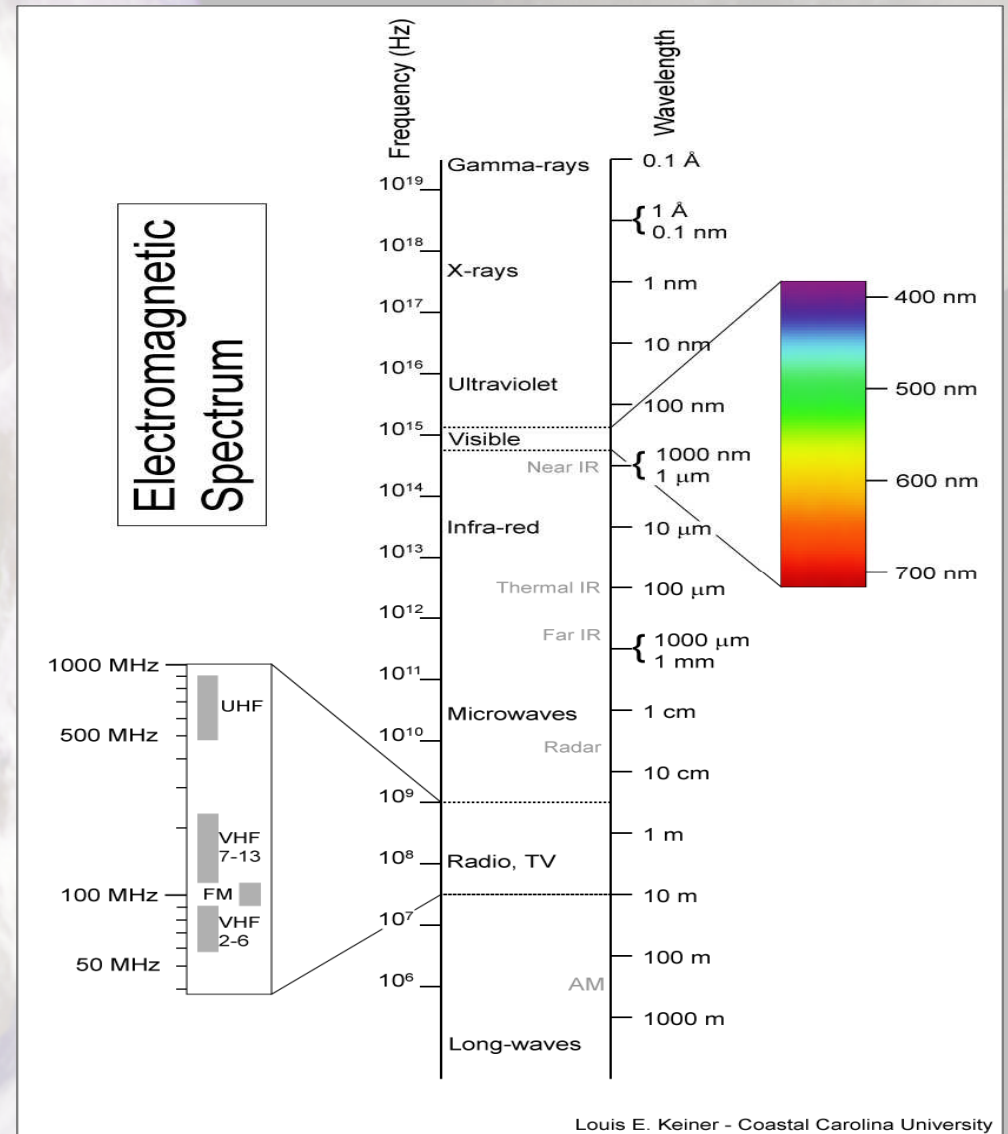
LULC classification of Birmingham, AL
Quickbird image from March 2005





NDVI

- Normalized Difference Vegetation Index (NDVI) algorithm was applied to all ASTER and Quickbird imagery
- Formula applies a ratio of the Near-Infrared and visible red bands to each pixel
- $NDVI = \frac{NIR-RED}{NIR+RED}$





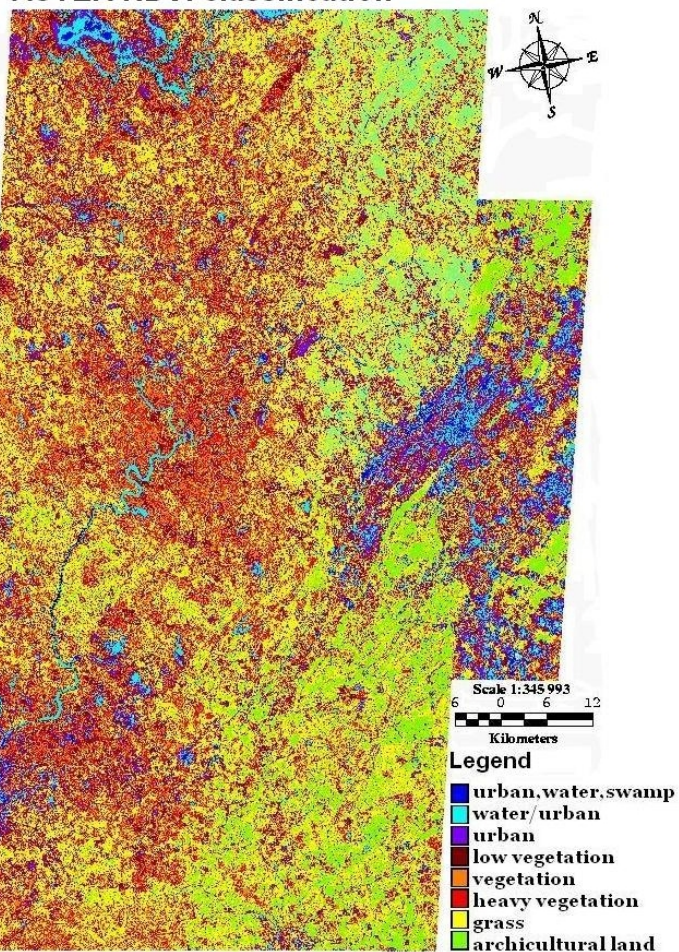
Soil Moisture

- Measured as a ratio of the mid- and thermal infrared bands
- Soil moisture = band 14 / band 10
- Image is classified to represent the different levels of soil moisture

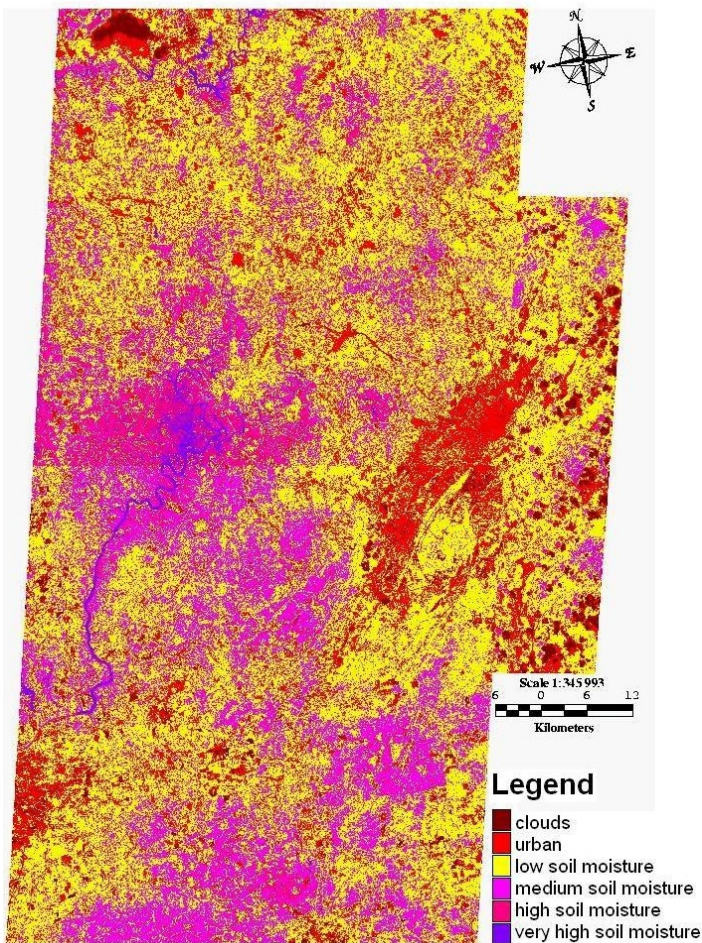


ASTER Results

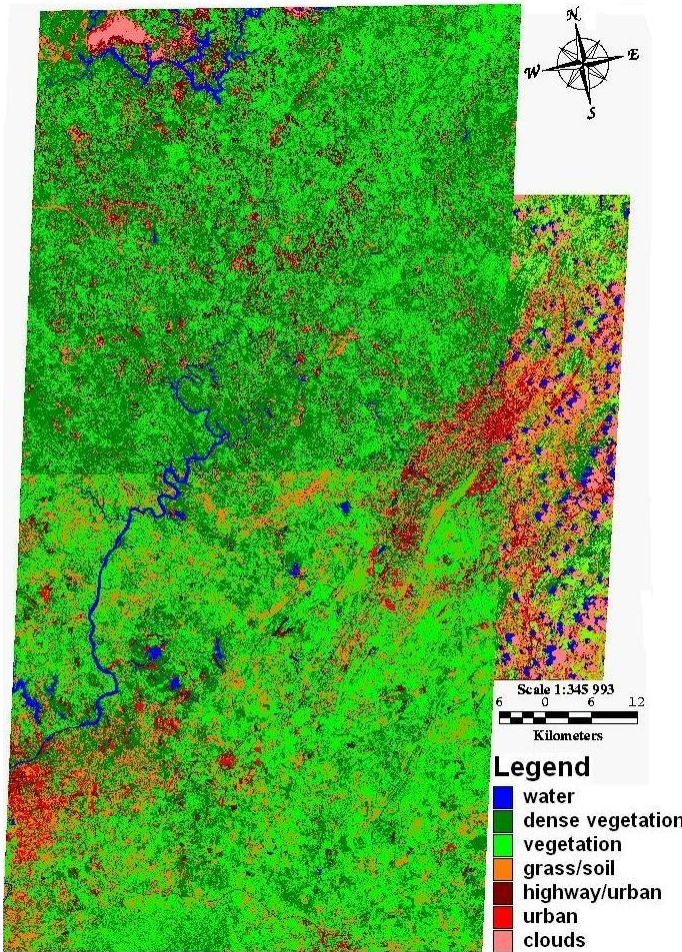
ASTER NDVI classification



ASTER soil moisture classification



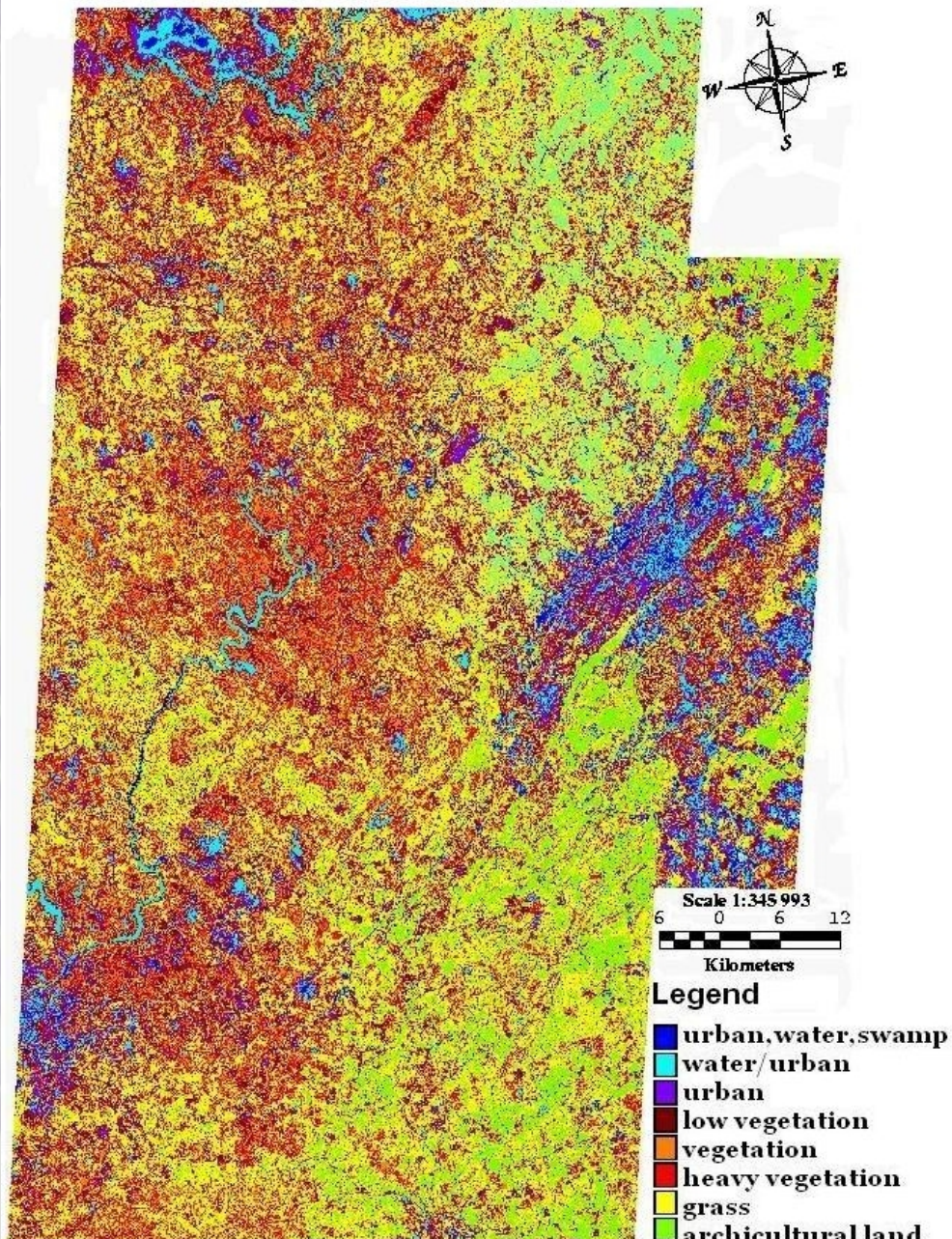
ASTER LULC classification



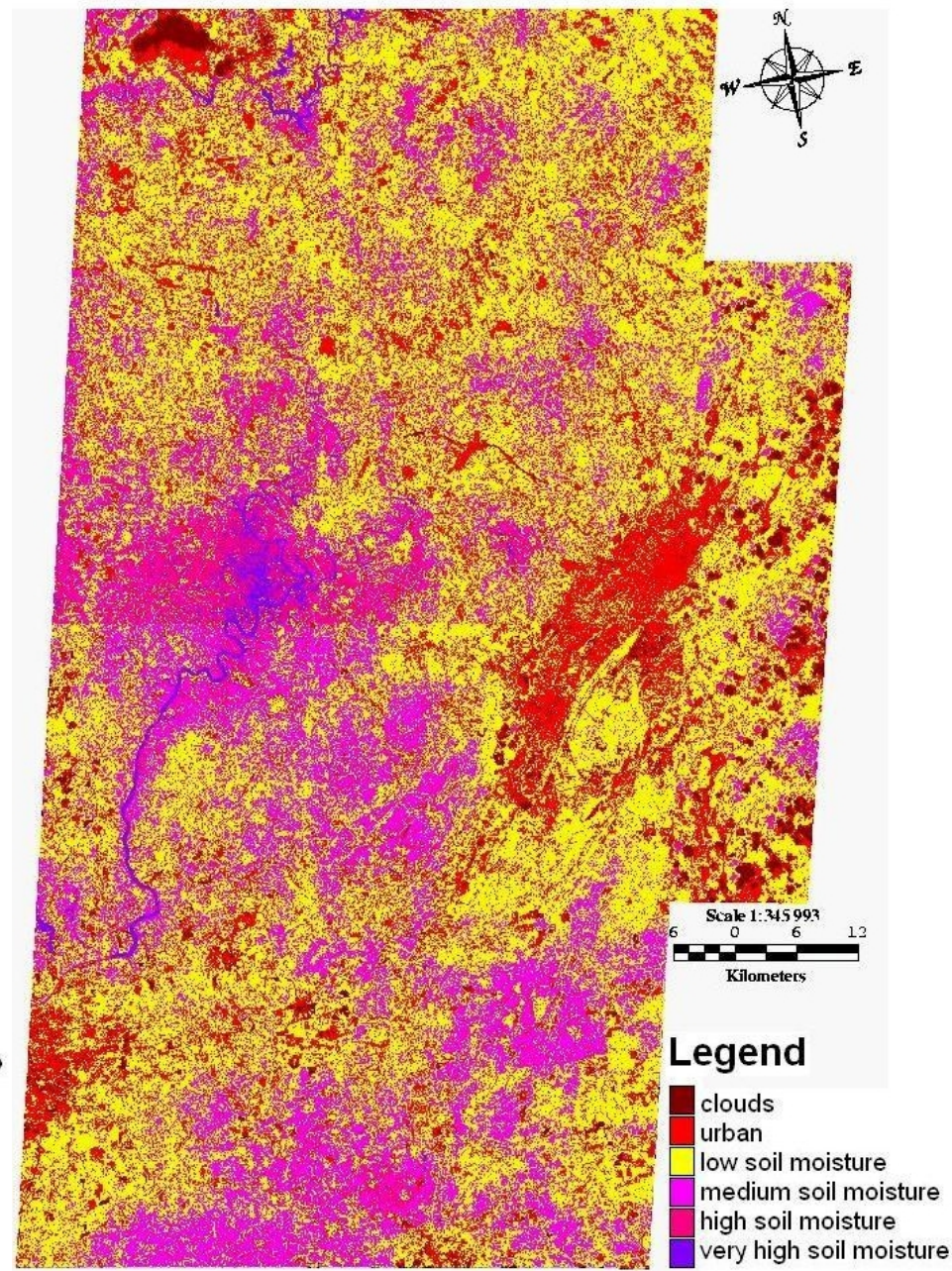


ASTER Vegetation and Soil Moisture Maps

ASTER NDVI classification



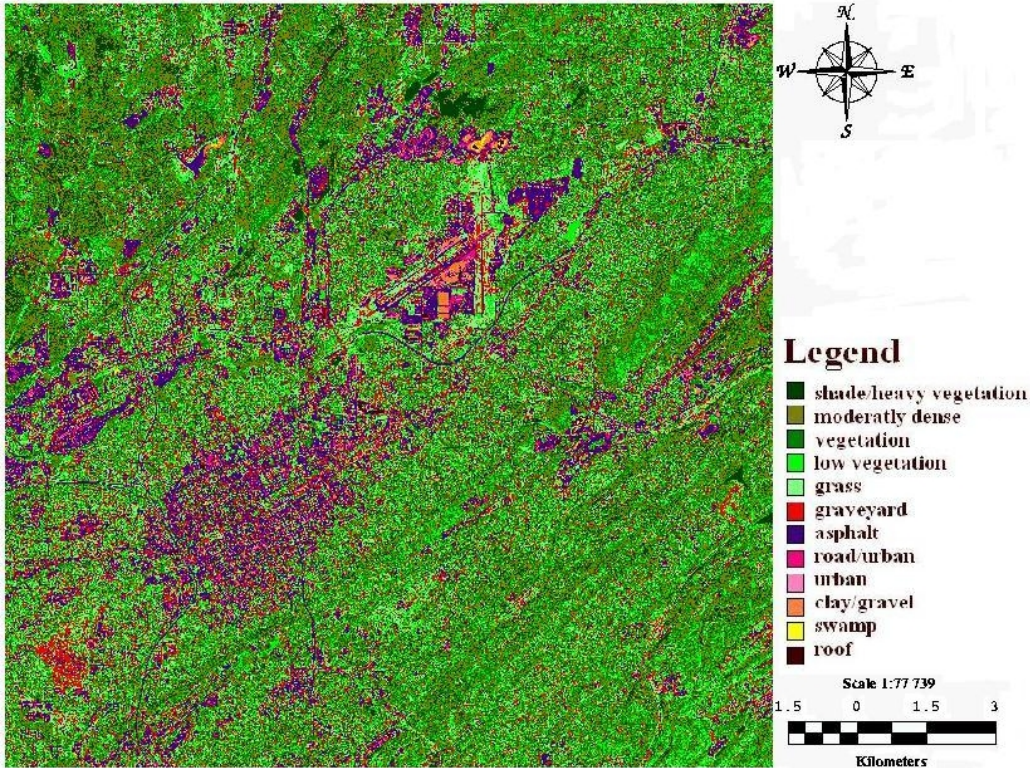
ASTER soil moisture classification





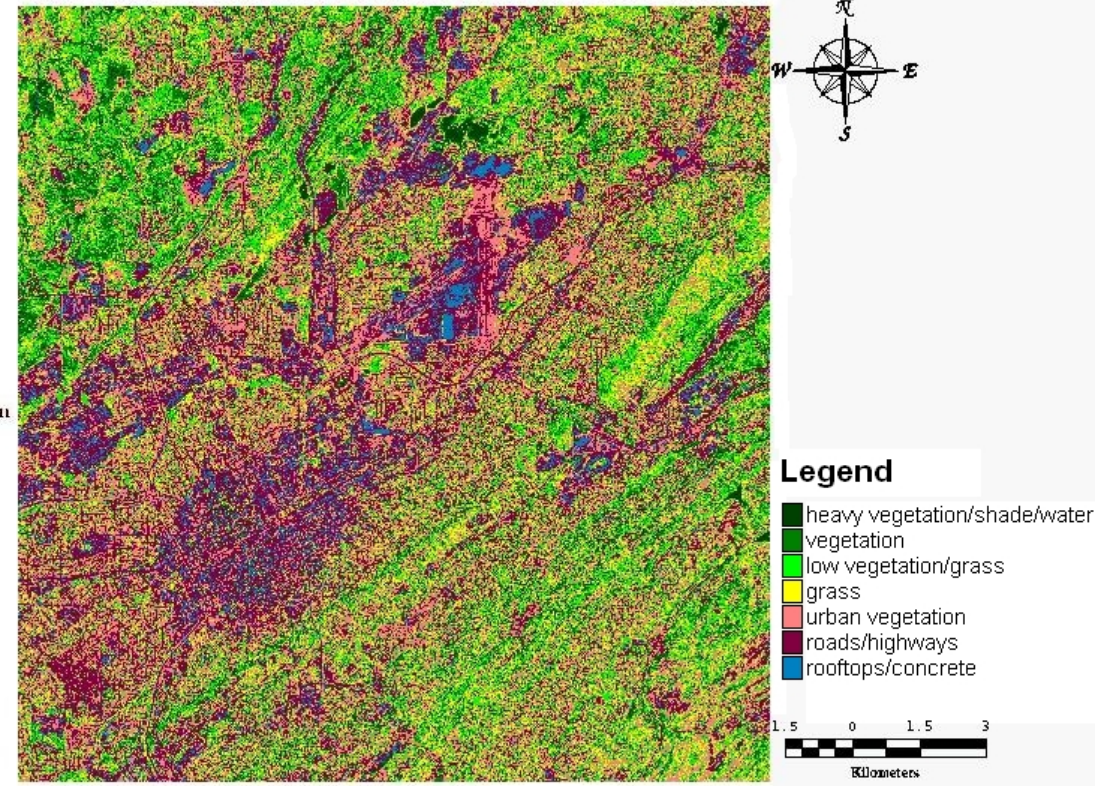
Quickbird Vegetation and Land Cover Maps

NDVI classification of Birmingham, AL
Quickbird image from March 2005



Digital Globe Quickbird image courtesy of Alabama View

LULC classification of Birmingham, AL
Quickbird image from March 2005



Digital Globe Quickbird image courtesy of Alabama view



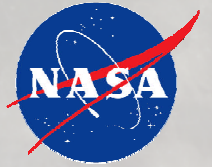
Summary

- High levels of soil moisture and dense vegetation are environmental factors that support large tick populations
- NASA Earth Observation Systems data analyses effectively identified potential tick habitats in Central AL based on environmental factors



Project Goals

1. Demonstrate the presence of the chain of infection in Alabama
 2. Identify areas with environmental factors that support tick population using NASA Earth Observation Systems data in selected areas of Alabama
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Primary Prevention

- Reducing exposure to ticks is evidenced to be the best defense against LD
- Primary personal protection methods:
 - Avoid or reduce time spent in high risk areas
 - Wear protective clothing
 - Apply tick repellants
 - Perform tick checks



Tick Removal

- Use tweezers to extract the tick from skin
- DO NOT use petroleum jelly, a hot match, nail polish, or other products





Secondary Prevention

- First sign of infection is typically a circular, “bull’s-eye” rash
- Early stages of infection can be treated with prescription antibiotics
- Untreated cases may develop chronic symptoms
- Lyme disease is serious but can be treated



Limitations

- Available tick data only represents the presence of ticks
- CDC case data does not indicate time of year or location of contraction
- STARI is often misdiagnosed as Lyme disease



Future Research

- Analyze ASTER imagery to identify likely tick habitats statewide
- Use Quickbird imagery to produce a more detailed vegetation representation
- Investigate LD preventive behaviors to better frame intervention campaigns
- Identify other significant factors for tick populations

