NASA's Applied Sciences DEVELOP National Program

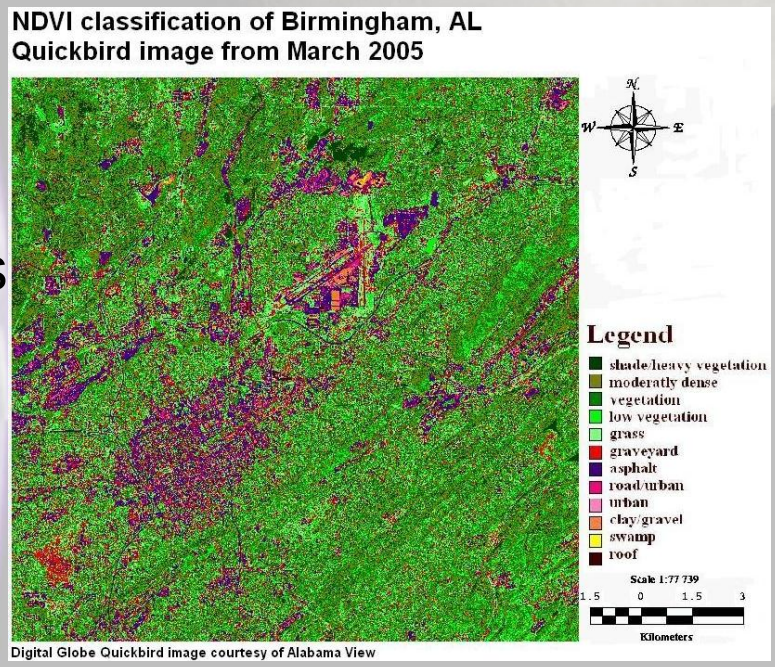
NASA's Applied Sciences

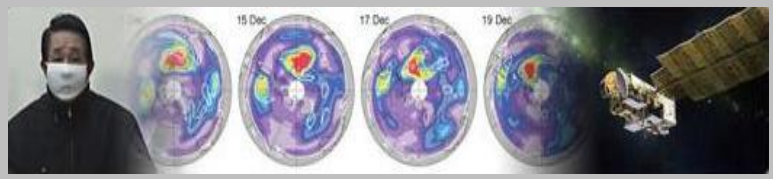
Public Health Program Review

FY 2009 DEVELOP Public Health Projects:

- Remote Sensing and Spatial Analysis of West Nile Virus Risk in Illinois

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



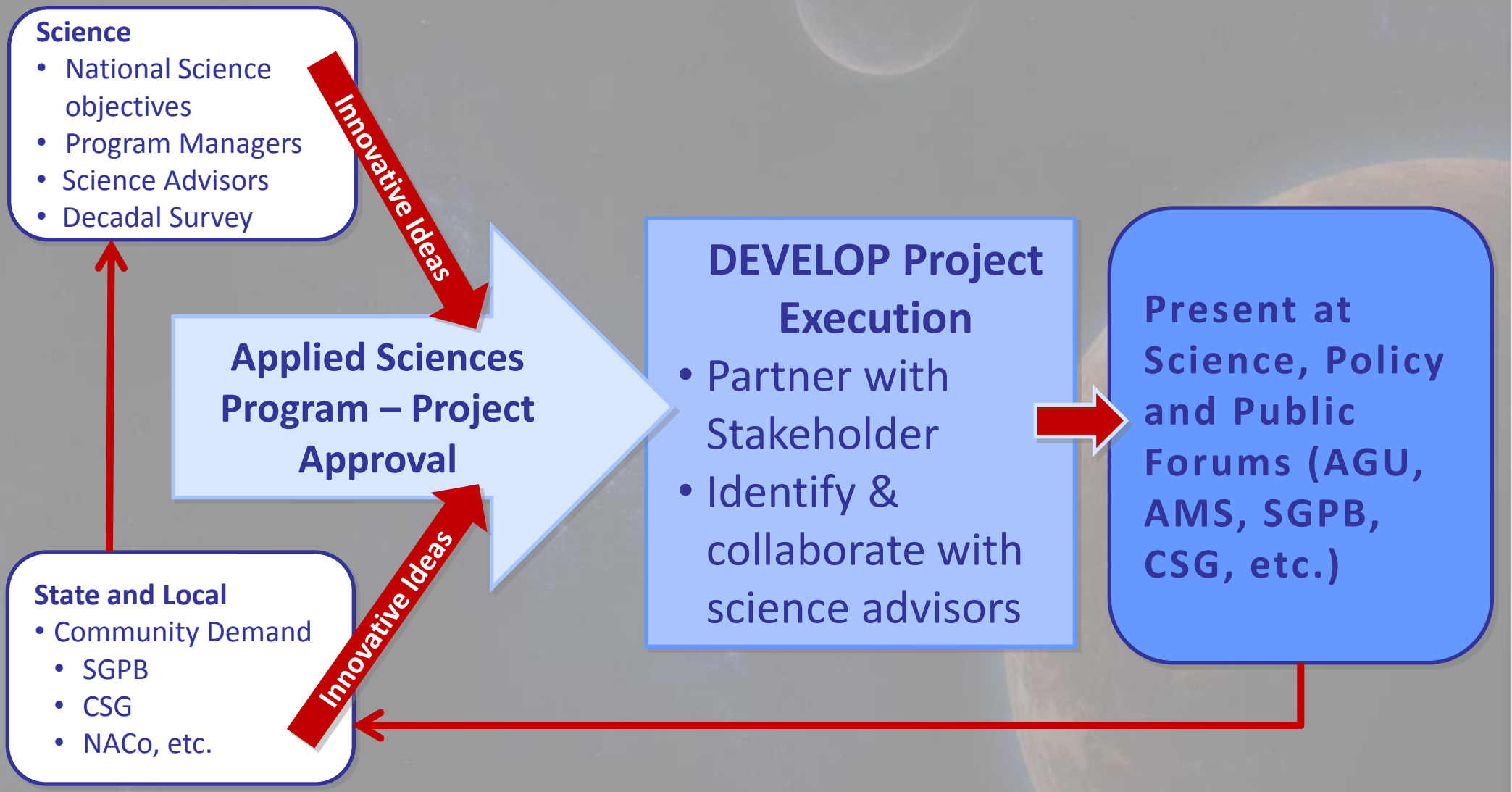


Nathan Renneboog, Marshall/UAB DEVELOP Student Director

NASA Knowledge- Organizational Chart

- NASA Administrator
  - Deputy Administrator
    - Exploration Systems Mission Directorate
    - Space Operations Mission Directorate
    - Science Mission Directorate
      - Earth Science Division
        - Applied Sciences Program
          - National Applications
          - DEVELOP
      - Heliophysics Division
      - Planetary Science Division
      - Astrophysics Division
      - Management & Policy Division
    - Aeronautics Research Mission Directorate

Project Lifecycle



DEVELOP National Program Locations

DEVELOP National Program Office – NASA Langley Research Center, Hampton, VA		
NASA Ames Research Center *Moffett Field, CA*	NASA Goddard Space Flight Center *Greenbelt, MD*	NASA Jet Propulsion Laboratory *Pasadena, CA*
NASA Langley Research Center *Hampton, VA*	NASA Marshall Space Flight Center/UAB *Birmingham, AL*	NASA Stennis Space Center *Stennis, MS*
Great Lakes and St. Lawrence Cities Initiative *Chicago, IL*	Mobile County Health Department *Mobile, AL*	Wise County *Wise, VA*

Remote Sensing and Spatial Analysis of West Nile Virus Risk in Illinois

University of Alabama at Birmingham (UAB) – NASA Marshall Space Flight Center (MSFC)

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Marilyn McAllister, M.S.
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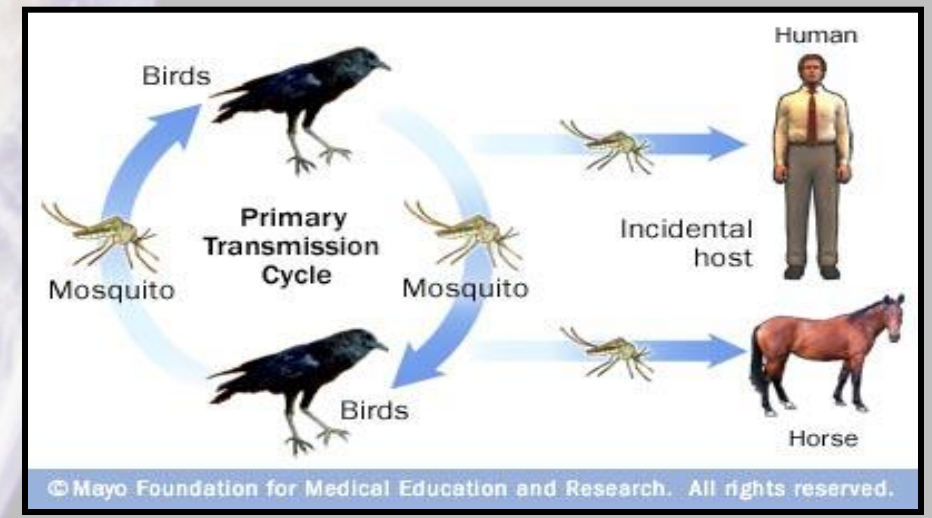


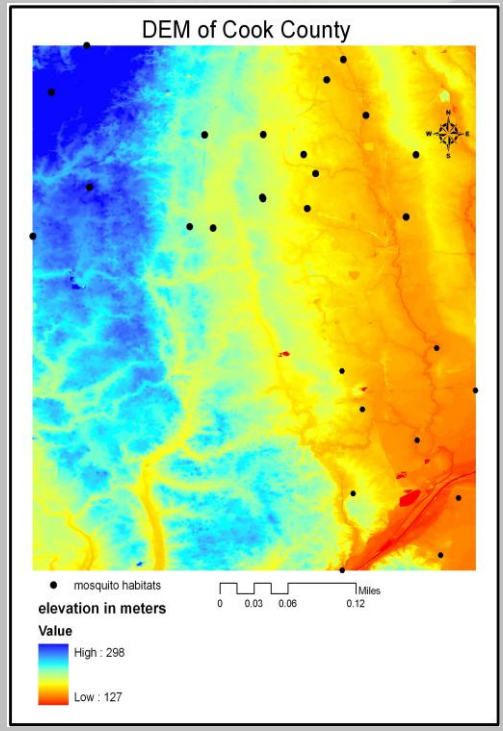
Remote Sensing and Spatial Analysis of West Nile Virus Risk in Illinois

Science Advisor

Jeffrey C. Luvall, Ph.D

NASA Marshall Space Flight Center

- **Objective**
  - Ascertain correlations between environmental factors and West Nile Virus outbreaks in Cook County, IL
- **Methodology**
  - Analyze spatial variation of *Culex* mosquitoes to estimate risk and species density and compare to environmental factors
- **Community Concerns**
  - Identify areas of possible high risk in Cook County, IL for a Virus outbreak and monitor disease transmission
- **Anticipated Results**
  - Potential WNV risk maps indicate environmental conditions with high vector density
  - Substantial outreach efforts: Make data accessible, Syndrome Reporting Information System (SYRIS)
- **Potential Partners**
  - UAB School of Public Health
  - UAB Gorgas Center for Geographic Medicine
  - Des Plaines Valley Mosquito Abatement District (MAD) & Northwest MAD
  - Chicago Dept. of Public Health



Remote Sensing and Spatial Analysis of West Nile Virus Risk in Illinois

Partners

Earth System Models

- **Image and Spatial Analysis**
  ERMapper
  ArcGIS
- **Disease Outbreak & Transmission Monitoring**
  SYRIS™ SYndrome Reporting Information System

- LU Classification
- Vegetation Health (NDVI, ARVI, SAVI)
- Elevation
- Spatial analysis of *Culex restuans* & *Cx. pipiens* mosquitoes
- Statistical interpotatlion and analysis

Data

Earth Observations

- **NASA Data**
  ASTER, SRTM
- **NASA Partner Data**
  UAB, DPMAD, NWMAD

- LULC information
- Entomological data
- Elevation
- Climate data

Results

- Established Data Contacts
- Related environmental variables to mosquito density
- Produced WNV Vector Abundance Prediction Maps
- Enhanced scientific knowledge base
- Performed outreach

Value & Benefits

Short-term

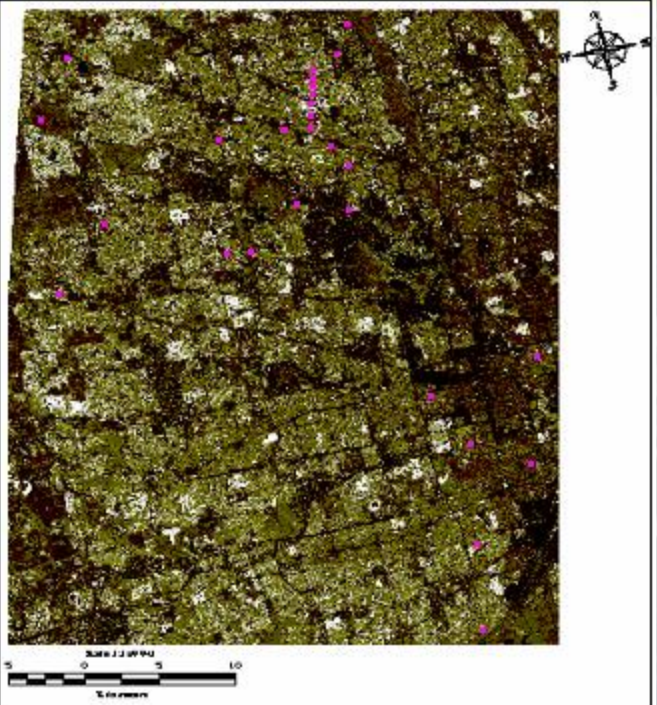
- Enhanced infectious disease prediction
- Assist state/federal agencies w/ disease monitoring

Long-term

- Improved infectious disease surveillance
- Enhanced understanding of NASA remote sensing capabilities
- Relationships with public health community

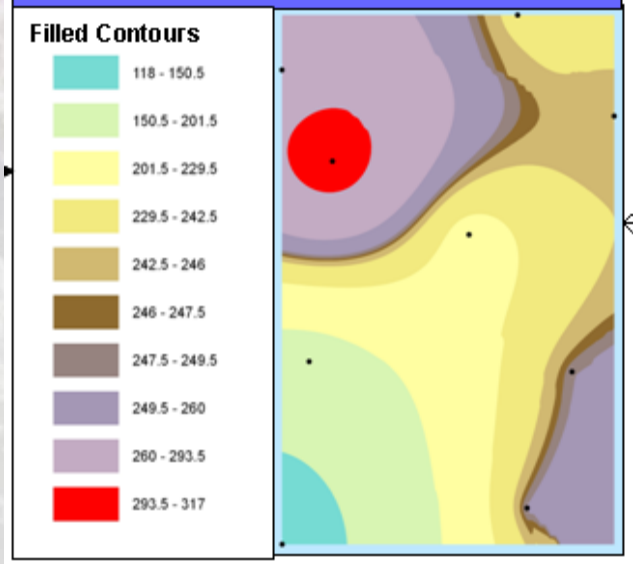
Results

NDVI Vegetation Index and Mosquito Points, April 2004

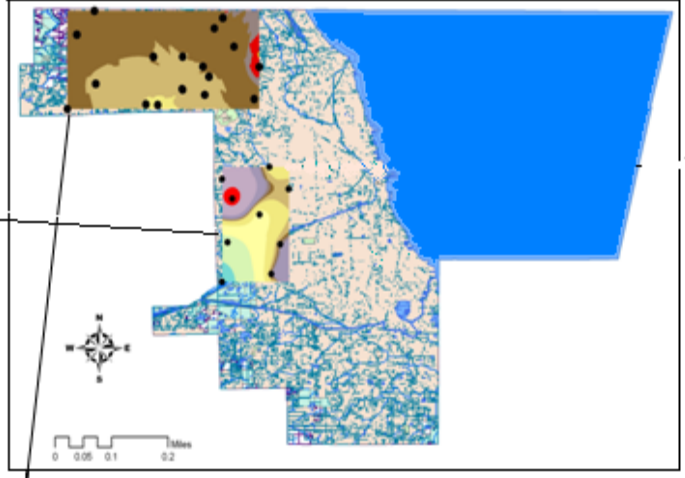


- NDVI = 0.24 – 0.58 Mixed / Light vegetation
- NDVI = 0 – 0.24 Grass
- NDVI = - 0.15 – 0.1 Bare soil / Urban areas
- NDVI = - 0.3 – 0.15 Water areas
- Mosquito data

Predictive Model: DesPlaines Valley MAD, Ordinary Kriging



Location: DesPlaines Valley & Northwest Mosquito Abatement District (MAD), Cook County, IL



Predictive Model: Northwest MAD, Ordinary Kriging

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

NASA Marshall Space Flight Center– University of Alabama at Birmingham (UAB)

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Kathryn Roa, M.D.
Shveta Setia, B.D.S.
Lili Xie, M.D.
Donna Burnett, Ph.D. (UAB Research Advisor)
Jeffrey C. Luvall, Ph.D. (Science Advisor)

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

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

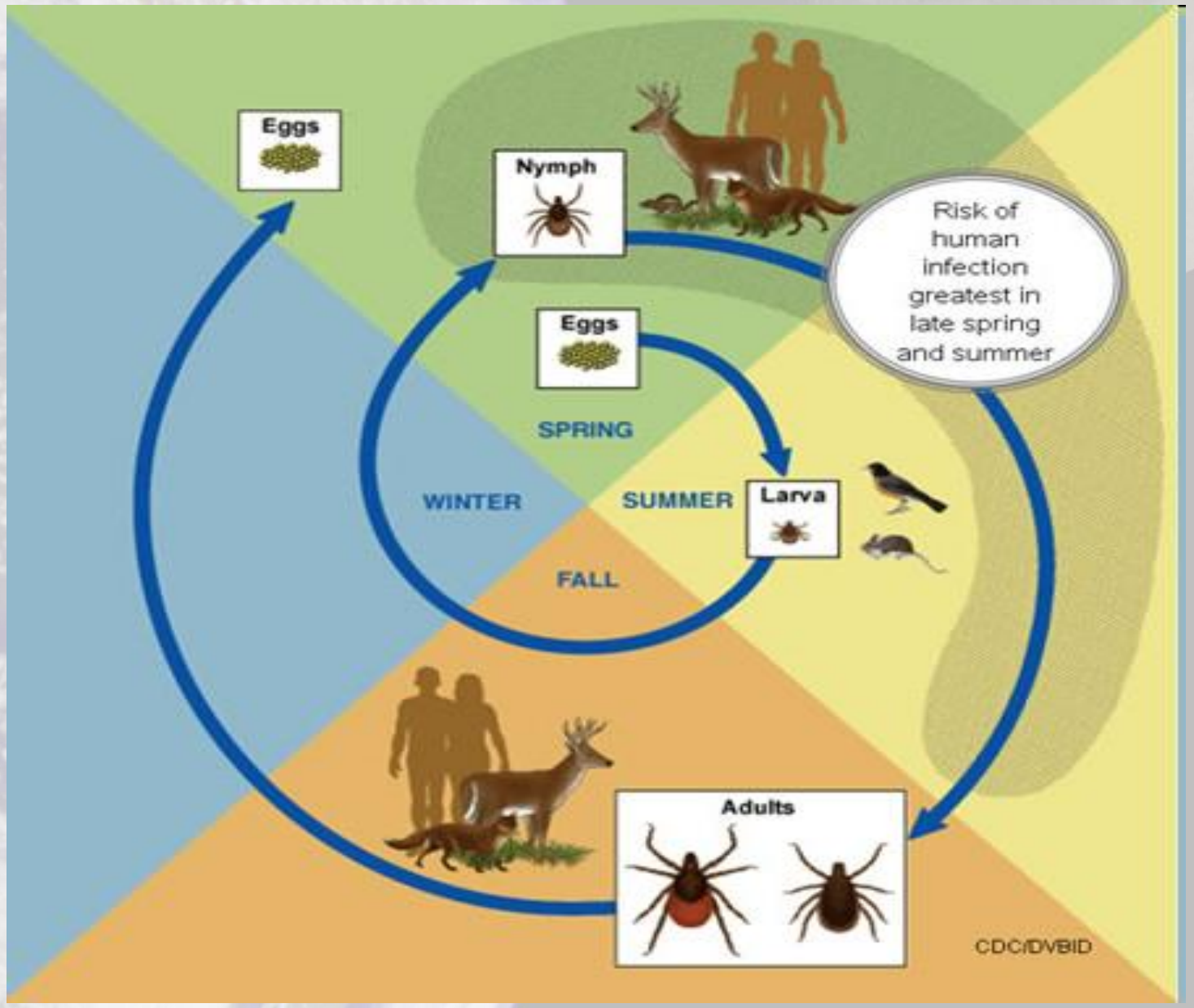
↓

Nymph

↓

Adult

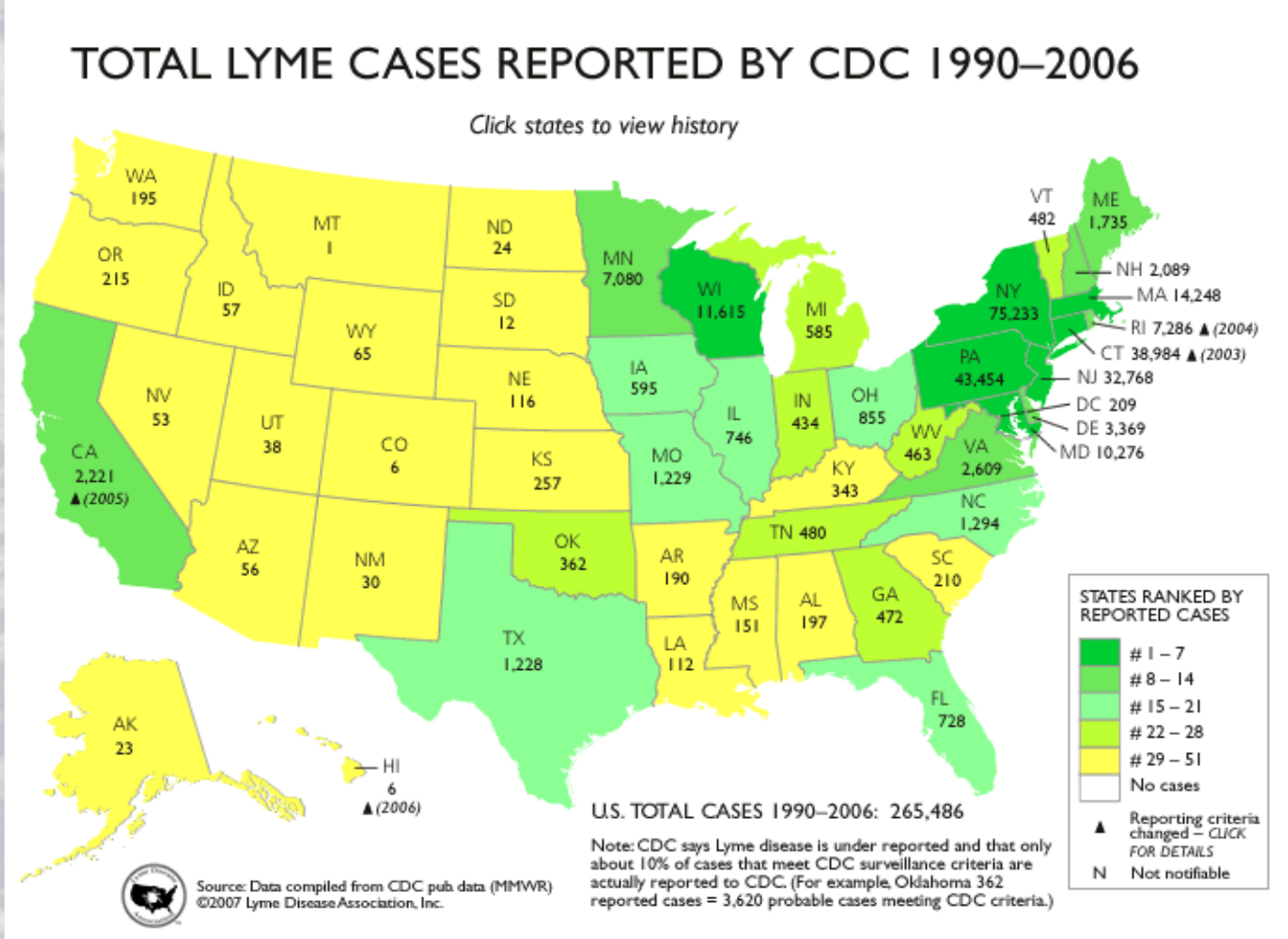
(2 years)



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



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

Project Goals

- 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

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

Remote Sensing Methods

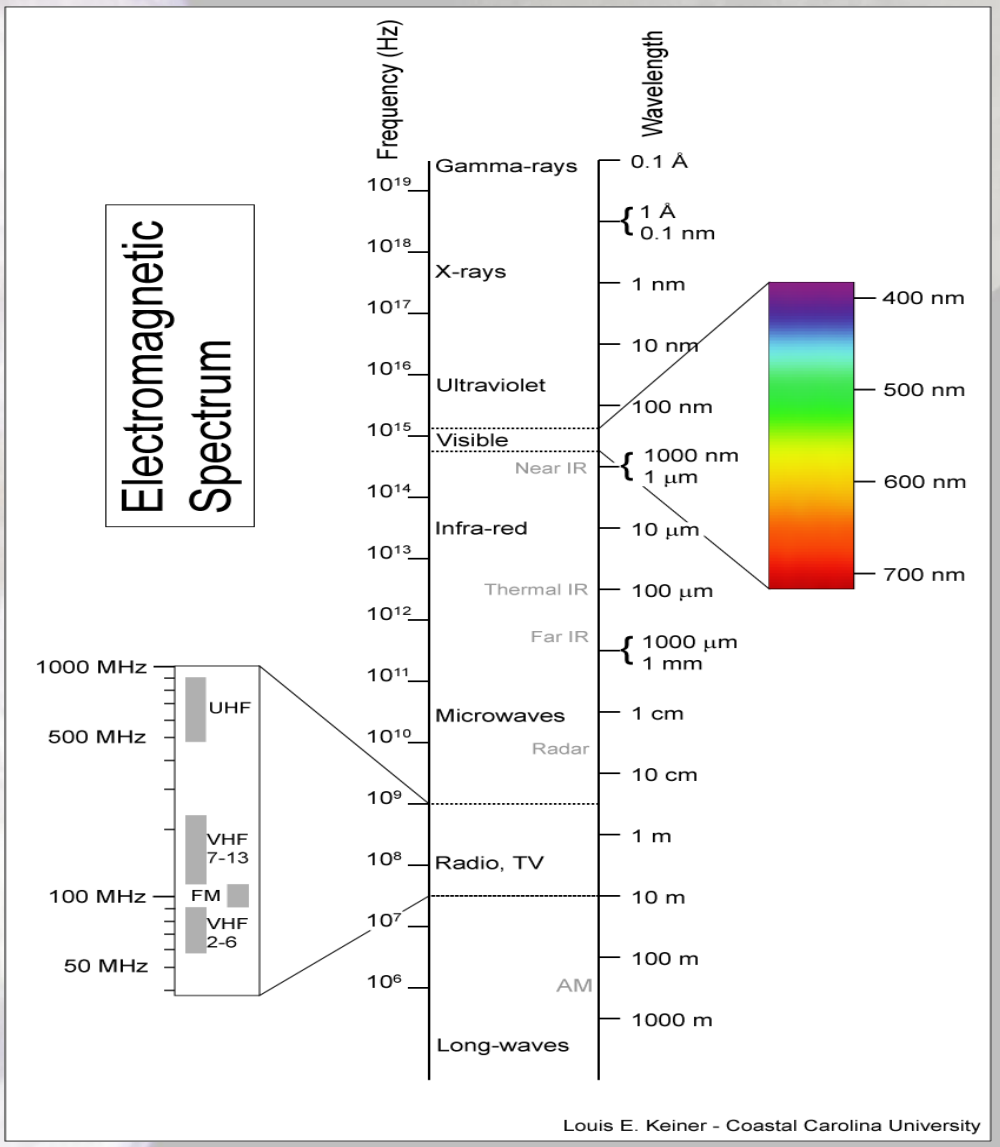
- Conducted literature review to identify environmental factors
- Analyzed Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and DigitalGlobe Quickbird satellite imagery from summer months
- Performed image analyses in ER Mapper 7.1

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

NDVI

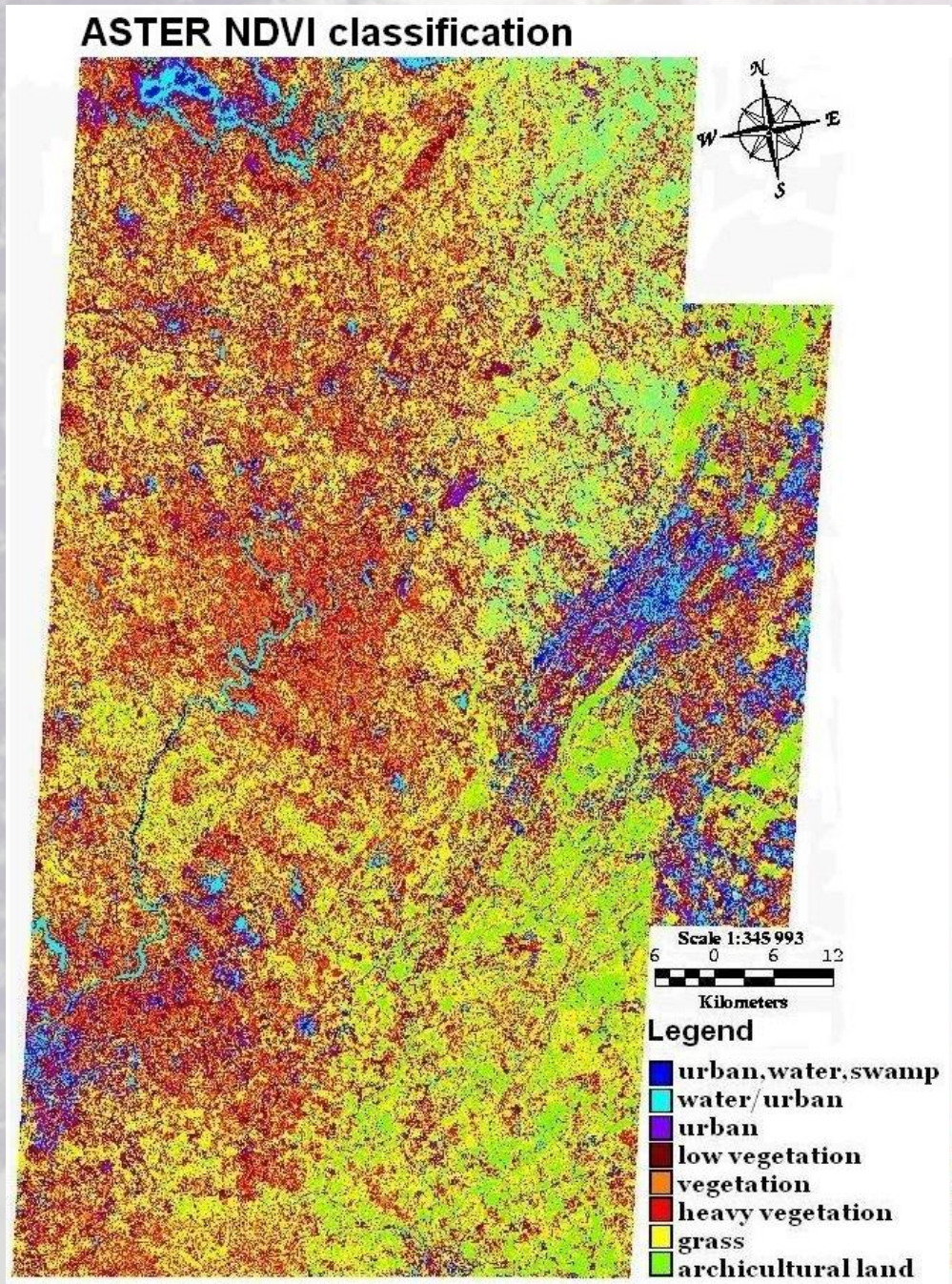
- Normalized Difference Vegetation Index (NDVI) algorithm was applied to all ASTER and Quickbird imagery
- Formula applies a ratio of the Near-Infrared and visible red bands to each pixel
- NDVI = NIR-RED/NIR+RED

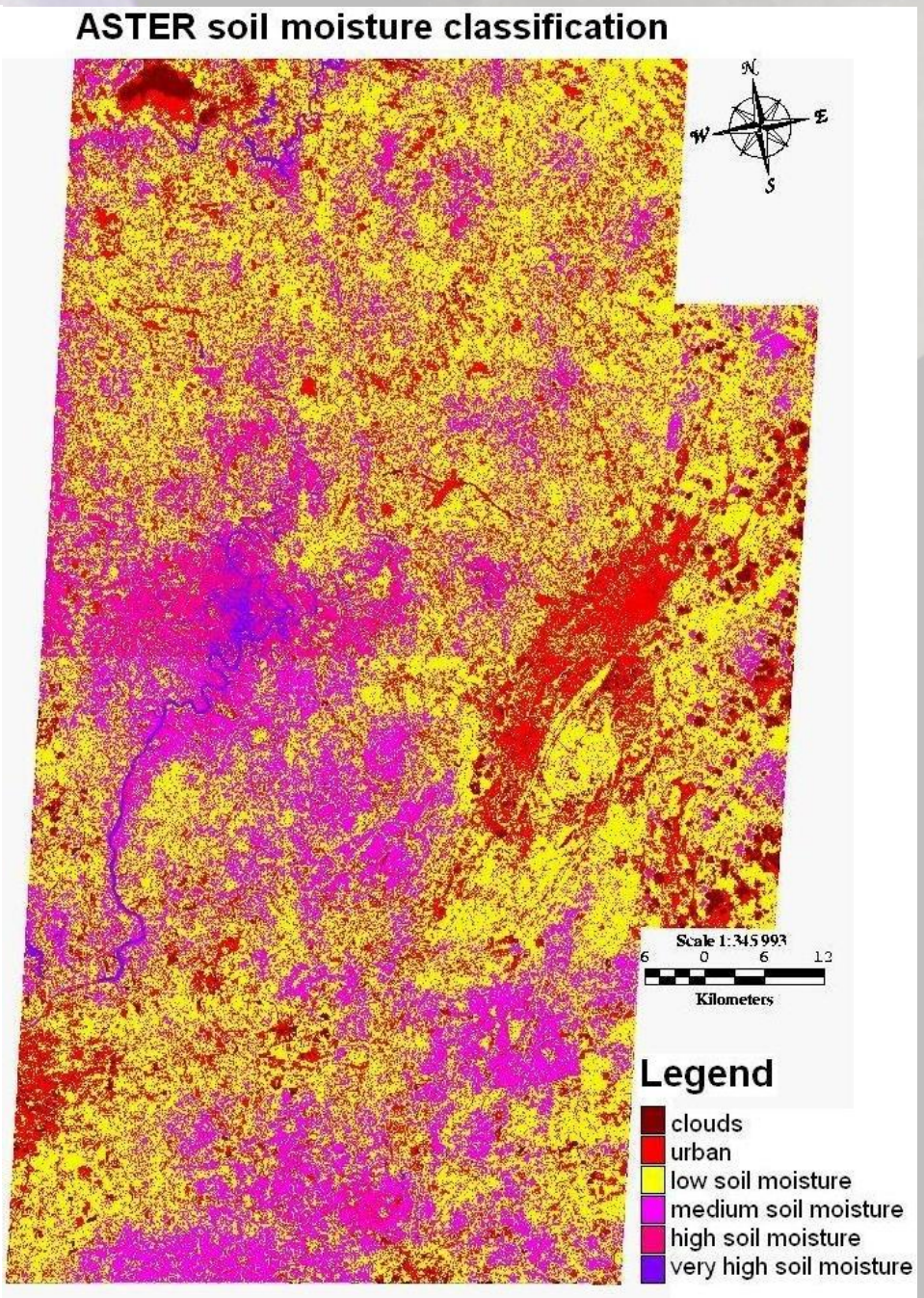


Soil Moisture

- 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

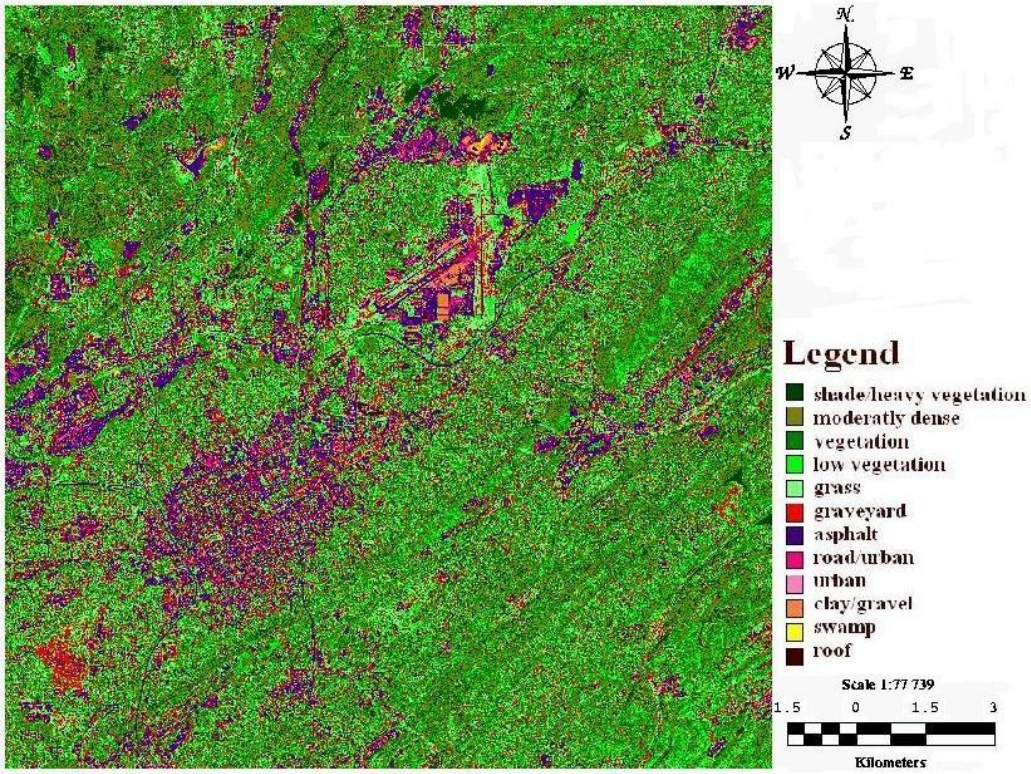
ASTER Vegetation and Soil Moisture Maps





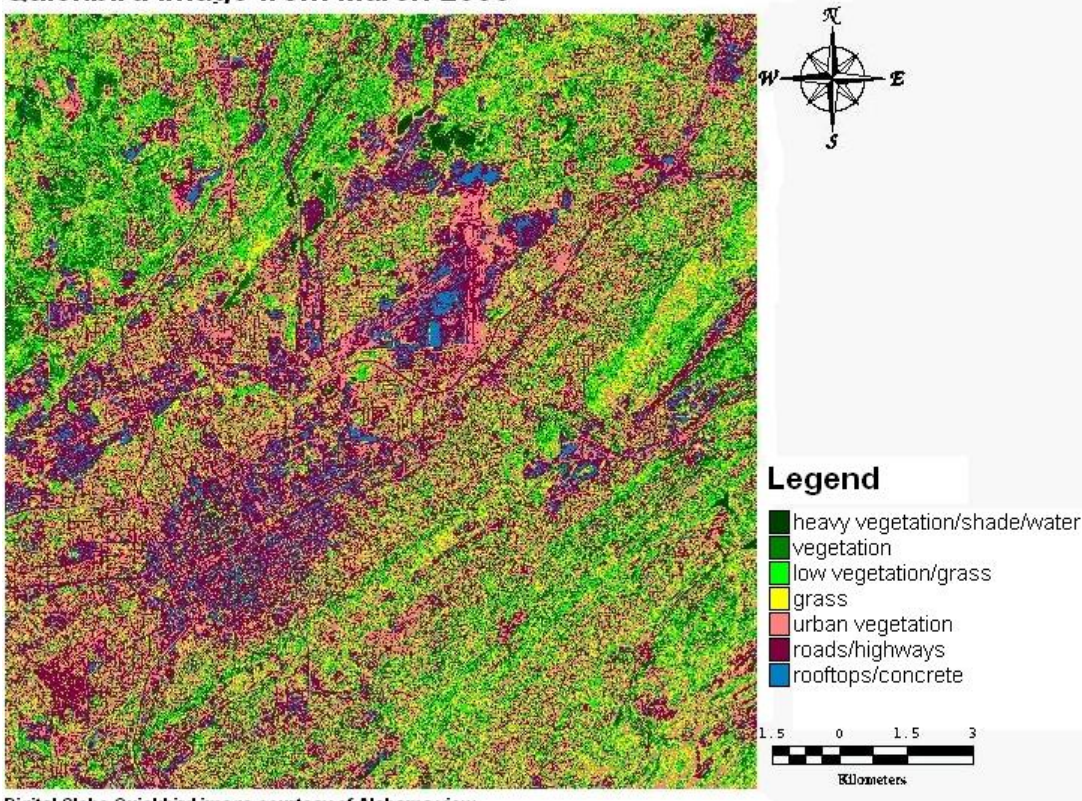
Quickbird Vegetation and Land Cover Maps

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

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

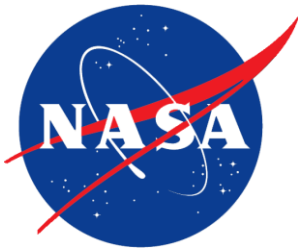
- Available tick data only represents the presence of ticks
- CDC case data does not indicate time of year or location of contraction
- STARI is often misdiagnosed as Lyme disease

Publications

- "University of Alabama at Birmingham students track Lyme disease to determine if cases underreported in Alabama." *Birmingham News paper.* August 13th 2009.
  - *Article also hosted on:*
    - www.al.com
    - www.medicalnewstoday.com
    - www.GISuser.com
    - www.gisdevelopment.net
    - www.newswise.com
    - www.educationgis.com
    - www.topix.com
- "Students Use Satellite Imagery To Track Lyme Disease-Carrying Ticks." *Space News. Volume 20 (issue 34).*
- Invited to give plenary presentation at International Lyme and Associated Diseases Society annual Lyme Disease conference in Washington D.C.

Future Research

- Analyze ASTER imagery to identify likely tick habitats statewide
- Possibly use Quickbird imagery to produce a more detailed vegetation representation
- Identify behaviors, beliefs and attitudes of people participating in outdoor activities in Alabama.
- Identify other significant factors for tick populations


NASA