American Public Health Association (APHA) 2010 Annual Meeting
Nov 6-10, 2010, Denver, CO

Presenter (Oral Presentation):
Sarah N. Hemmings

Authors:
Sarah Hemmings[1], Nathan Renneboog[1], Stephen Firsing[2], Emily Capilouto[1], Joshua Harden[1], Robyn Hyden[1], Meghan Tipre[1], Yan Zhang[1], **Jeffrey Luvall**[3]. (1) NASA DEVELOP Program, Laboratory for Global Health Observation, University of Alabama at Birmingham School of Public Health, 912 Building 169, 1530 3rd Ave. South, Birmingham, AL 35294-1200. (2) Dept of Human Studies, College of Arts and Sciences, Univ of Alabama at Birmingham, Room EB 233, 1530 3rd Ave So, Center for Educational Accountability, Birmingham, AL 35294-1250. (3) VP61, NASA Marshall Space Flight Center, 320 Sparkman Dr NW, Huntsville, AL 35805-1912.

Session:
NASA session titled: Using Remote Sensing for the Study of the Environment and Possible Associations with Disease Occurrence

Title:
Reducing tick-borne disease in Alabama: Linking health risk perception with spatial analysis using the NASA Earth Observing System

Abstract
Lyme disease (LD) accounts for most vector-borne disease reports in the U.S., and although its existence in Alabama remains controversial, other tick-borne illnesses (TBI) such as Southern Tick-Associated Rash Illness (STARI) pose a health concern in the state. Phase One of the Marshall Space Flight Center-UAB DEVELOP study of TBI identified the presence of the chain of infection for LD (*Ixodes scapularis* ticks carrying *Borrelia burgdorferi* bacteria) and STARI (*Amblyomma americanum* ticks and an as-yet-unconfirmed agent) in Alabama. Both LD and STARI are associated with the development of *erythema migrans* rashes around an infected tick bite, and while treatable with oral antibiotics, a review of educational resources available to state residents revealed low levels of prevention information.

To improve prevention, recognition, and treatment of TBI in Alabama, Phase Two builds a health communication campaign based on vector habitat mapping and risk perception assessment. NASA Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite imagery identified likely tick habitats using remotely sensed measurements of vegetation vigor (Normalized Difference Vegetation Index) and soil moisture. Likely tick habitats, identified as those containing both high vegetation density and soil moisture, included Oak Mountain State Park, Bankhead National Forest, and Talladega National Forest. To target a high-risk group — outdoor recreation program participants at Alabama universities — the study developed a behavior survey instrument based on existing studies of LD risk factors and theoretical constructs from the Social Ecological Model and Health Belief Model. The survey instrument was amended to include geographic variables in the assessment of TBI knowledge, attitudes, and prevention behaviors, and the vector habitat model will be expanded to incorporate additional environmental variables and *in situ* data. Remotely sensed environmental data combined with risk perception assessments inform an ongoing outreach campaign consisting of stakeholder meetings and educational seminars.

APHA 2010 Annual Meeting, Nov 2010, Denver, CO
Proposed submission on 2/4/10 by UAB-MSFC DEVELOP Fall 2009 Team

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Title:
Reducing tick-borne disease in Alabama: Linking health risk perception with spatial analysis using the NASA Earth Observing System

Learning Objectives
1) Describe the use of remotely sensed NASA Earth Science Data for projects related to human health.
2) Discuss the benefits of using remote sensing in the prediction and mitigation of diseases.
3) Discuss the combination of health behavior data with vector habitat mapping to inform a health communication campaign.

Abstract (max. 300 words; 5 sections):
Background
Lyme disease (LD) accounts for most vector-borne disease reports in the U.S., and although its existence in Alabama remains controversial, other tick-borne illnesses (TBI) such as Southern Tick-Associated Rash Illness (STARI) pose a health concern in the state. Phase One of the Marshall Space Flight Center-UAB DEVELOP study of TBI identified the presence of the chain of infection for both LD (*Ixodes scapularis* ticks carrying *Borrelia burgdorferi* bacteria) and STARI (*Amblyomma americanum* ticks and an as-yet-unidentified agent) in Alabama.

Objective/Purpose
Both LD and STARI are associated with the development of *erythema migrans* rashes around an infected tick bite, and while treatable with oral antibiotics, a review of educational resources available to state residents revealed low levels of prevention information. To improve prevention, recognition, and treatment of TBI in Alabama, Phase Two builds a health communication campaign based on vector habitat mapping and risk perception assessment.

Methods
NASA Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite imagery identified likely tick habitats based on remotely sensed measurements of vegetation vigor (Normalized Difference Vegetation Index) and soil moisture. To target a high-risk group —outdoor recreation program participants at Alabama universities—

the study developed a behavior survey instrument based on existing studies of LD risk factors and theoretical constructs from the Social Ecological Model and Health Belief Model.

Results

Likely tick habitats, identified as those containing both high vegetation density and soil moisture, included Oak Mountain State Park, Bankhead National Forest, and Talladega National Forest. The survey instrument was amended to include geographic variables in the assessment of TBI knowledge, attitudes, and prevention behaviors.

Discussion/Conclusions

Remotely sensed environmental data combined with risk perception assessments inform an ongoing outreach campaign consisting of stakeholder meetings and educational seminars. The vector habitat model will incorporate additional environmental variables and *in situ* data.

Acknowledgments:
Sarah Parcak, PhD, Assistant Professor, UAB School of Social and Behavior Sciences; Director, Laboratory for Global Health Observation
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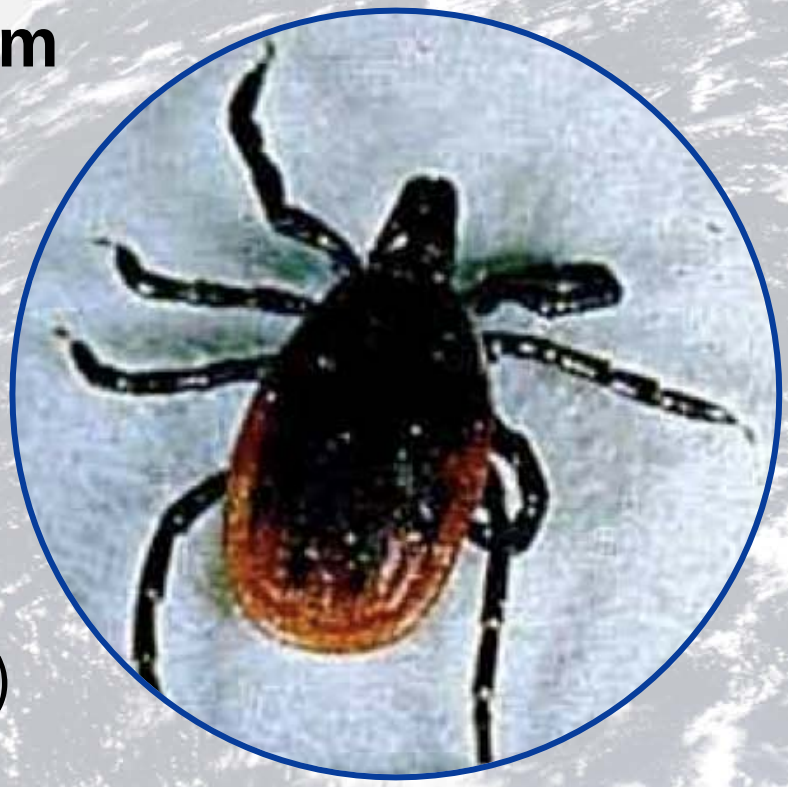
Karen Allsbrook, DEVELOP Financial Manager, Science Systems and Applications, Inc., NASA Langley Research Center
Tracey Silcox, DEVELOP National Program, NASA Langley Research Center
Kartikey Acharya, Resident at the University of Arkansas for Medical Sciences
DEVELOP Summer 2009 Team Members

Reducing tick-borne disease in Alabama: Linking health risk perception with spatial analysis using the NASA Earth Observing System

DEVELOP National Program at
NASA Marshall Space Flight Center &
University of Alabama at Birmingham

Sarah N. Hemmings, MS, MPH
Nathan Renneboog, BS
Stephen Firsing III, MPA, MA
Emily G. Capilouto
Joshua Harden
Robyn Hyden, BA
Meghan Tipre, BDS, MSPH
Zhang Yan
Jeffrey C. Luvall, Ph.D. (NASA Science Advisor)



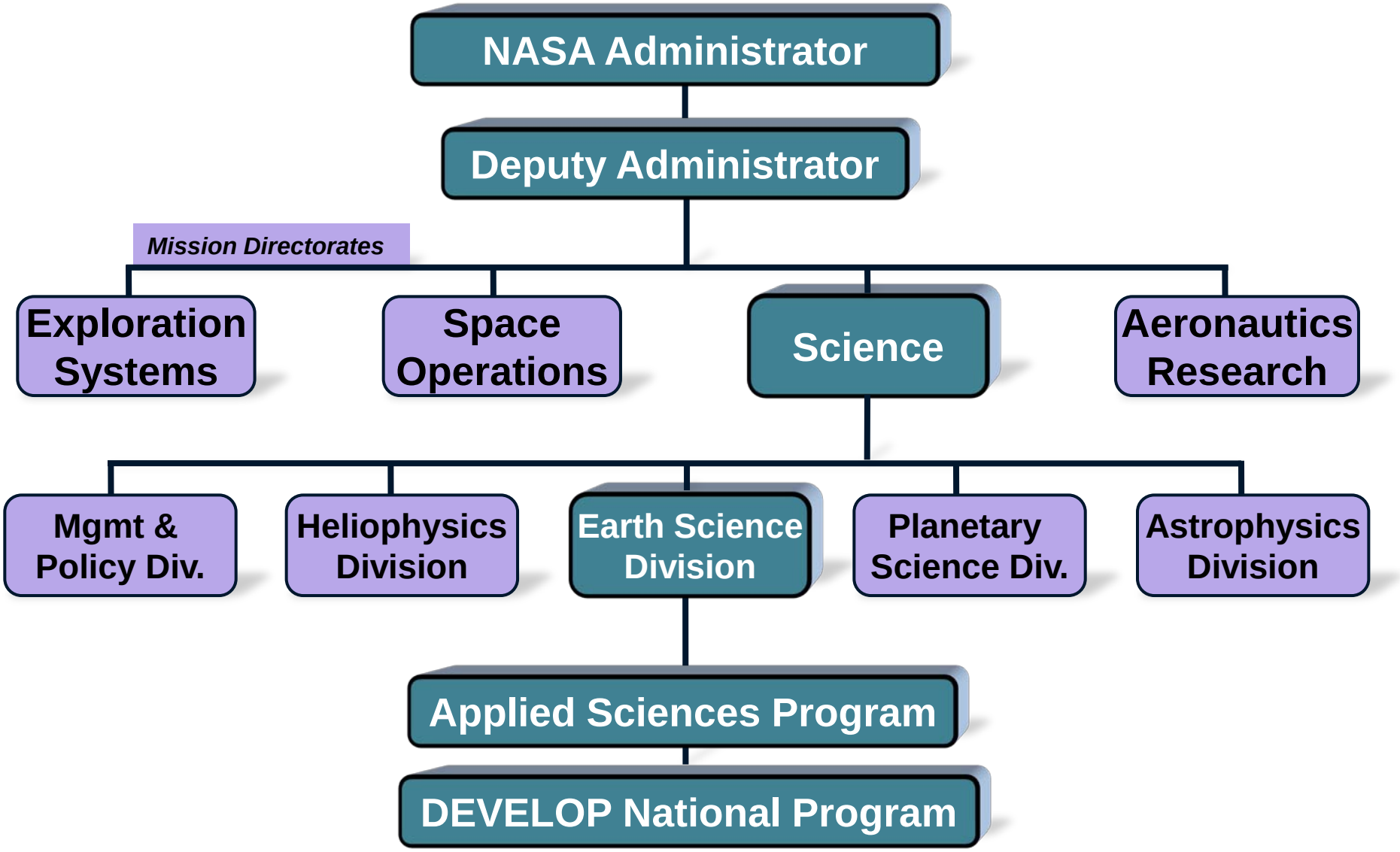
Presenter Disclosures

Sarah Hemmings

The following personal financial relationships with commercial interests relevant to this presentation existed during the past 12 months:

No relationships to disclose

NASA Organization



What is DEVELOP?

DEVELOP demonstrates applications of NASA technology

to science and community policy makers

to establish student projects,

supported by leveraged partnerships.

Projects address Applied Science Application Areas and

demonstrate how NASA information

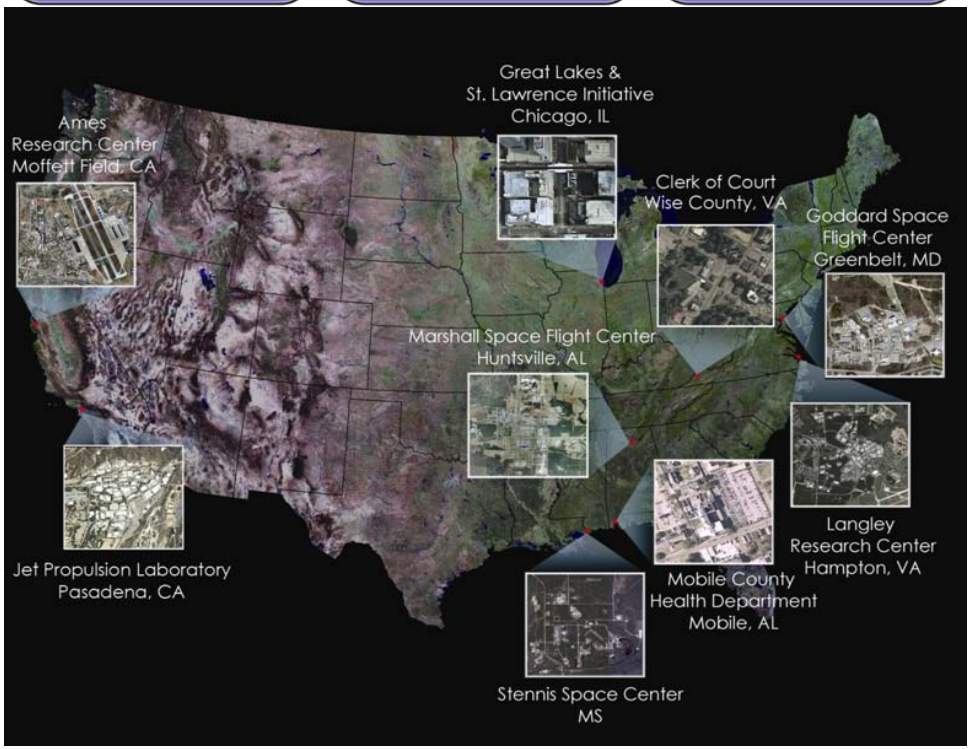
can enhance decision support and

generate demand for NASA science predictions.

DEVELOP Locations

NASA Applied Sciences Program – NASA Headquarters, Washington D.C.

Ames Research Center Moffett Field, CA	Goddard Space Flight Center Greenbelt, MD	Jet Propulsion Laboratory Pasadena, CA	Langley Research Center Hampton, VA	Marshall Space Flight Center / UAB Birmingham, AL	John C. Stennis Space Center Stennis, MS
Great Lakes & St. Lawrence Cities Initiative Chicago, IL	Mobile County Health Department Mobile, AL	Clerk of Court Office Wise County, VA			



Lyme Disease

Accounts for 95% of vector borne disease case reports in U.S.

- Bites from Blacklegged tick (*Ixodes scapularis)* can transmit *Borrelia burgdorferi* (spirochete) from tick gut
- 1993-2008: 300,000 CDC confirmed U.S. cases
- 2008: 29,000 cases

Lyme Disease Symptoms

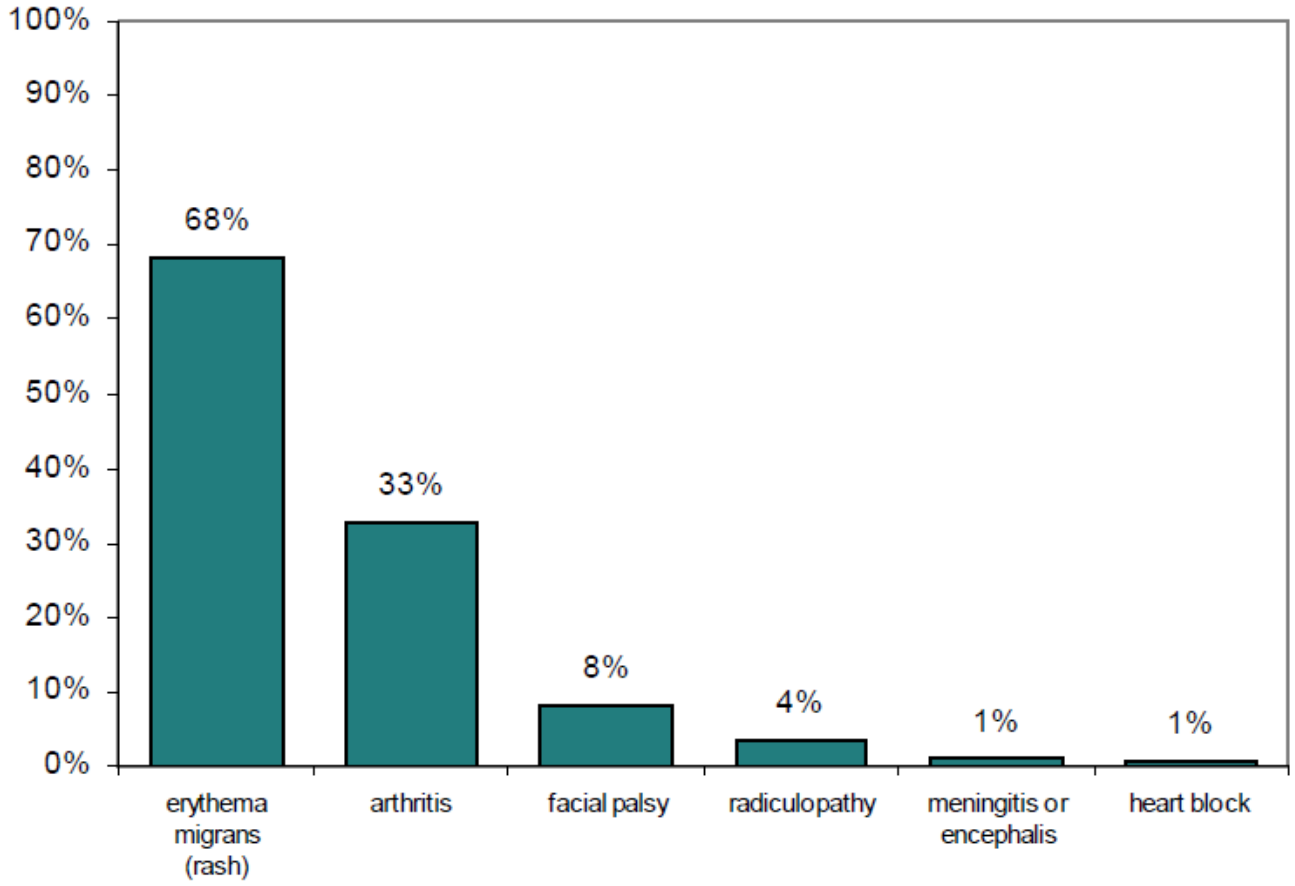
Acute:

- Erythema migrans
- Fever
- Fatigue
- Headache

Chronic:

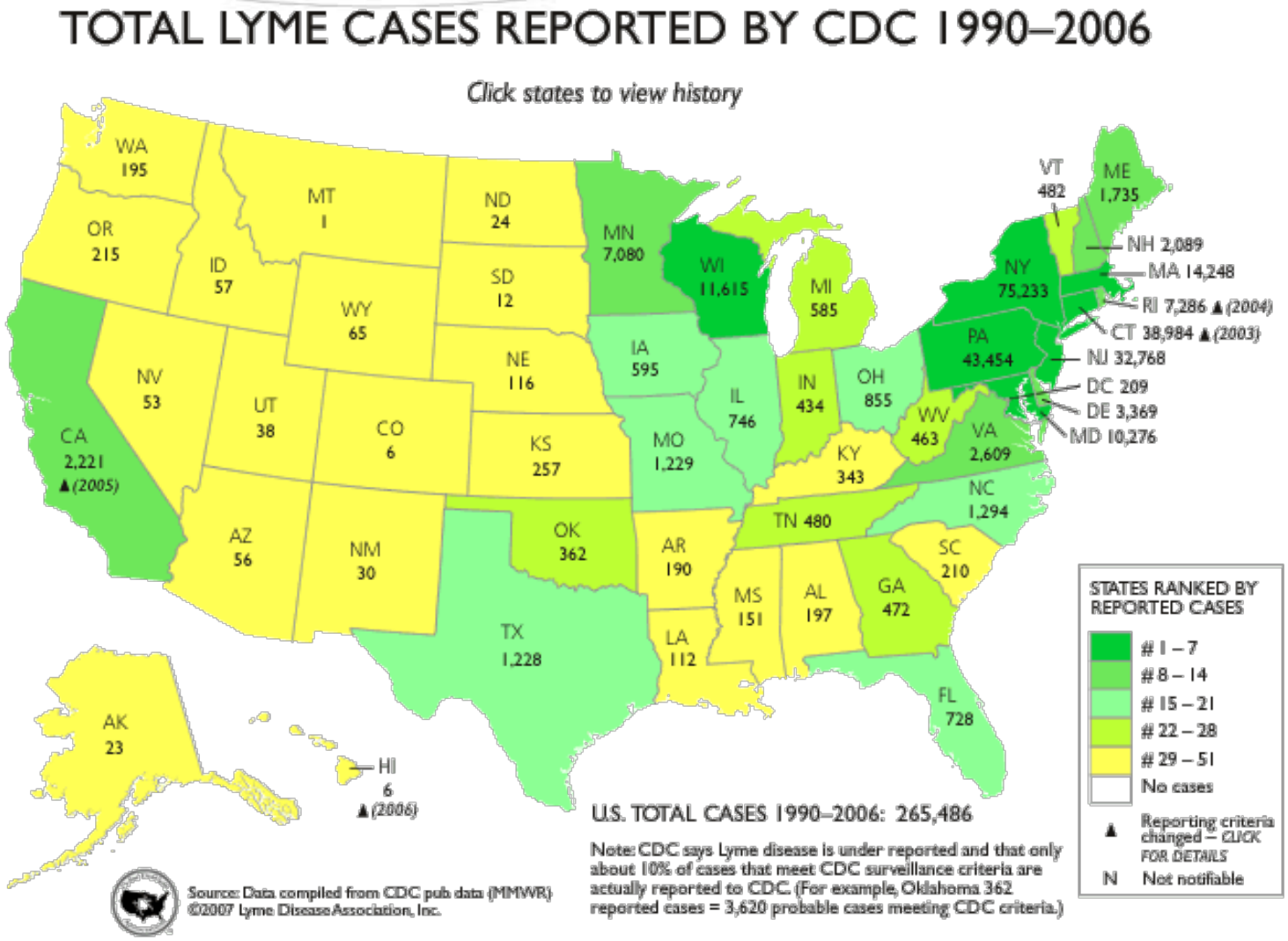
- Arthritis
- Neuro-cognitive difficulties
- Fatigue

Reported Clinical Findings for Lyme Disease Cases
United States, 1992-2004



Percent of clinical findings among 119,965 patients for whom at least one symptom was reported.

CDC Lyme Disease Cases

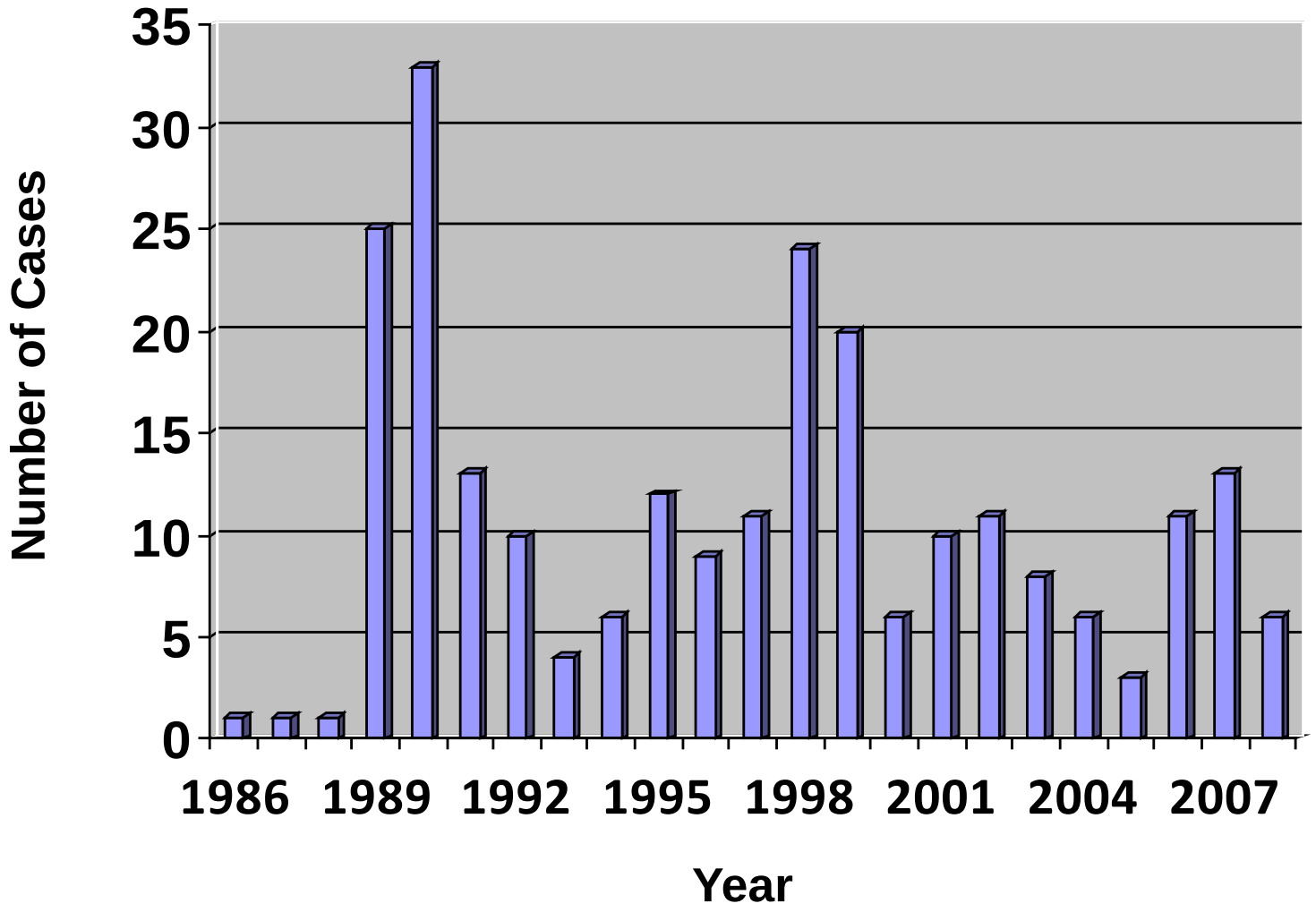


It has been suggested that underreporting issues may exist

(Young, 1998; Coyle et al., 1996; Meek et al., 1996)

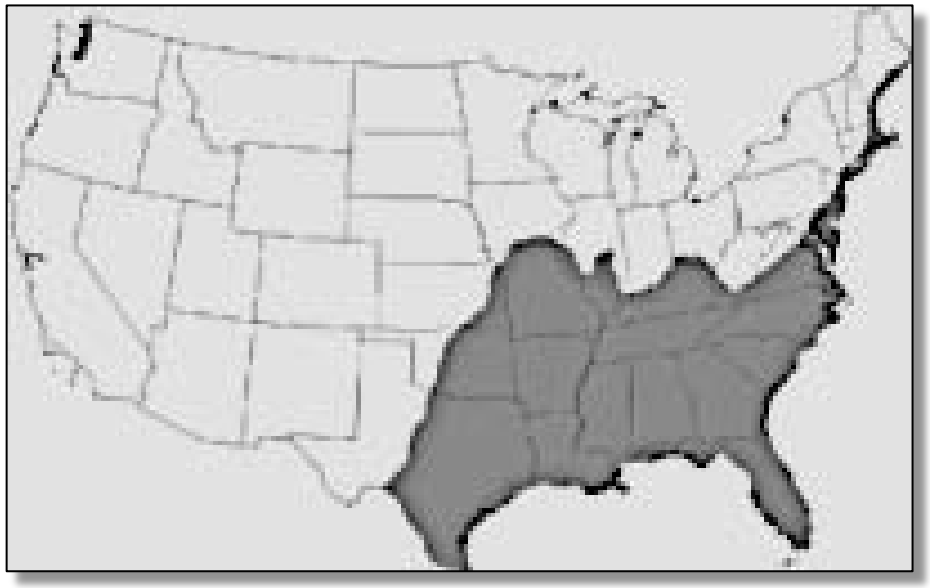
Lyme Disease in Alabama

Yearly Lyme disease cases in Alabama, 1986 to 2008 (CDC)



Southern Tick-Associated Rash Illness (STARI)

- Lone star tick (*Amblyomma americanum*)
- Most common in Southeast
- Produces “bulls eye” lesion
- Symptoms: fatigue, fever, headache, muscle and joint pains

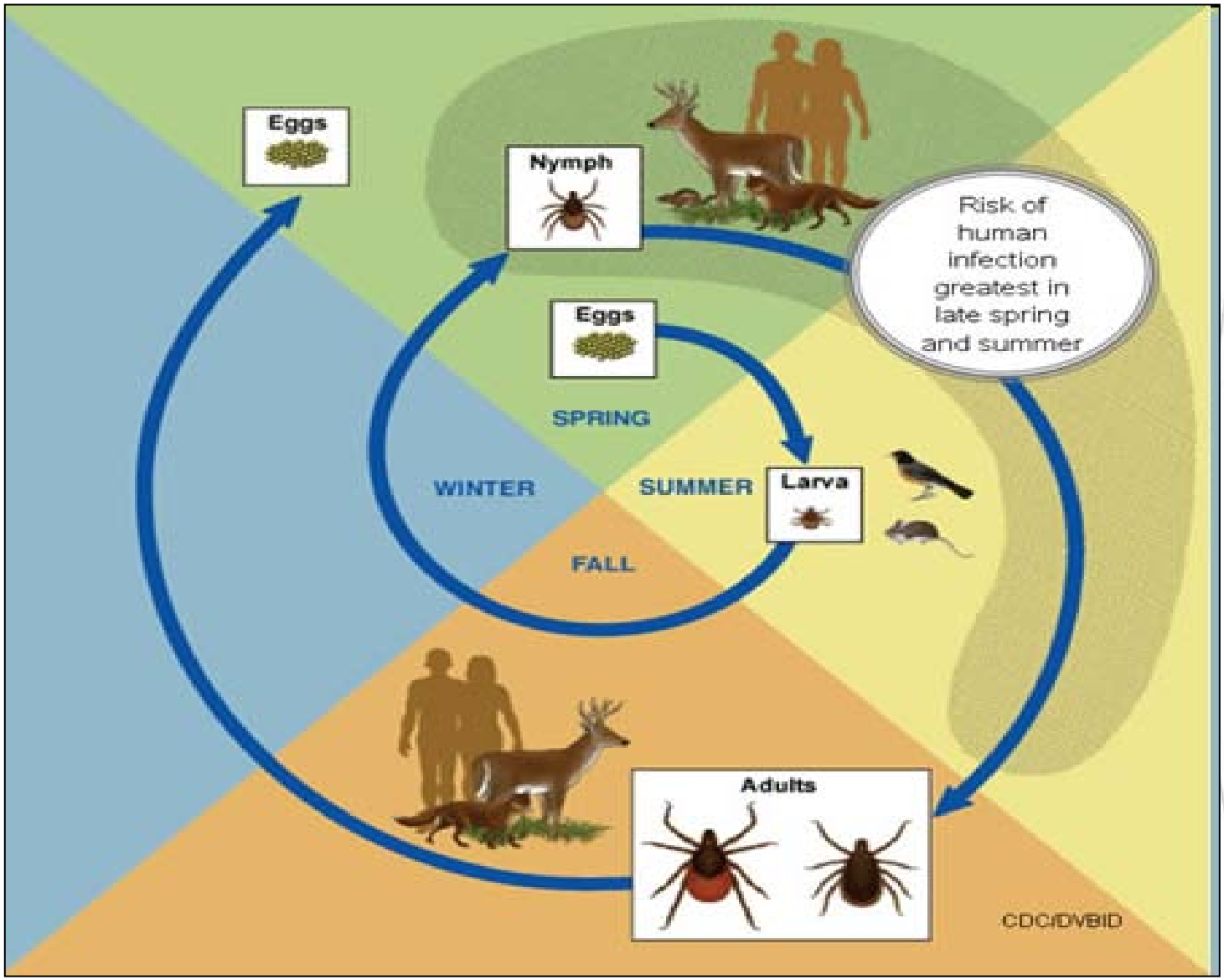


STARI presence in the US

Other Tick-Borne Diseases

Disease	Vector
Rocky Mountain Spotted Fever	*Dermacentor variabilis*
Babesiosis	*Ixodes scapularis*
Ehrlichiosis	*Amblyomma americanum*
Anaplasmosis	*Ixodes scapularis*
Tularemia	Several

Tick Life Cycle



Stages:

Egg

↓

Larva

↓

Nymph

↓

Adult

(2 years)

Tick Hosts

- Small mammals
  - Larval and nymphal stages
- Nymph stage more likely to cause LD due to small size
- White-tailed deer
  - Tick adult stage

30+ types of wild animals and birds

PHASE 1: Established Chain of Infection in Alabama

Lyme Disease

Causative agent:

- *Borrelia burgdorferi*
- Presence identified through literature review

Vector:

- *Ixodes scapularis*
- Presence identified through literature review

Vector hosts:

- Presence identified through literature review

STARI

Causative agent:

- Unconfirmed; under investigation

Vector:

- *Amblyomma americanum*
- Presence identified through literature review, tick drags

Vector hosts:

- Presence identified through literature review

CDC Prevention Info

CDC Lyme disease prevention webpage states:

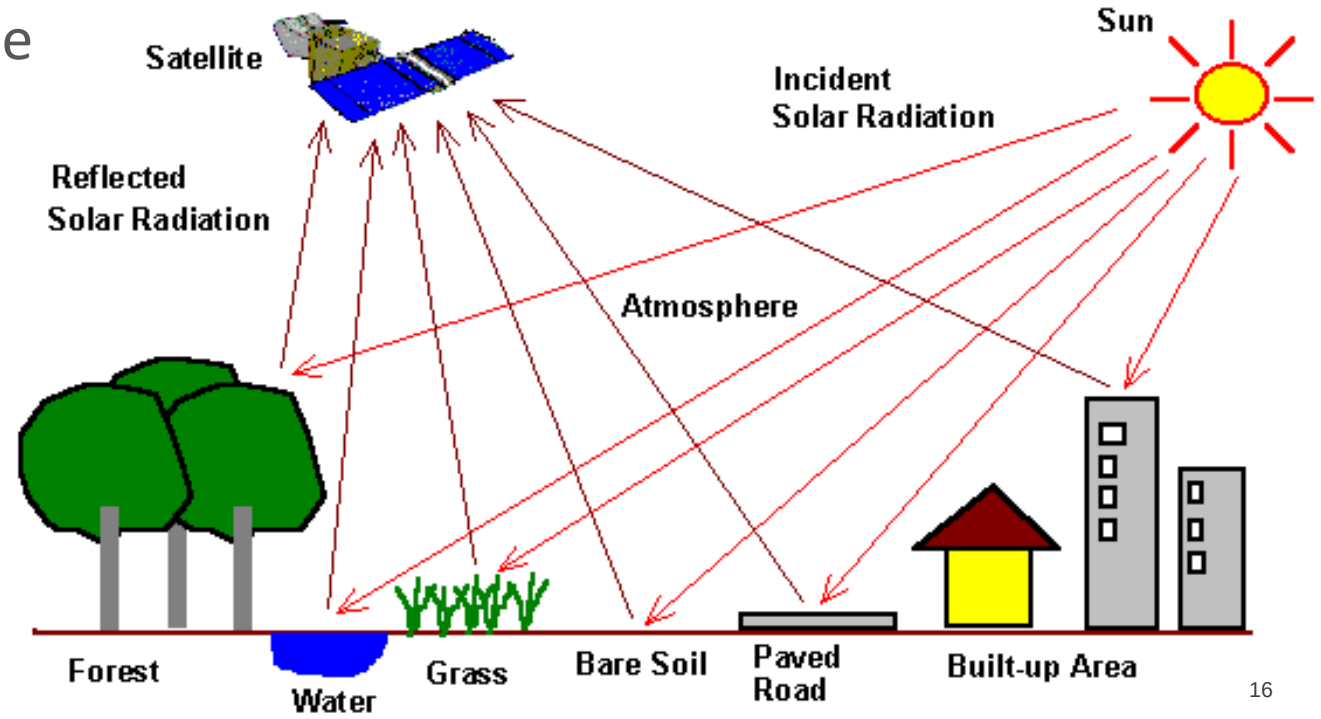
- "Ask your local health department and park or extension service about tick infested areas to avoid."
- However, NO local health department and park or extension service in the state of Alabama provide information about tick infested areas.

State of Alabama
Courtesy of Google Earth

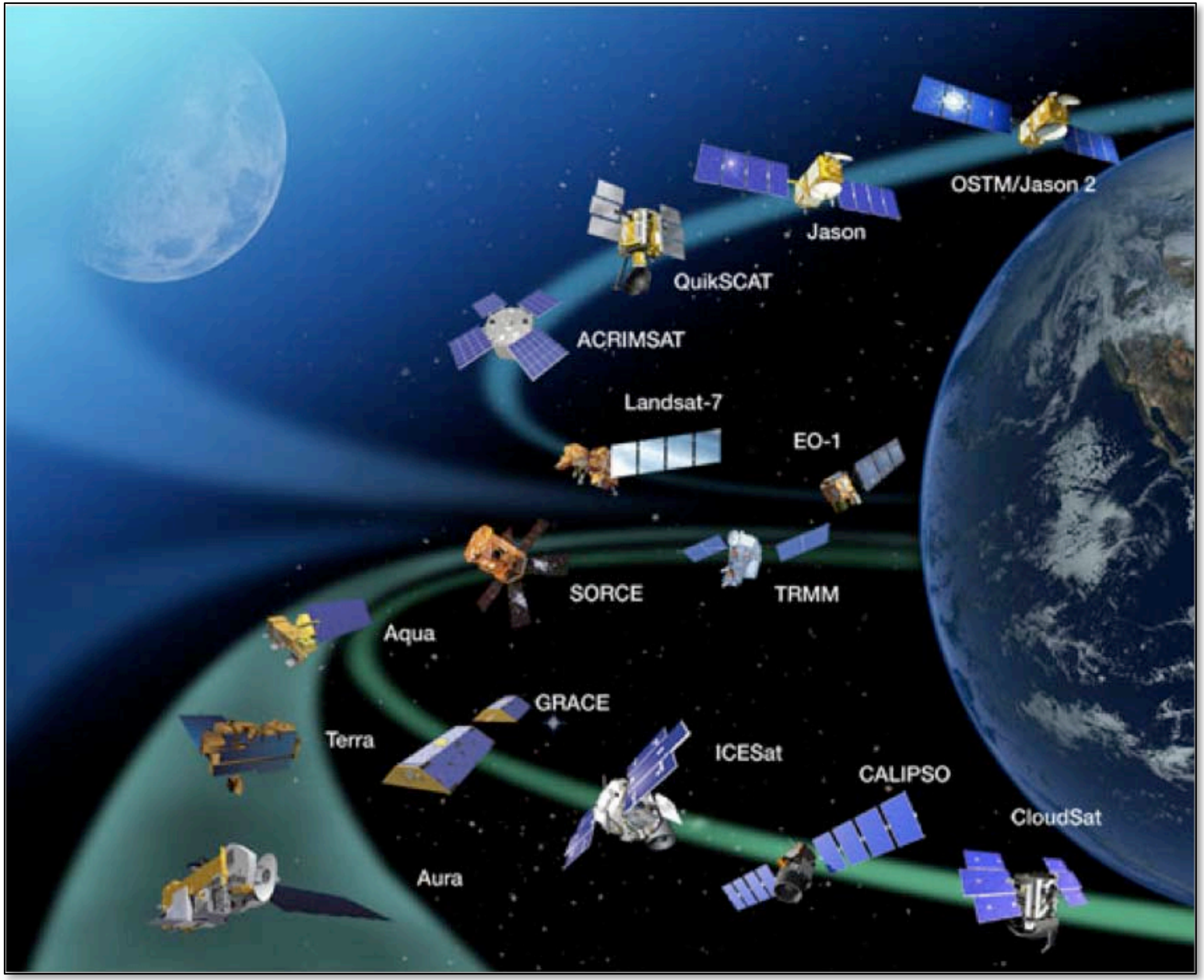
PHASE 1: Map Likely Vector Habitats to Inform a Primary Prevention Campaign

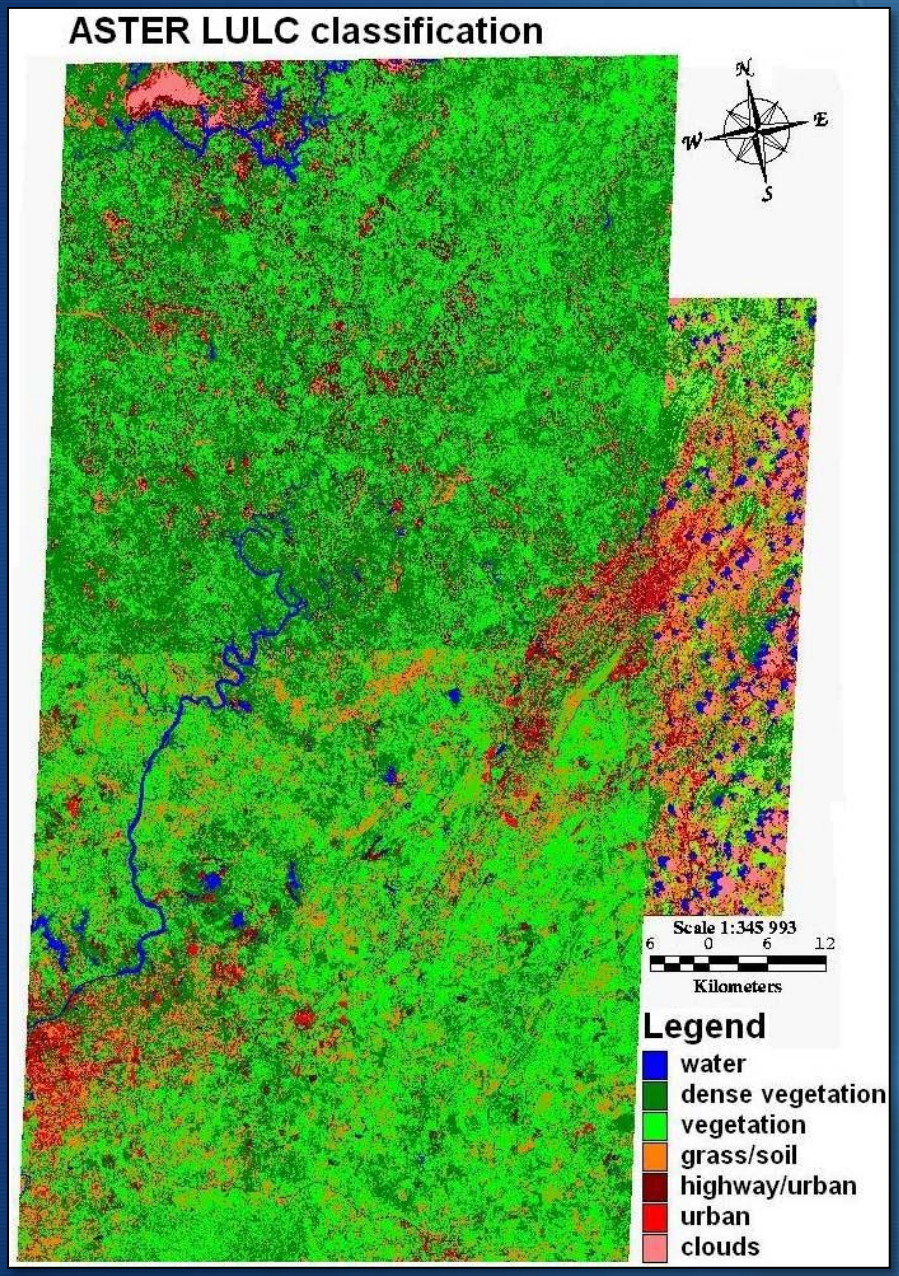
Remote Sensing

- Observing an object without touching it
- Emitted and reflected energy from earth in multiple parts of the electromagnetic spectrum
- Captured by aircraft and satellites



Satellite Imagery





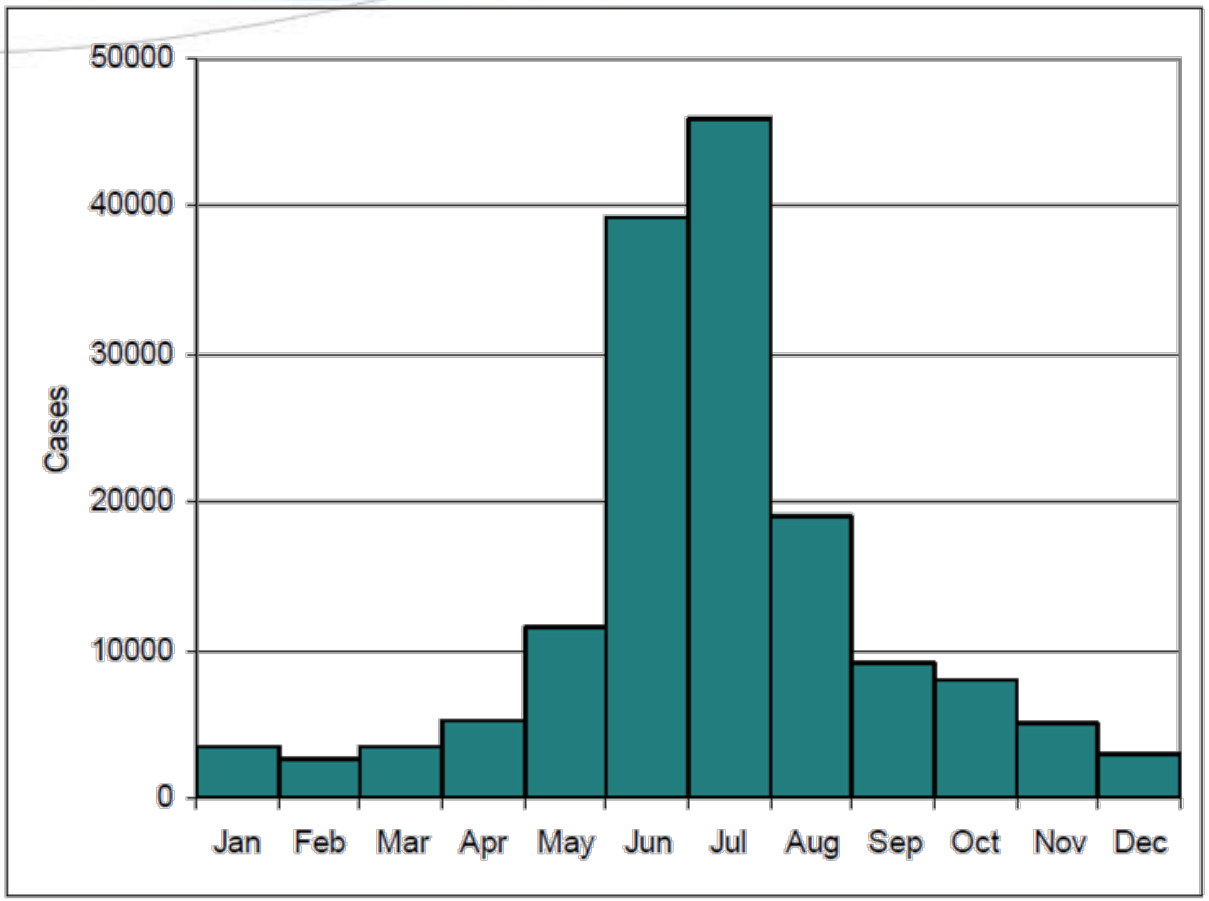
Satellite Imagery: ASTER

Advanced Spaceborne Thermal Emission and Reflection Radiometer

- 15 bands
- Visible (15m resolution)
- Near infrared (15m)
- Mid infrared (30m)
- Thermal infrared (90m)

Environmental Factors Related to Tick Habitats

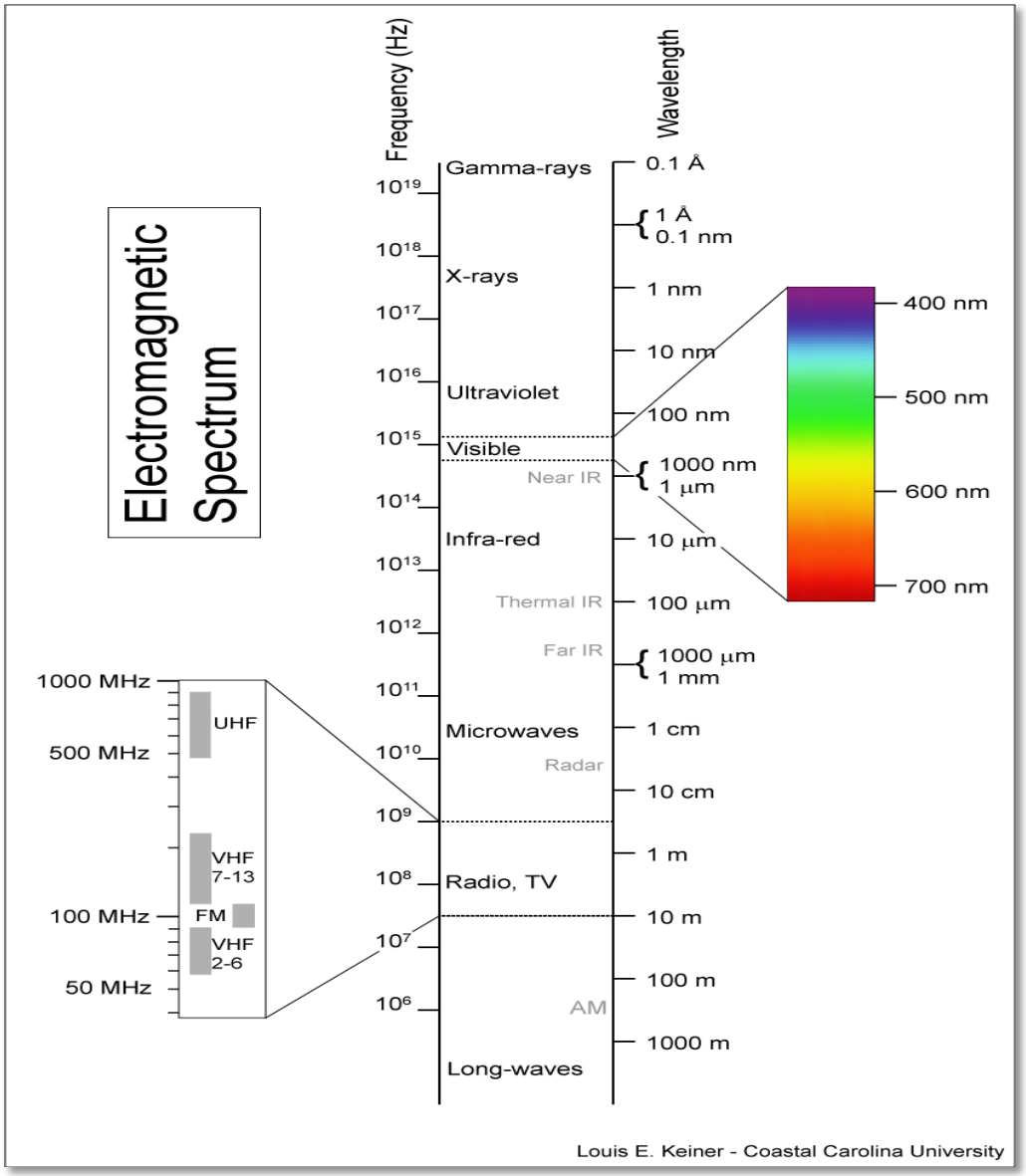
- Temperature: -10 to 35°C
- Vegetation: forest cover
- Soil characteristic: moist soil
- Landscape: edge effects



Reported Cases of Lyme by Month of Illness Onset, U.S., 1992-2004

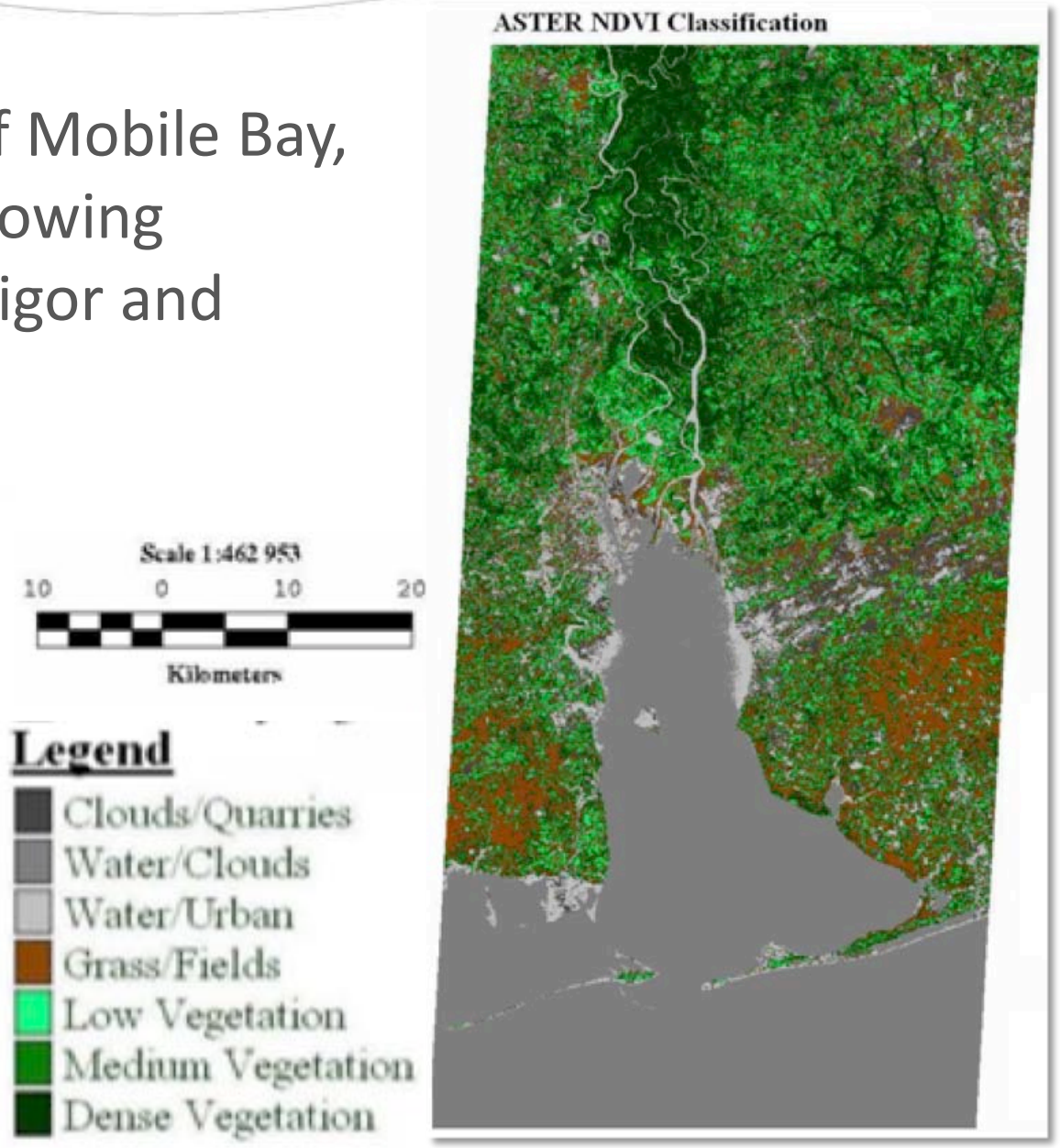
Vegetation: NDVI

- Normalized Difference Vegetation Index (NDVI) algorithm was applied to ASTER imagery
- Vegetation reflects and emits 20% of its energy in the visible light range
- 50% reflected in NIR
- NDVI = $\frac{\text{NIR-RED}}{\text{NIR+RED}}$



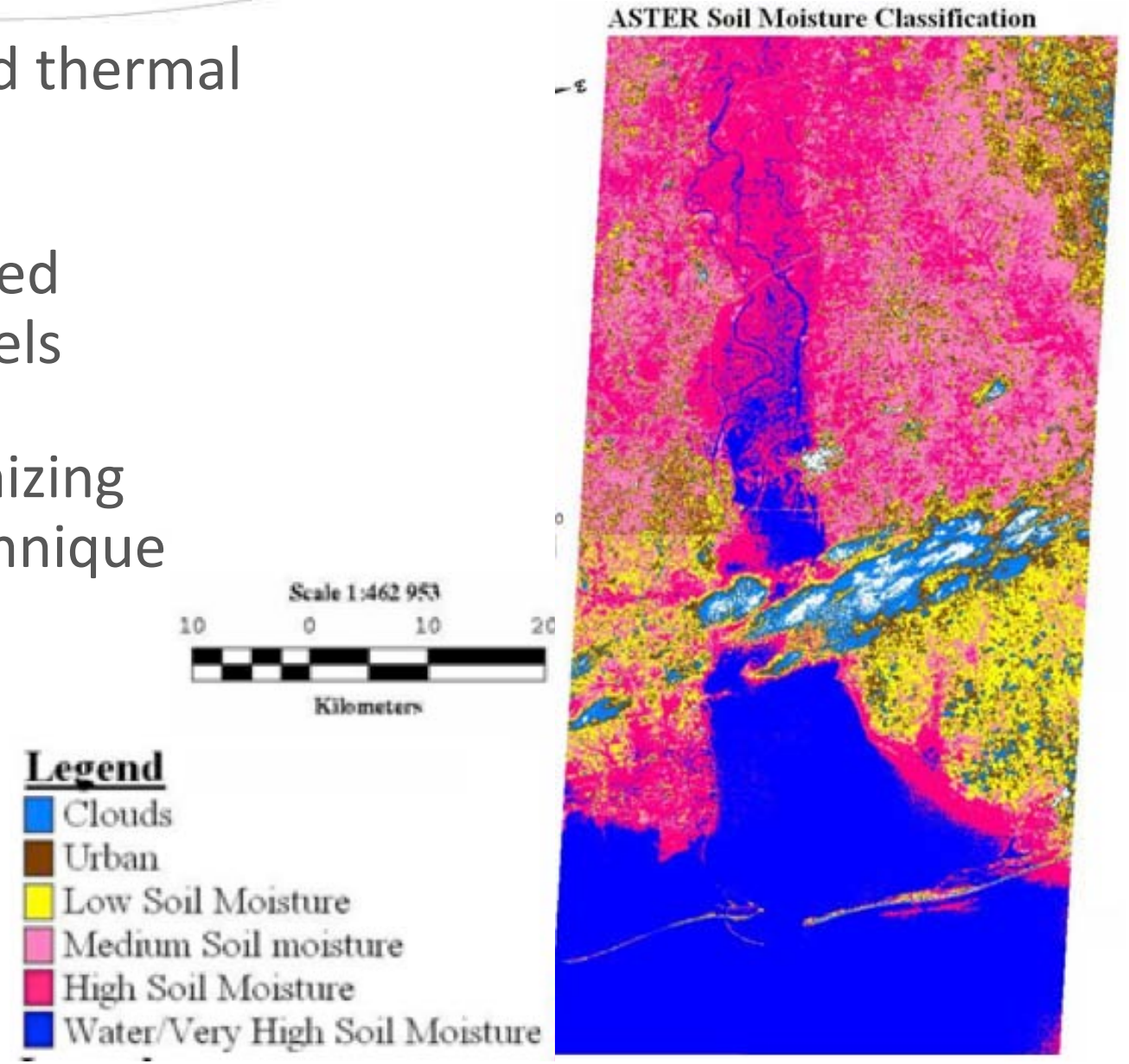
Vegetation: NDVI

- NDVI map of Mobile Bay, Alabama, showing vegetation vigor and types.

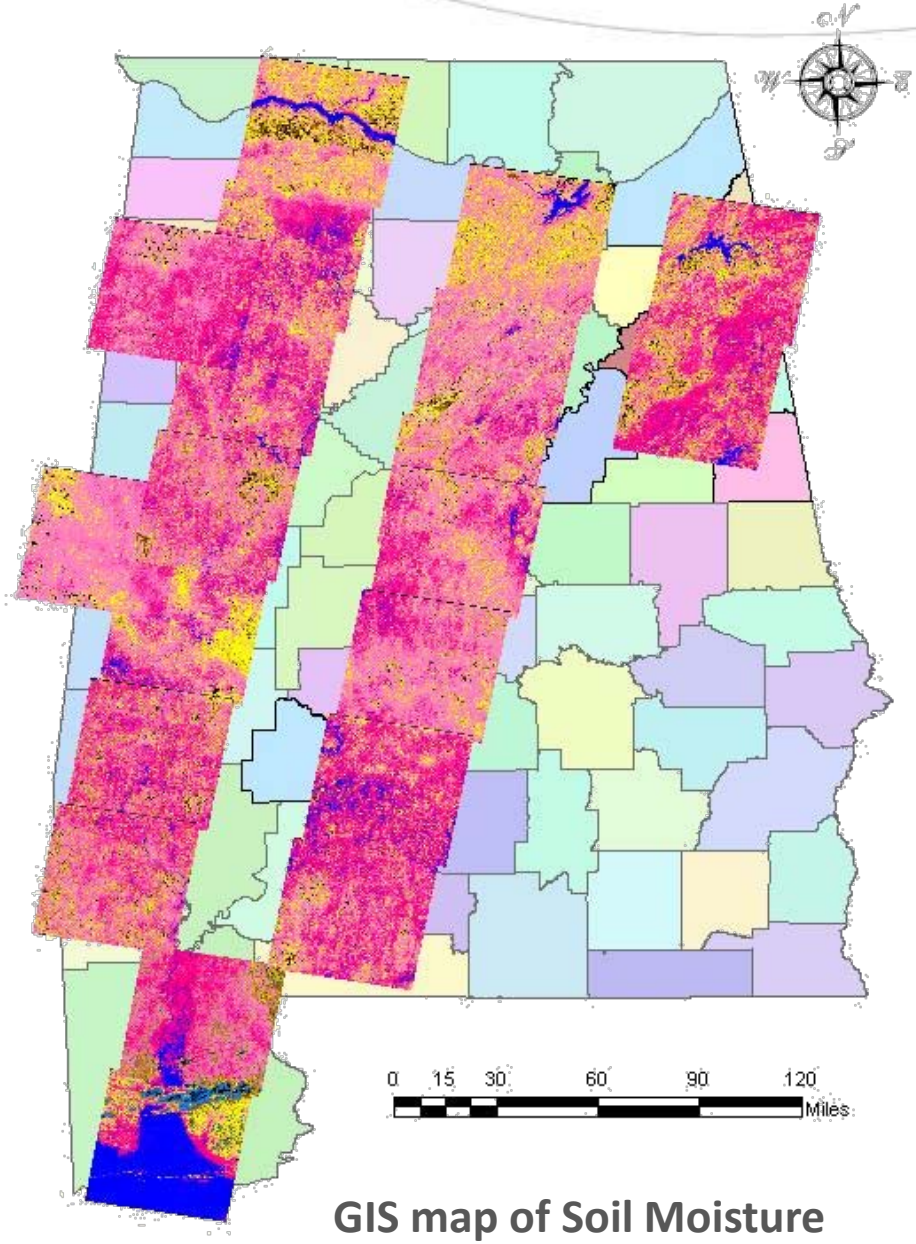


Soil Moisture & Classification

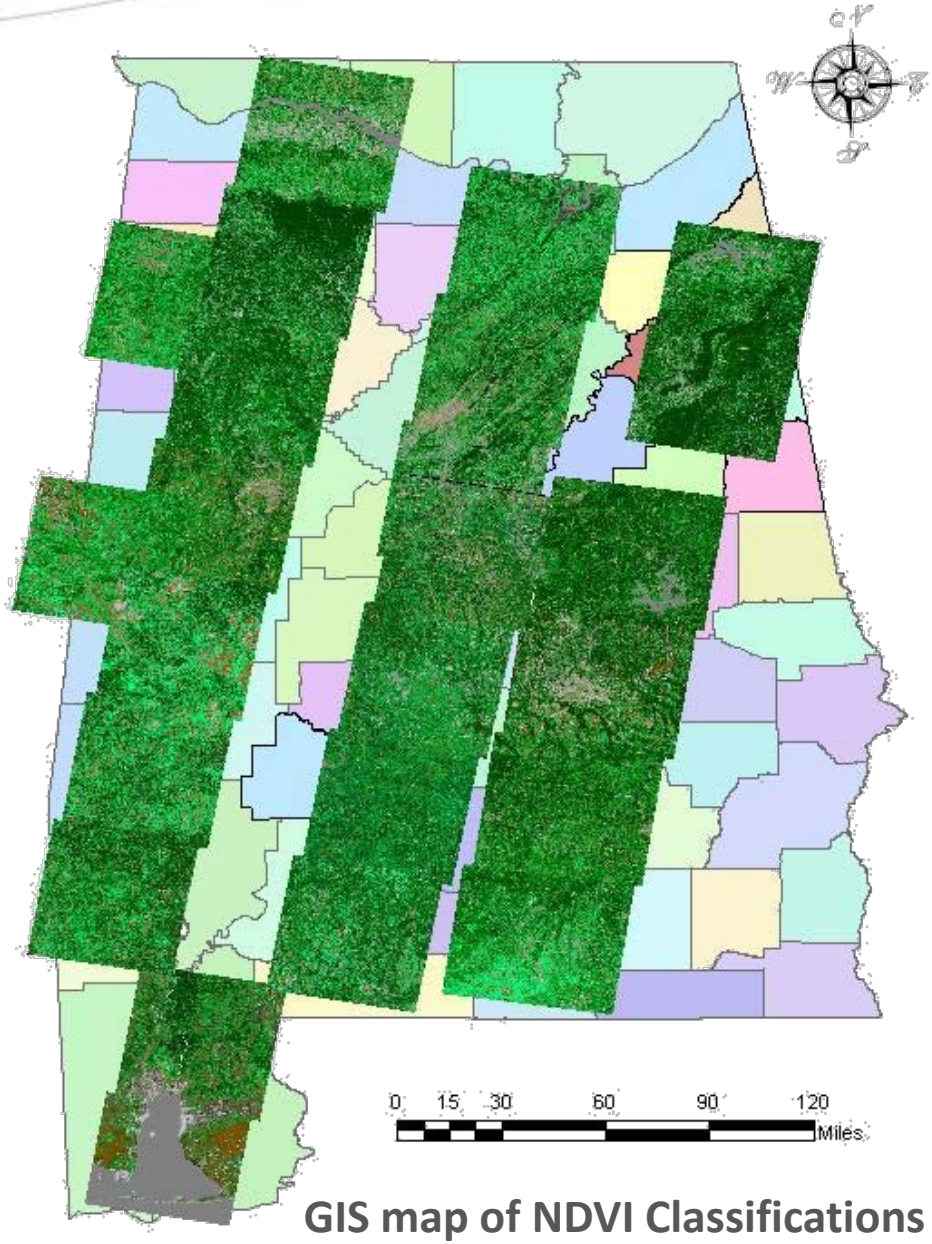
- Ratio of the mid and thermal infrared bands
- Image pixels classified by soil moisture levels
- Iterative Self- Organizing Data (ISODATA) Technique
- Groups pixels into similar “classes”
- Supervised or Unsupervised



Results



GIS map of Soil Moisture Classifications of ASTER for Alabama

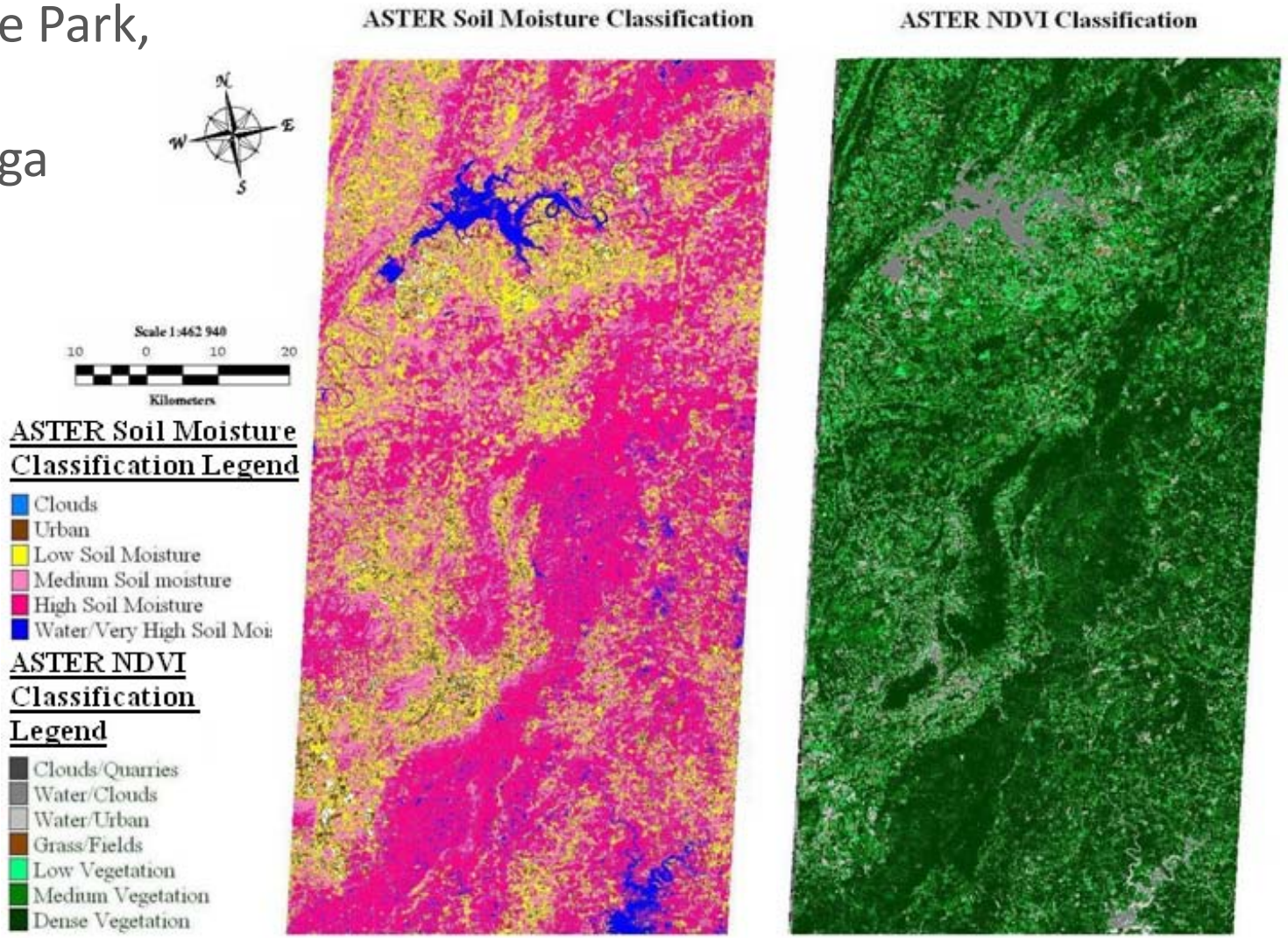


GIS map of NDVI Classifications of ASTER for Alabama

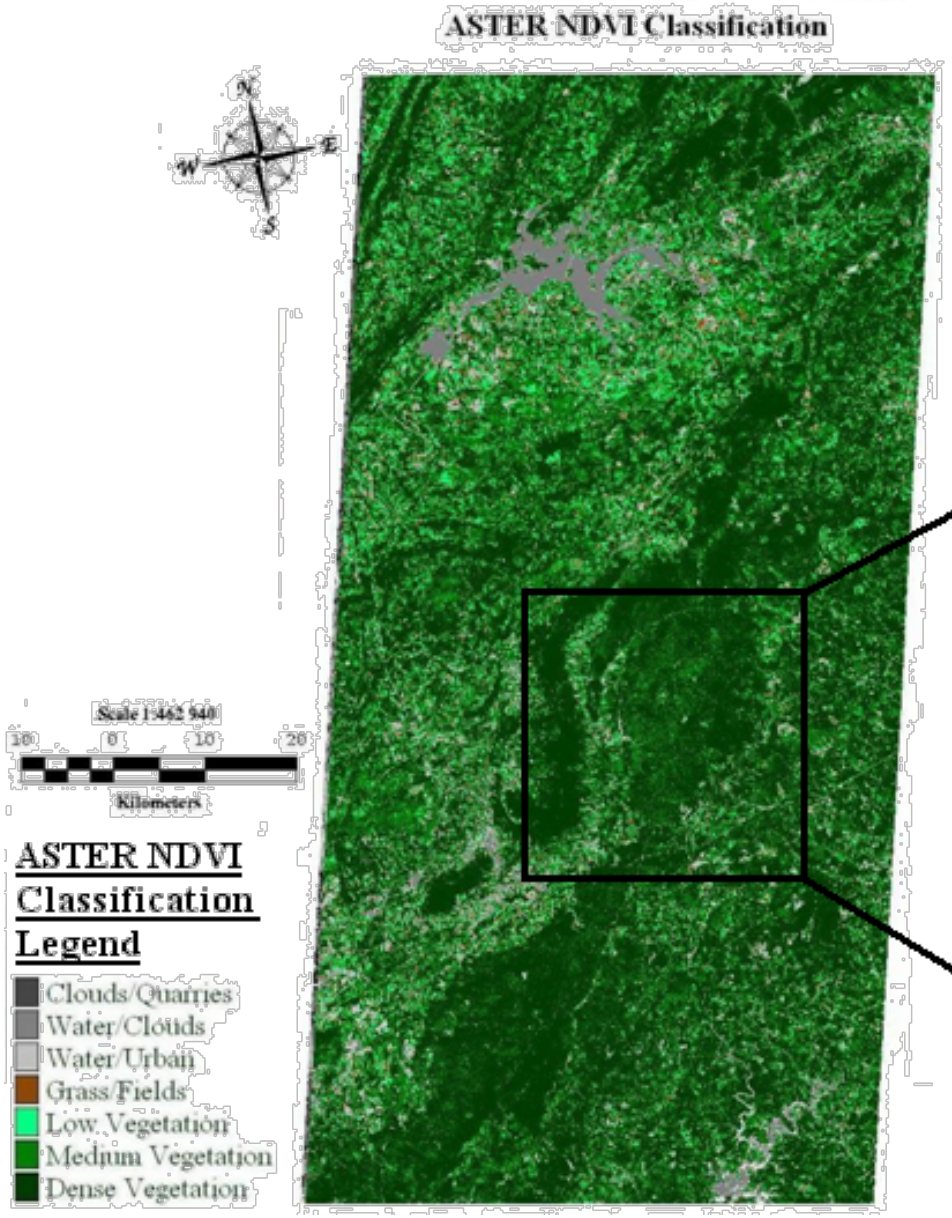
Results

Likely Tick Habitats:

Oak Mountain State Park, Bankhead National Forest, and Talladega National Forest showed coincident high NDVI and high Soil Moisture

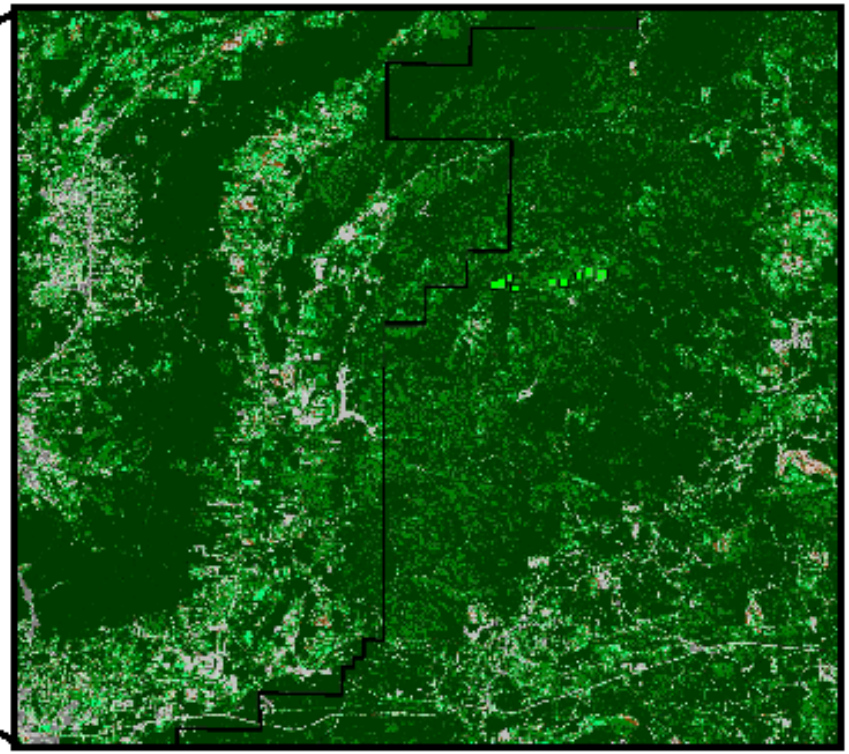


Ground Truthing

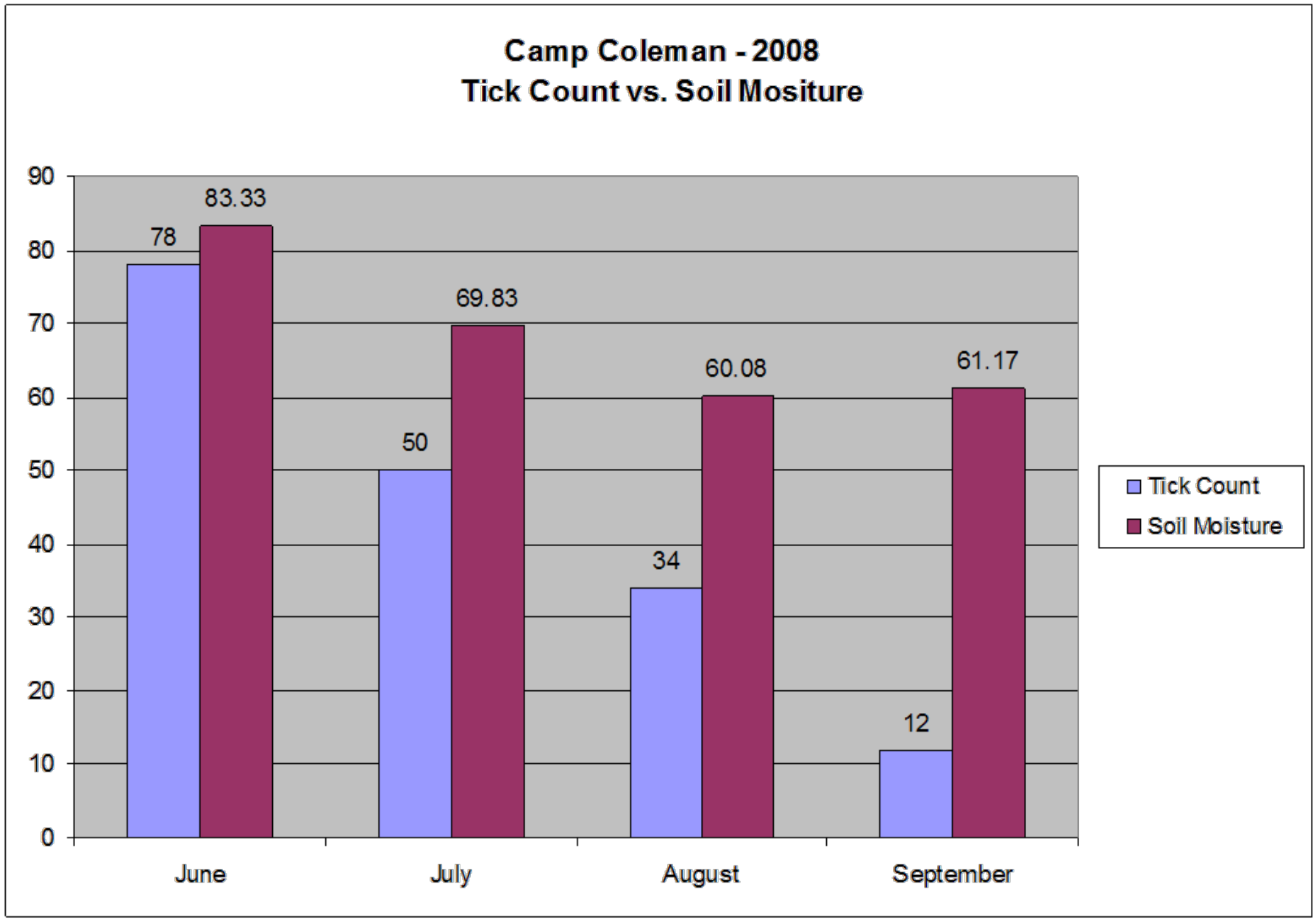


In situ soil and tick data gathered at Talladega National Forest

Talladega National Forrest



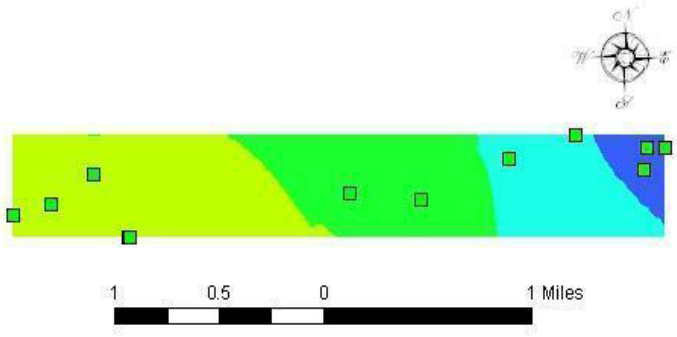
Results

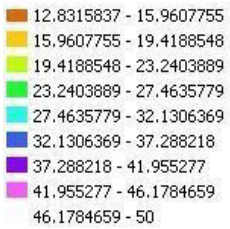

Camp Coleman - 2008
Tick Count vs. Soil Mositure
90
80
70
60
50
40
30
20
10
0
78
83.33
50
69.83
34
60.08
12
61.17
June
July
August
September
Tick Count
Soil Moisture

Spatial Statistics

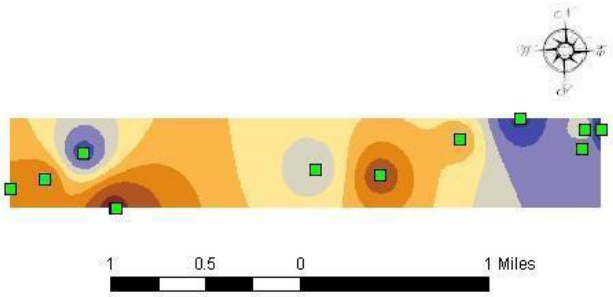
Compared Ordinary Kriging and Inverse Distance Weighting to model tick collection points and predicted tick counts in Talladega National Forest.

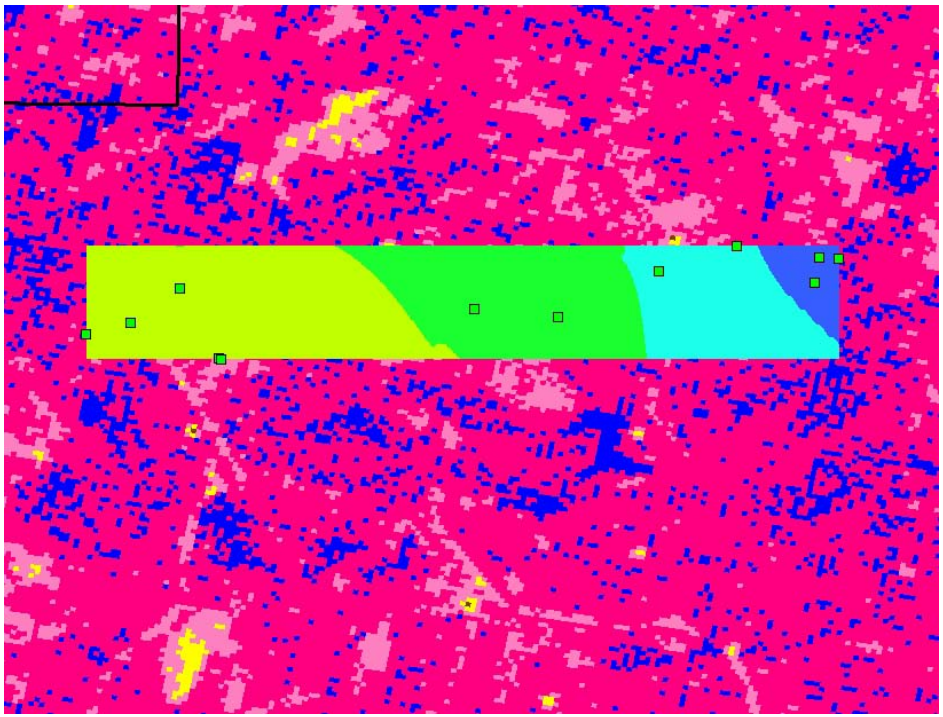
Ordinary Kriging





Inverse Distance Weighting





Ordinary Kriging had lowest root mean square error→ better fit

Community Outreach

Literature review revealed:

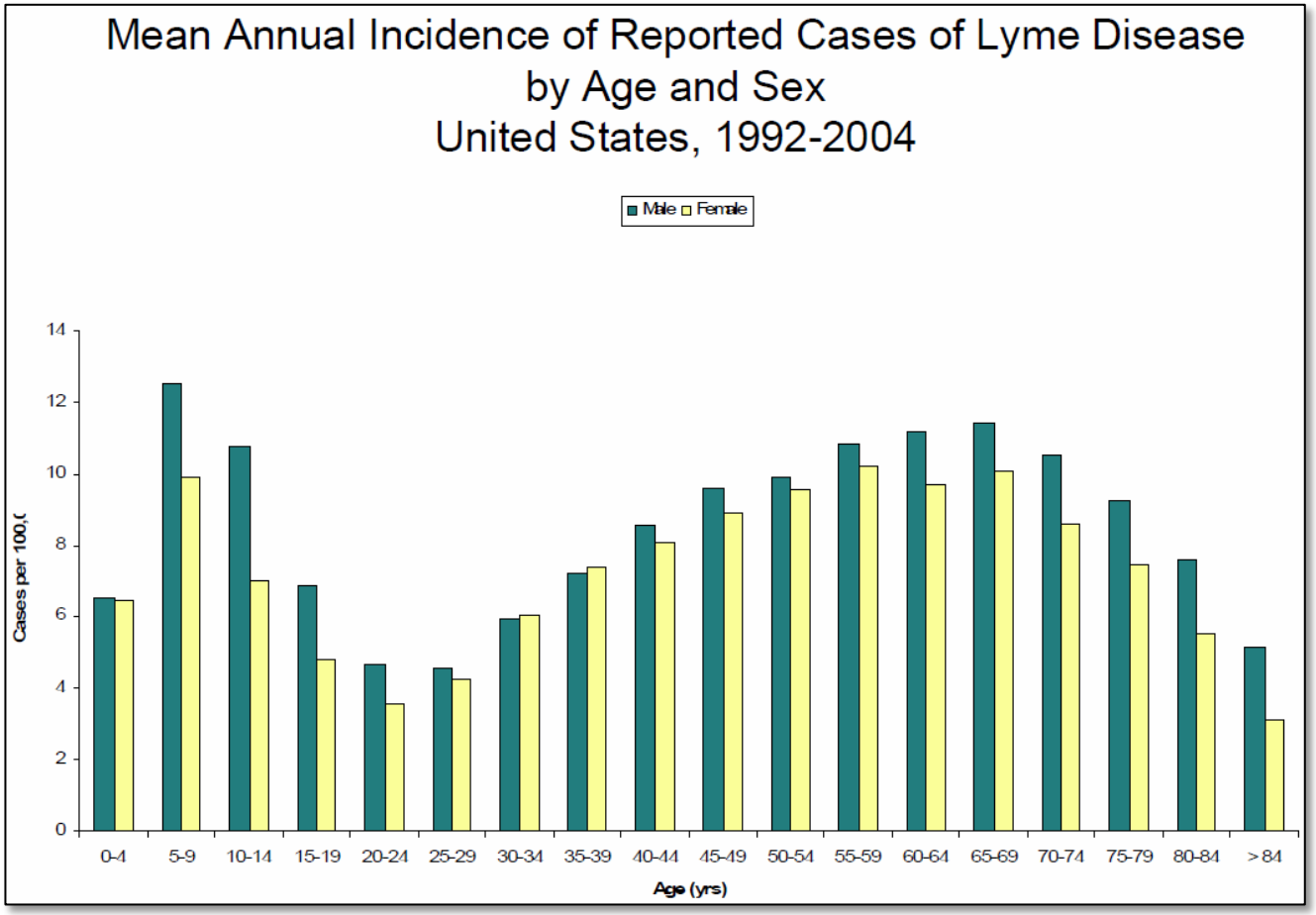
- Prevention campaigns and interventions common in NE and West Coast States
- Simple to highly sophisticated
- Materials and messages distributed by state and local public health departments, non-profits, physicians, teachers
- Campaigns and information less common in SE
- Little-to-no materials available to Alabamians from state health and natural resource organizations

→ Team Decision: Develop a Primary Prevention Campaign for High-Risk Groups in Alabama, informed by tick habitat mapping.

Community Outreach

Population at Risk

- Outdoor enthusiasts
- Outdoor workers
- Rural/peripheral settlement dwellers
- Pet owners and veterinarians



Age & Gender Factors

Ongoing Work: Outreach

Educational seminars for Girl Scouts of North-Central Alabama

- Camp Coleman and Kanawahala, summer 2010
- Content based on literature
- Structure based on Health Belief Model

KAP assessment of tick borne illness prevention behaviors

- Assess beliefs and practices of high-risk groups (Campus Outdoor Recreation Club participants)
- Online using Survey Monkey
- Target prevention messages

Health Belief Model Components:
1) Perceived susceptibility
2) Perceived severity
3) Perceived benefits
4) Perceived barriers
5) Cues to action
6) Self-efficacy

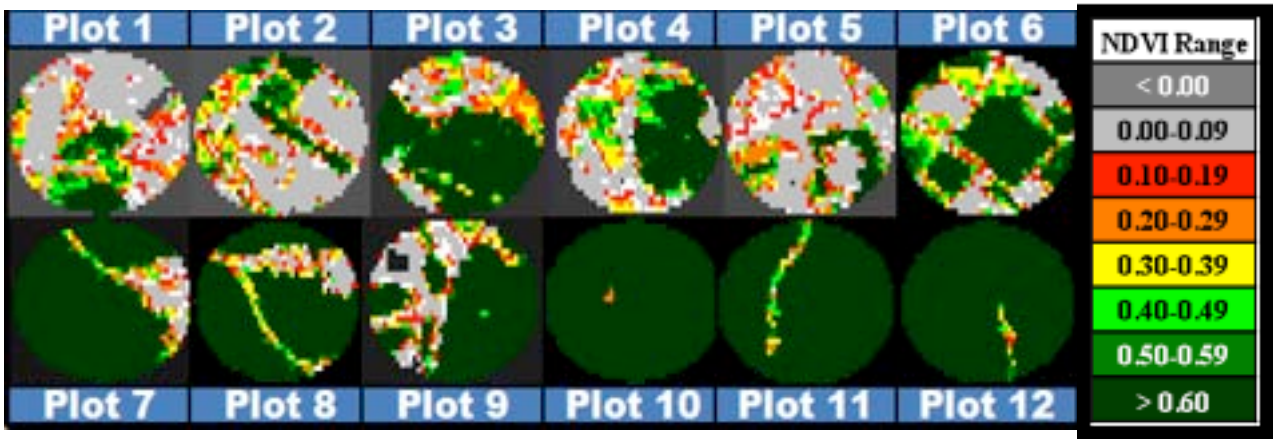
Ongoing Work: Outreach

Prevention Messages (CDC Website)

- Avoid or reduce time spent in likely tick habitats
- Wear protective clothing (long sleeved, light colored clothes)
- Tuck in pants and shirts
- Use tick repellants such as DEET or permethrin
- Perform tick checks
- Remove ticks properly (with tweezers, slowly pulling tick out straight from close to its embedded mouthparts)
- Remove ticks within 24 hours of attachment

Phases 3 & 4

- Analyze Landsat satellite imagery to identify likely tick habitats in areas not covered by ASTER
- Perform geo-located tick drags at Fort McClellan to establish correlations between tick populations and additional environmental variables
- PCR analysis of tick infection rates for multiple diseases
- "Task" (request) NASA Terra Satellite to take ASTER images for summer 2010
- Use new ASTER and tick data to test accuracy of predictive model
- Investigate edge effects and patch size in the spatial model



Conclusions

Remote sensing can be useful for:

- Conducting surveillance
- Targeting prevention messages

DEVELOP is an exceptional model for student collaboration, research training, and community outreach:

- Student-led team (graduate, undergrad, high school)
- Diverse, interdisciplinary group: 6 countries, 6 disciplines
- Training in remote sensing, GIS, modeling
- Community outreach of NASA assets and products for societal benefit

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  - Karen Allsbrook
  - Tracey Silcox

UAB Laboratory for Global Health Observation

- Dr. Sarah Parcak, Director
- Dr. Donna Burnett
- Steve Padgett-Vasquez, current DEVELOP lead
- Dr. Herman Foushee
- Kartikey Acharya, University of Arkansas
- Jacksonville State University

Previous and current DEVELOP team members

Works Cited

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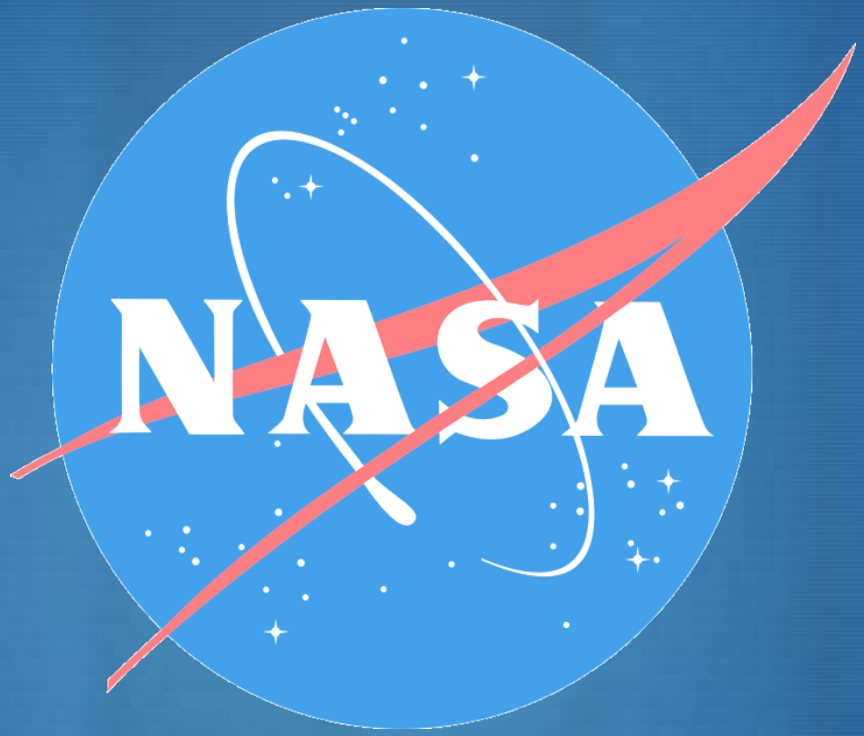

Questions?

sarah.n.hemmings@nasa.gov