Environmental Factors Affecting Host-seeking *Ixodes scapularis* Ticks in the Eastern United States

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October 9th, 2007

Ixodes scapularis

•In the United States, the arthropod vector *Ixodes scapularis* transmits the disease agent associated with Lyme disease, *Borrelia burgdorferi*

- *I. scapularis*
  - is a hematophagus parasite.
  - has a multistage life cycle
    - eggs, larval, nymphal, and adult.
  - uses desiccation as an over-wintering strategy.
  - is often found in deciduous leaf litter in the eastern United States
  - has several mammalian hosts
    - *Peromyscus leucopus* /white-footed mouse
    - *Odocoileus virginianus*/white-tailed deer

Image: **Scott Bauer USDA**

Disease Agent *B. burgdorferi*

- *B. burgdorferi* is:
  - a spirochetal bacterium.
  - transmitted during blood meals.
  - prevalent in *I. scapularis* host-seeking nymphs.
  - the causative agent of Lyme disease.

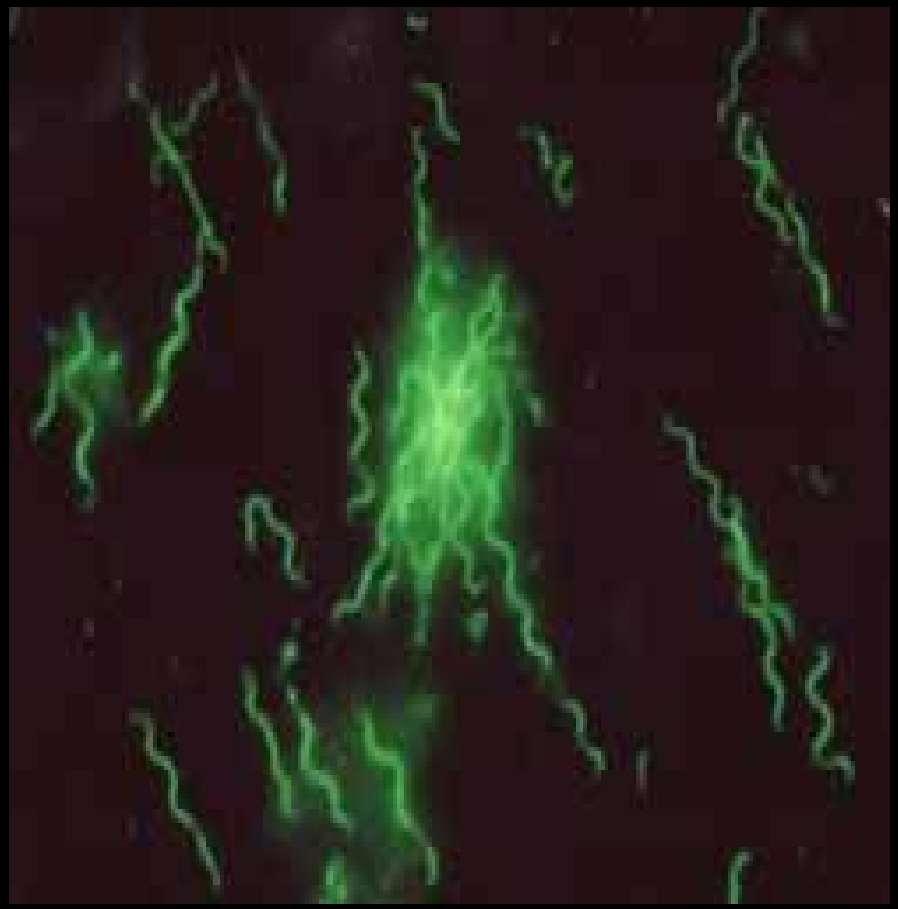


Image: ALDF

Lyme Disease

- **Stage 1**
  - Erythemea mygrans or bull’s eye rash
  - Achiness
  - Swollen lymph glands
- **Stage 2**
  - Fever, head aches, Abnormal pulse
  - Facial Palsy
  - Migrating pain in joints
  - Severe fatigue
- **Stage 3**
  - Neurological Disorders
  - Paralysis
  - Numbness in Limbs
  - Arthritis

Image: ALDF

Key Points

- The risk of Lyme Disease in the eastern United States is dependent on the density of host-seeking *I.* scapularis nymphal stage ticks infected with *B. burgdorferi* (Diuk-Wasser et. al. 2006).

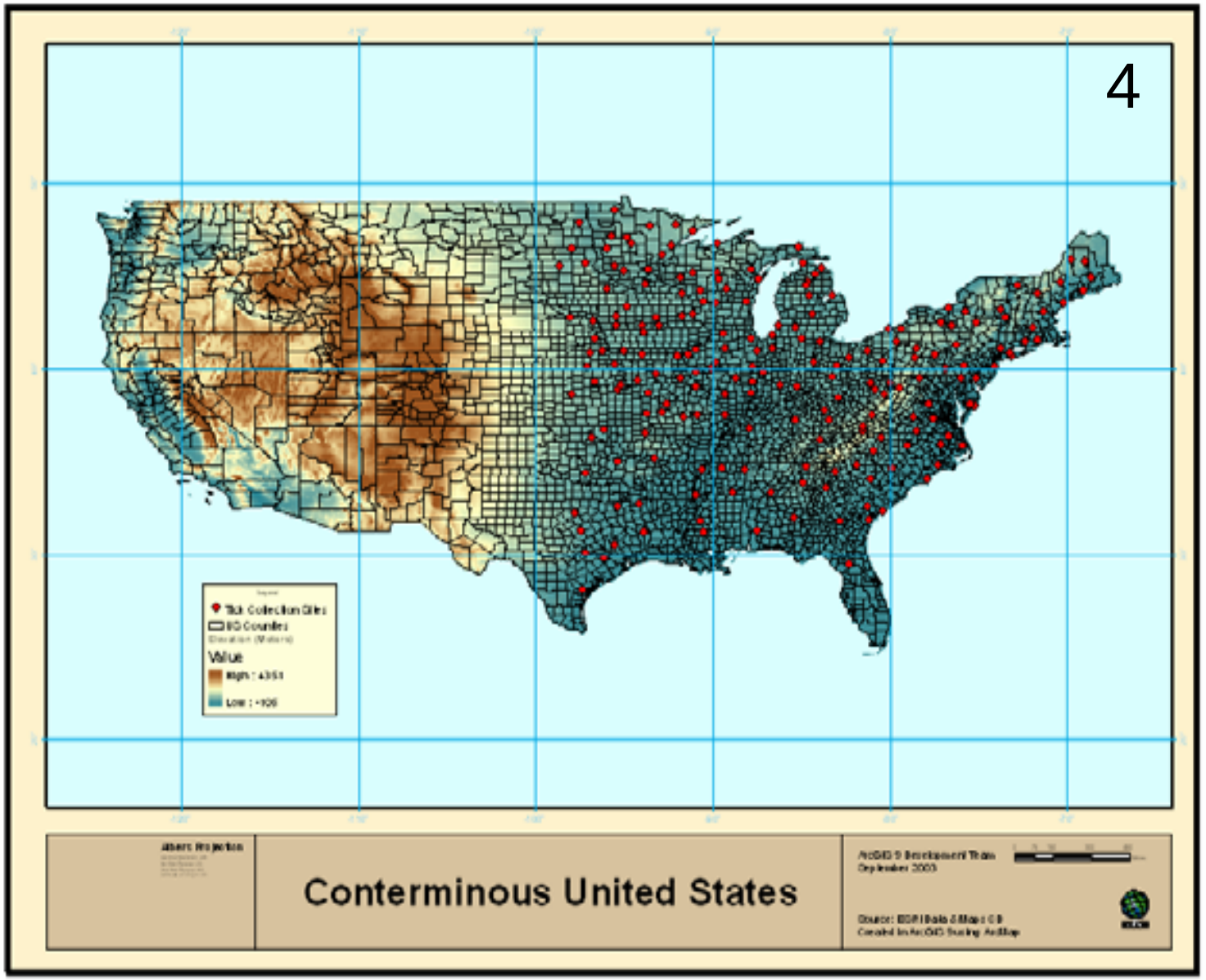
- Tick distributions may be predicted by investigating the correlation between tick presence and environmental factors (Brownstein et.al. 2003).

Objectives

- Determine environmental factors significantly correlated with host-seeking *I.scapularis* tick presence.

- Map all locations with significant ($p<0.05$) environmental factors pertaining to probable host-seeking *I.scapularis* tick presence.

Sampling Site Overview



Sampling Site Detail

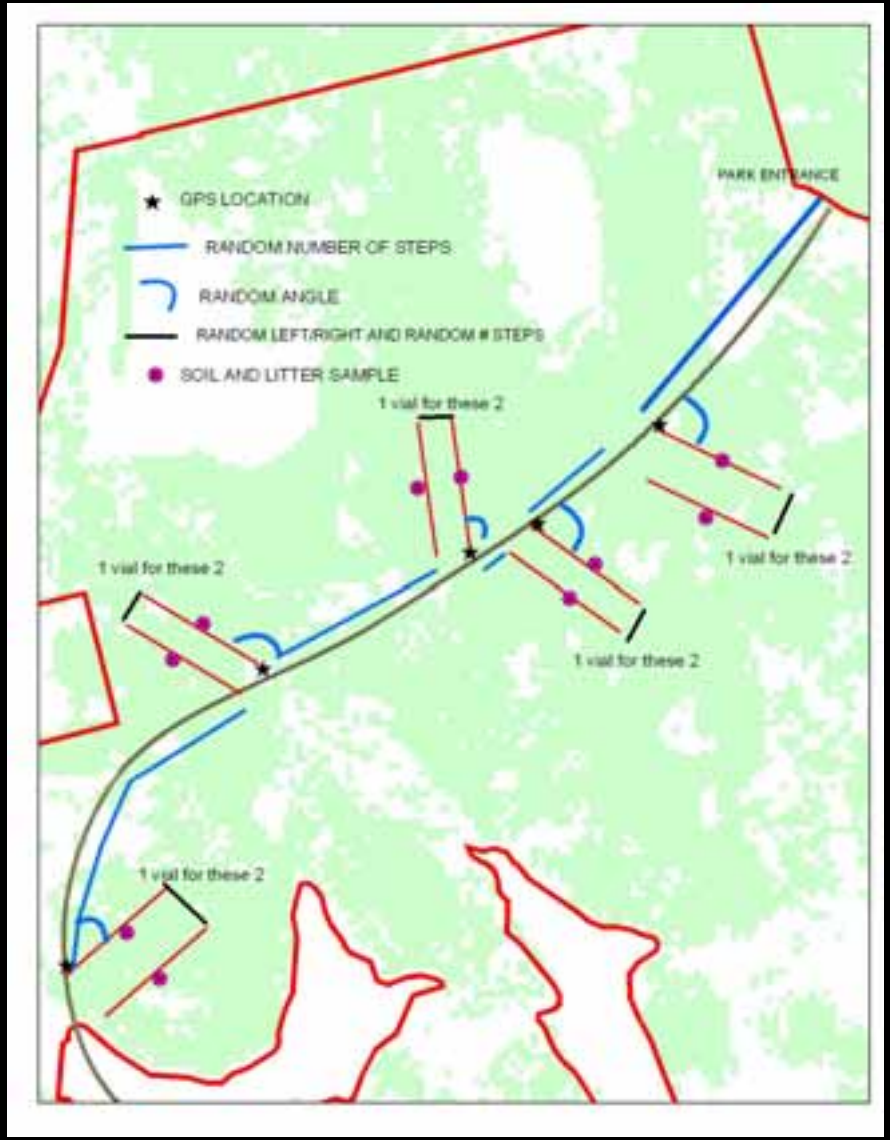


Image: Dr. Diuk-Wasser, Yale Vector Ecology Lab

Environmental Factors

- Weather Station Data
  - Interpolated monthly averages

    - Worldclim (1955-2000)
      - Temperature
      - Precipitation
      - Altitude

    - Global 30-Year Mean Monthly Climatology (1961-1990) New et.al.
      - Vapor Pressure

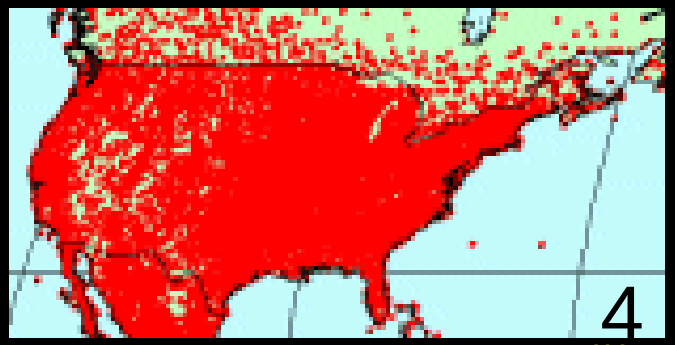
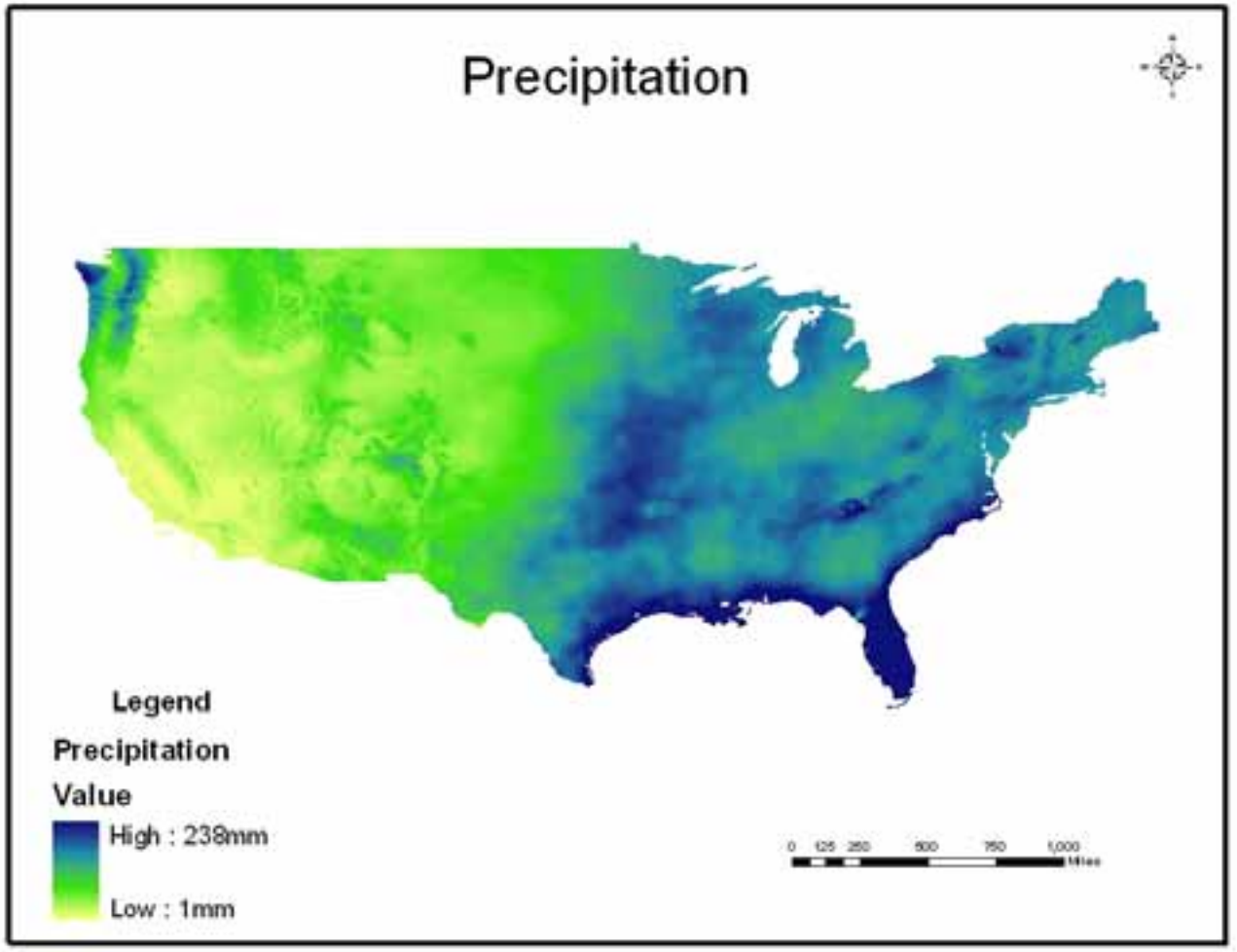


Image: Worldclim

Methods

•Created raster layers from the environmental factors data, example: Precipitation Raster



Methods

•Extracted environmental values (precipitation, temperature, altitude, and vapor pressure) from the weather station-based raster layers for the n=192 study sites

•Designated the host-seeking *I.scapularis* status of all study sites as: present =1 or absent = 0; based on field collection and Identification results (n = 3,323 *I. scapularis* nymphs).

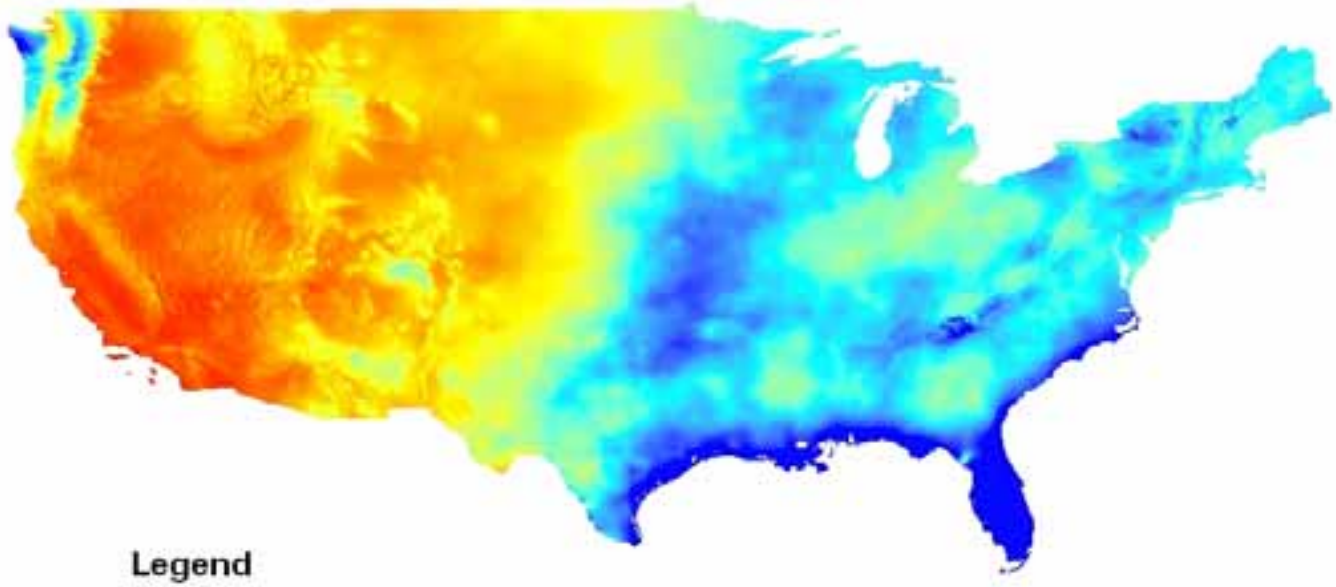
•Used stepwise-descending logistic regression to model environmental factors significantly correlated with host-seeking *I.scapularis* tick presence.

Logistic Regression Results

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	0.5346	1.3208	0.1638	0.6857
Pre_09	1	0.0401	0.014	8.2092	0.0042
Vap_01	1	-0.0807	0.0163	24.5207	<.0001
Alt_01	1	-0.00844	0.00182	21.5285	<.0001

A Spearman-Pearson analysis was conducted to assess any potential co-linearity between the significant correlation coefficients; No co-linearity found.

September Precipitation



Legend

Precipitation, September

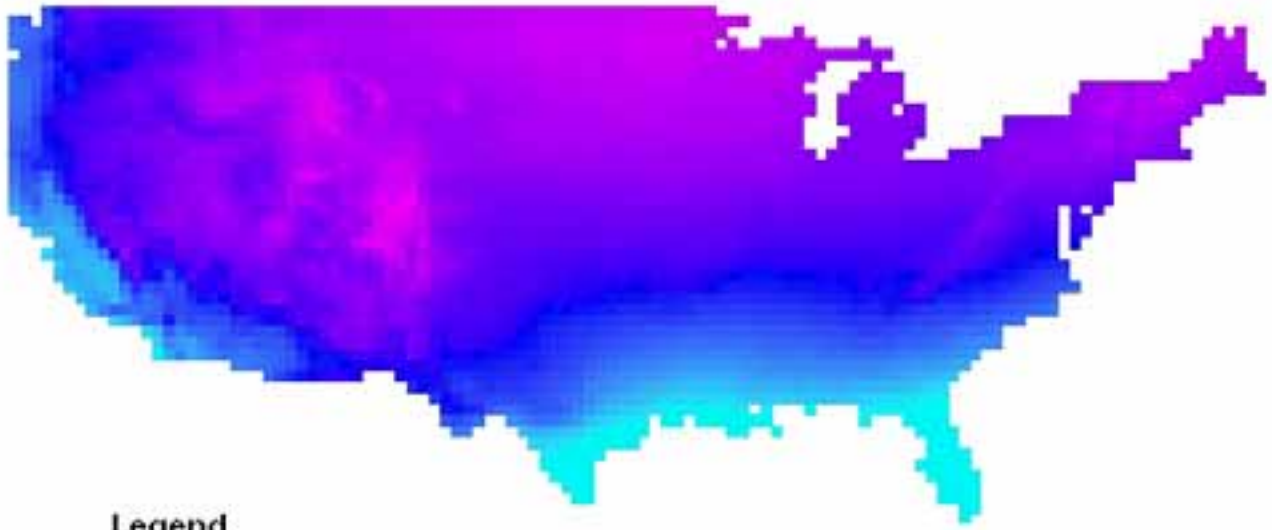
Value

High : 238 mm

Low : 1 mm

0 875 350 700 1,050 1,400
Kilometers

January Vapor Pressure



Legend

Vapor Pressure, January

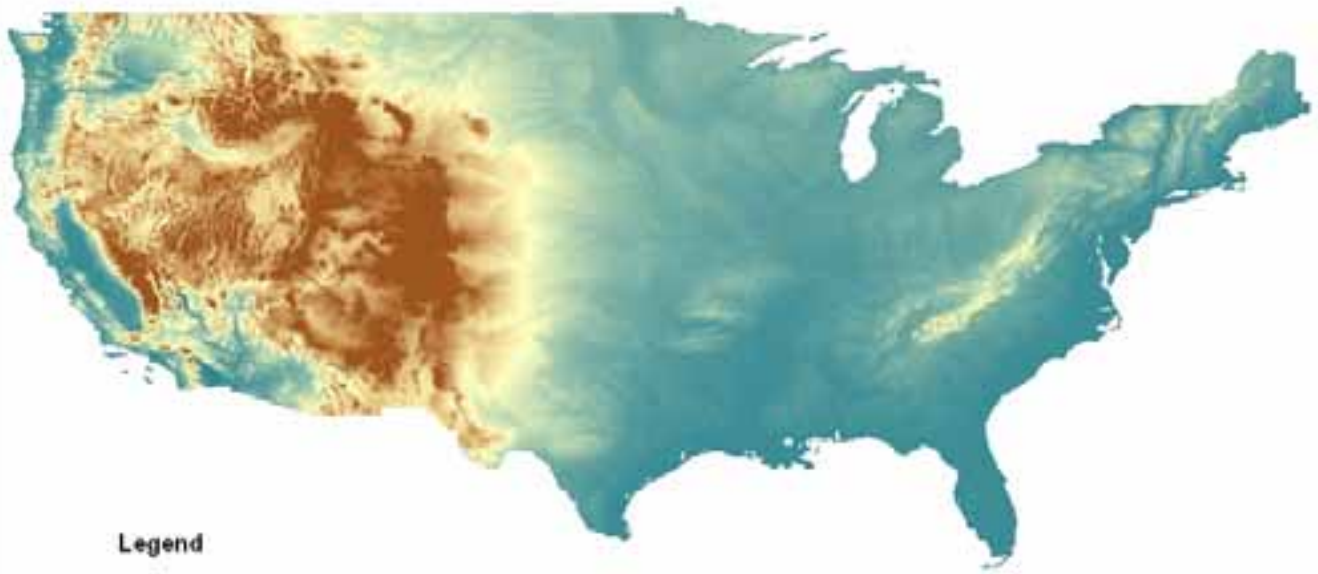
Value

High : 176 mmHg

Low : 4 mmHg

0 175 350 700 1,050 1,400
Kilometers

Altitude



Legend

Altitude

Value

High : 4351m

Low : -105m

0 185 370 740 1,110 1,480

Kilometers

Results

- January vapor pressure, September precipitation, and altitude are the environmental factors significantly correlated with *I.scapularis* presence.

- As precipitation increases in September, vapor pressure decreases in January, and altitude decreases the likelihood of *I. scapularis* host-seeking nymph presence increases.

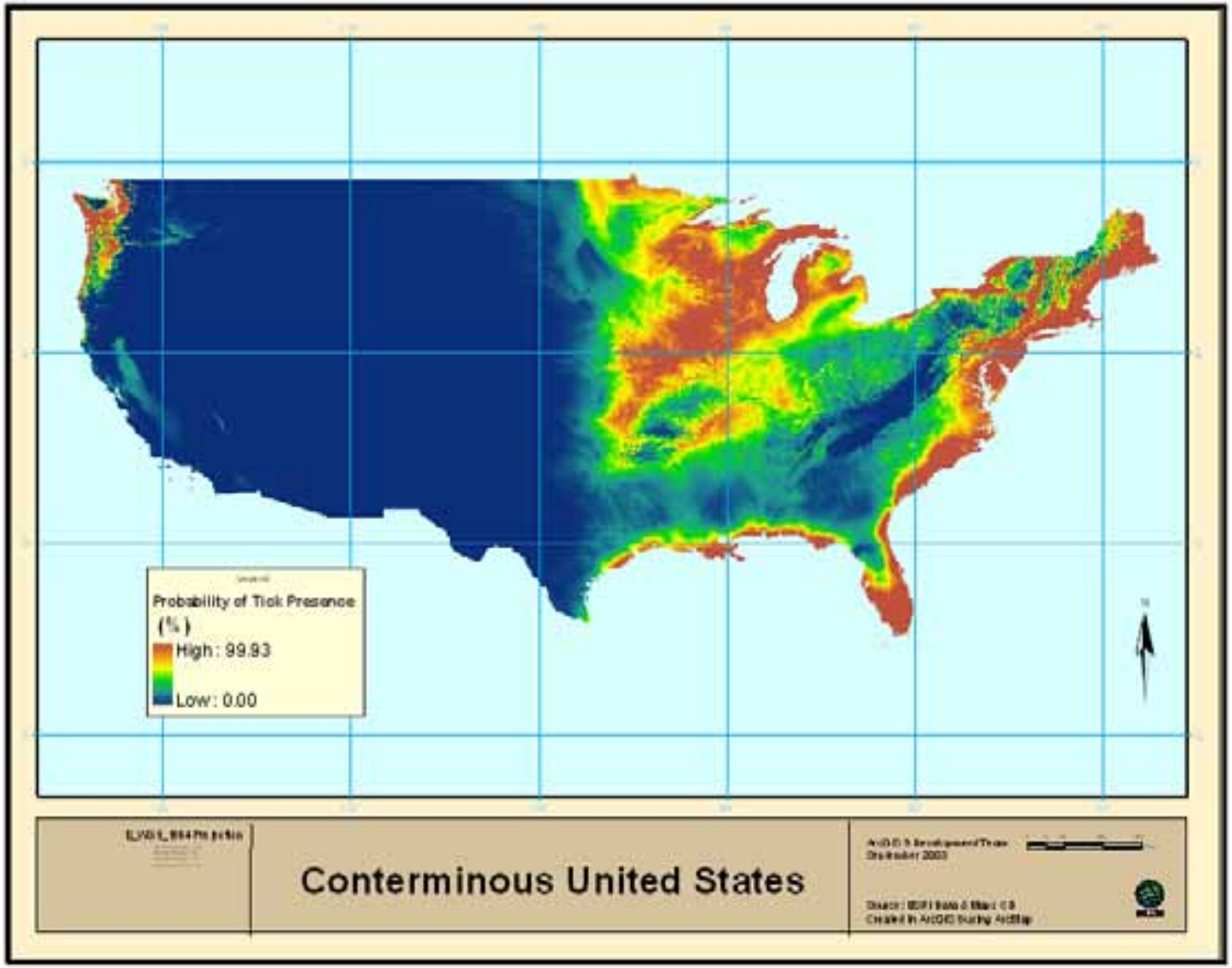
Probability Mapping

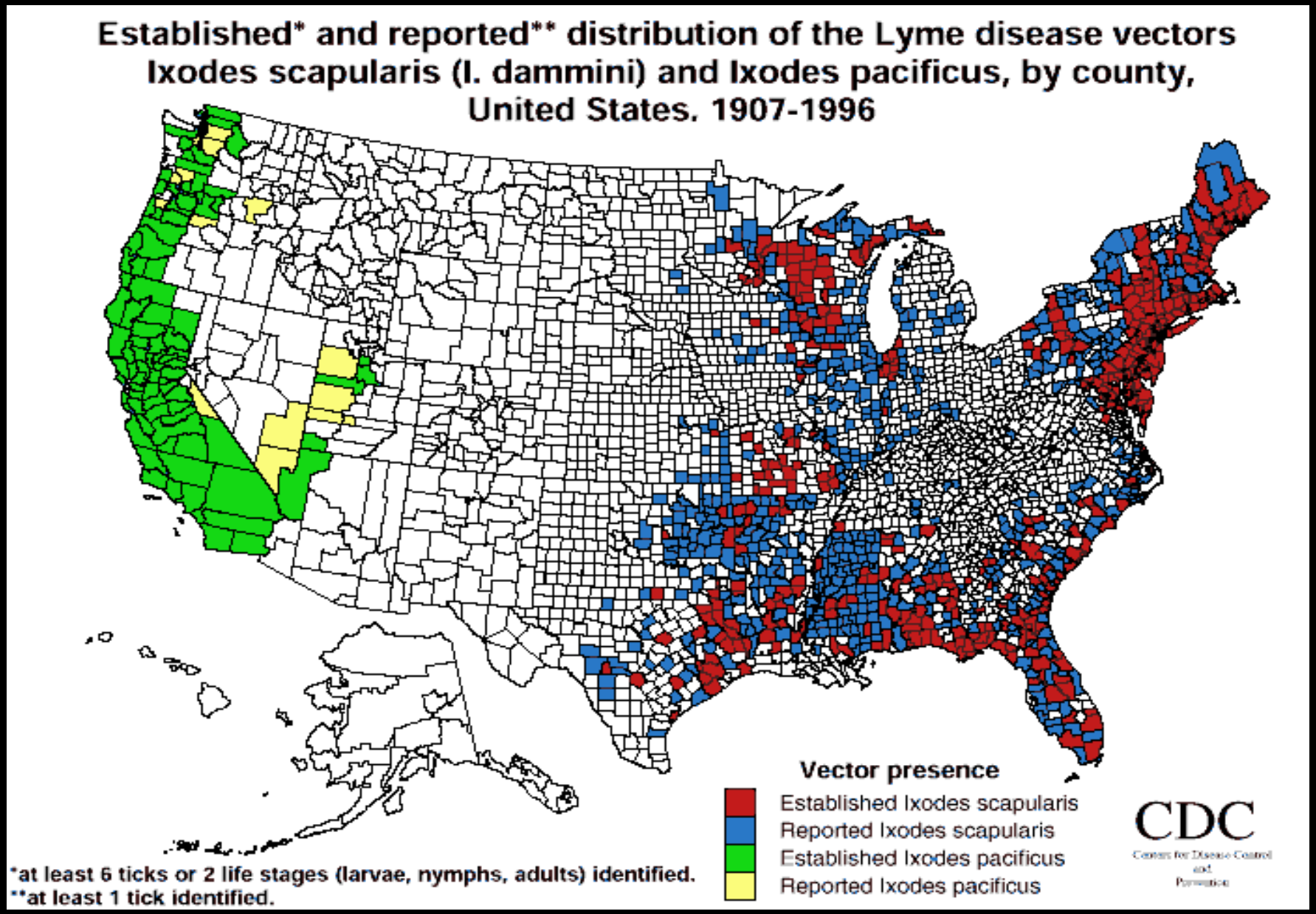
- Once significant environmental factors were established, all potential locations with environmental conditions conducive to the presence of host-seeking *I. scapularis* ticks were mapped.

- The significant parameter estimates from the logistic regression model were entered with the appropriate correlation coefficient raster layer into ArcMap 9.1 spatial analyst raster calculator.

  - Map=1/(1+EXP(-(model)))
    - (S. Maples, unpublished)

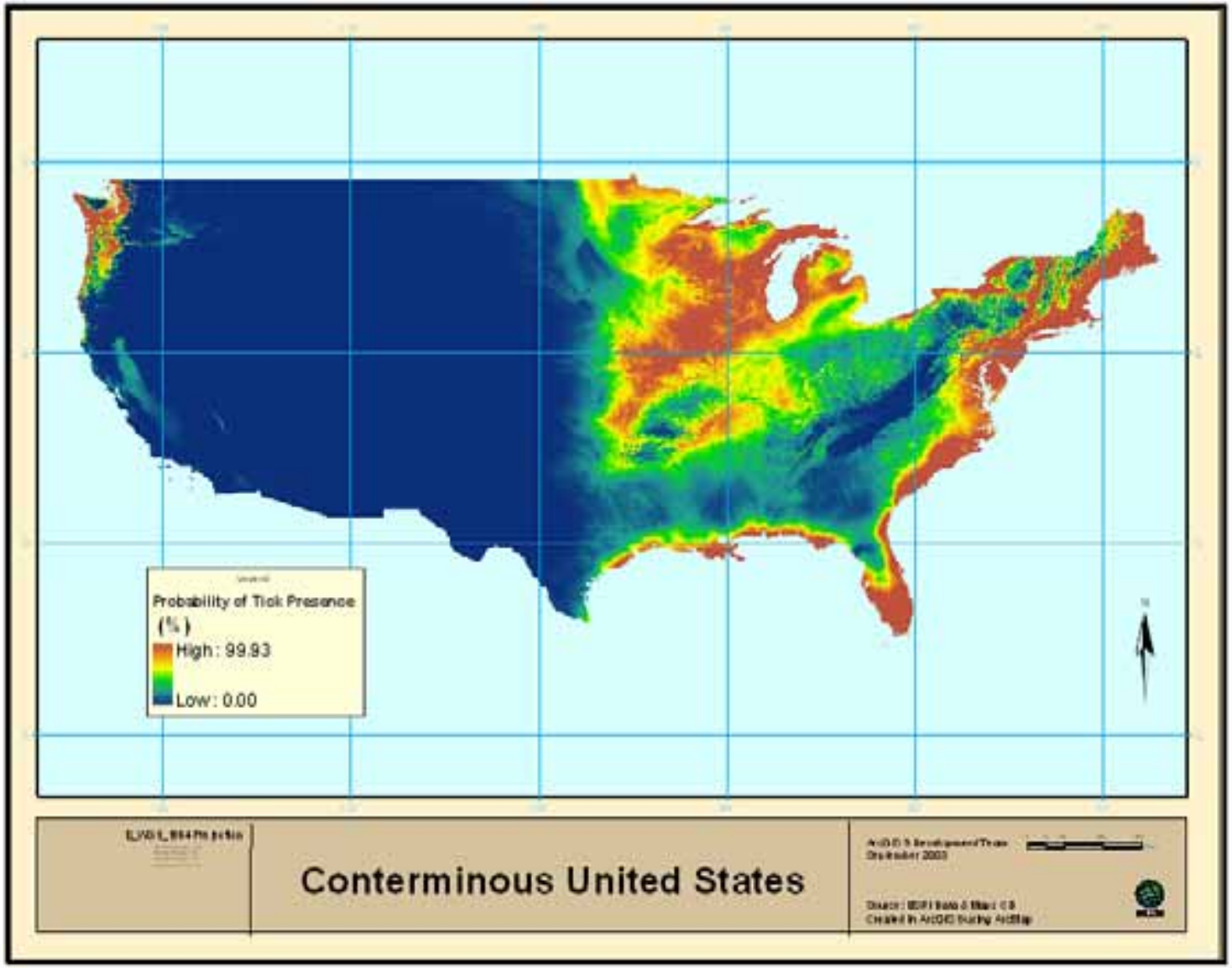
Probable Tick Presence





http://www.cdc.gov/ncidod/dvbid/lyme/tickmap.htm

Probable Tick Presence



ALDF Lyme Disease Case Map

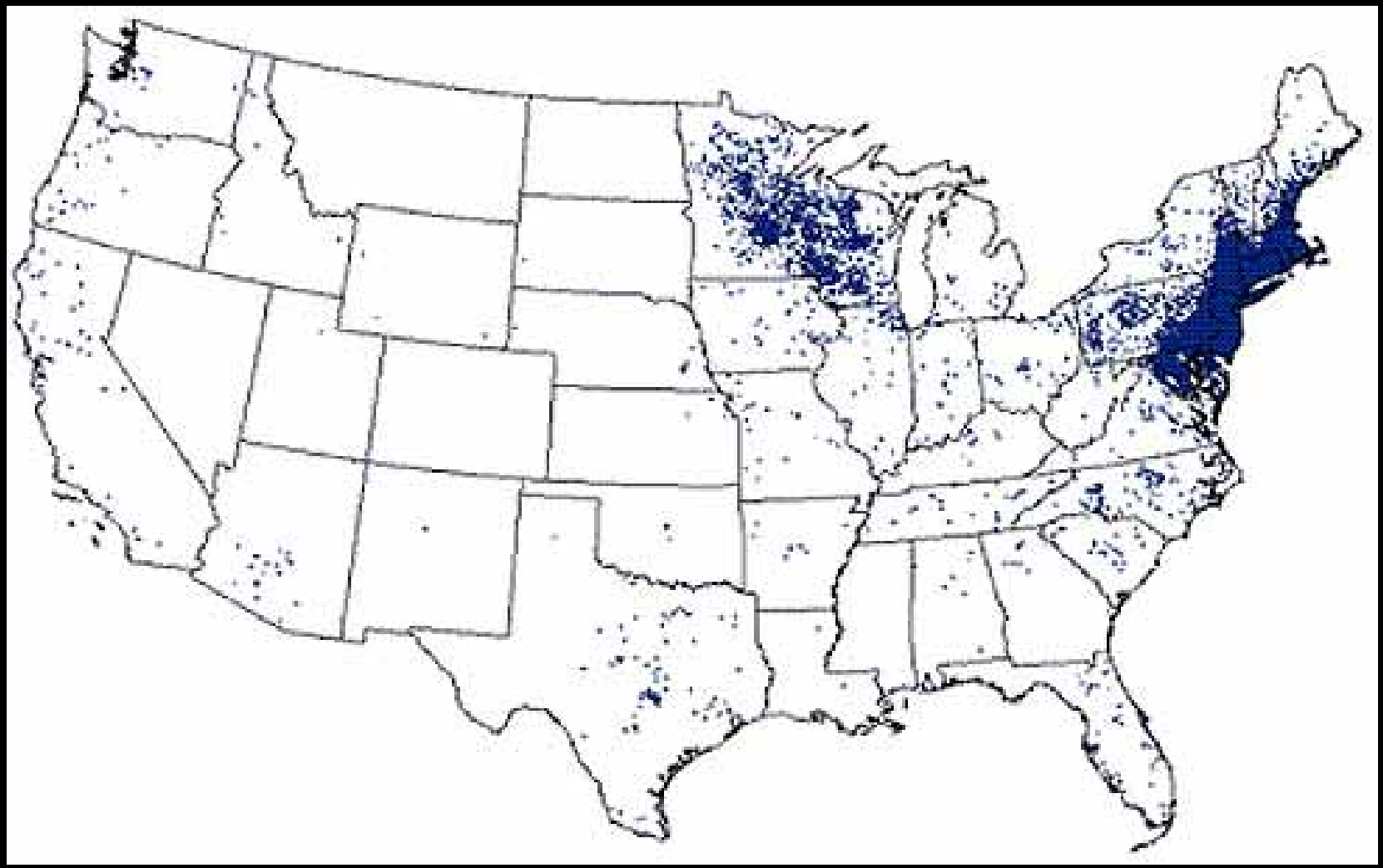
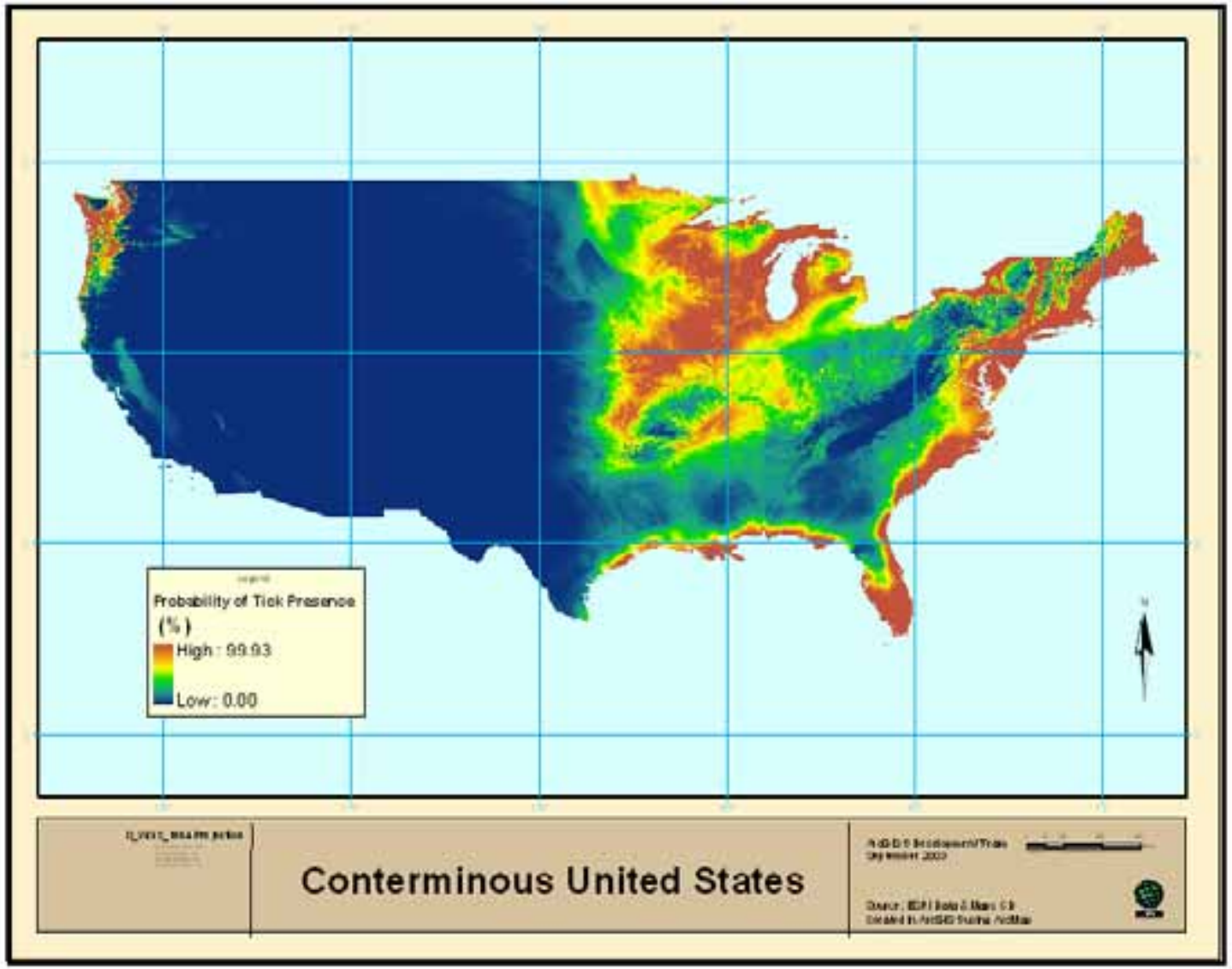


Image: http://www.aldf.com/images/2004LymeDiseaseCaseMap.jpg

Probable Tick Presence



Conclusions

- From a biological perspective the model makes sense.
  - September precipitation occurs at the end of the *I. scapularis* active season.
  - Vapor pressure in January would affect tick desiccation and over-wintering success.
  - Altitude reflects multiple changes in habitat quality.
- Based on the environmental factors model, potential exists for host-seeking *I.scapularis* range expansion.
- The probability map reinforces the importance of taking environmental conditions into account when creating disease vector distribution models.

Conclusions

- A key issue in the control of any infectious disease is to identify which areas are at risk, definitively or potentially.

- Informing the public about areas harboring a known infectious agent, so that appropriate precautions and control efforts are implemented, is tantamount to suppressing an infectious agent.

References

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Acknowledgements

- Dr. Durland Fish
- Dr. Maria Diuk-Wasser
- Annie Gatewood c.PhD.
- Dr. John Brownstein
- Yale Vector Ecology Lab, Field Crew, and Collaborators
- Yale GIS Office
- American Lyme Disease Foundation
- CDC