Malaria Modeling and Surveillance

Richard Kiang, Farida Adimi, Radina Soebiyanto
NASA Goddard Space Flight Center
Greenbelt, MD 20771

OUTLINE

- Background – partners, DSS, objectives, highlights
- Spatiotemporal modeling for testing transmission hypothesis
- Malaria in Afghanistan
- Benchmark

THE PROBLEM

- 40% of the world's populations at risk
- 300-500 million cases per year
- 1-3 million deaths per year
- Highest risks for children, pregnant women, and people with depressed immunoresponse
- ≈ One death every 30 seconds
- ACT is becoming less sensitive.
- Previously unaffected regions may have outbreaks due to climate change.
- Significant increases of fundings for malaria control and vaccine research have rekindled hope for eradication.

richard.kiang@nasa.gov

OBJECTIVES

Risk detection
Detection of larval habitats
Textural-contextual classification

Risk prediction
Prediction of current and future endemicity
Neural network methods

Risk reduction
Identification of key factors that sustain or promote transmissions
Agent-based discrete event simulation

BENEFITS

Applying larval control as a preventive measure

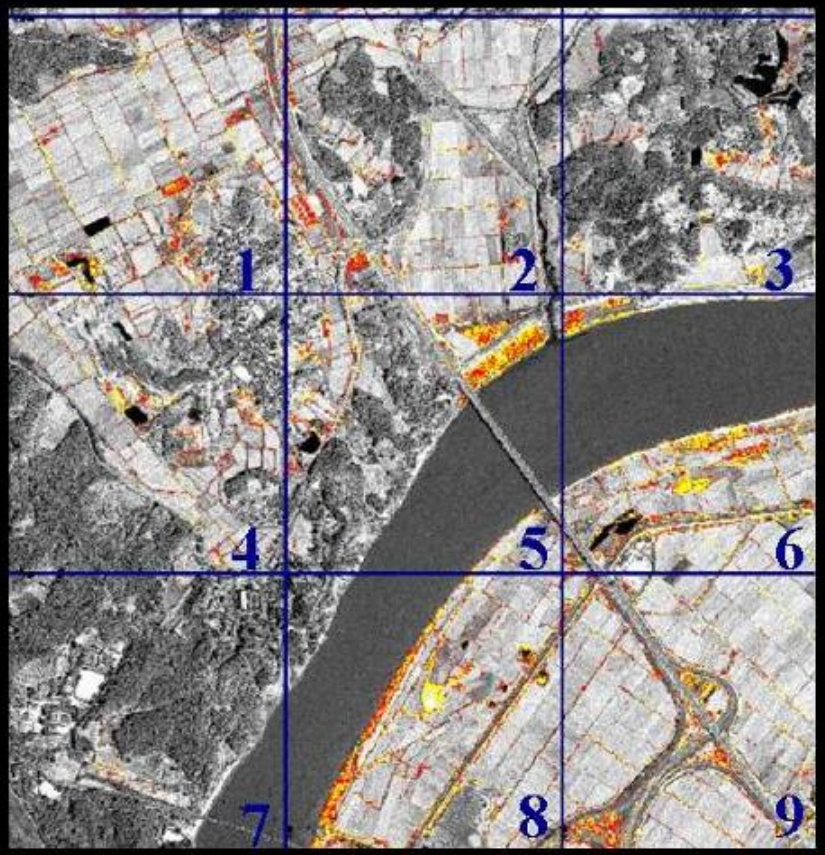
Strengthening and mobilizing public health support

Cost-effectively curtailing malaria transmission

richard.kiang@nasa.gov

Detection of Ditches using Pan-sharpened Ikonos Data

(Larval Habitats of *Anopheles sinensis* in Korea)



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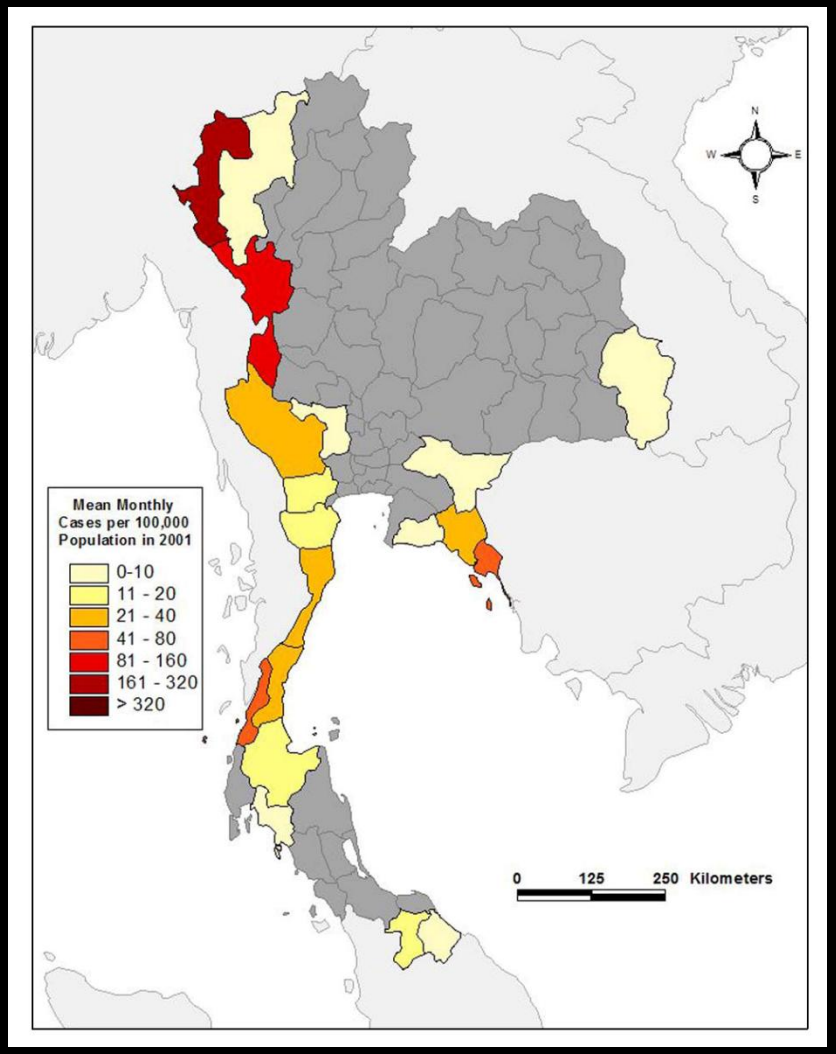
THAILAND

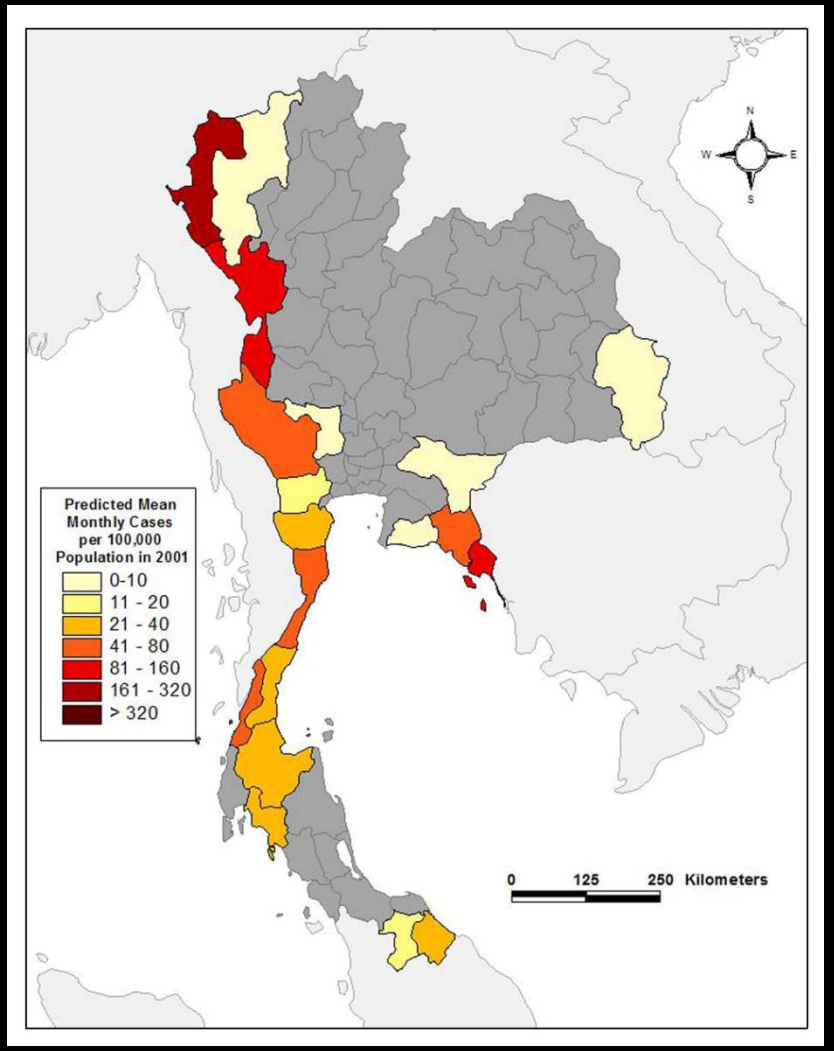


A. minimus, A. dirus, A. maculatus

Actual Malaria Incidence



Hindcast Incidence



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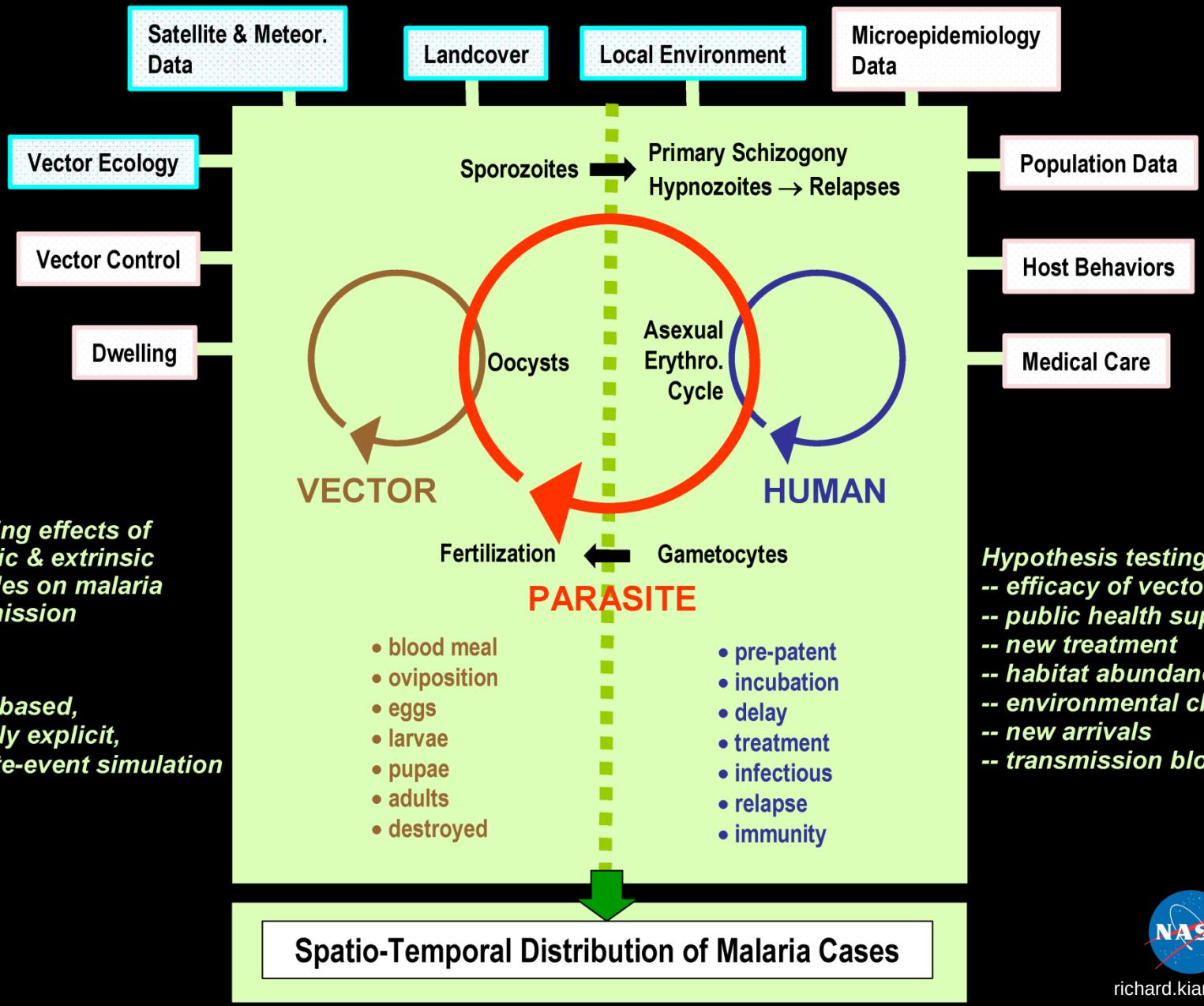
Dynamic Transmission Modeling Framework



Modeling effects of intrinsic & extrinsic variables on malaria transmission

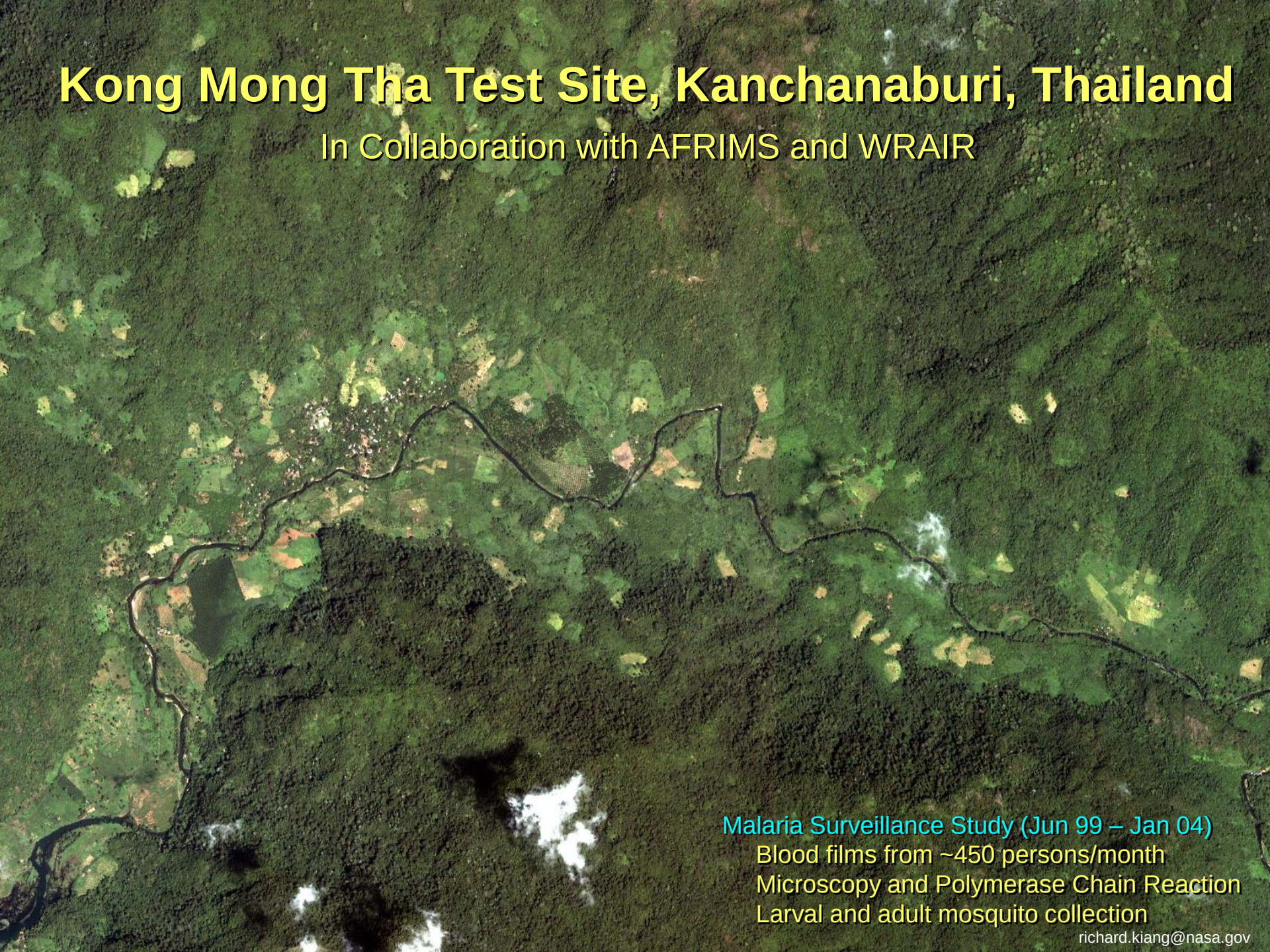
Agent-based, spatially explicit, discrete-event simulation

Hypothesis testing:
-- efficacy of vector control
-- public health support
-- new treatment
-- habitat abundance
-- environmental changes
-- new arrivals
-- transmission blocking

richard.kiang@nasa.gov

Kong Mong Tha Test Site, Kanchanaburi, Thailand

In Collaboration with AFRIMS and WRAIR



Malaria Surveillance Study (Jun 99 – Jan 04)

- Blood films from ~450 persons/month
- Microscopy and Polymerase Chain Reaction
- Larval and adult mosquito collection

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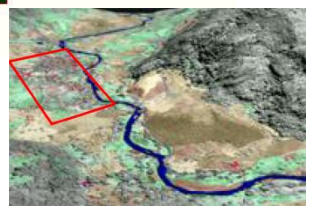
Example: A Small Hamlet

23 houses
2 cattle sheds
24 clusters of larval habitats

69 adults
23 childrens
8 cows

1/7 of KMT



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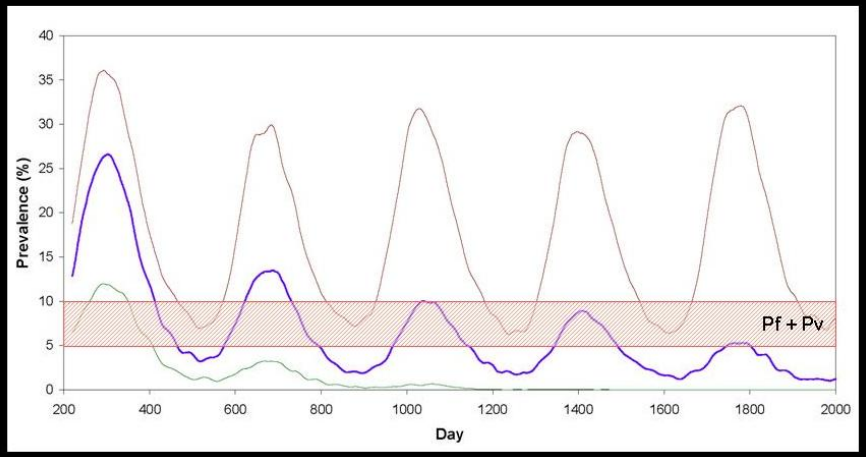
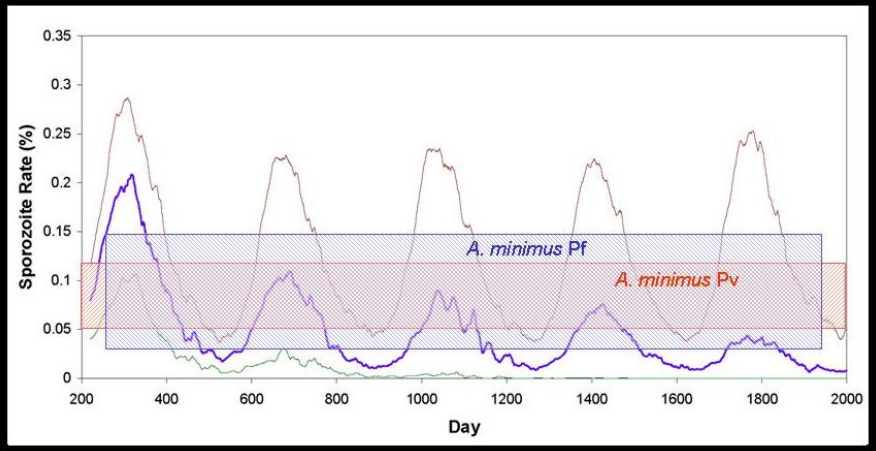
Modeled and Observed Prevalence

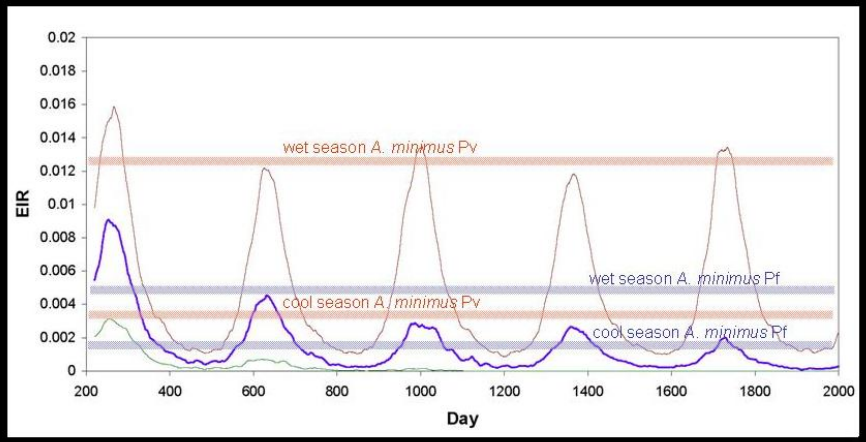


Modeled and Observed Sporozoite Rates

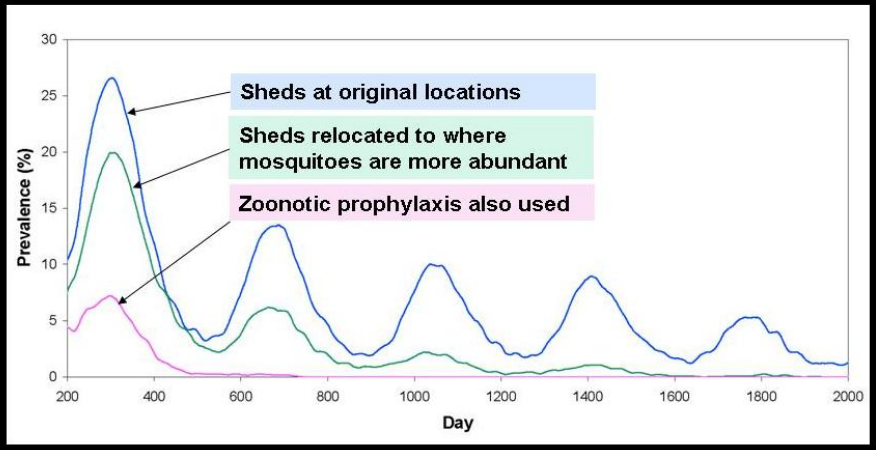


Modeled and Observed Entomological Inoculation Rates

(number of infective bites / person / day)



Well Placed Farm Animal Sheds and Zoonotic Prophylaxis May Significantly Reduce Malaria Transmission



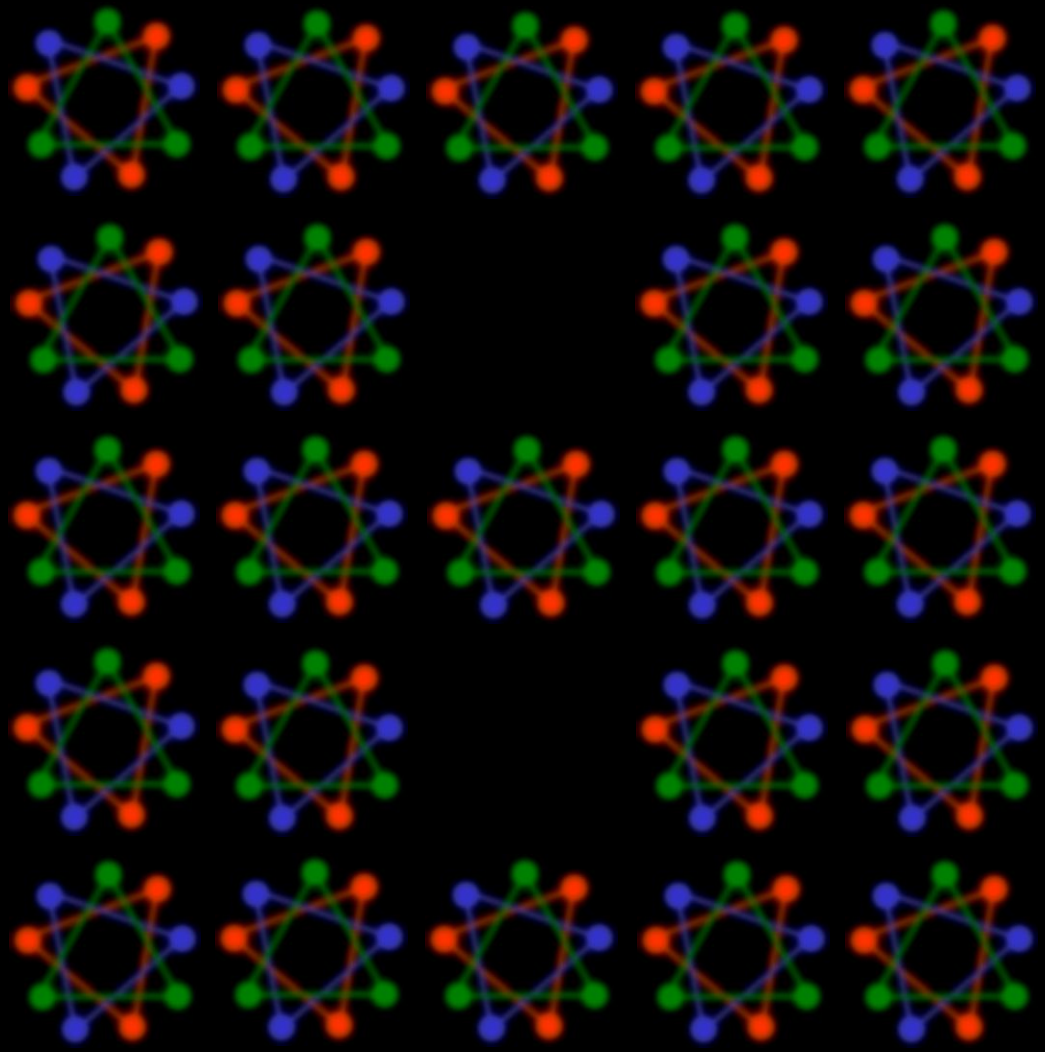
Sensitivity Studies and Simulations Performed

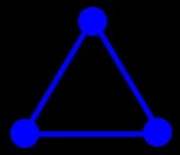
Using Agent-Based Discrete Event Simulation Model

- Abundance of larval habitats
- Access to health care and appropriate treatment
- Asymptomatic cases
- Acquired immunity
- Active and passive case detections
- Bednets or personal protections
- Improved dwelling construction
- Parasite infectivity in mosquitoes
- Zoonotic prophylaxis
- Arrival of non-immune populations (such as migrant workers, refugees, foreign military forces)

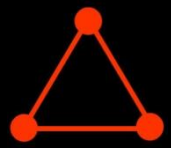
richard.kiang@nasa.gov

Analytic Biological Model for the Small Hamlet

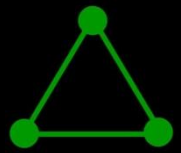




HUMANS

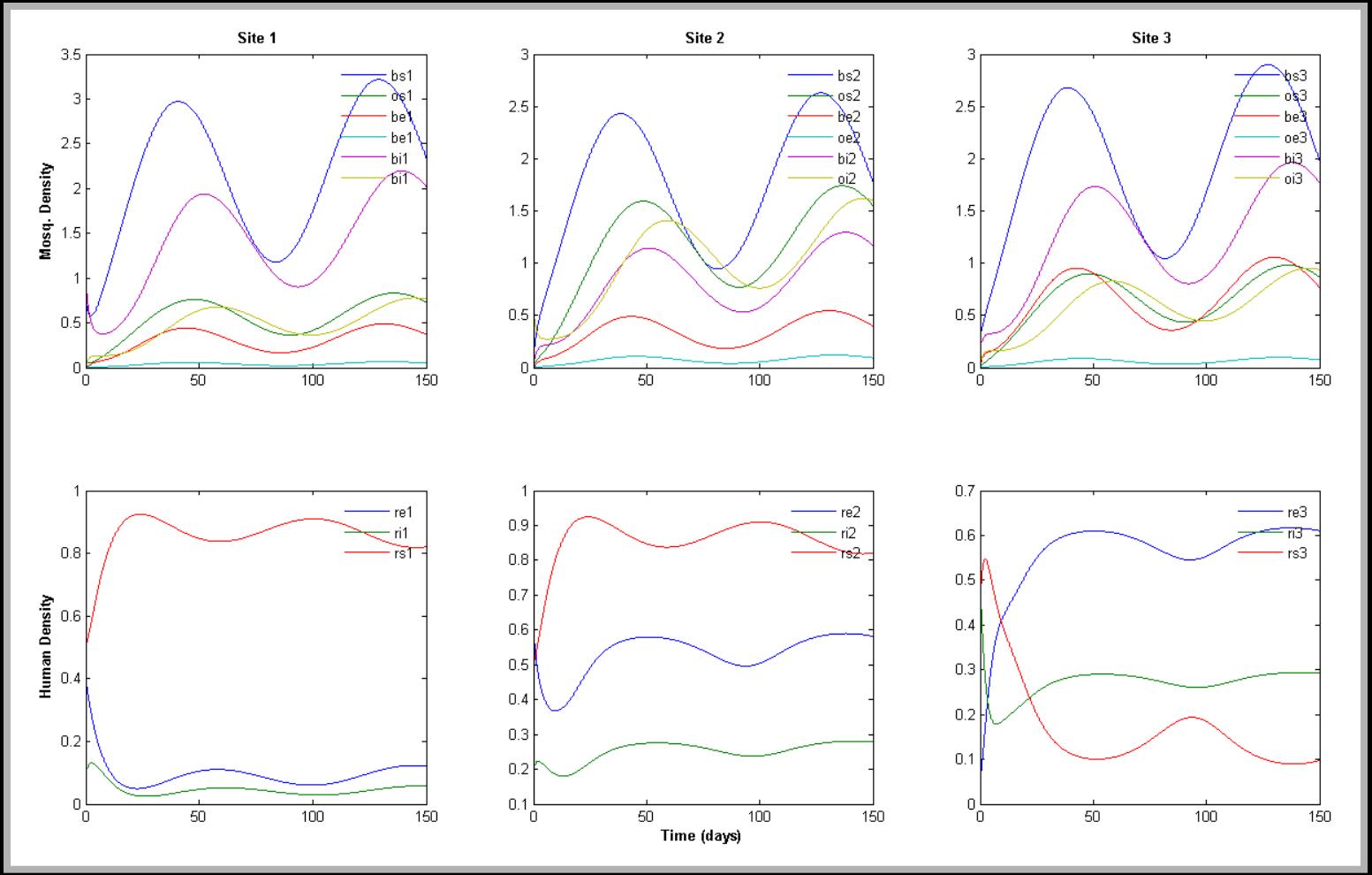


MOSQUITOS
SEEKING
BLOODMEALS



MOSQUITOS
IN OVIPOSITION

Malaria Transmission Among 3 Locations Under Seasonal Sinusoidal Larval Forcings



INDONESIA



A. balabacensis, A. minimus, A. maculatus

AFGHANISTAN



A. stephensi, A. culicifacies, A. fluviatlis

Malaria in Afghanistan

- Little public health support is available after three decades of non-stopped military conflicts and instability. The once successful vertical malaria control program has long been abandoned.
- Wars promote malaria transmission owing to altered environment, man-made larval habitats, damaged dwellings, tent or outdoor living, lack of personal protection, non-immune refugees and displaced populations.
- Approximately 14 million people live in endemic areas. It ranks the 2nd highest in the WHO EMRO region, and 4th highest outside Africa.
- International aids help to establish a Basic Public Health Service Package, which includes malaria treatment and control.

Climate and Malaria

- It is a relatively dry country with frequent sandstorms.
- Climate varies according to elevation and location. Kabul (1,795m) has cold winters and pleasant summers. Jalalabad (550m) is subtropical. Kandahar (1,006m) is mild year-round.
- Daytime temperatures may range from freezing at dawn to ~38°C at noon. Summer temperatures can be as high as 49°C in the northern valleys. Midwinter temperatures can be as low as 9°C at 1,980m in the Hindu Kush.
- Malaria occurs at altitudes < 2,000m and is most prevalent in snow-fed river valleys and rice growing areas.
- Transmission is seasonal from June to December.

richard.kiang@nasa.gov

Phlebotomine sandfly

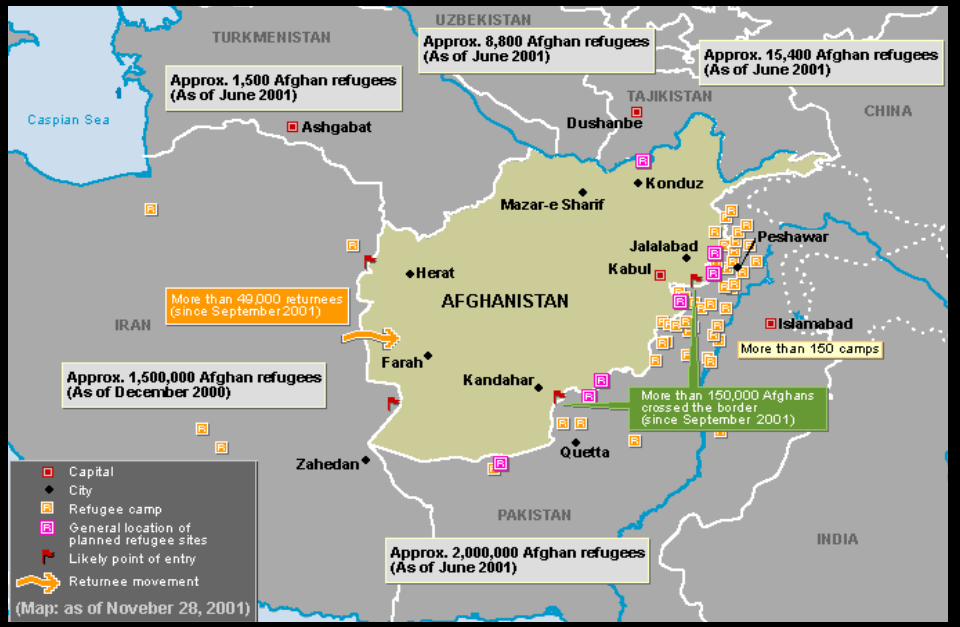
Cutaneous leishmaniasis

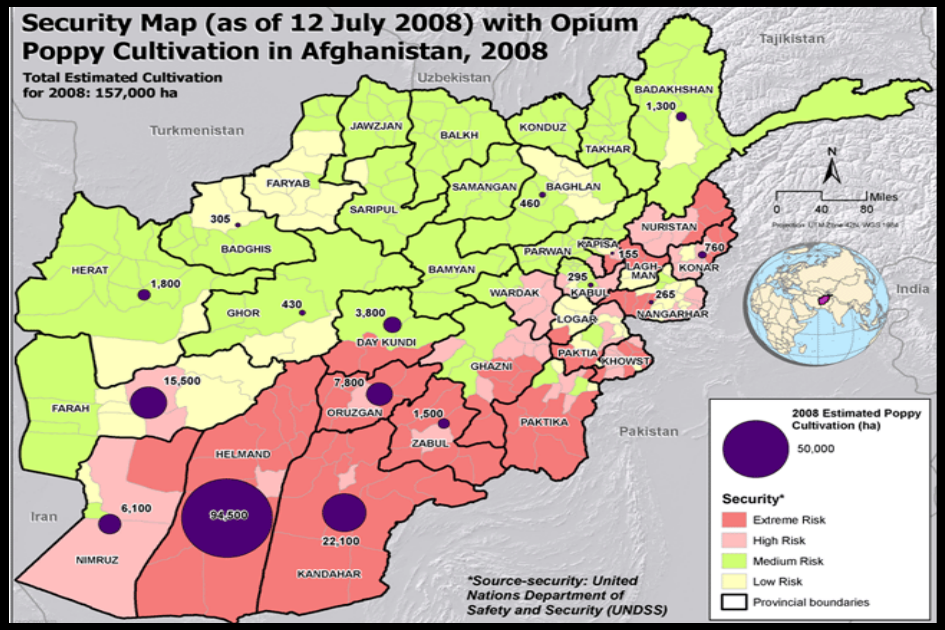
Mucocutaneous leishmaniasis

Visceral leishmaniasis

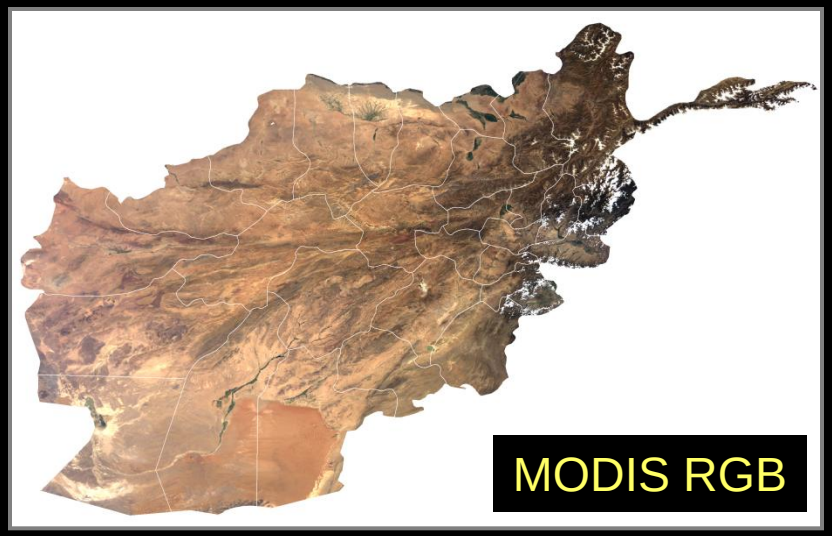
Agriculture in Afghanistan

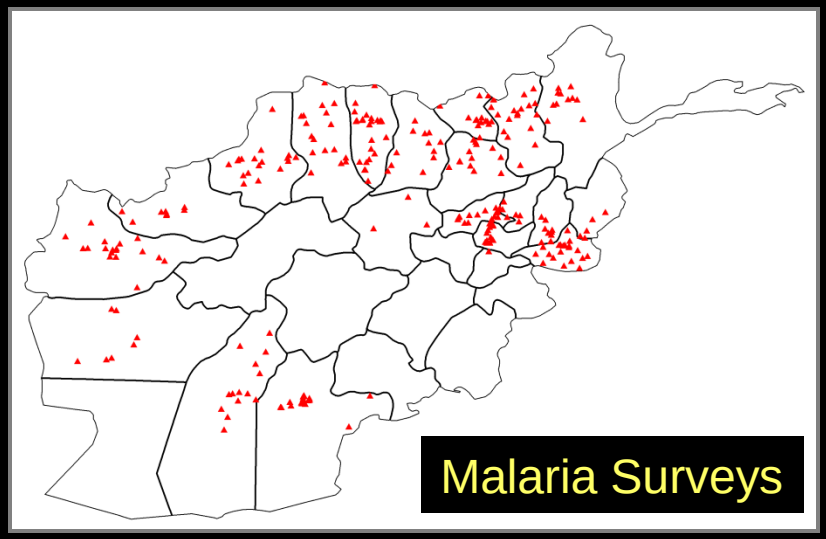
ISAF, Refugees, Poppy, Security & Malaria

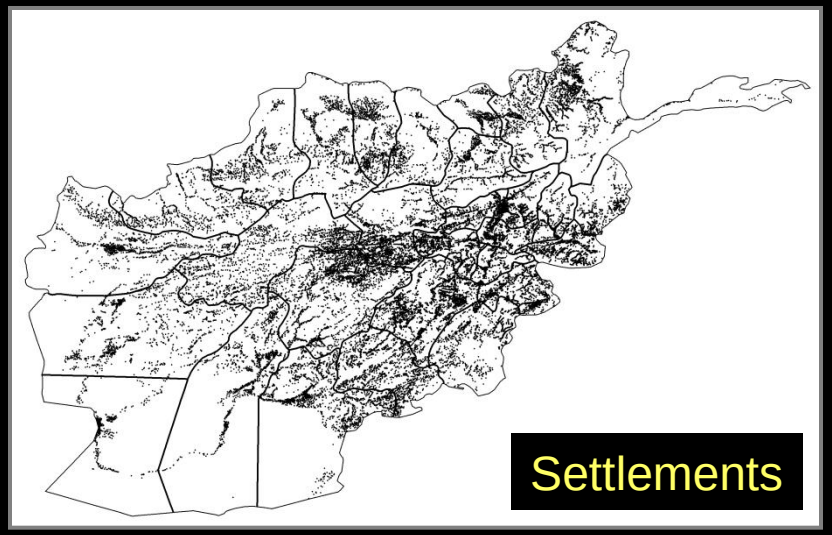


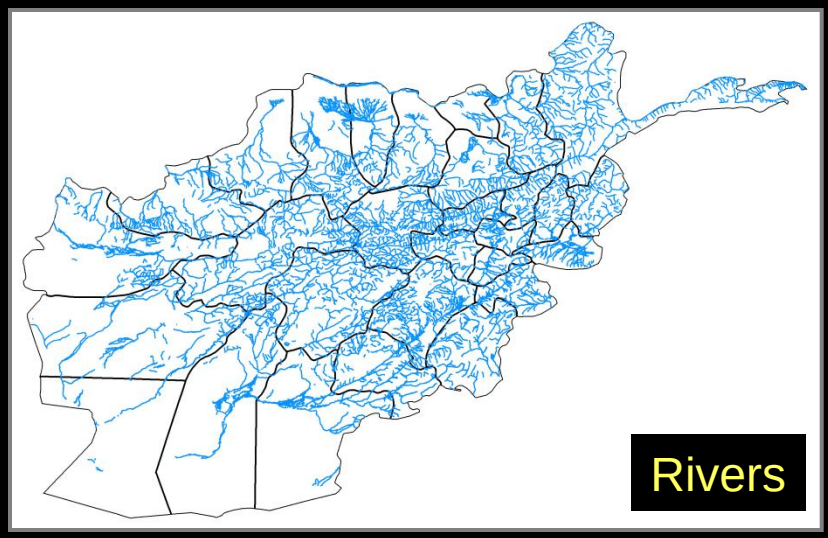


Afghanistan









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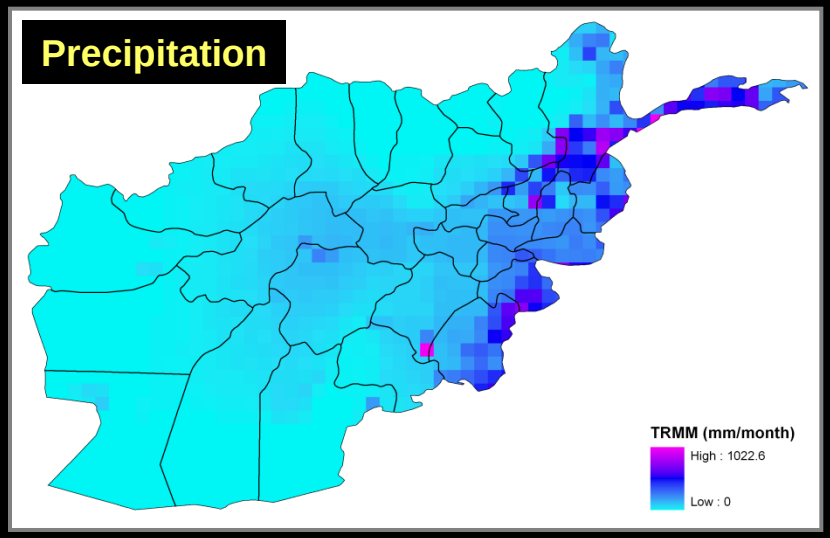
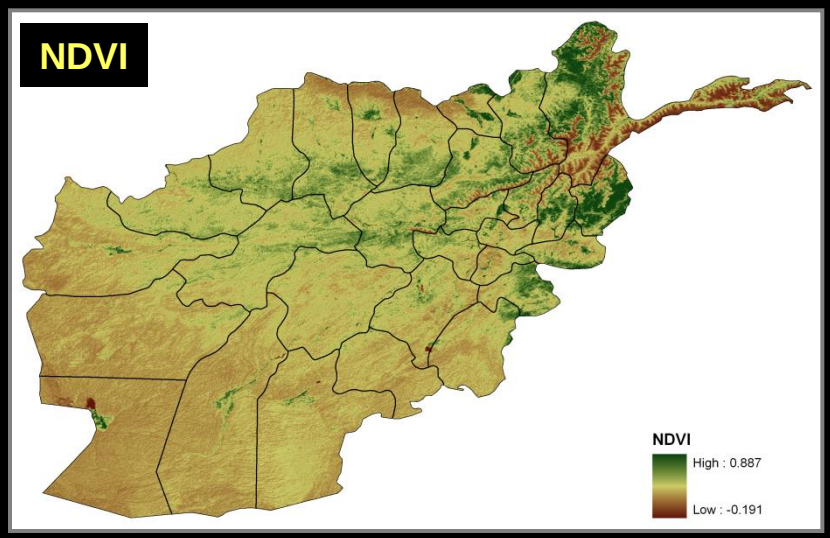
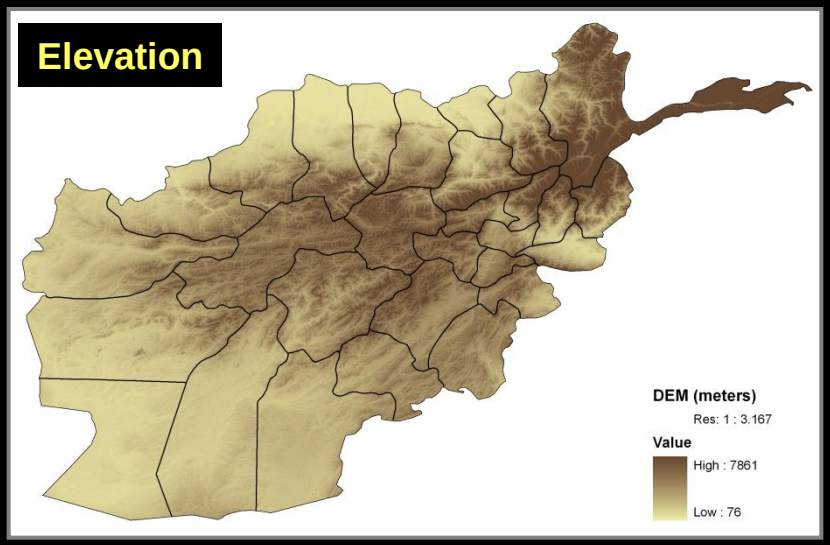
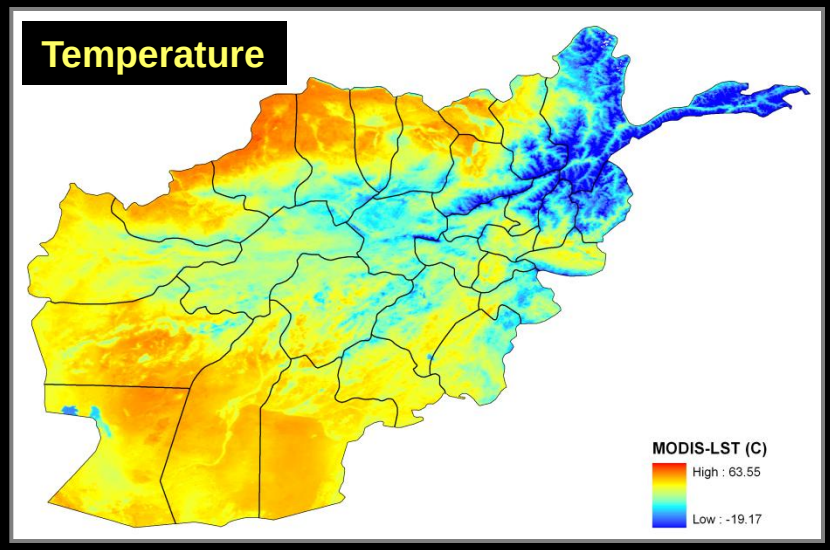
Afghanistan









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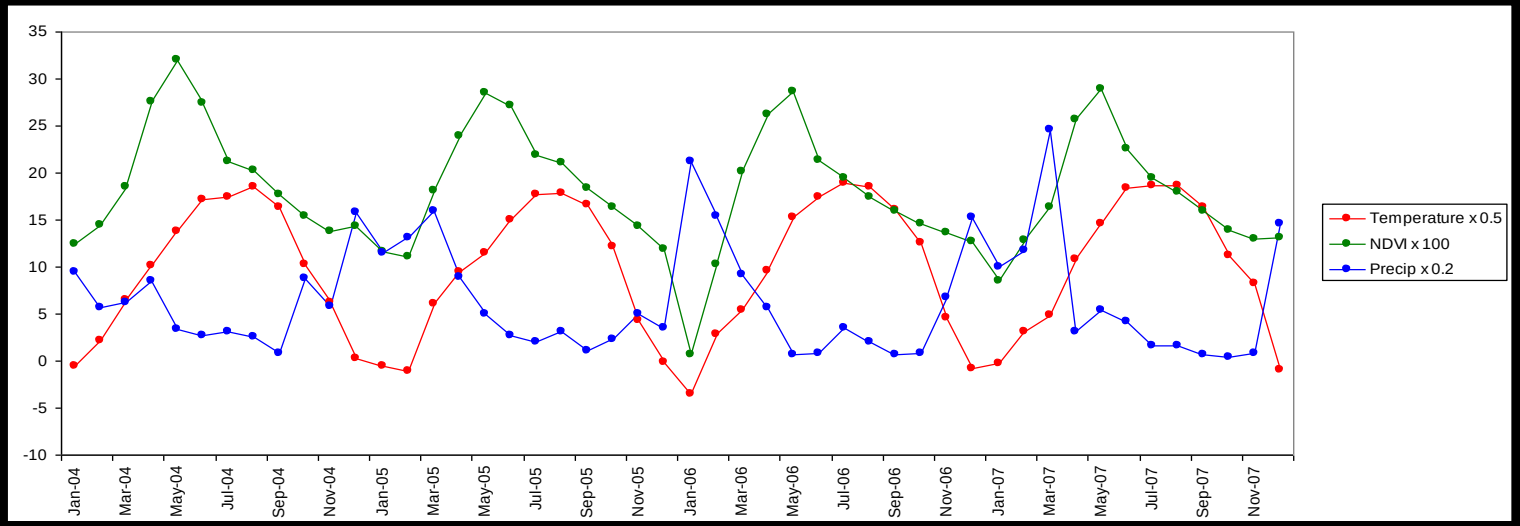
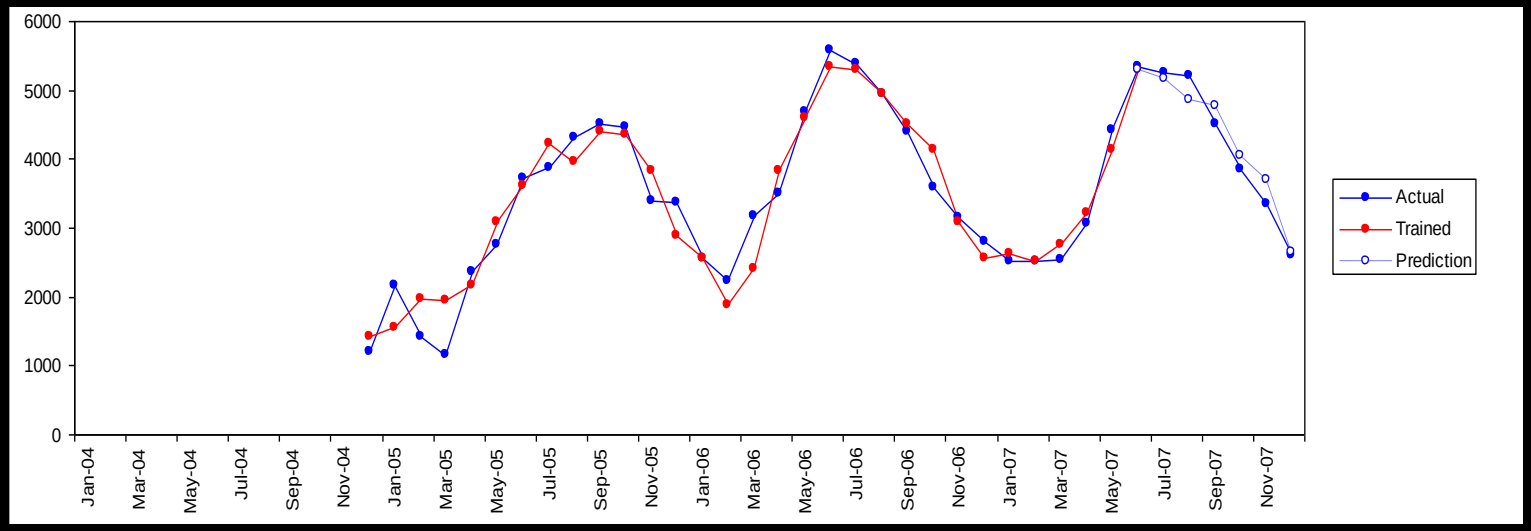
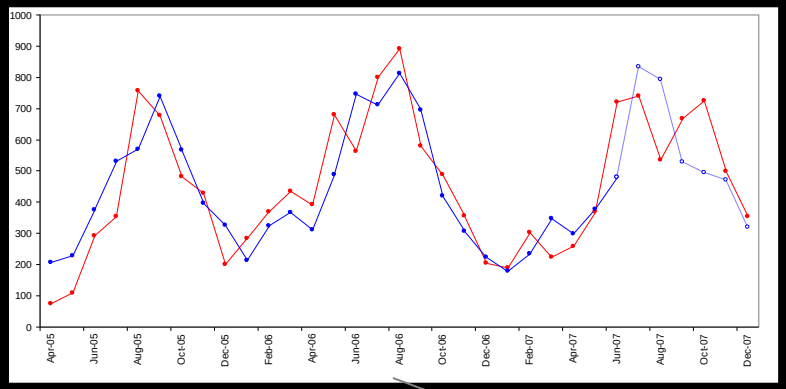
Modeling and Predicting Malaria Prevalence

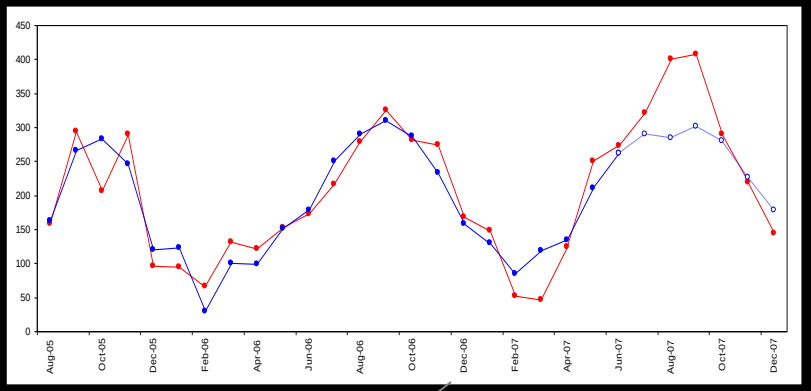
Takhar Province, Afghanistan



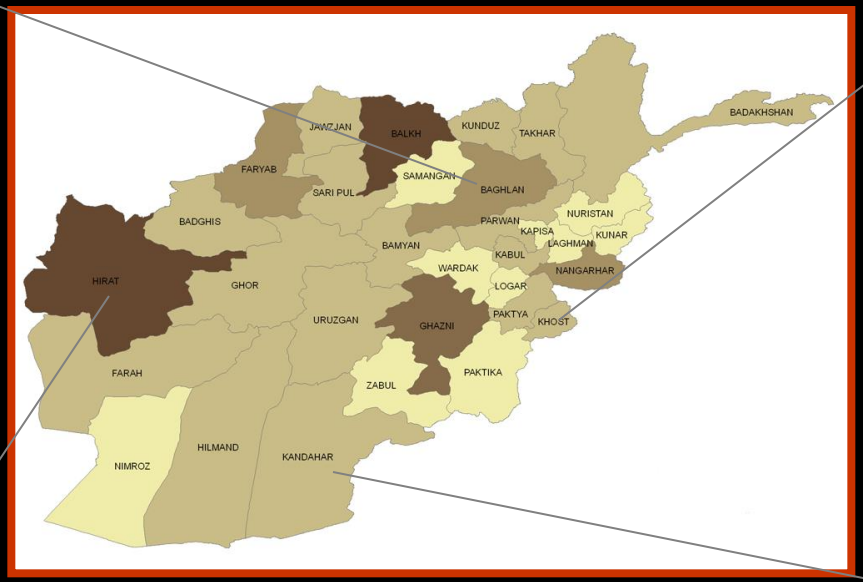




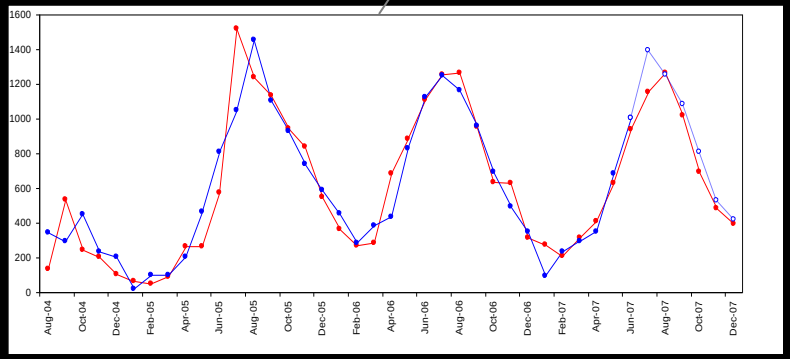
BAGHLAN



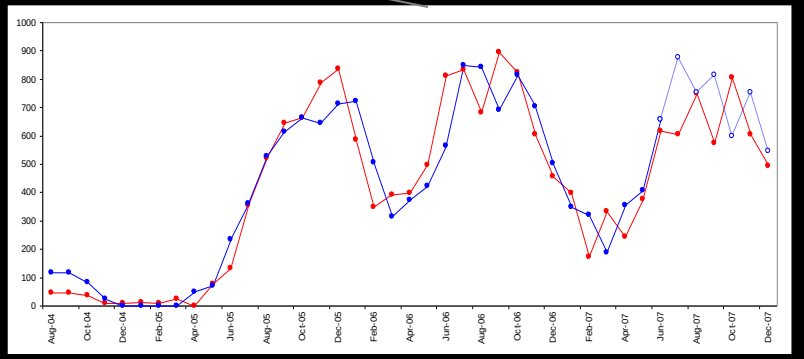
KHOST



HIRAT



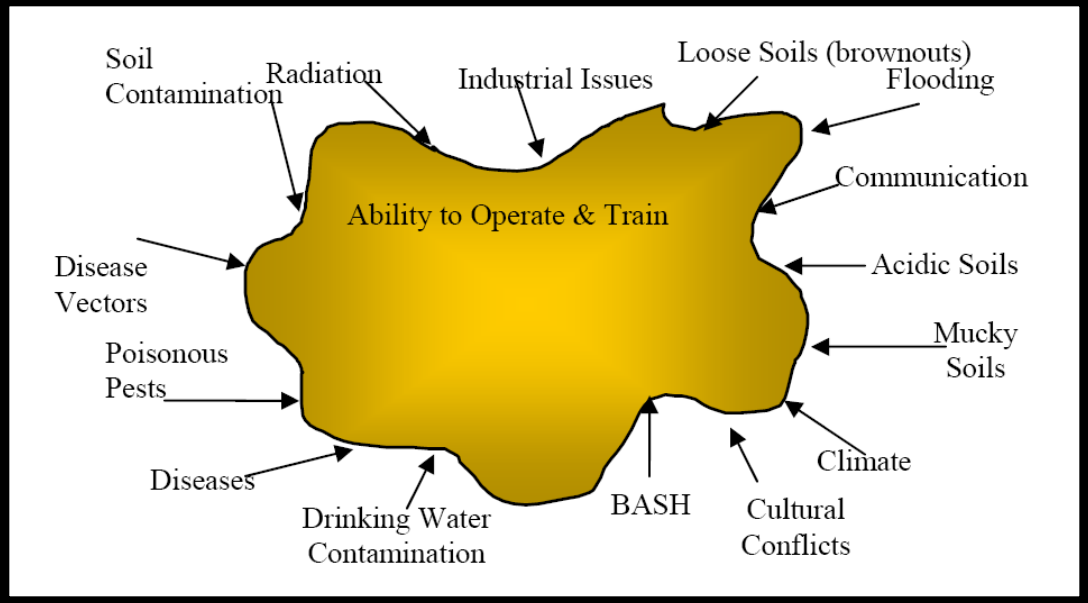
KANDAHAR



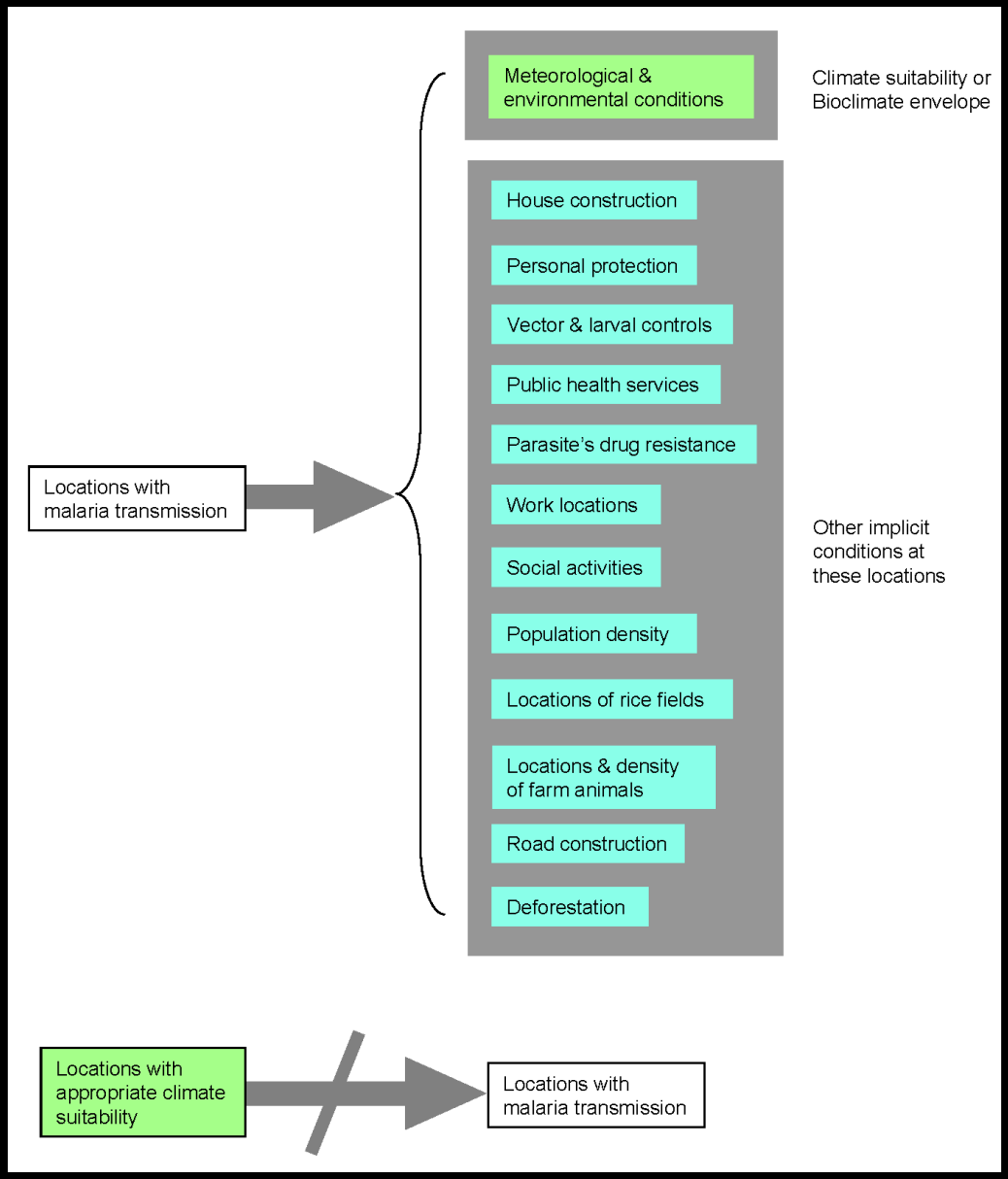
BENCHMARKING

Rationale for Developing GSAT

"Costly environmental and preventive medical assessments are usually conducted AFTER troops are deployed to austere sites around the world. This results in unplanned exposures and risks toward warfighters. GSAT is aimed to address this capability gap."

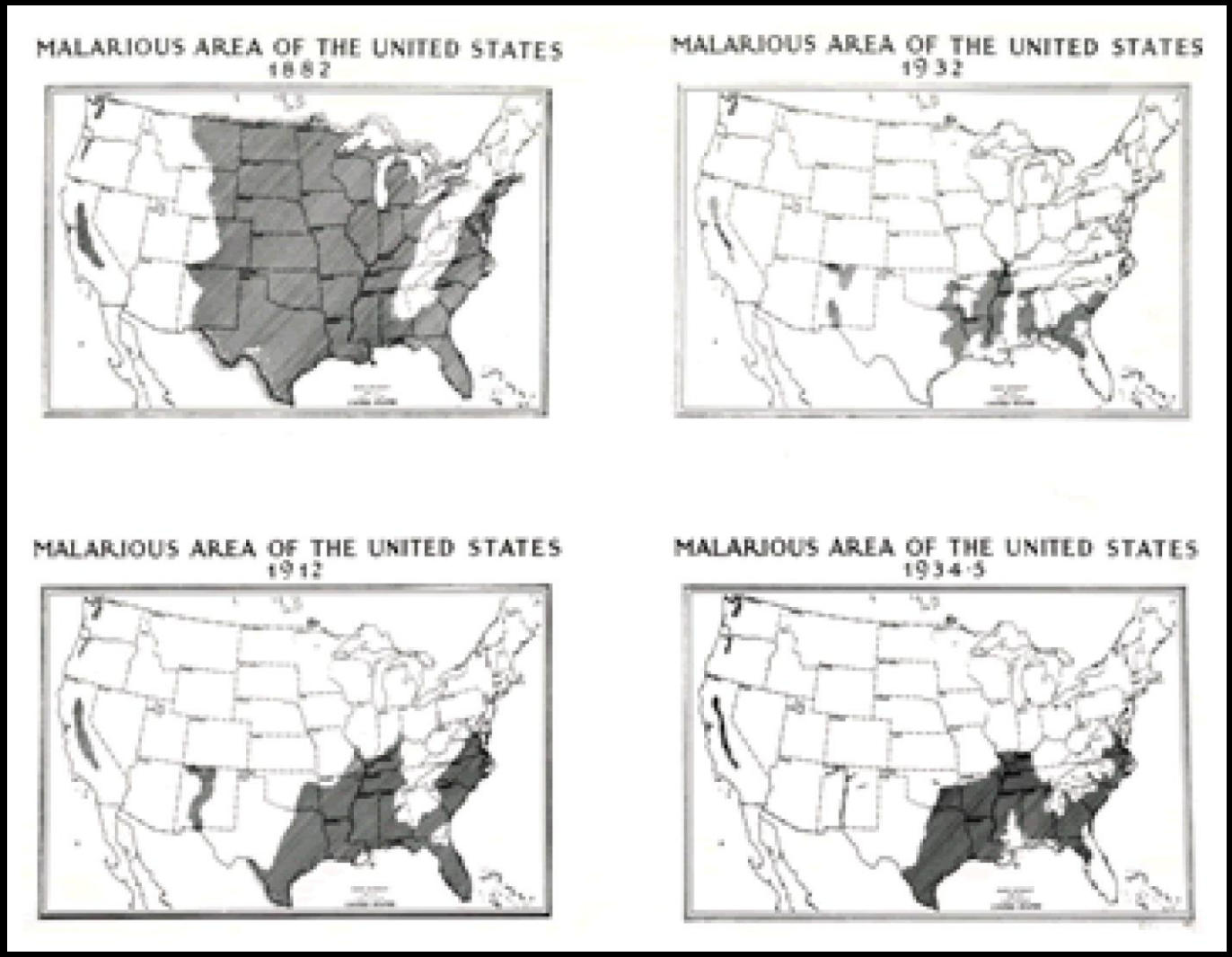


"These factors constrain and erode the operational effectiveness of our forces."



Potential Complications with Climate Suitability or Bioclimate Envelope Based Modeling of Malaria Risks

Historical Malaria Distribution in the US



Thank you!

richard.kiang@nasa.gov