Development of a Detection and Early Warning System for Malaria Risk in the Amazon

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The Peruvian Amazon

- Almost 90% of malaria in the Western Hemisphere is located in the Amazon
- 25% of the malaria burden in the Americas is in 12 municipalities of Peru, Brazil and Venezuela
- 60% of cases in Peru are in the Department of Loreto

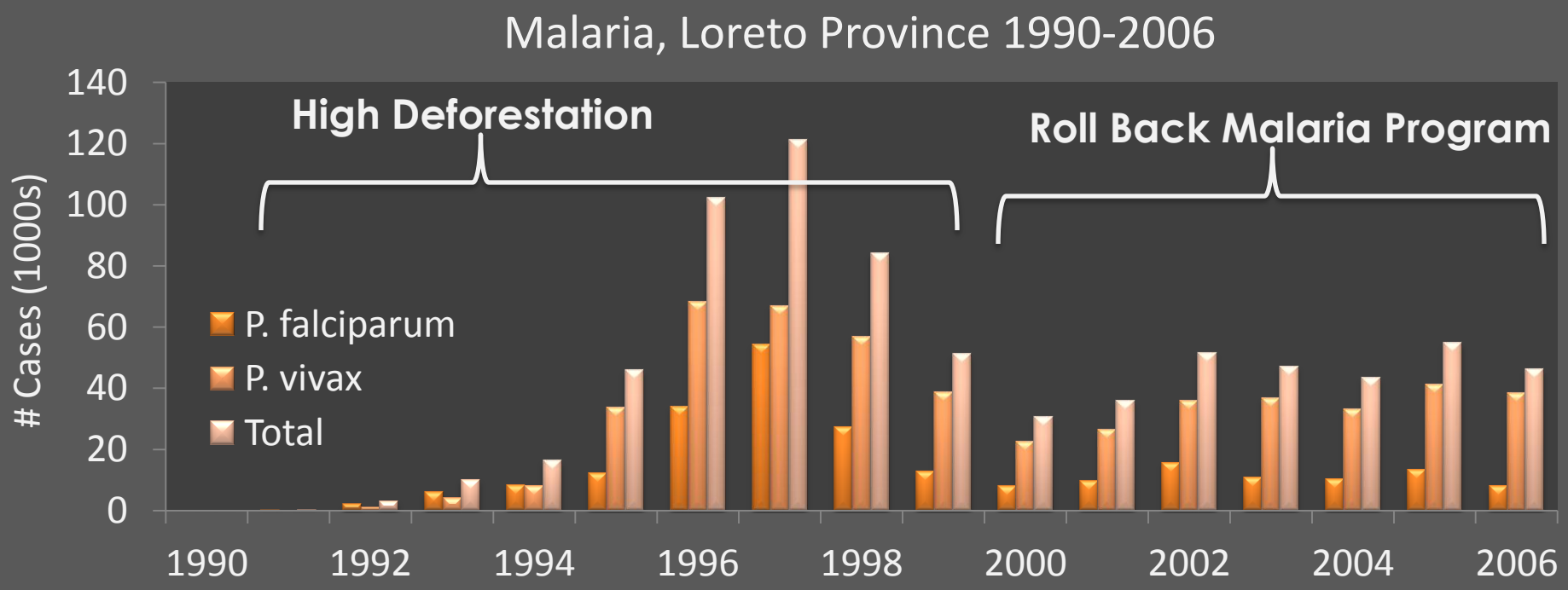
Aims

Feasibility Study: develop a spatially explicit model of malaria transmission risk on the basis of predicted *Anopheles* density and mapped human settlement and activity patterns

End application: operational risk monitoring system to inform decisions on resource distribution and vector management by our collaborators (PRISMA, State Health Ministry, US NMRCD)

Malaria on the Amazon Frontier

- Relationships between land use, mosquito ecology, climate, human activity, and malaria risk are complex

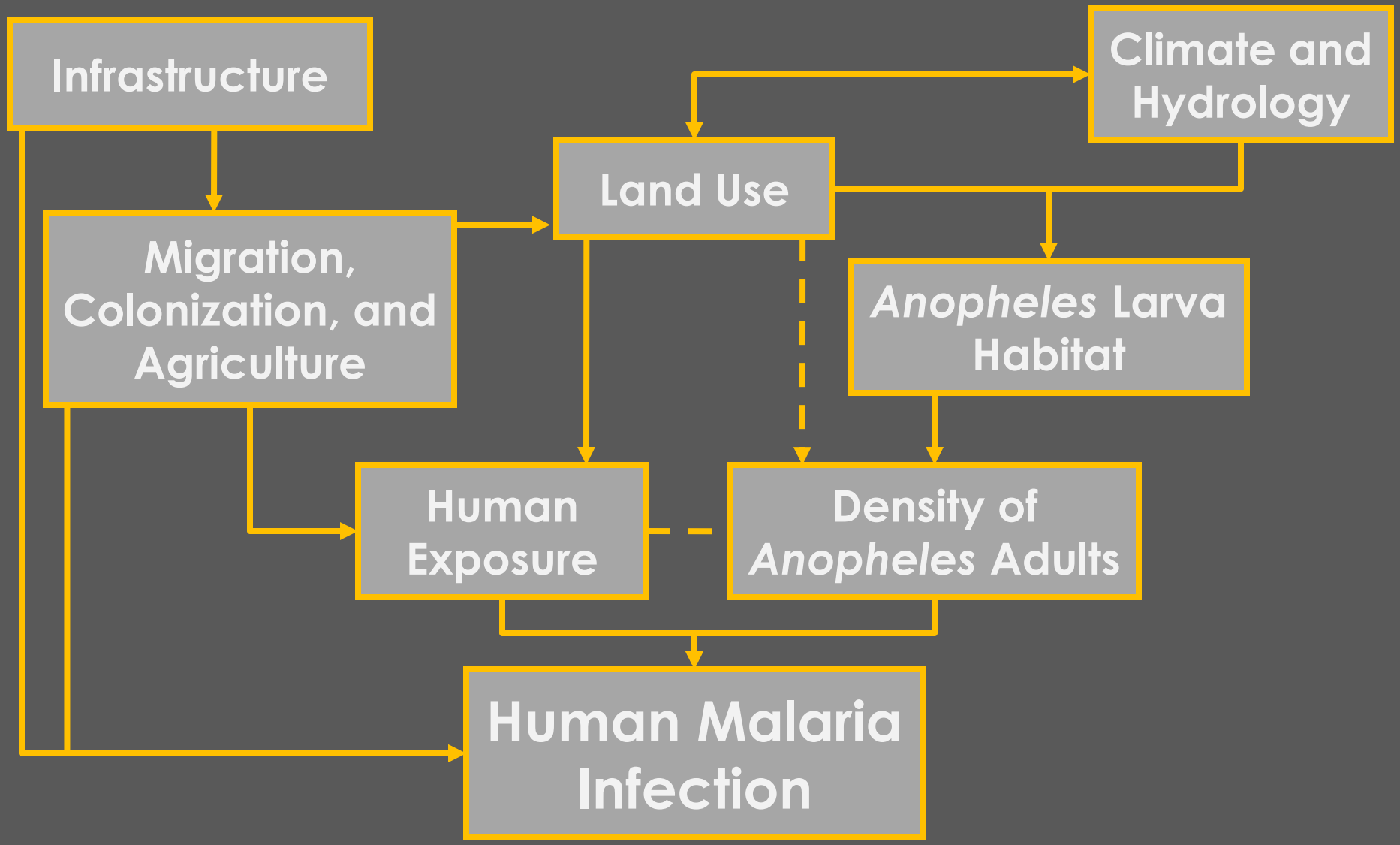


Malaria on the Amazon Frontier

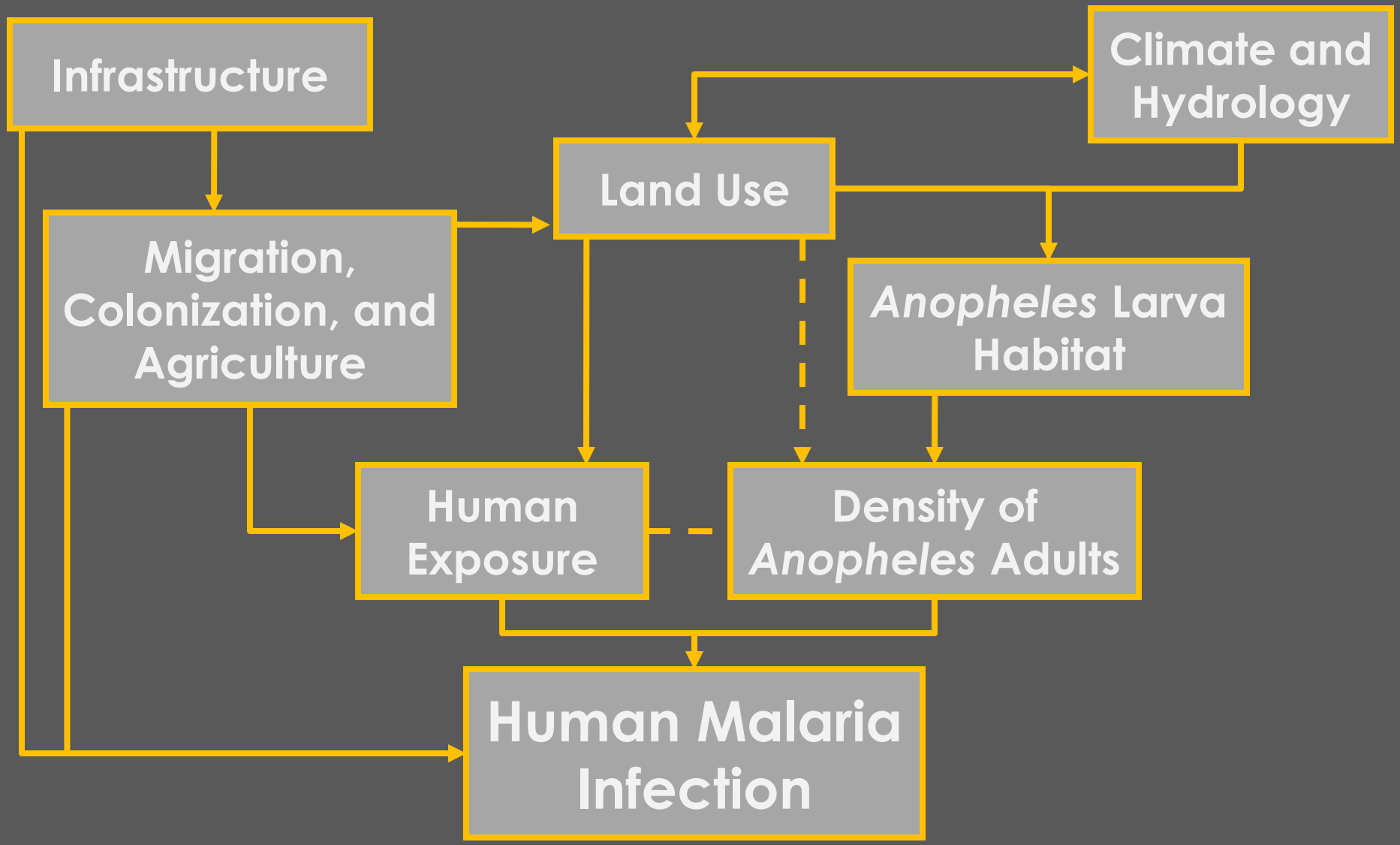
- Relationships between land use, mosquito ecology, climate, human activity, and malaria risk are complex

- But strong biophysical links exist, and they can be monitored and addressed through integrated analysis

Malaria on the Amazon Frontier



Malaria on the Amazon Frontier



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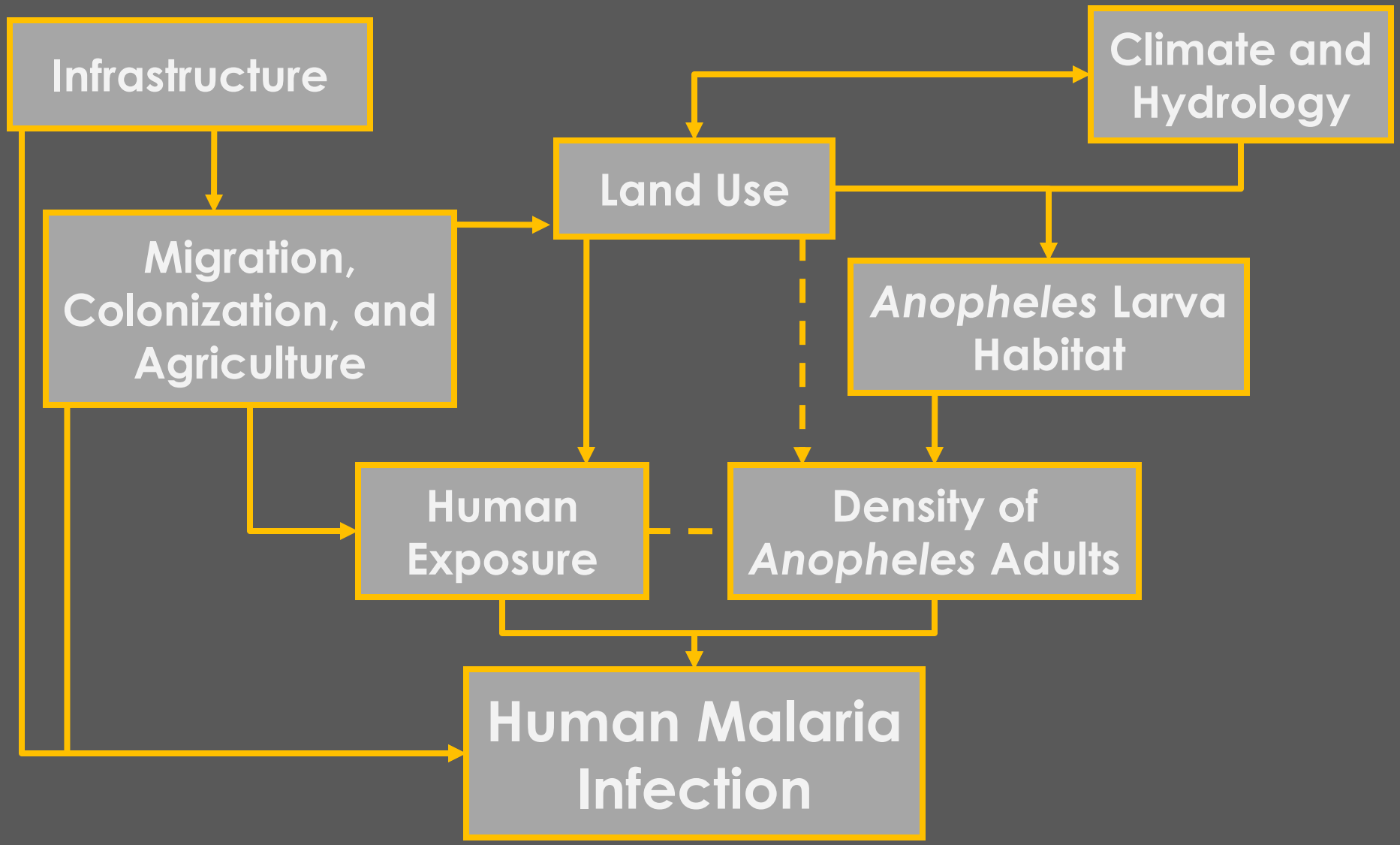


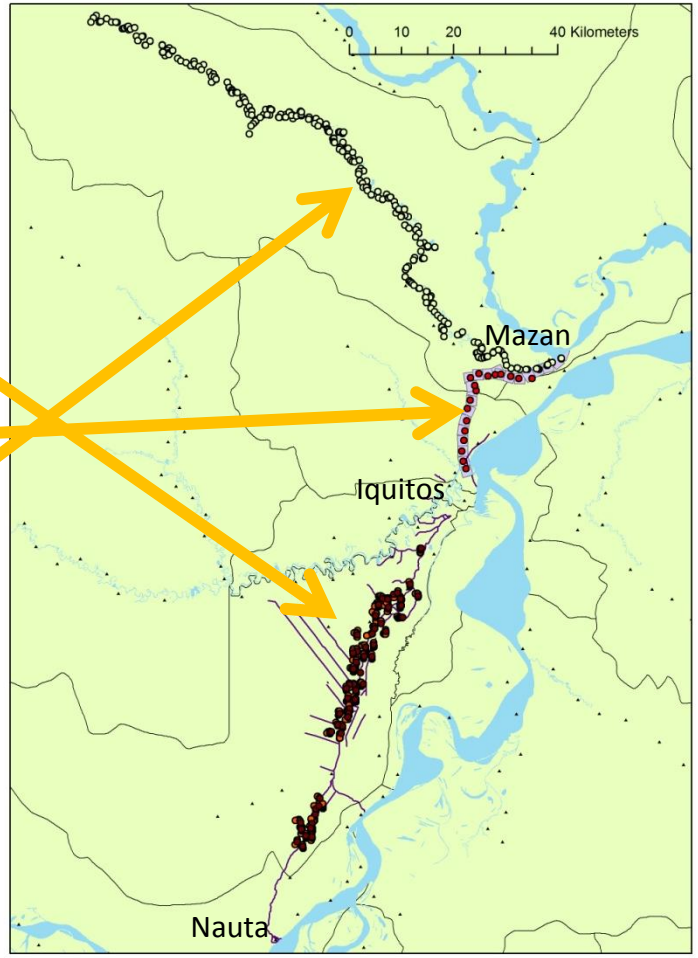
Approach

- Spatio-temporal Ecological *Anopheles* model
  - Input 1: Satellite-based land cover maps
  - Input 2: Meteorological data
  - Input 3: Land Data Assimilation System
- Human Activities and Settlements Map
  - Input 1: Satellite and *in situ* mapping
  - Input 2: Census and Economic data
- Eco-epidemiological Malaria Transmission Model
  - Application: Risk monitoring and prediction

Anopheles Collections

<u>Mosquito Collection</u>

- Iquitos-Nauta road: 1999-2001
- Iquitos-Mazan road: 2007-2011
- Additional survey of logging camps



Land Cover Change

Infrastructure Expansion

- Oil Exploration
- Highway construction
- Urban growth

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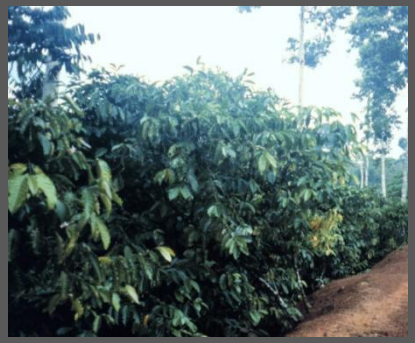
Migration, Colonization, and Phases of Agriculture Development

Annual Crops

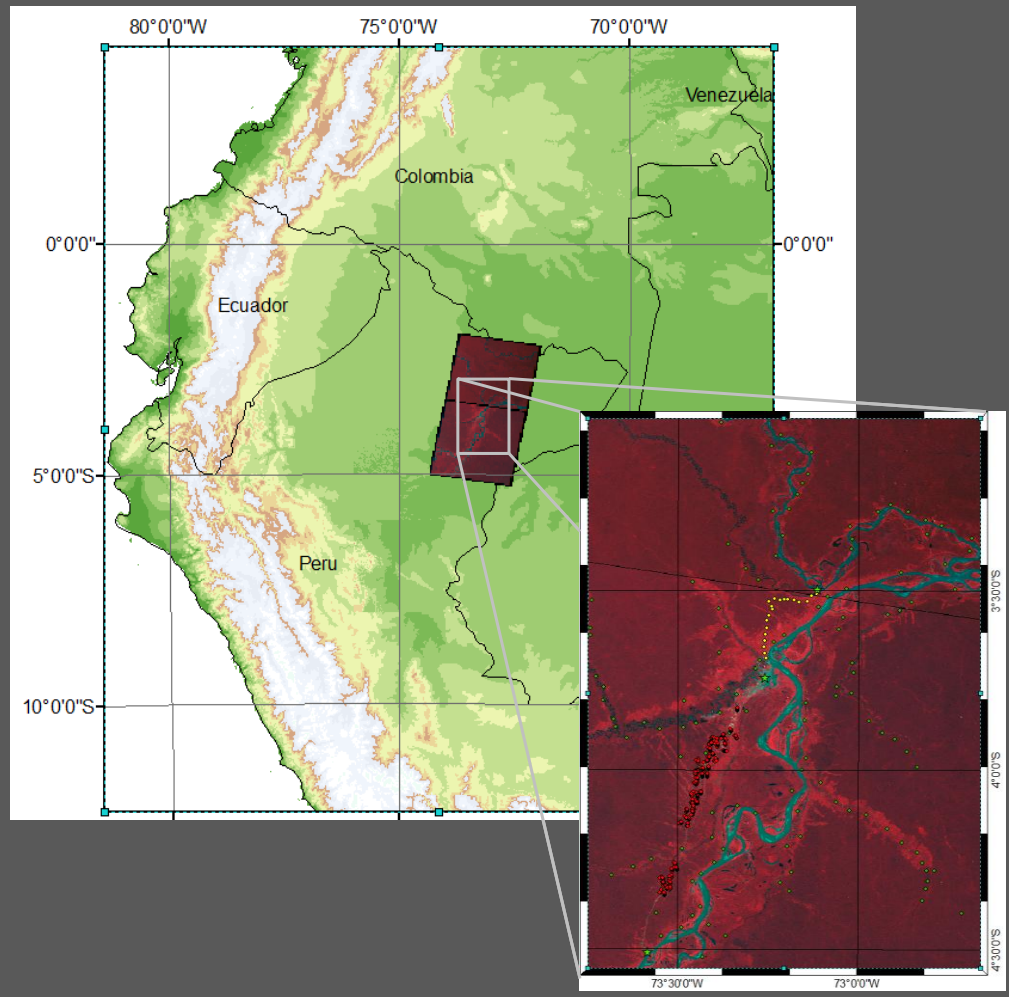
Perennial Crops



Pastures

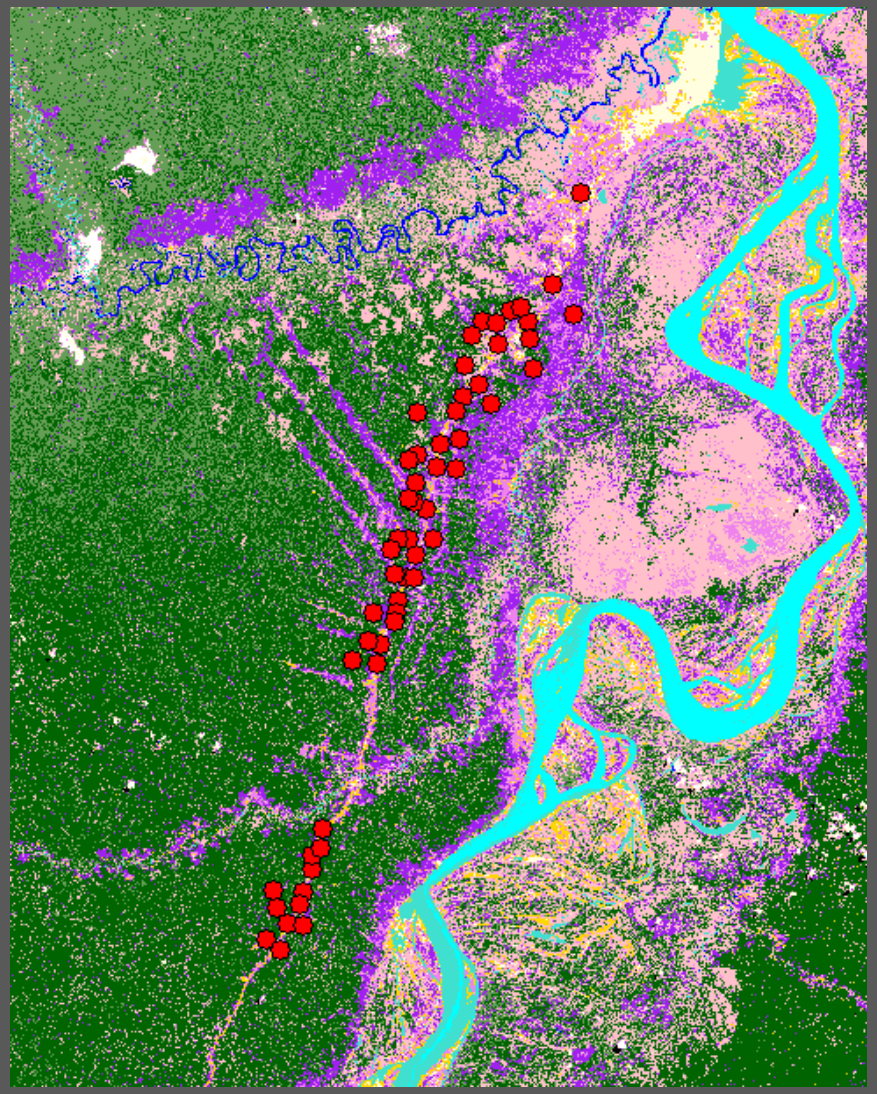
Land Cover Change

- Deforestation and forest disturbance in Peru can be subtle
- Primary tool: Landsat, multi-temporal analysis
- Supplemented with commercial high resolution imagery
- Extensive ground truth

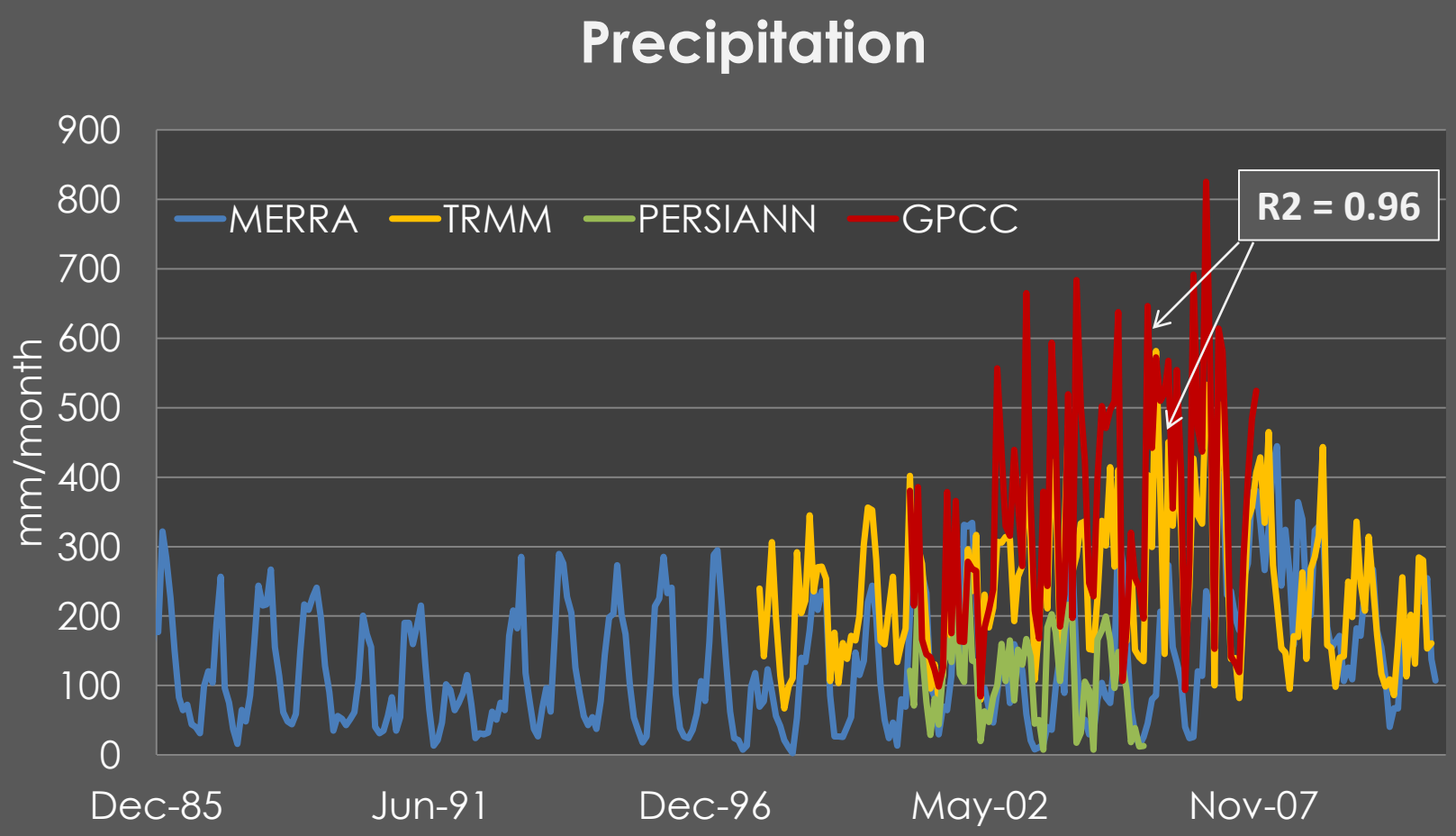


Land Cover Change

- 12 class supervised classification
- Nauta-Iquitos road in 2001and Iquitos-Mazan road in 2009
- Distinction between forest and non-forest appears to be adequate
- Identification of secondary forest is not



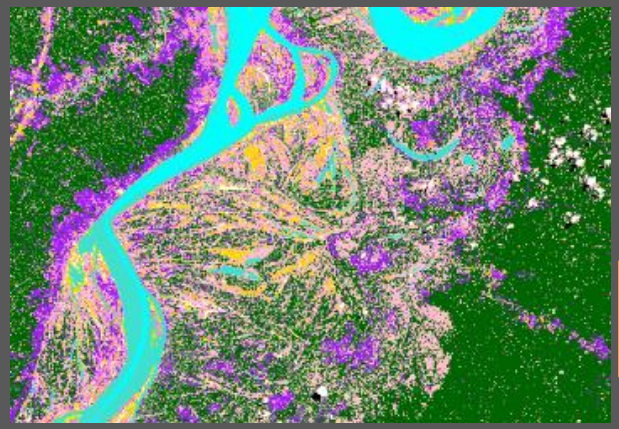
Meteorological Data



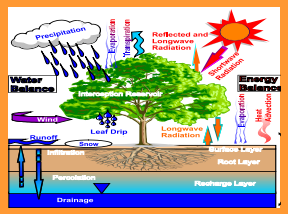
Land Data Assimilation System

Update Observations

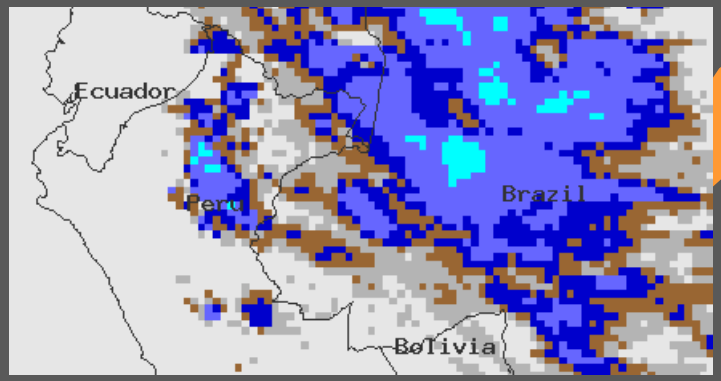
Landscape Information



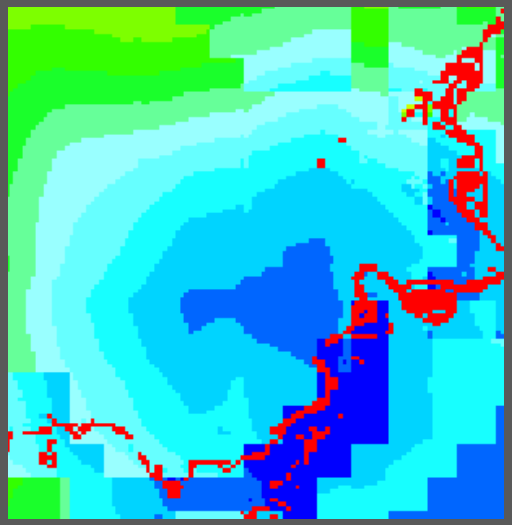
Numerical Model



Meteorological Data

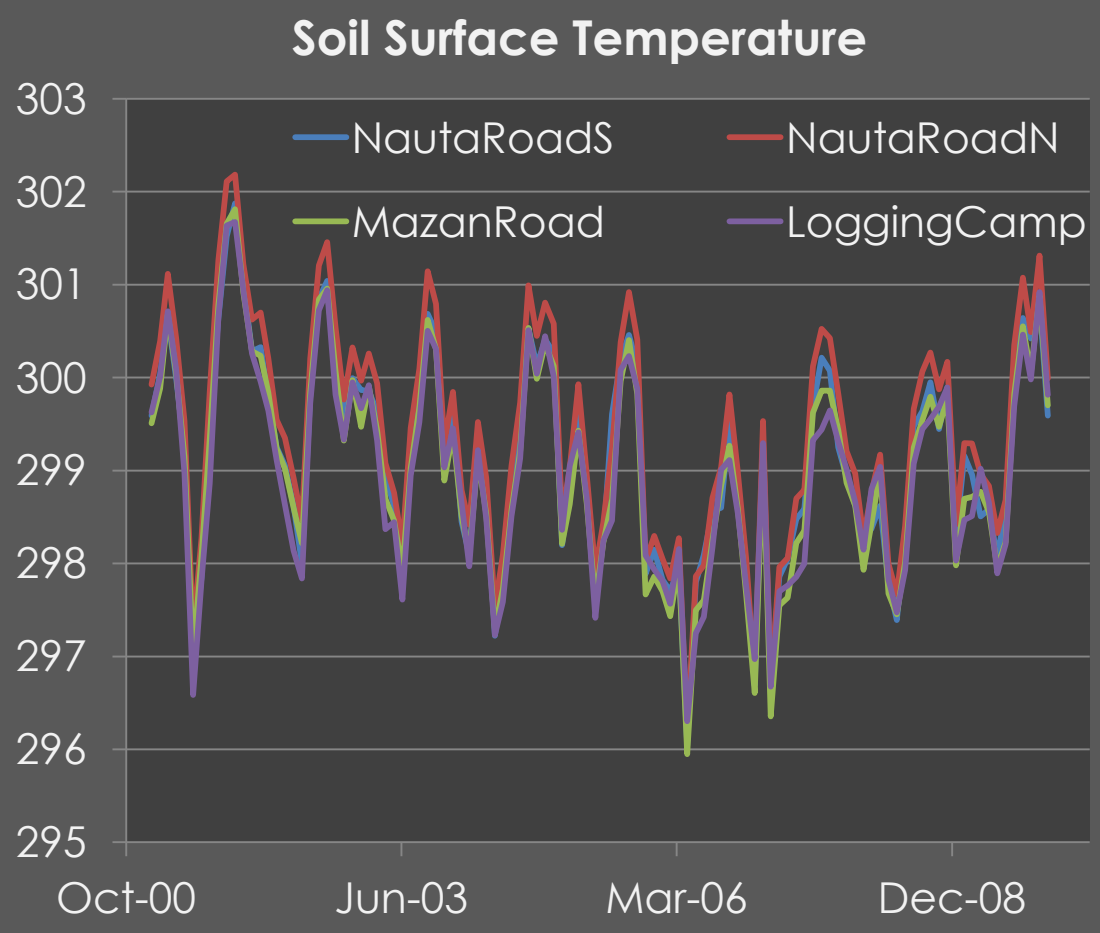


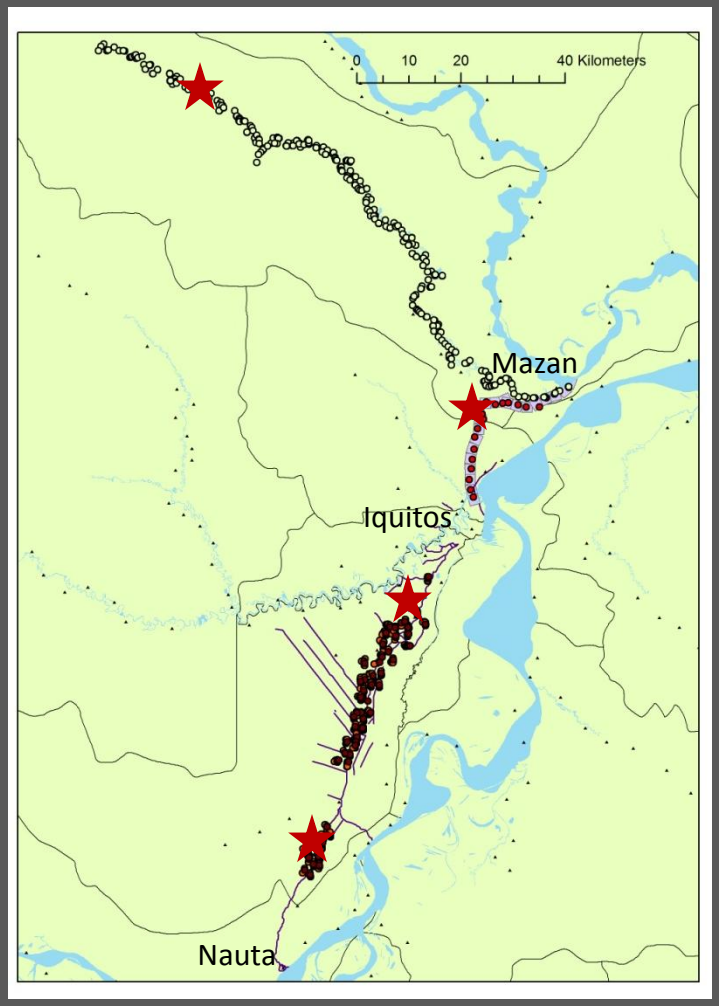
LDAS Output



- Hydrological fluxes and storage
- Localized meteorology
- Surface energy balance

Land Data Assimilation System





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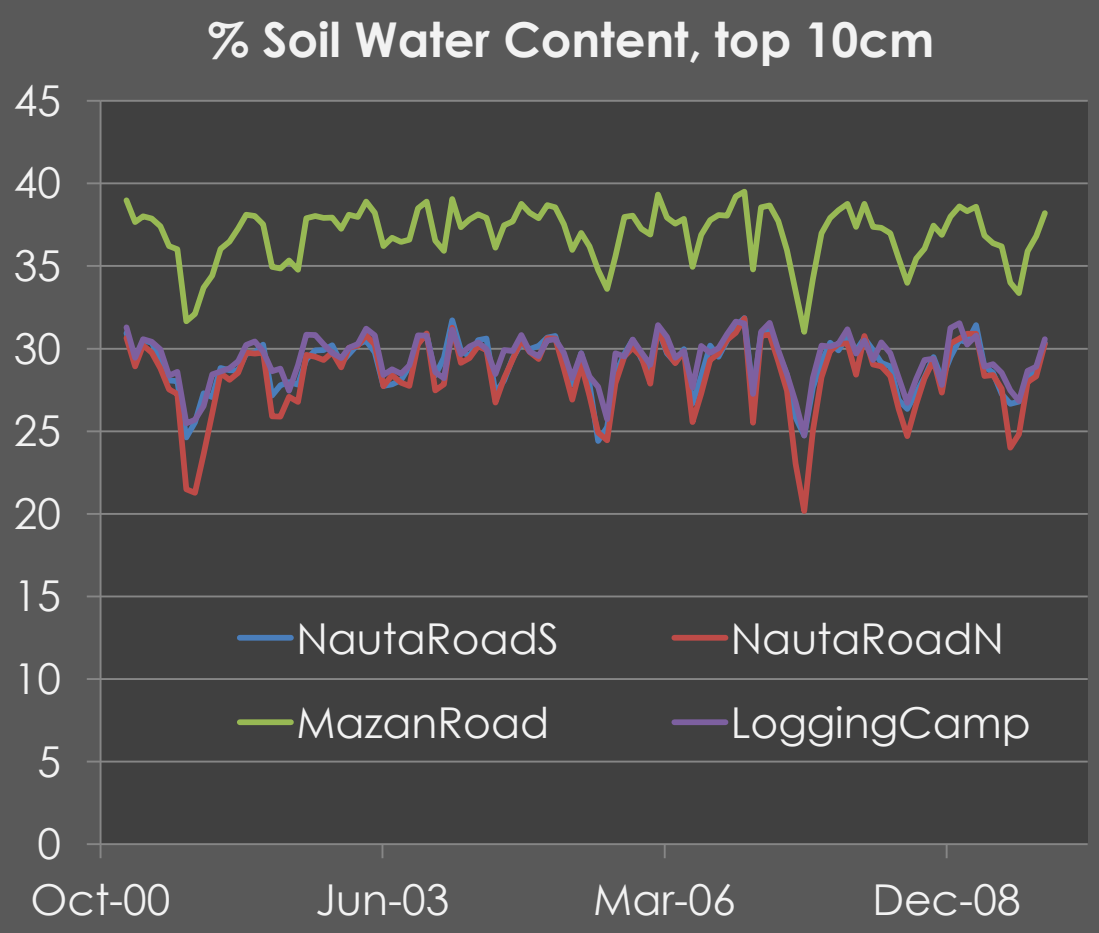
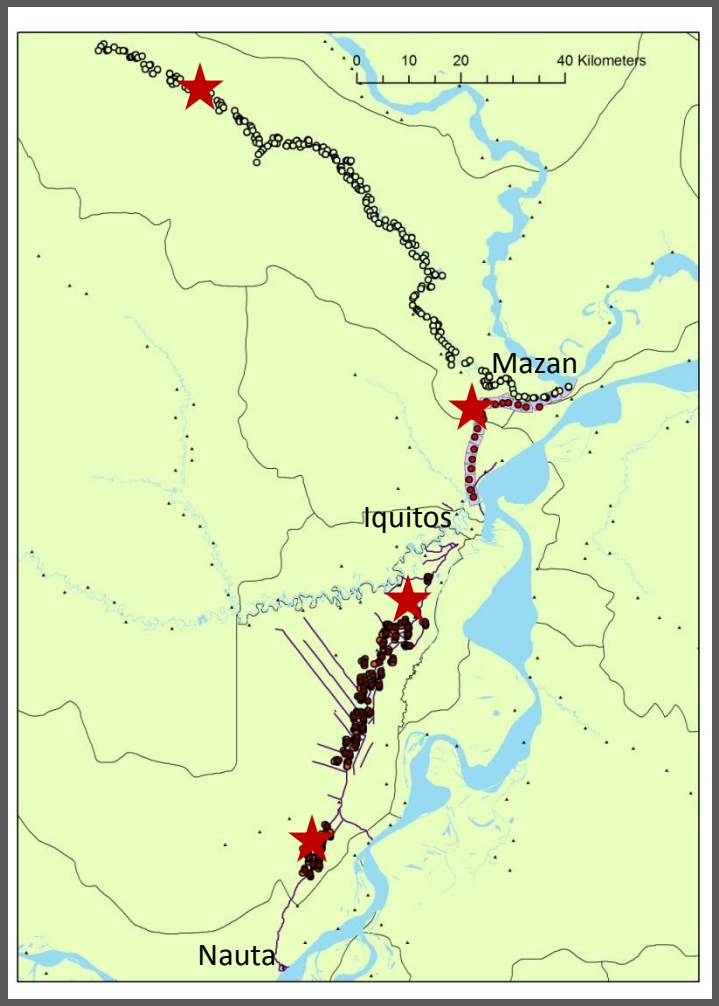
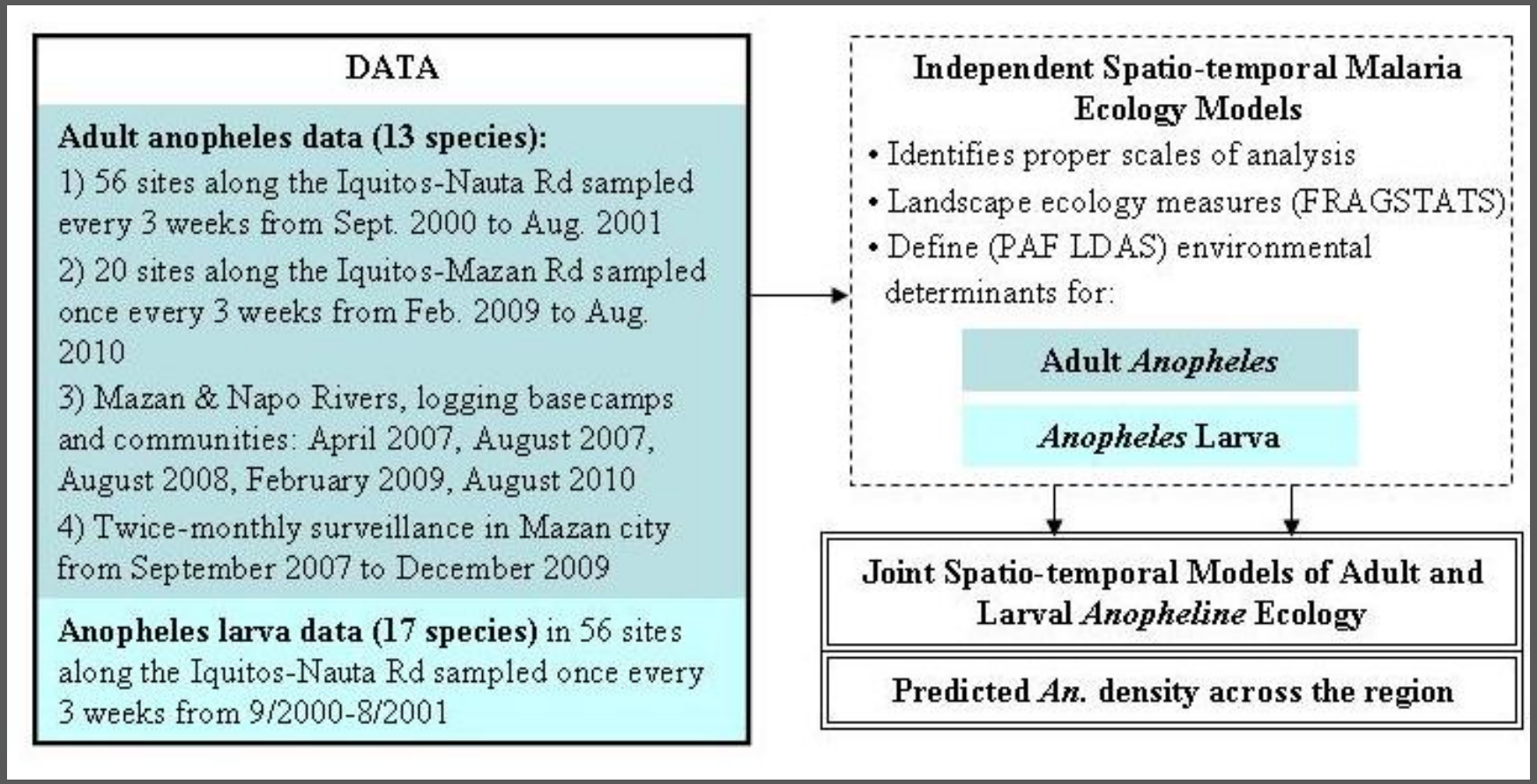




Spatially Explicit *Anopheles* Model



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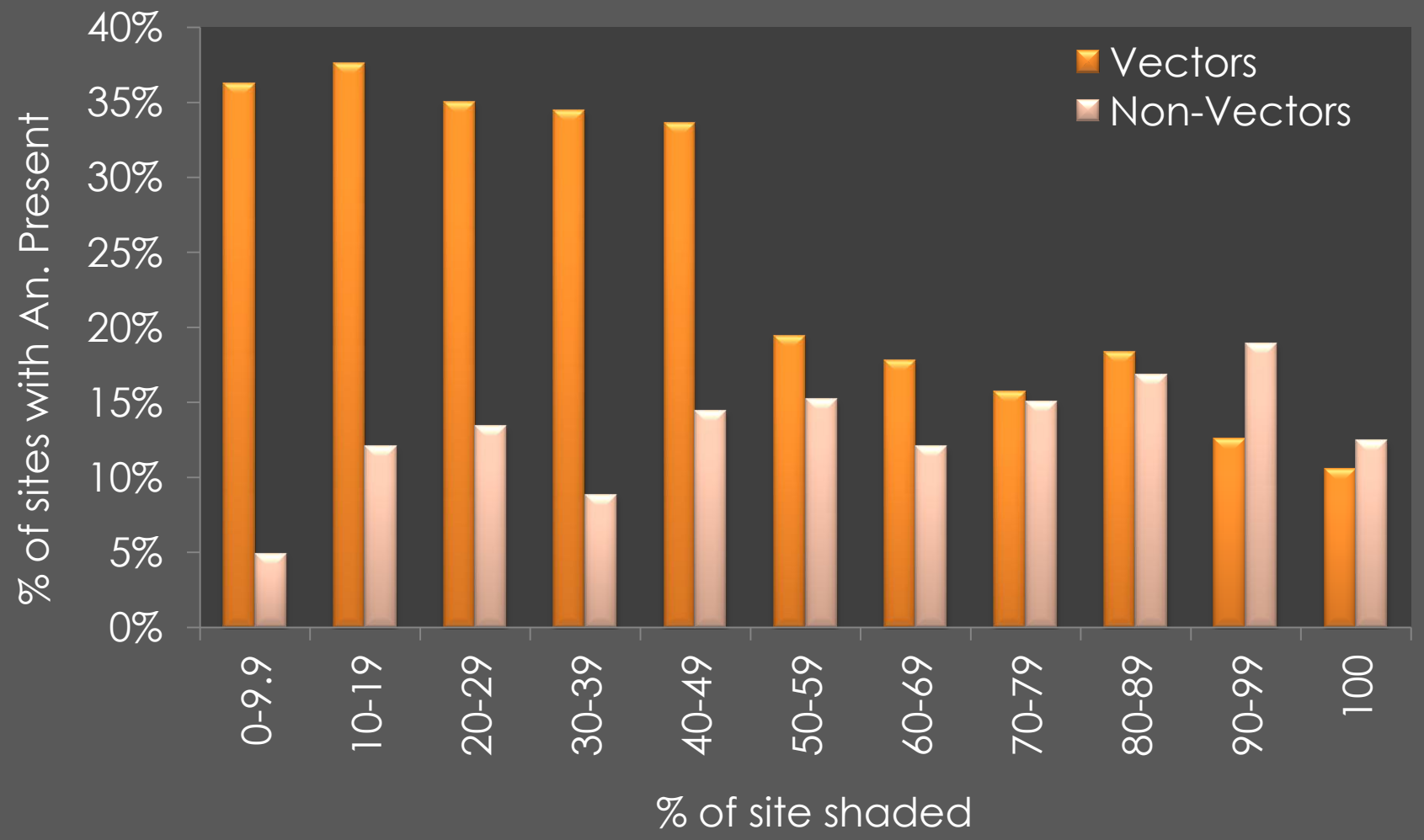

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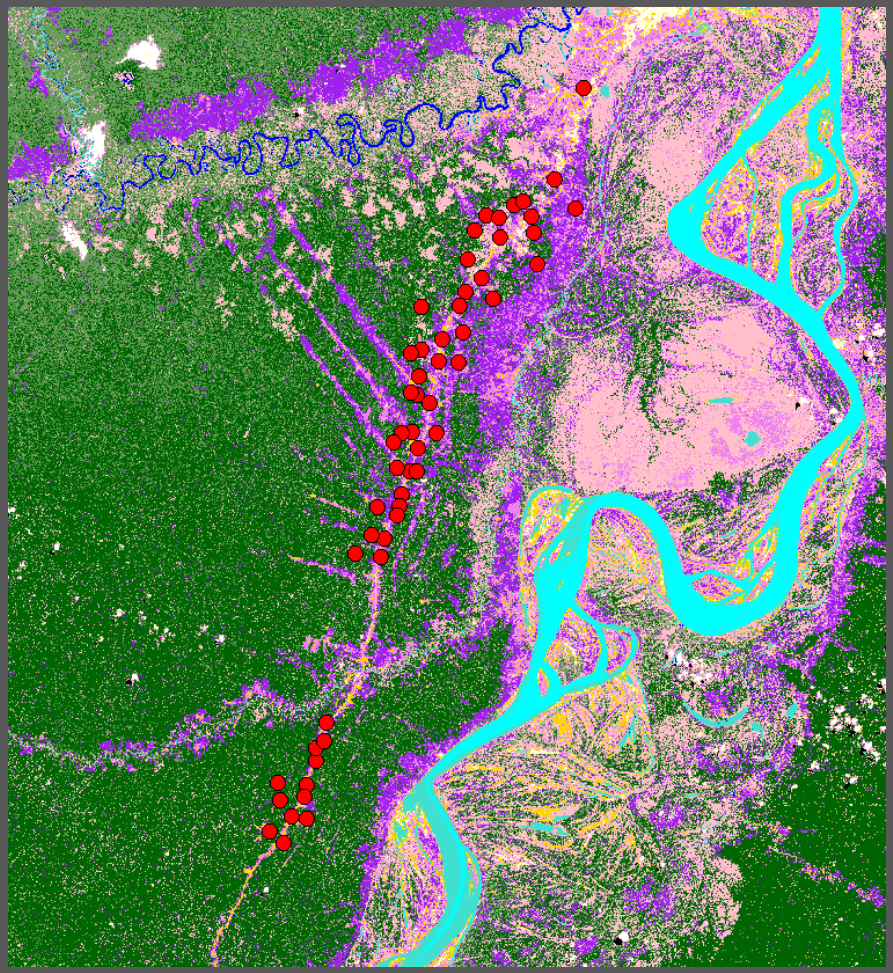
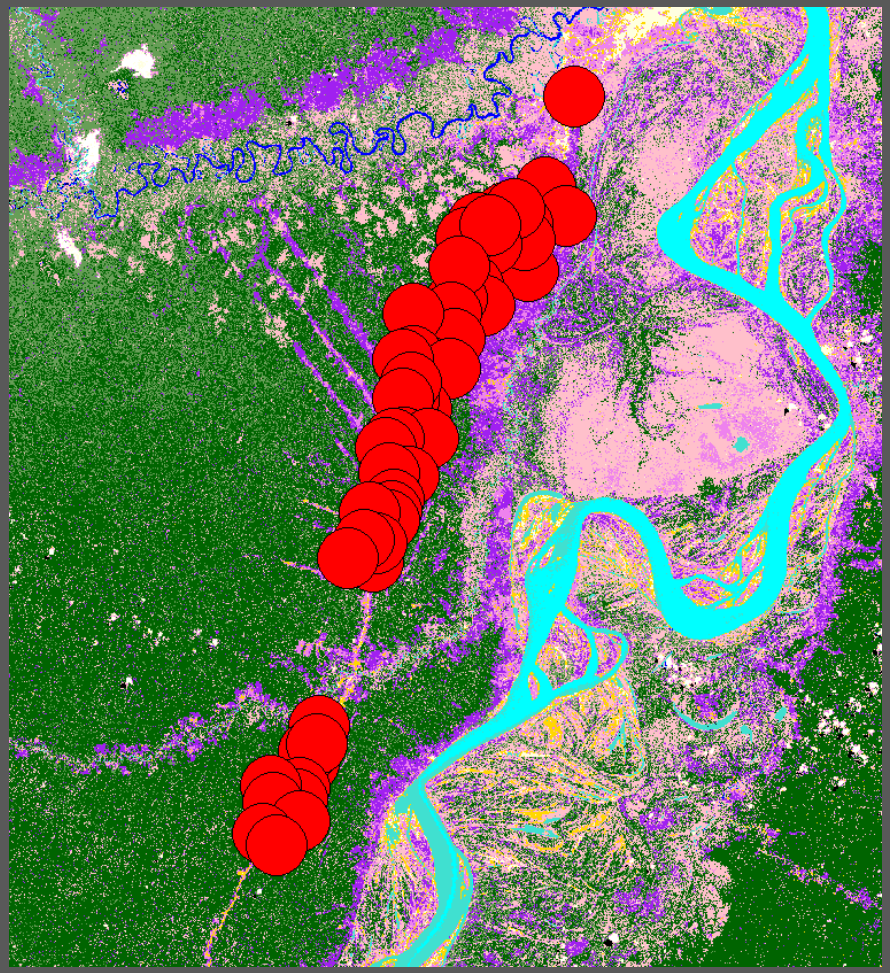


250 m radius



1000 m radius

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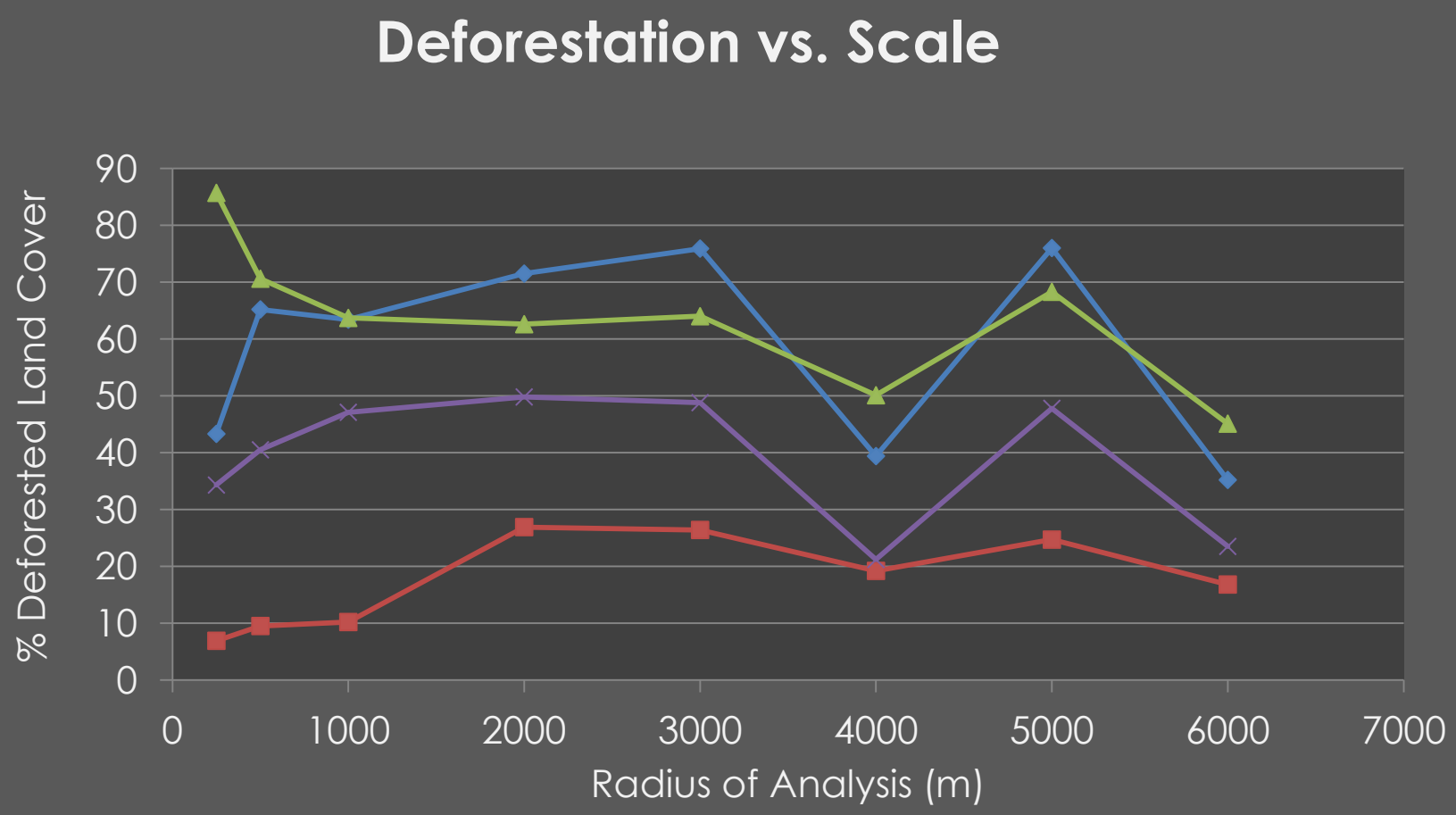

State of Analysis

- Land Surface Model simulations show strong potential to inform predictions of *Anopheles* distribution
  - Active data assimilation not yet tested

- The relationship between land cover and mosquito distribution is robust and species-specific, and it appears to be strongest at 3-5km radius of influence

Next Steps

- Integrate LDAS results to *Anopheles* distribution models
- Compile Human Settlements and Activities map
- Implement spatially explicit transmission risk model
- Continued and enhanced mosquito collection and malaria monitoring
- Work with end-user partners to ensure that the products are taking on a useful form

THANK YOU