GeoHealth: A Surveillance and Response System Resource for Vector Borne Disease in the Americas

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GeoHealth: A geospatial surveillance and response system resource for vector borne diseases in the Americas

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Objectives

- Construct a geospatial health resource data portal (GeoHealth) compatible with GEOSS

- Map and model the epidemiological risk of two prototype vector borne diseases: Visceral leishmaniasis and Aedes borne arboviruses

- Process big data to discover 'hidden' associations of disease for ecological niche modeling vs hypothesis-driven statistical analysis

- Implement dissemination and training programs to promote geospatial mapping and modeling for VBD as envisioned in GEOSS.

Clinical VL Infected Child with Hepatomegaly (Top)

Advanced VL Infection in a Dog, the Principal Reservoir (Below)

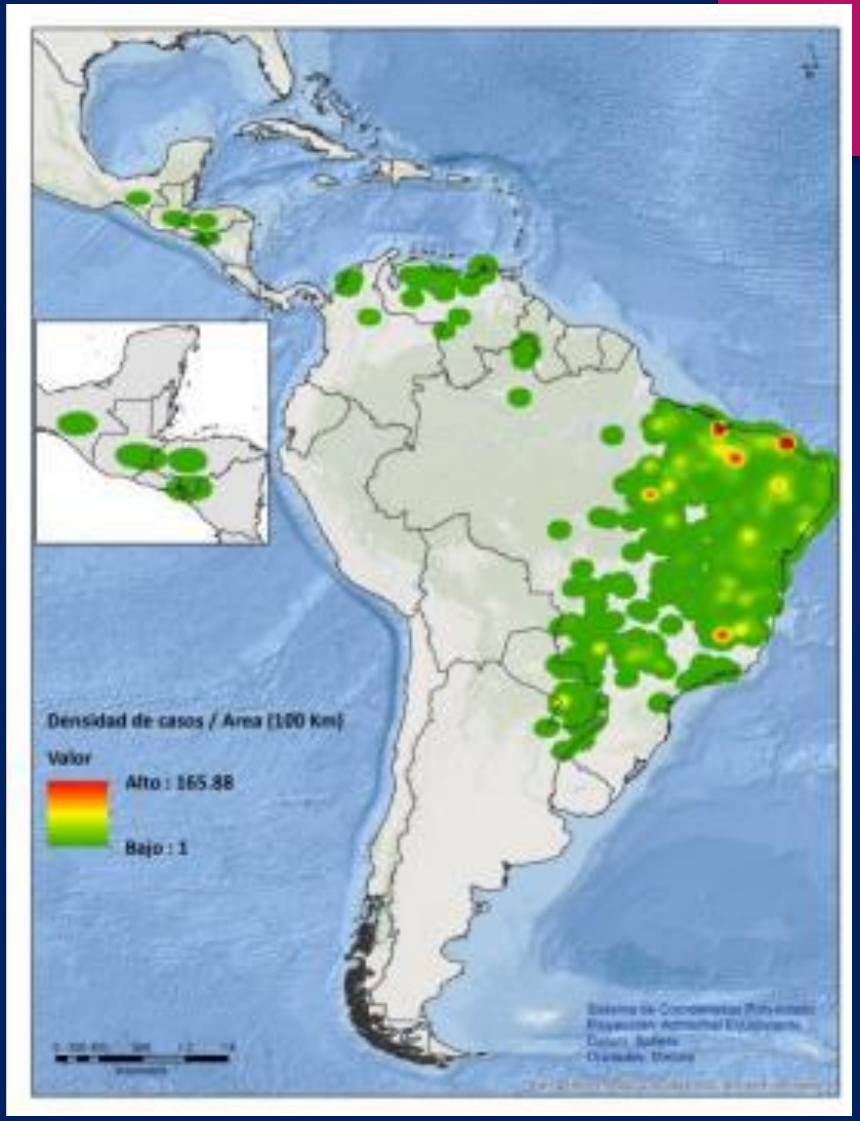
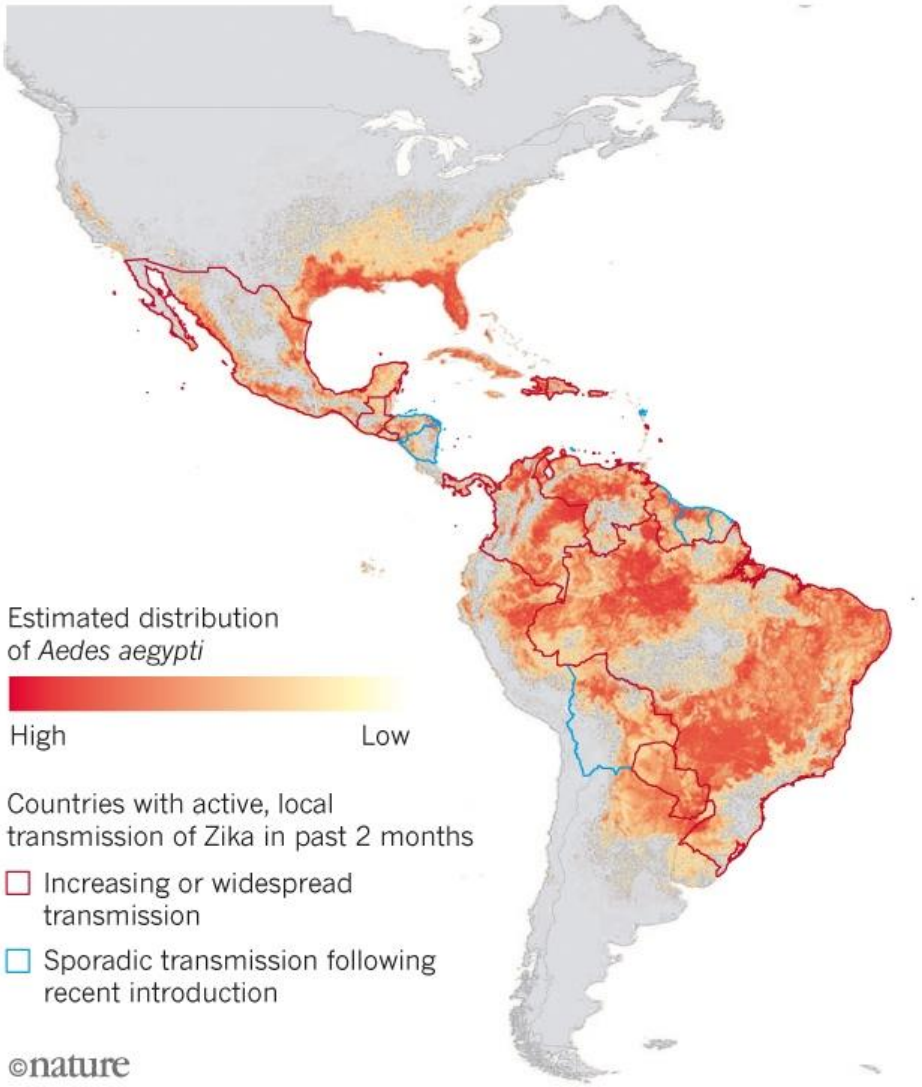


Figura 14. Densidad de los casos de leishmaniasis visceral por segundo nivel administrativo, Américas, 2015.
Fuente: SisLeish-OPS/OMS: Datos reportados por los Programas Nacionales de Leishmaniasis/Vigilancia
Datos disponibles en el 20 de febrero 2017.

ZIKA IN THE AMERICAS

Following its arrival in the Americas in 2015, Zika virus is now being actively transmitted in many of the countries that harbour its main carrier, the *Aedes aegypti* mosquito.



Data Portal

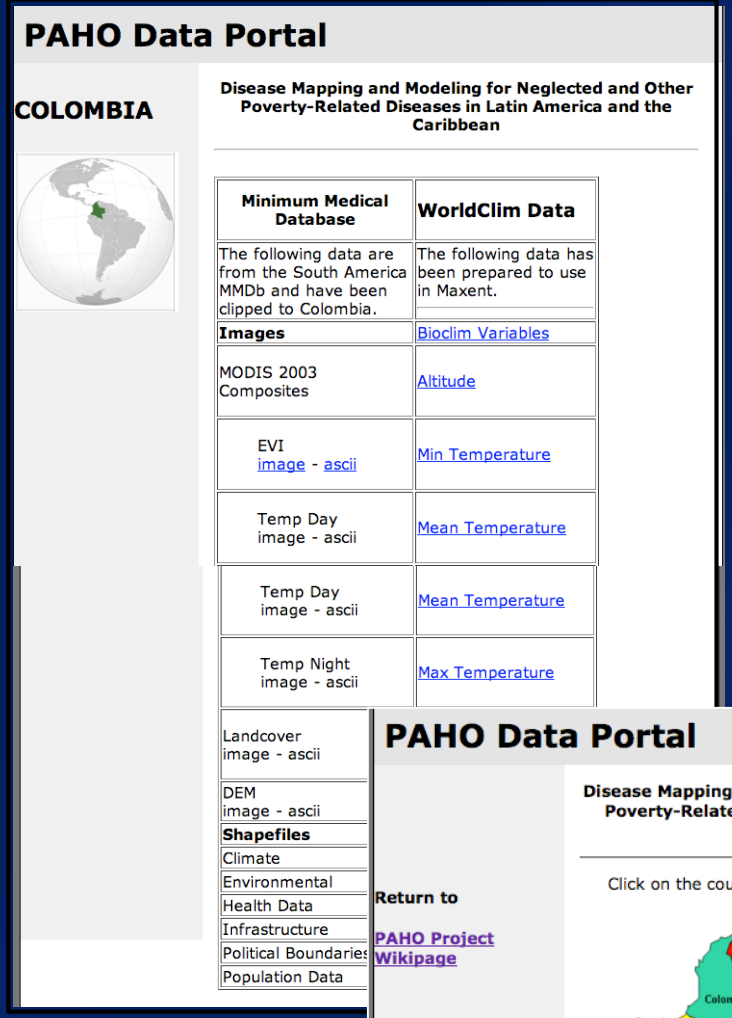
All data clipped to the country boundary; WGS84 projection, 1 km spatial resolution; in ASCII format for Maxent or Bayesian modeling

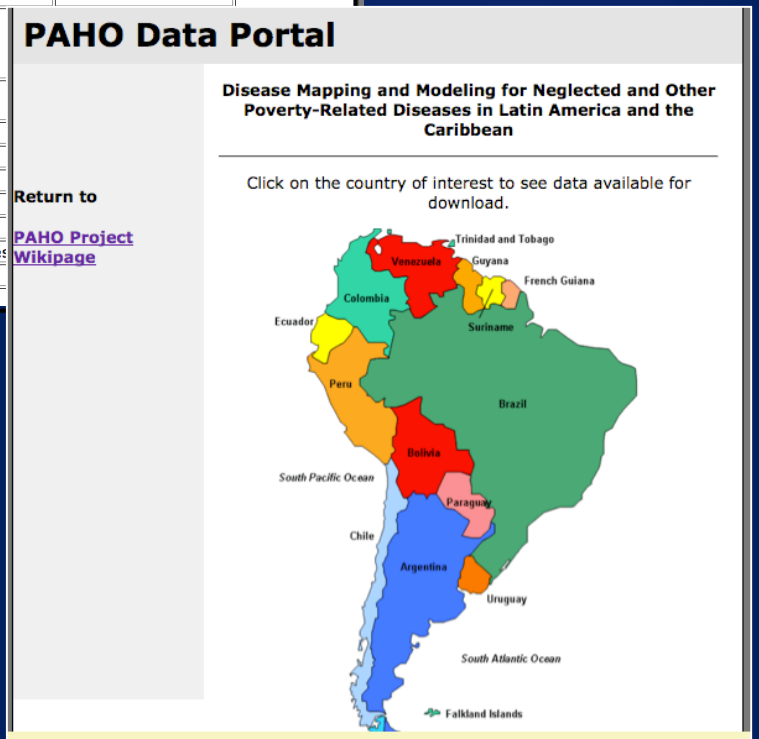
This example shows the data available for Colombia

Worldclim (global coverage, Ikm resolution) used for ecological Niche modeling and by climate change community

MODIS EVI, LST annual composites for 2005-2009

Socioeconomic Data at the Municipality level





GeoHealth Data Portal Content

Regional Scale Data

Climate Data:

*Worldclim - Precipitation, Tmax, Tmin, Potential Evapotranspiration monthly.
*Bioclim ($1km^2$) - 50 year long term normal climate data.
*NCEP/NCAR CDAS Re Analysis ($50km^2$); daily, complete data eg. specific humidity.

Earth Observing Satellite data:

*SRTM Shuttle Radar Topography Mission ($30m^2$)
*Global Precipitation Mission (GPM) – 3 hour/daily/monthly
*MODIS 8day-16day NDVI, LST, Land Cover ($1km^2$);
*VIIRS 8day
*SMAP Soil Moisture ($9km^2$); Resample to $1km^2$
GOES 16 – Land Surface Temperature – 3 hour/daily
ECOSTRESS – 5day data; day-night pairs
DESIS- 5 day hyperspectral data – selected sites

Feature data

*DIVA Political boundaries, World Wildlife Fund Ecosystems
*Hydrology – Rivers, streams, lakes; Watersheds
*Landscan – global population data; Census tract population data of Brazil

GeoHealth Data Portal Content

Community Scale (15-30 m)

Landsat 8; Landsat Legacy data; ASTER*

ESA Sentinel L2 and L1 (cloud-free)

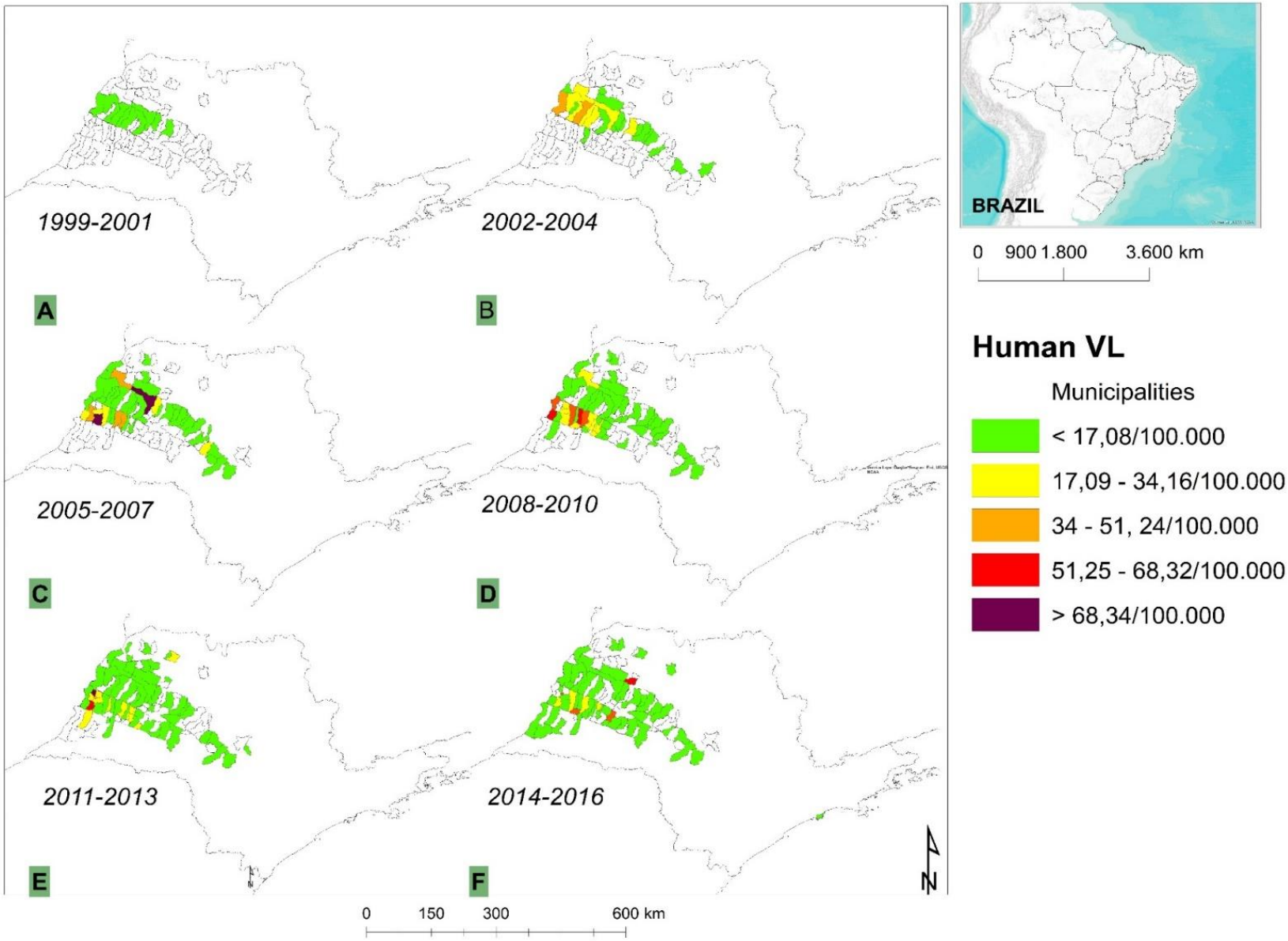
Harmonized Landsat/Sentinel-2 (HLS) v. 1.2

Land Use, Soil Type

Habitat-Household Scale (<1m)

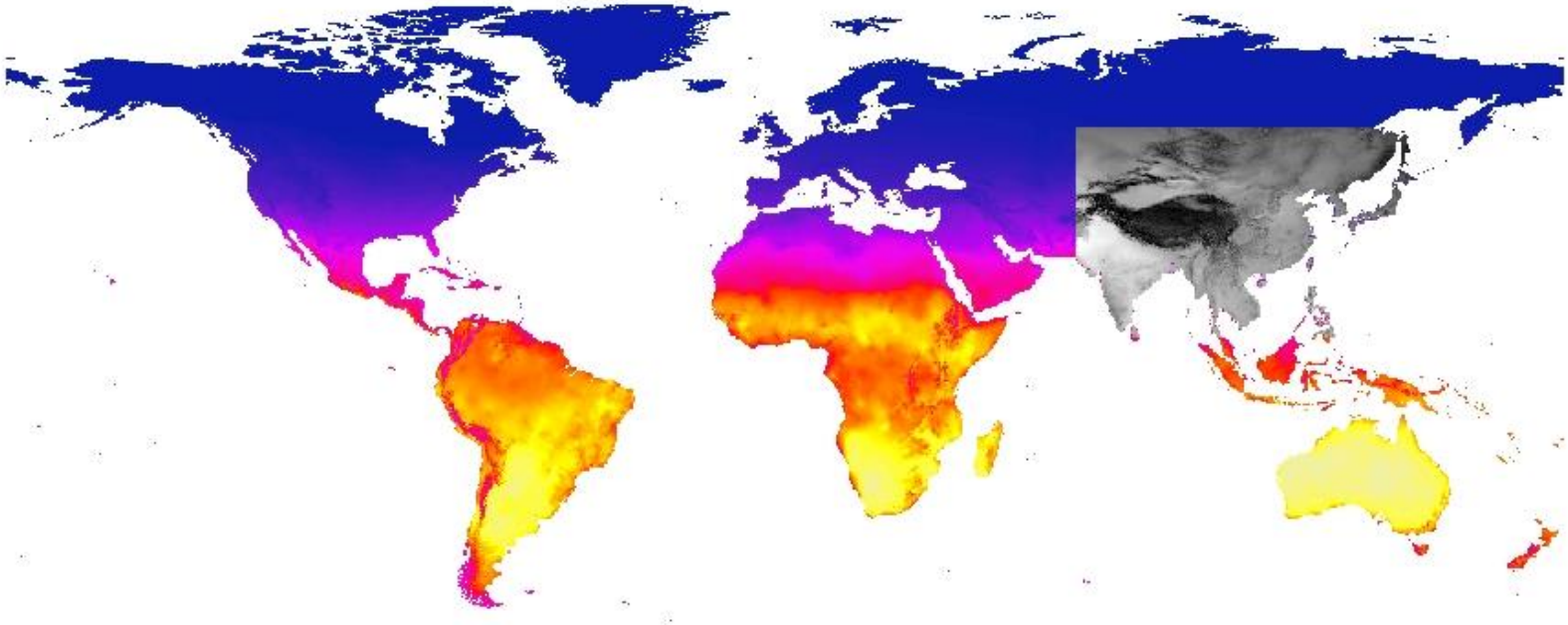
Worldview 2*, Worldview 3

Visceral leishmaniasis Incidence – 3 year periods Sao Paulo State, Brazil

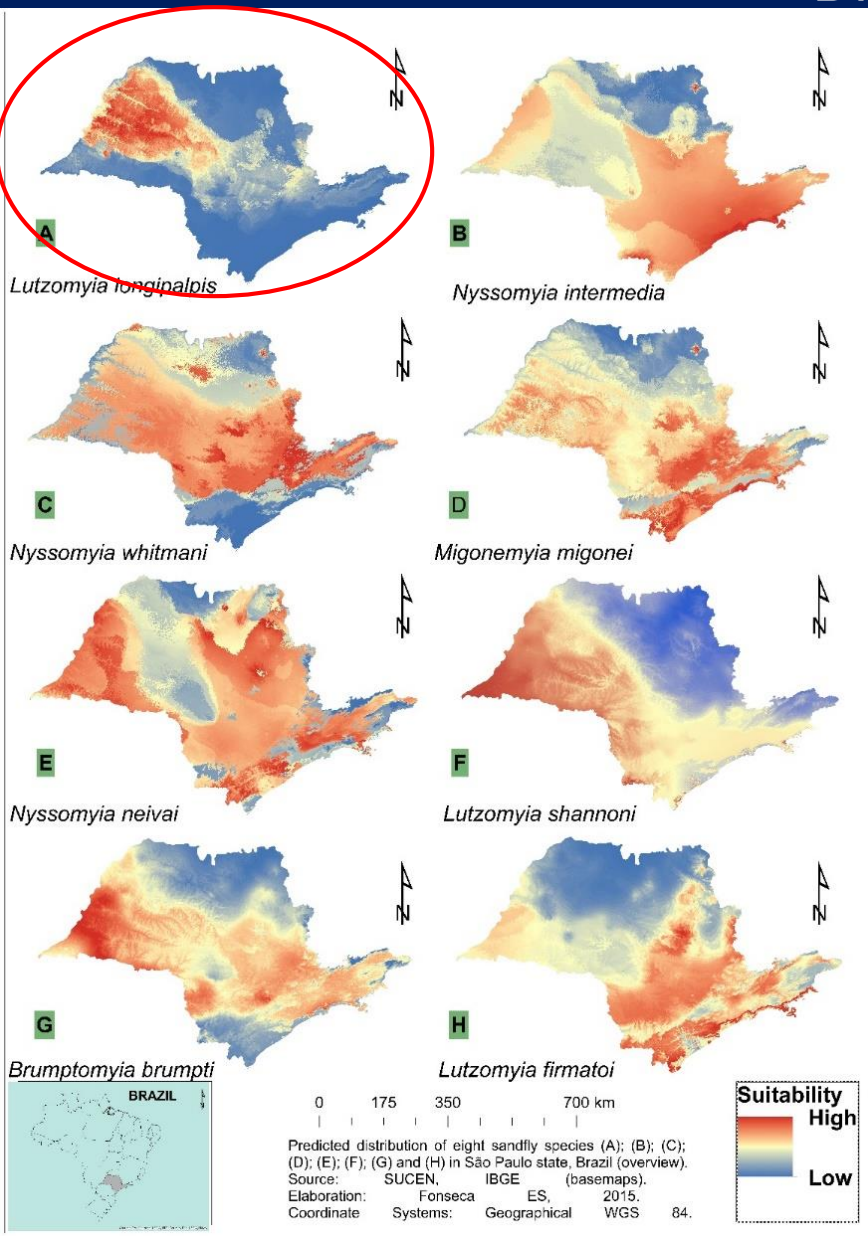


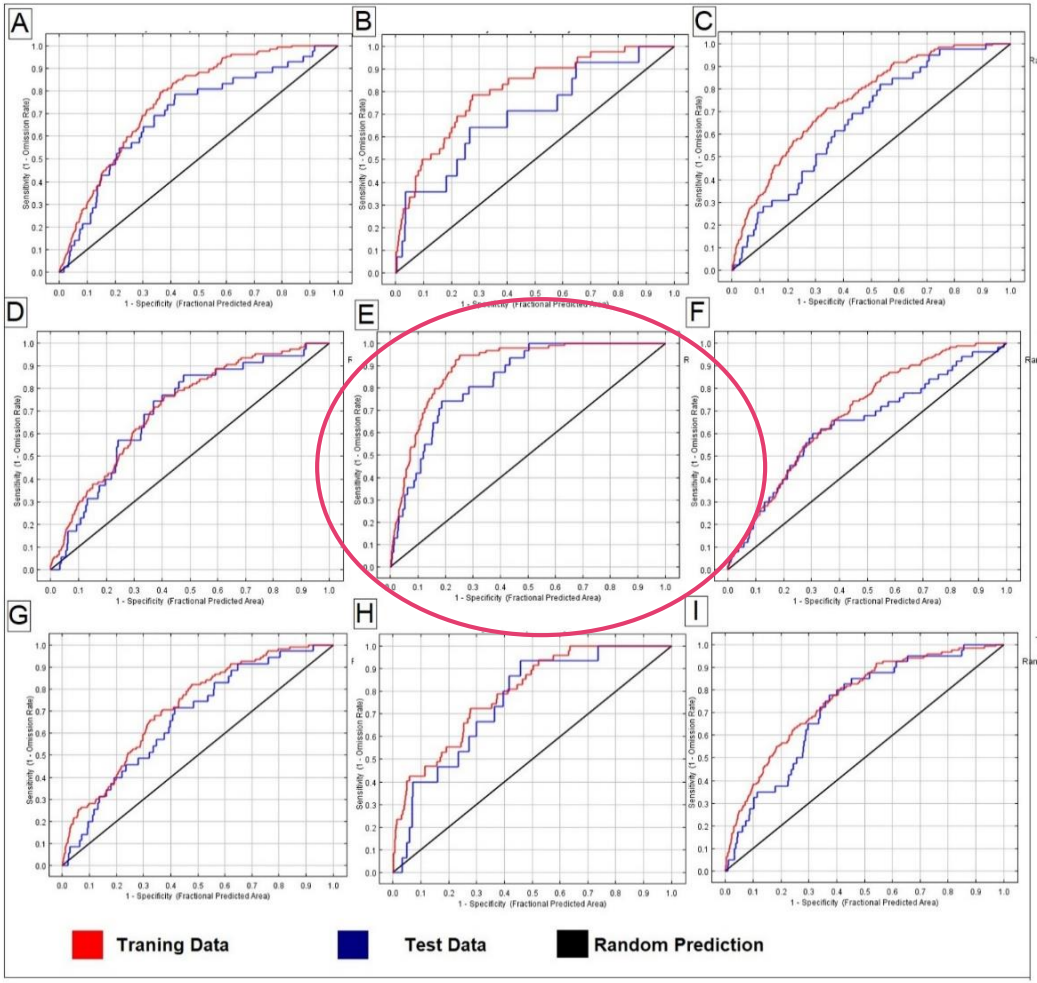
Worldclim -

Asia Tmax6 clipped from Global PET12



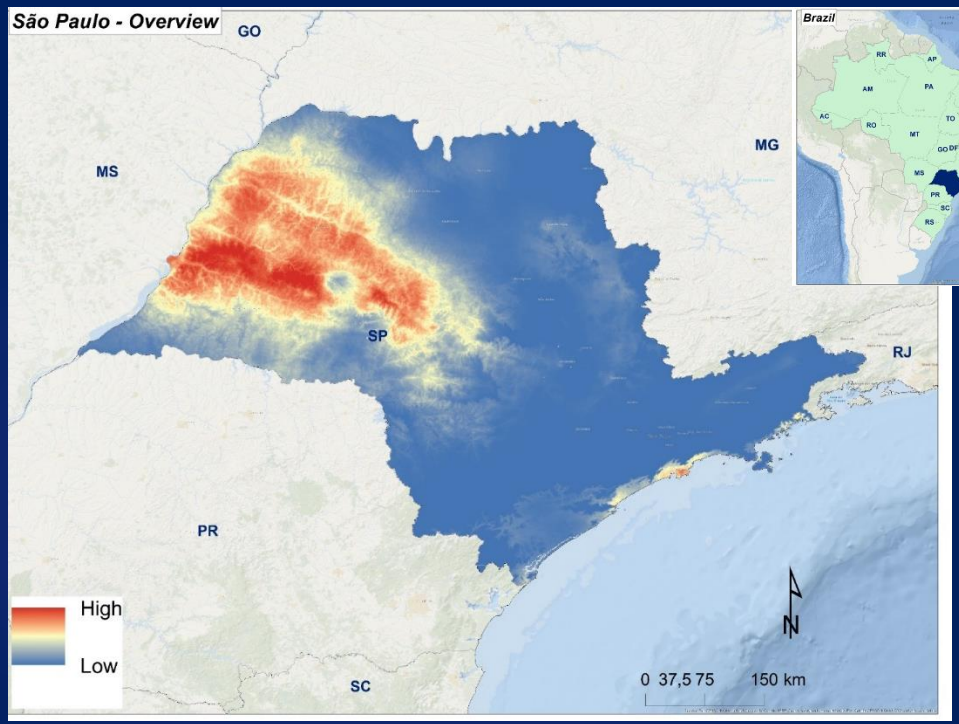
Sand Fly Species Distribution – Sao Paulo State BioClim





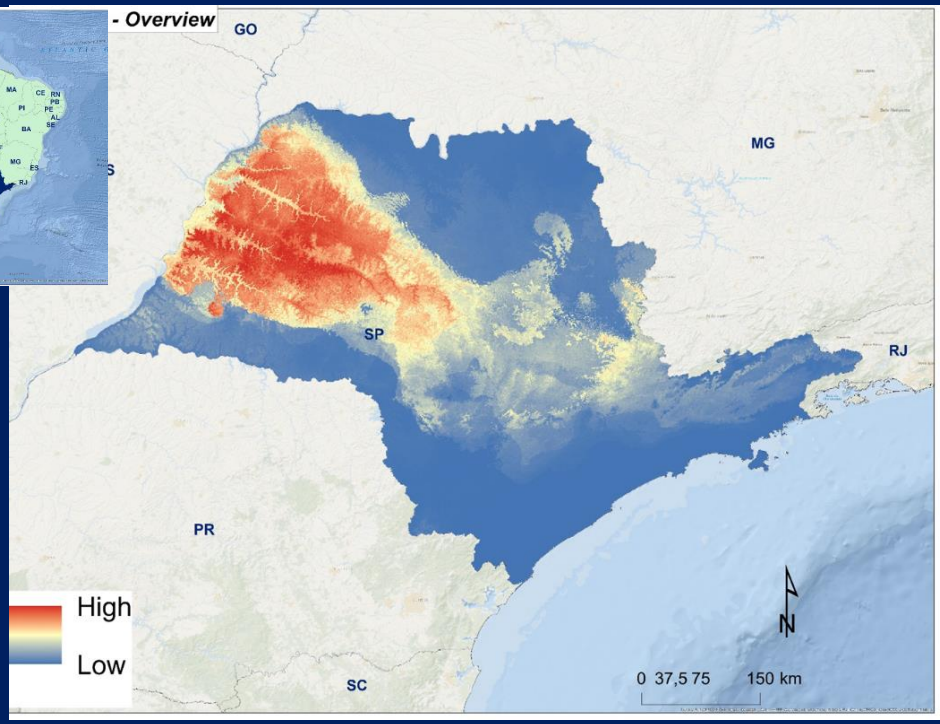
Receiver operating characteristic (ROC) curve for the different species of Sand Fly vector. Fig. 3: **A**: *Nyssomyia whitmani*. **B**: *Lutzomyia cortelezii*. **C**: *Migonemyia migonei*. (0.5). **D**: *Lutzomyia ubiquita*. **E**: *Lutzomyia longipalpis*. **F**: *Nyssomyia intermedia*. **G**: *Nissomyia neivai*. **H:** *Lutzomyia monticola*. **I:** *Lutzomyia fischeri*.

WorldClim
Visceral Leishmaniasis



AUC VL Worldclim – 0.882
Tmax12 35.7%
Prec06 19.7%
Tmax01 13.9%

BioClim
Lutzomyia longipalpis

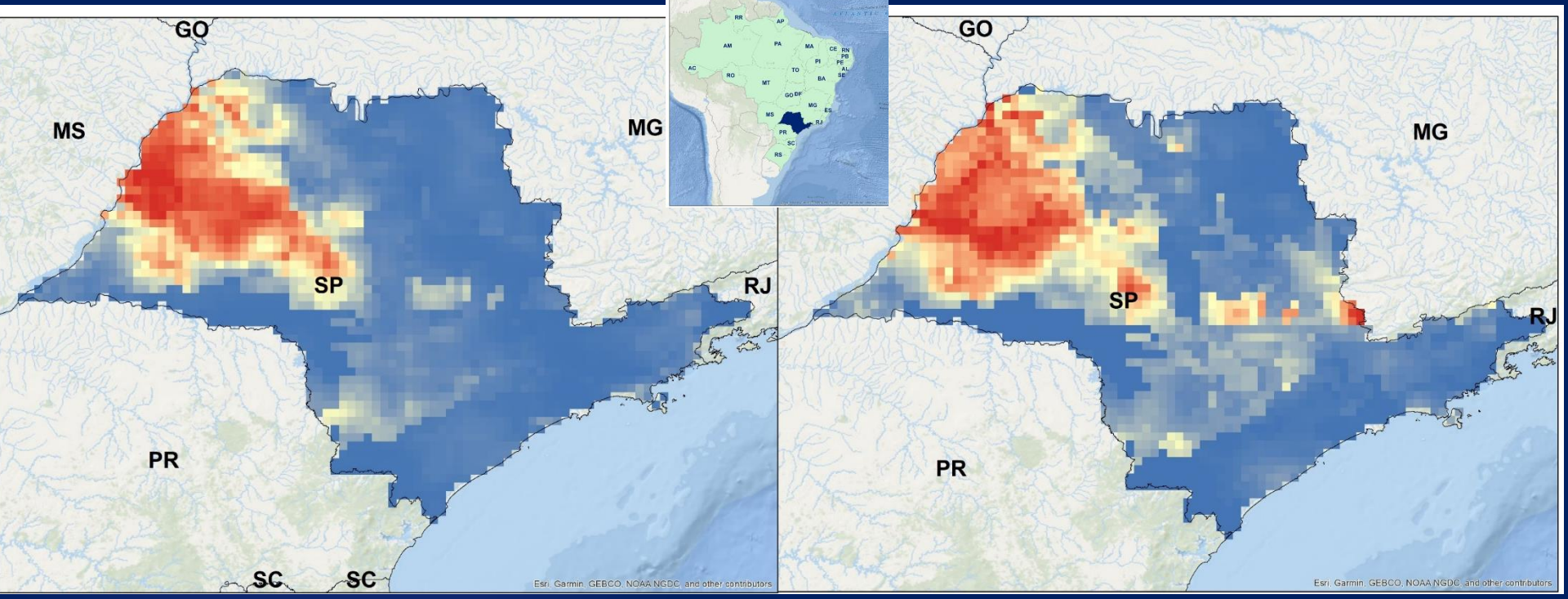


AUC LL BioClim – 0.835
Bio 14 21.3% - Prec Driest Mo
Bio 15 13.8% - Prec Seasonality
Bio 16 16.9% - Prec Wettest Q

Soil Moisture Active Passive (SMAP)

Visceral Leishmaniasis

Lutzomyia longipalpis



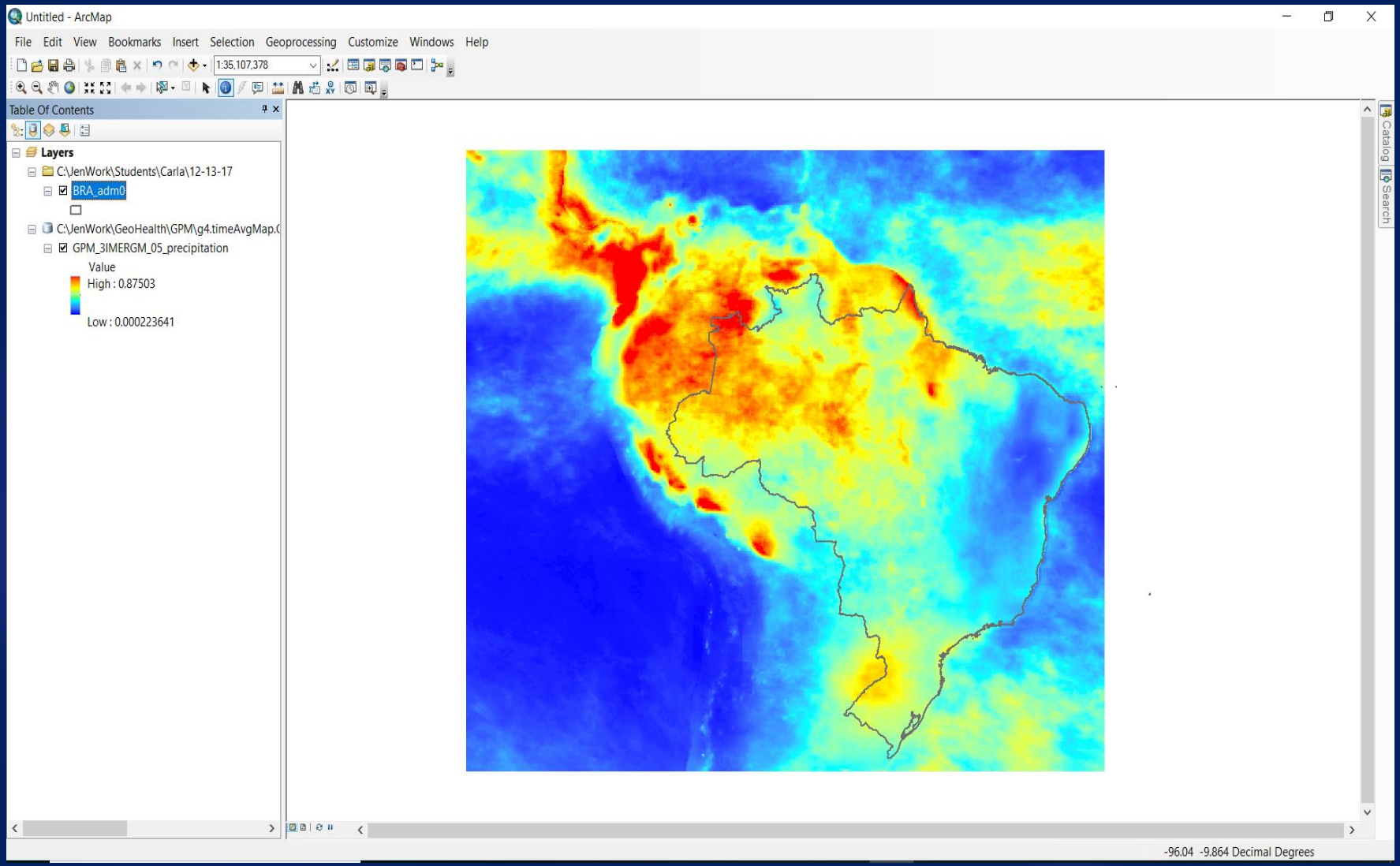
AUC VL SMAP – 0.884

Oct	27.1%
Aug	24.8%
Sept	20.4%

AUC LL SMAP – 0.793

July	37.4%
Dec	17.0%
March	14.5%

Global Precipitation Model (GPM) – April, 2015



Models – Habitat-Household level

Teodoro Sampaio: Indices using World View 2

NDVI - Normalized difference vegetation index;

SAVI - Soil-adjusted vegetation index;

NDBI - Normalized Difference Built-Up Index;

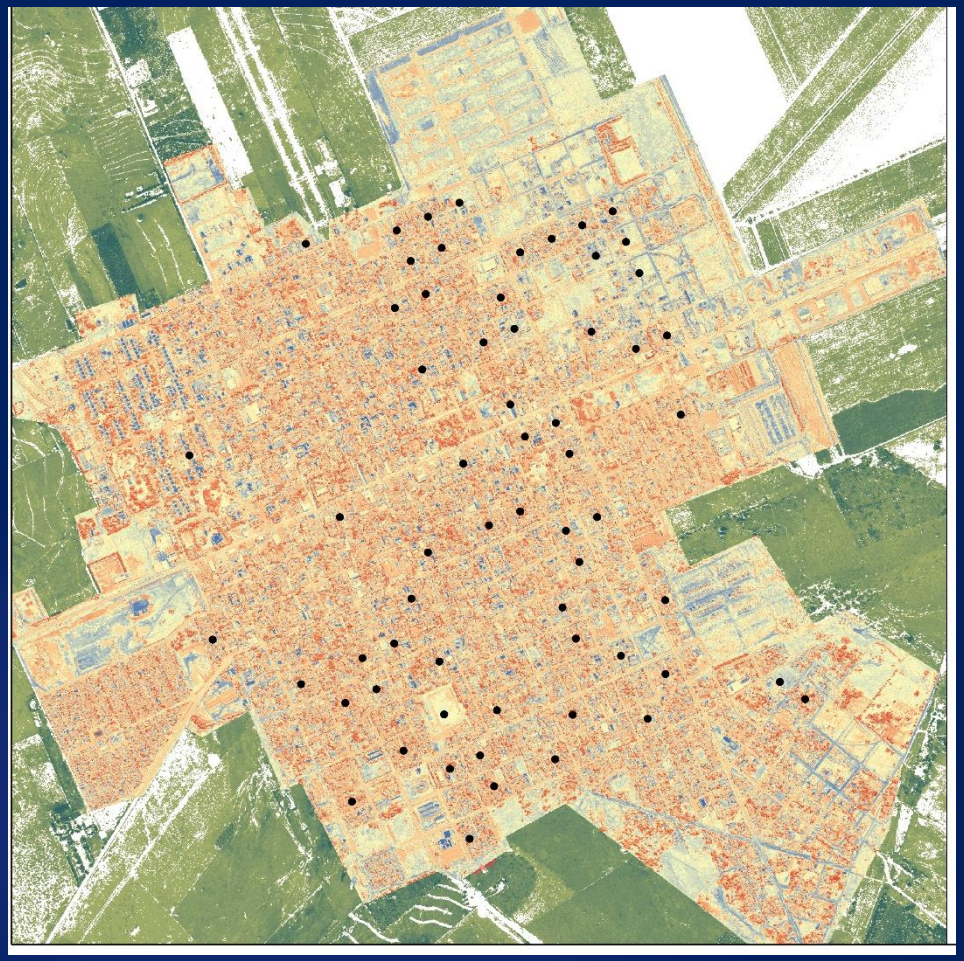
WV-WI - WorldView Water Index;

NDSI – Normalized Difference Soil Index;

WV-NHFD - Non-Homogeneous Feature Difference;

NDMI - Normalized Difference Mud Index.

Teodoro Sampaio



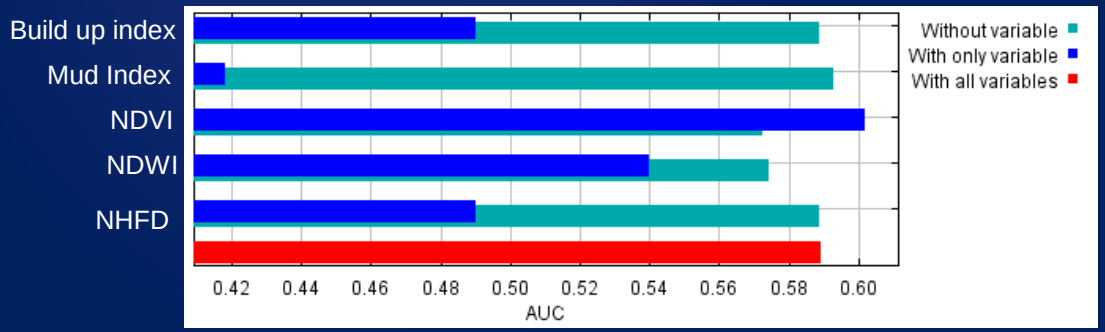
NDVI

NDWI

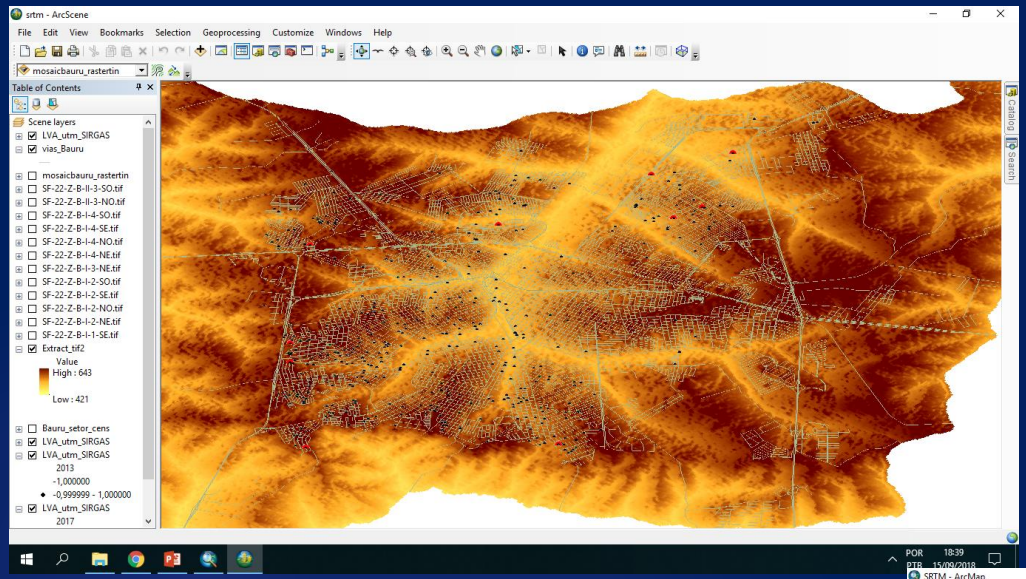
Mud Index

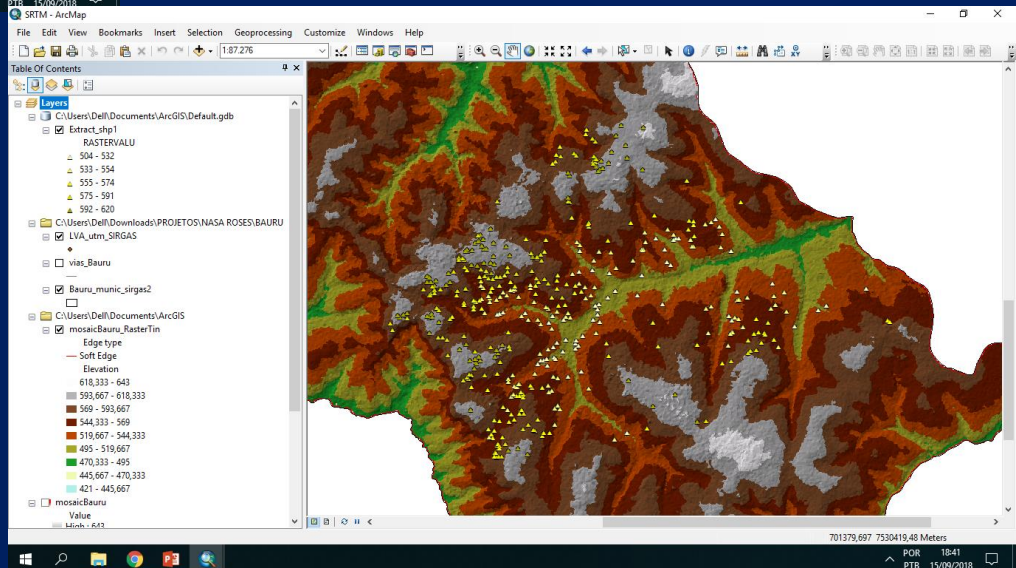
NHFD

Build up index

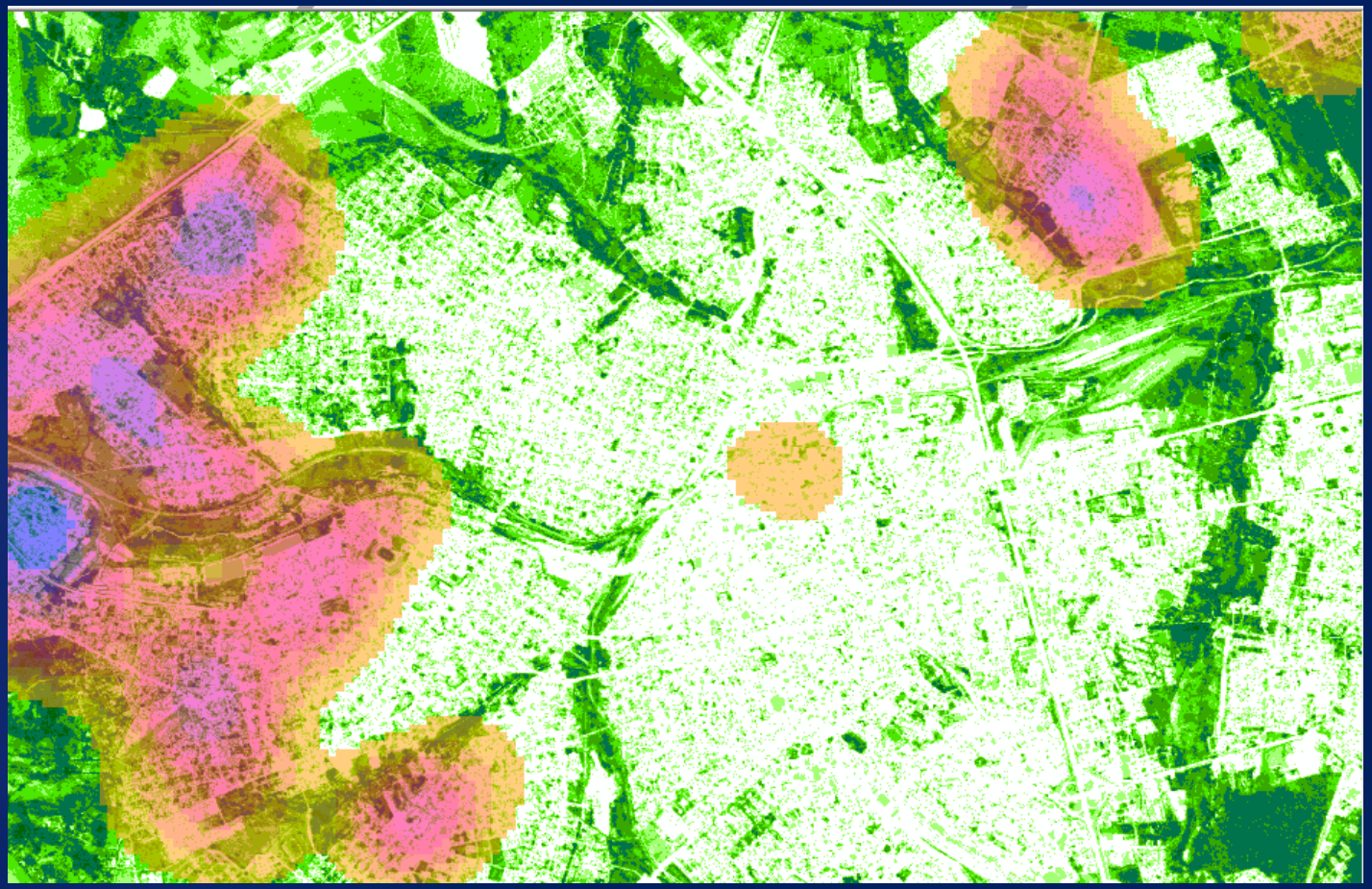


SRTM - VL Surveillance and Response Systems - Bauru





VL Surveillance and Response Systems - Bauru



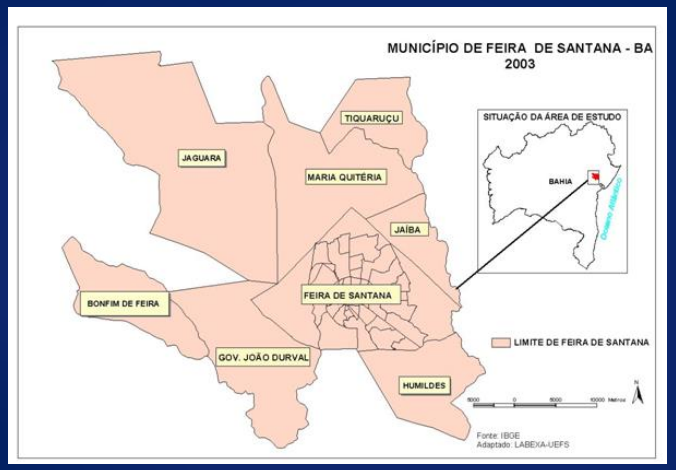
Vegetation and Kernel density – dog population

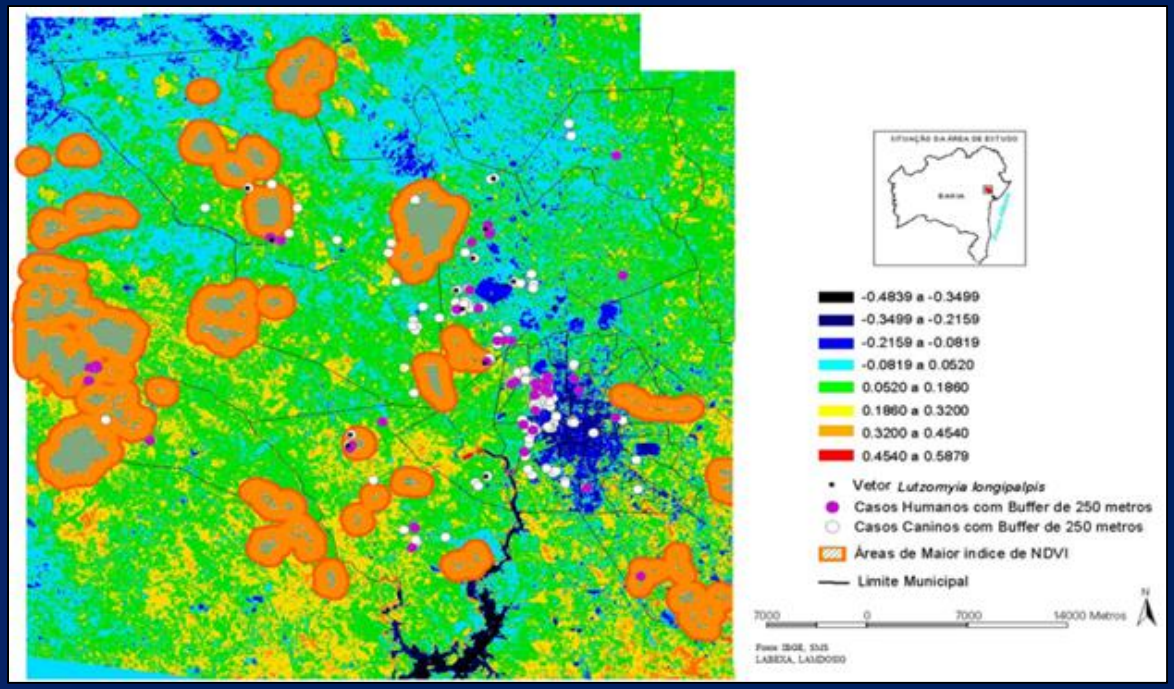
Five Groups for Case-Control GIS/Hot Spot Guided

	I	II	III	IV	V
Action	Collars All dogs survey (mass treatment) No GIS/Hot Spot Guided criteria Entire area	GIS/ Hot Spot Guided Collars Vector Fogger Engagement: - Screened - Bed Net - CDC Traps - Backyards - Amplifier of infection Chicken	GIS/ Hot Spot Guided Collars Fogger	GIS/ Hot Spot Guided Collars	GIS/ Hot Spot Guided
Metrics	1) Serum Convertion of Dogs 2) Clinical cases dogs and Human 3) Sand Fly -Population dynamics -Infection rate -Blood meal 4) Survey of KAP - Knowledge-Attitude and Practice Cost-effective analysis and protocols for control programs				

Visceral Leishmaniasis

NDVI and visceral leishmaniasis cases, seropositives dogs, sand fly (*Lutzomyia longipalpis*) in Feira de Santana, Bahia, Brazil (2000 to 2002)





Extrinsic Incubation Period (EIP). This process is known to be influenced by both intrinsic factors (such as viral strain and/or mosquito population) and extrinsic factors (such as temperature and humidity)

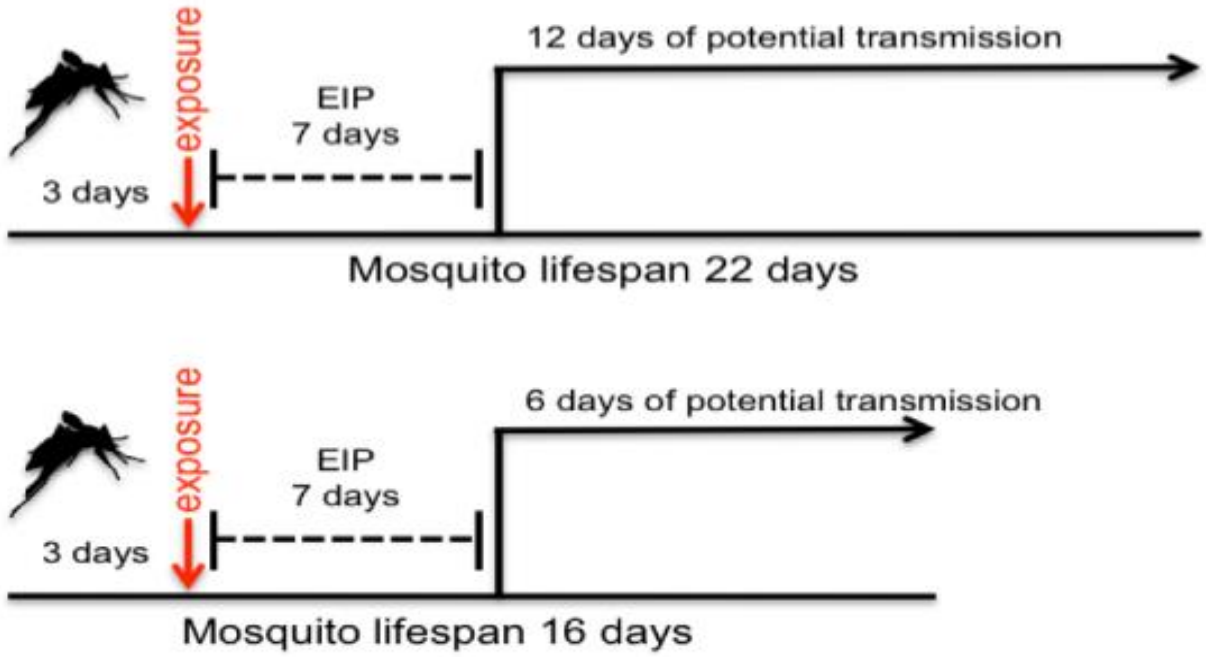
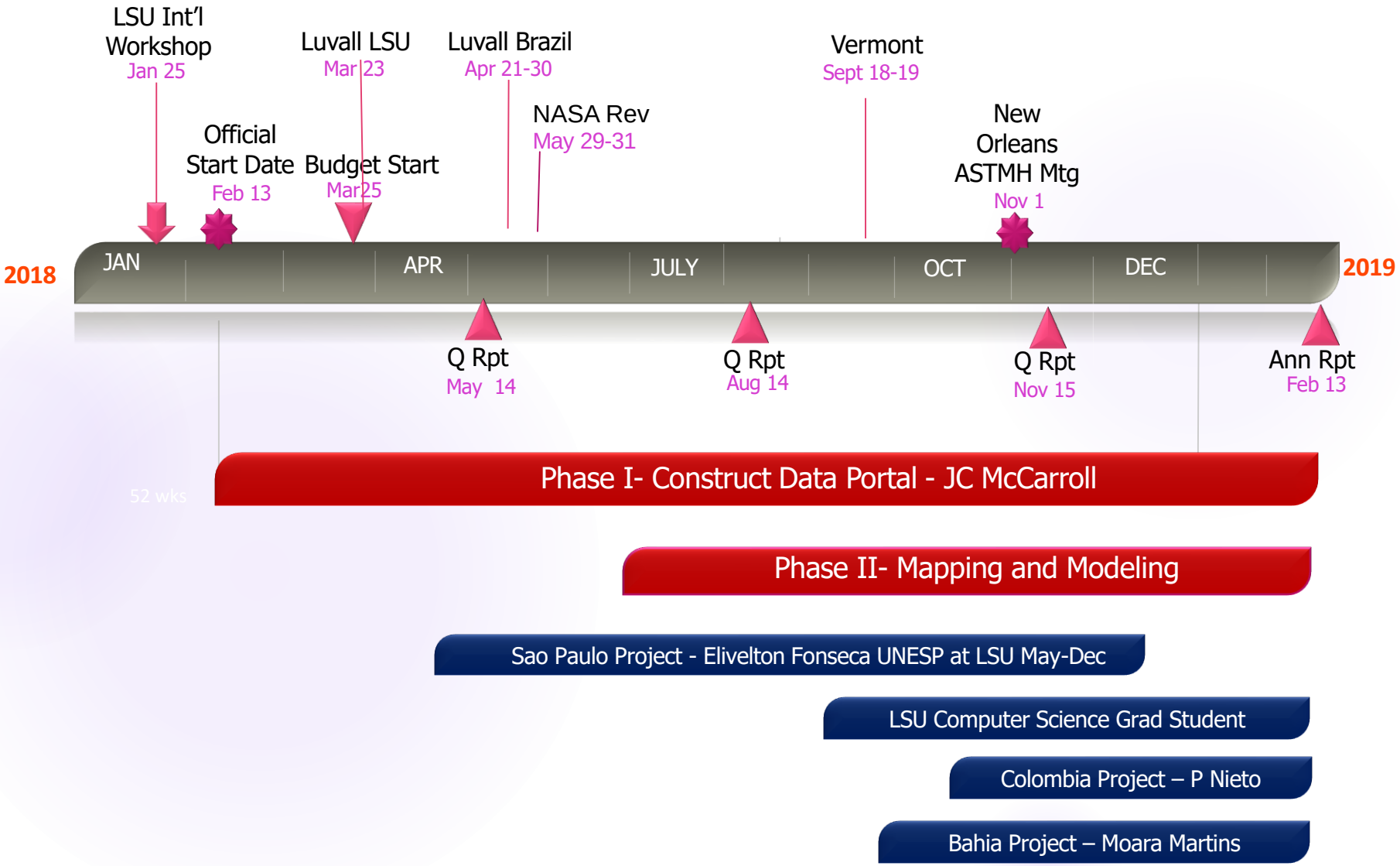


Figure 8 (from Christofferson & Mores 2016): Schematic demonstrating the impact of mosquito mortality on the cumulative transmission potential of an arbovirus.

GeoHealth Project -Year 1



CA-	GeoHealth Americas: Vector Borne Diseases

Objectives: Develop prototype risk models for visceral leishmaniasis and *Aedes*-borne arboviruses as part of the AmeriGEOSS initiative to demonstrate the benefits of satellite data products in mapping and modeling the ecological niche of vector borne diseases at different spatial and temporal scales.

•Access data from NASA's current earth observing programs on GPM, GOES16/17, SMAP/SMOS, WorldView 2/3, Ecostress and SPoRT

•A number of active sensors will eventually provide direct estimates of the ecological niche of vector borne diseases in the Americas at a very high resolution.

Outputs Expected

•Development of a vector borne disease network and a data portal archive for the Americas.

•American continent data portal archives will be organized at Louisiana State University and the NASA Marshall Space Flight Center.

Leads and contributors

Lead: John B Malone, Louisiana State University (vtmalon@lsu.edu) and Jeffrey C Luvall, NASA Marshall Space Flight Center, Huntsville, AL (jluvall@nasa.gov)

2018-2020 Activities

During the period of the 2018-2020 work plan this activity will develop prototype risk models for visceral leishmaniasis and *Aedes*-borne arboviruses as part of AmeriGEOSS.

2018-2020 Resources

The activities are primarily carried out with support from NASA Grant 80NSSC18K0517 supplemented by work on a volunteer basis by colleagues employed at universities and public health agencies in the Americas

The AmeriGEOSS initiative is a framework that seeks to promote collaboration and coordination among the GEO members in the American continent, “to realize a future wherein decisions and actions, for the benefit of the region, are informed by coordinated, comprehensive and sustained Earth observations and information”.

Schedule

Oct ***Jan*** ***Apr*** ***Jul*** ***Oct***

Year I **– GEO Community of Practice (CoP)**

CoP Milestone |

|*GEO/ASTMH Meetings*|

| *Begin Internal Data Portal*

QRpt *QRpt* *QRpt* *Annual Rpt*

|*Develop Architecture and Content of GeoHealth Databases*|

| Map and Model Leishmania and Arboviruses|

Year II **– GEO Initiative**

GEO Initiative Milestone |

|*GEO/ASTMH Meetings*|

Short course |*GEO Graduate Course*| *Short course*

| *Begin Open Access Data Portal*

QRpt *QRpt* *QRpt* *Annual Rpt*

|*Map and Model Leishmania and Arboviruses*|

Year III **– GEO Broker Status**

GEO Broker Milestone |

|*GEO/ASTMH Meetings*|

Short course |*GEO Graduate Course*| *Short course*

QRpt *QRpt* *QRpt* *Final Rpt*

|*Internet Dissemination, Implementation and Training via GEOSS*|

| Map and Model Leishmania and Arboviruses|

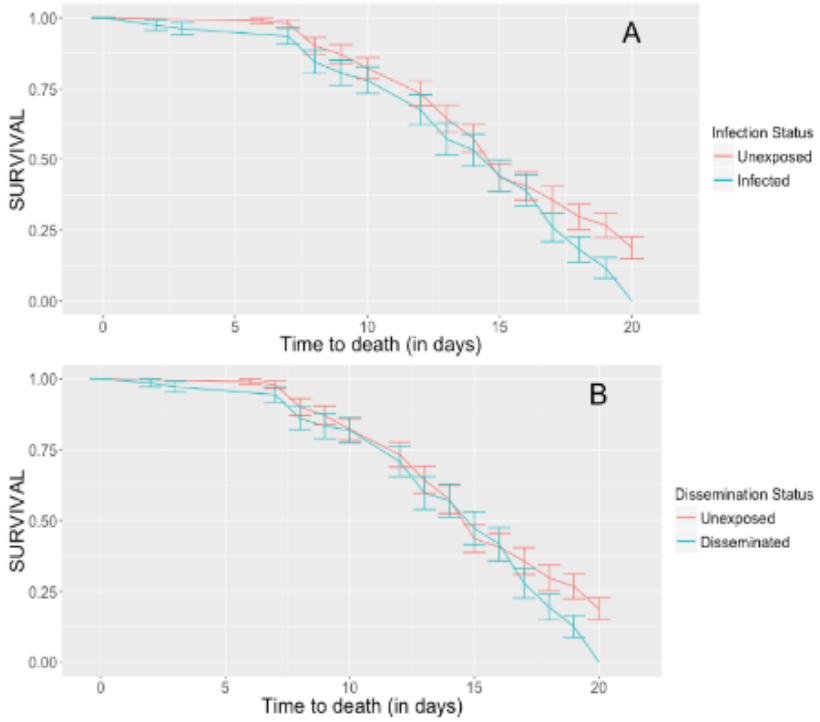


Figure 6 (from Christofferson & Mores 2016): Survival curves for comparisons of A) unexposed to infected mosquitoes at 30°C and B) unexposed to mosquitoes with a disseminated infection were significantly different.

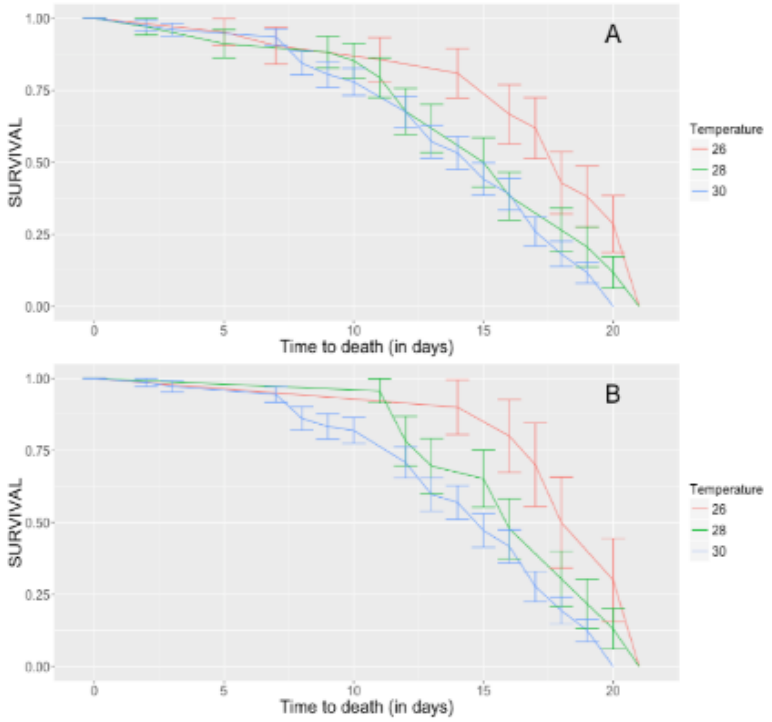
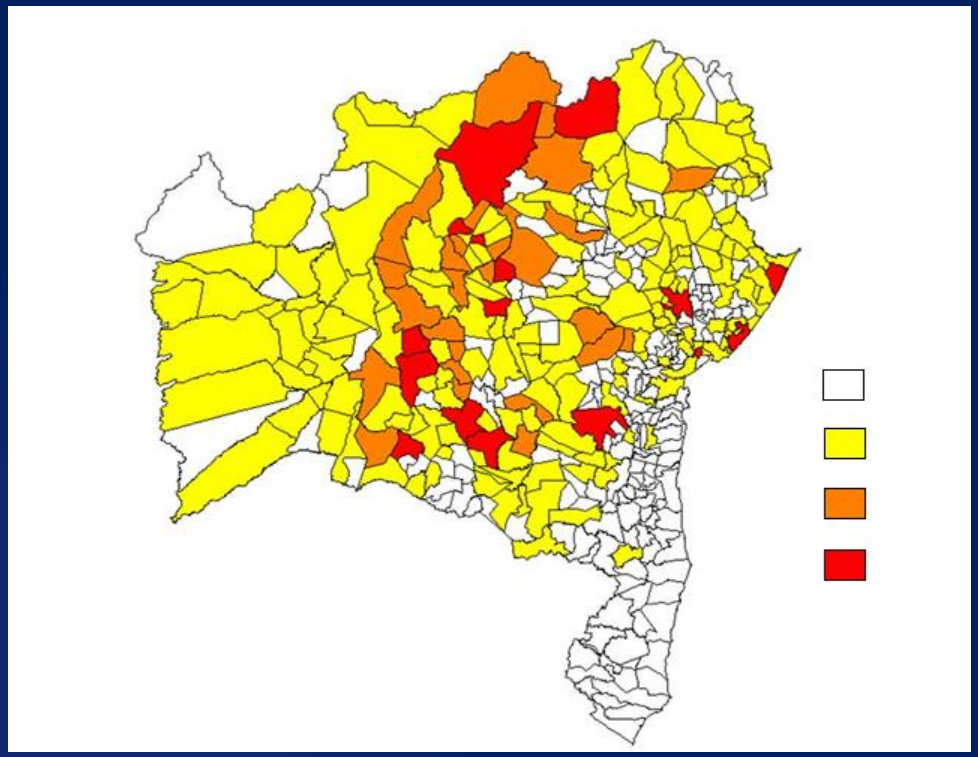


Figure 7 (from Christofferson & Mores 2016): Survival curves for comparisons of A) infected mosquitoes across all three temperatures and B) mosquitoes with a disseminated infection across all three temperatures. Significant differences were found only between 26°C (red) and 30°C (blue) in both cases.

Visceral Leishmaniasis

Bahia municipallities classification level of VL transmission. 2013-16



No cases notified

Sporadic < 2,4 casos (175)

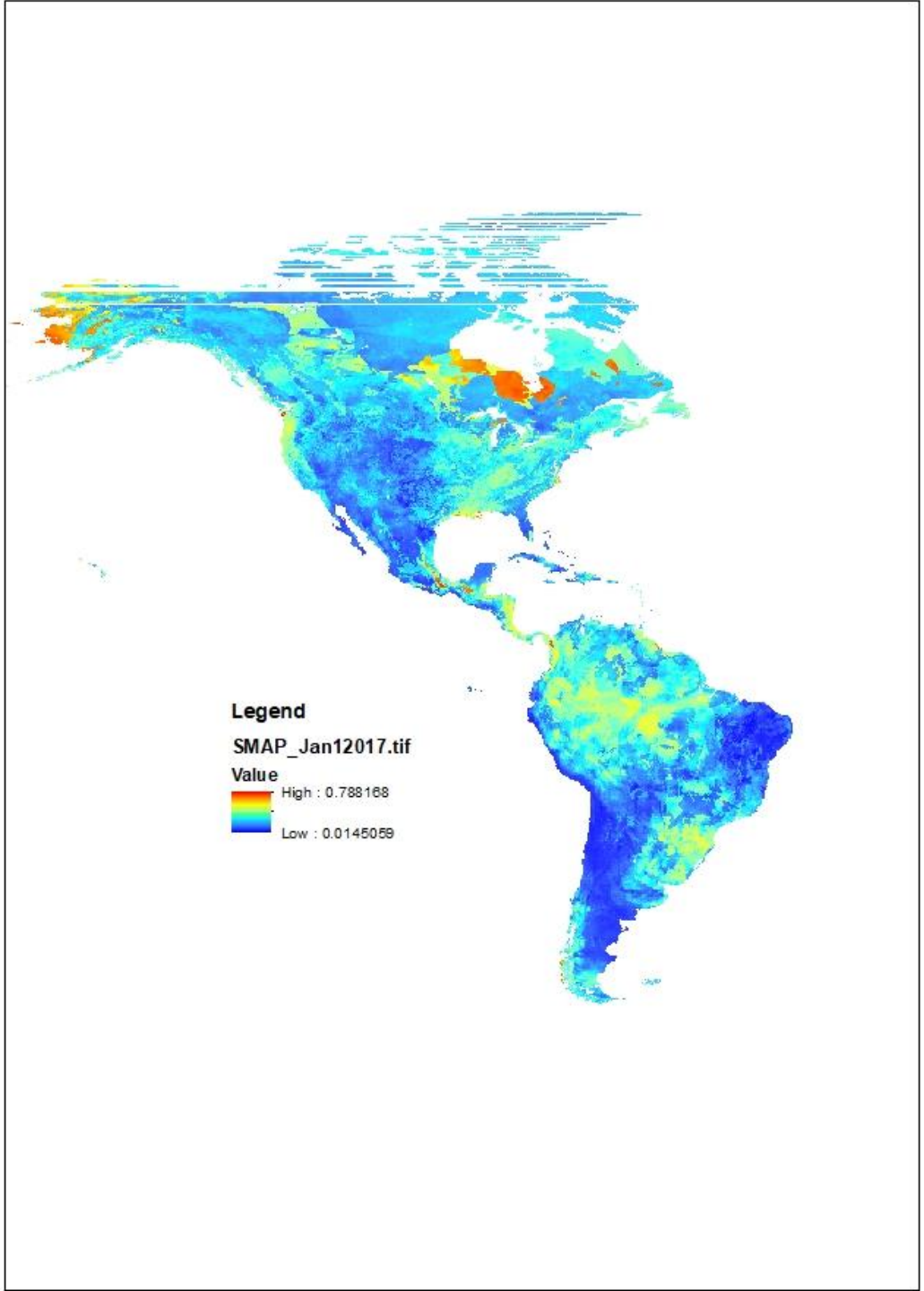
Moderate: ≥ 2,4 e < 4,4 (26)

Intense ≥ 4,4 (16)

2000 a 2016

- 6.165 cases (anual mean 385)
- Inicidence: 1.3 to 11.8 (100,000 inhabitants)
- Mean lethality 6.7%

Source: SESAB/SUVISA/DIVEP, 2017


Legend
SMAP_Jan12017.tif
Value
High : 0.788168
Low : 0.0145059