Vector Hazard Report:

Mosquito, Sand Fly, Tick and Triatomine Hazards of Panama

A product of The Walter Reed Biosystematics Unit (WRBU)
[Systematic Catalog of Culicidae]
[VectorMap]

Compiled by David Pecor

WRBU
WALTER REED BIOSYSTEMATICS UNIT
Know the vector, know the threat

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Background

Mosquitoes:

Panama is considered an endemic zone for malaria. According to the CDC, 99% of malaria cases in Panama are caused by Plasmodium vivax with Plasmodium falciparum making up the remaing 1% of cases. A map of the provinces where CDC recommends travelers use prophylaxis to protect from infection is provided in the Malaria Risk Maps section of this report. Yellow Fever is also considered endemic to Panama with CDC recommending all travelers receive vaccinations when visiting mainland areas east of the canal zone. As of October 2017, the CDC has categorized Panama as a level 2 alert for Zika virus transmission. All areas in Panama below 6,500 feet are considered at risk for ZIKV infection by mosquito according to the CDC. For more information about the Zika virus outbreak, read (Demir and Kilic, 2016). There is evidence to suggest that the level of disturbance or human influence within a landscape can directly impact mosquito diversity and abundance in Panama (Loaiza, et al. 2017). It is important to note that co-infection within mosquitoes has occurred involving various arboviruses and that this coinfection can impact virus transmission efficiency (Valderama, et al. 2017).

Sand Flies:

Cutaneous leishmaniasis which is caused by the parasite *Leishmania panamensis* is the most common form of Leishmaniasis encountered in Panama. The primary sand fly vectors found in Panama are *Lutzomyia gomezi*, *Lutzomyia panamensis* and *Lutzomyia trapidoi*. There is some evidence showing a correlation between the landscape type and sand fly vector species abundance. In 2011, these three vectors were found to significantly more abundant in fragmented forest landscapes as compared to rural and forested areas (Valderama, 2011). There is evidence demonstrating that El Nino weather patterns have a direct impact on the population densities of leishmaniasis vectors (Chaves, et al. 2014).

Ticks:

Rocky Mountain Spotted Fever is the only major tick-borne disease hazard reported from Panama. Although infections are rare, a fatal case of RMSV was reported from Panama in 2004 confirming it is still present in the country. RMSV is caused by the bacteria *Rickettsia rickettsia* and transmitted to humans via ticks of the Genus *Amblyomma. Amblyomma cajennense* is considered the primary vector of RMSF in Panama (Rodaniche, 1953).

Background

Triatomines:

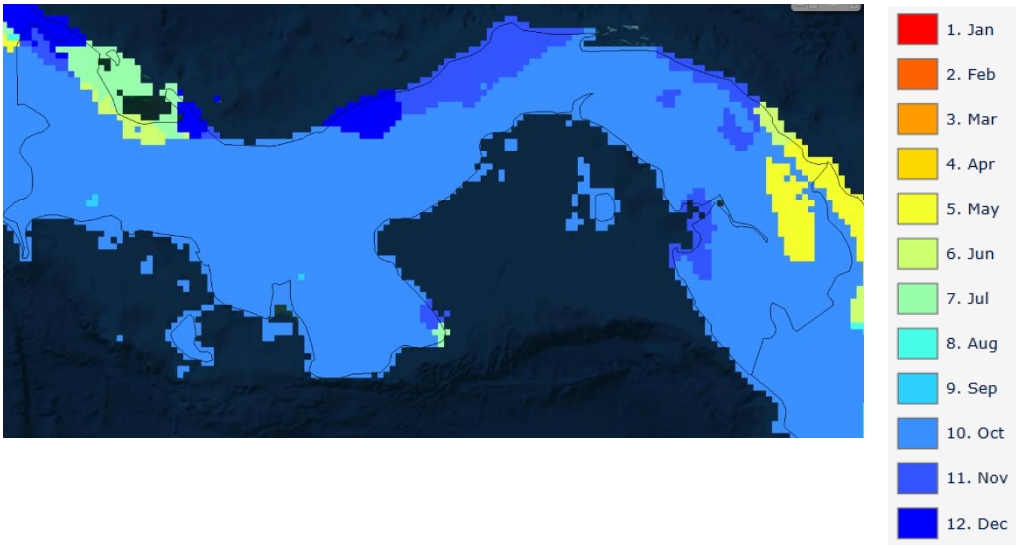
Chagas Disease, also known as American trypanosomiasis, is caused by the parasite *Trypanosoma cruzi.* This parasite is spread through the bite of infected Triatomines. If left untreated, Chagas disease can damage the nervous system, digestive system but about 2/3 of all cases involve damage to the heart, which can cause heart rhythm abnormalities and death.

Emerging Threats:

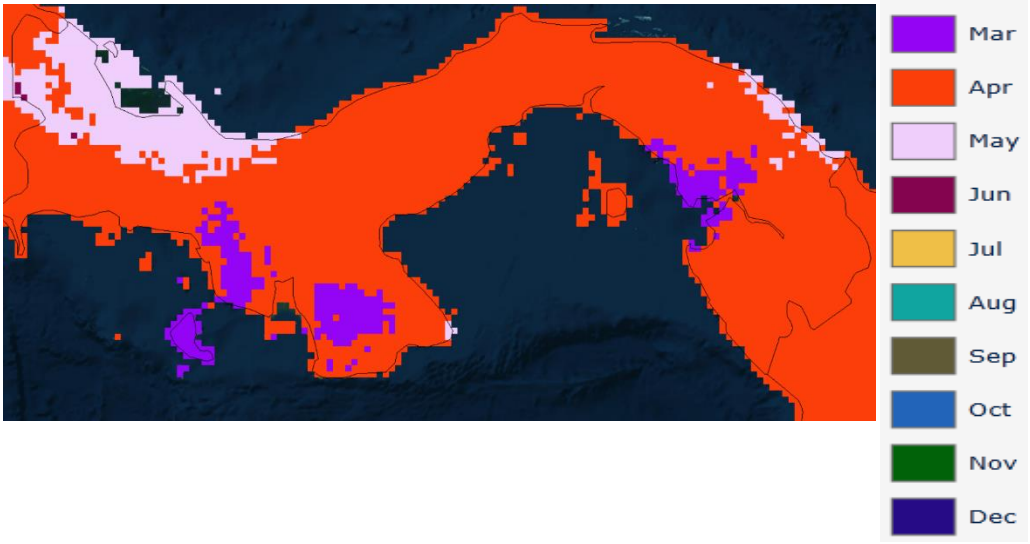
Emerging vector-borne disease threats detected in Panama recently include the following:
Punta Toro Virus complex: PTVs are thought to be transmitted by sand flies. However, more research is needed to determine vector capacity and to rule out mosquito-borne transmission.
Eastern Equine Encephalitis: EEE is transmitted by a number of mosquito species and has been detected in some wild Culex sp. collected in Panama.
Oropouche Virus: OROV causes Oropouche fever in humans and is transmitted by mosquitoes of the genus *Coquillettidia*.
Mercadeo Virus: MECDV is a mosquito-specific flavivirus recently reported from Panama. This virus has been isolated from wild caught Culex mosquitoes.

Climate Impacting Vector-born Disease Transmission

Climate of Panama

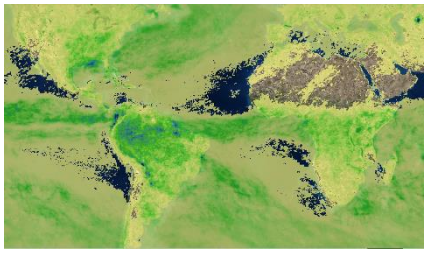


Month of maximum precipitation, WorldClim (50 year average)



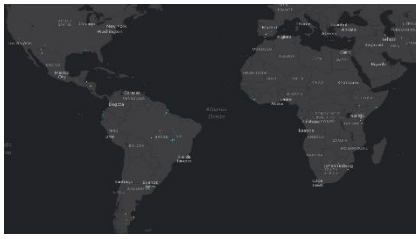
Month of maximum temperature, WorldClim (50 year average)

Monthly Climate Maps
Click here to view the maps described below

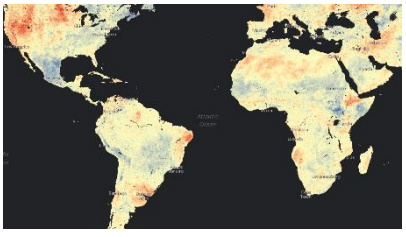


Rainfall
This map shows the accumulated rainfall for the past month. Updated monthly.
-NASA Earth Observations

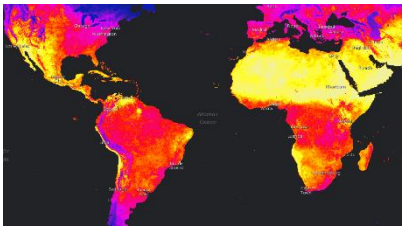
Consistent Above and Below Average Precipitation
Areas with consistent above average monthly rainfall over the past 3 months may indicate increased mosquito breeding sites which may lead to increased mosquito-borne disease transmission. Areas with consistent below average rainfall may also indicate increased water storage or ponding which can provide additional habitat for mosquito species that lay eggs in human containers, protected micro environments, or long lasting pools. Updated monthly. -NASA Earth Observations.



Drought Breaking Rain
Areas receiving above average rainfall for the past month and below average rainfall for the previous 12 months. Drought breaking rain may indicate recent suitable conditions for vectors and diseases in a stressed environment or human population. Updated monthly. -WorldClim, Giovanni online data system NASA GES DISC, Tropical Rainfall Measuring Mission (TRMM).



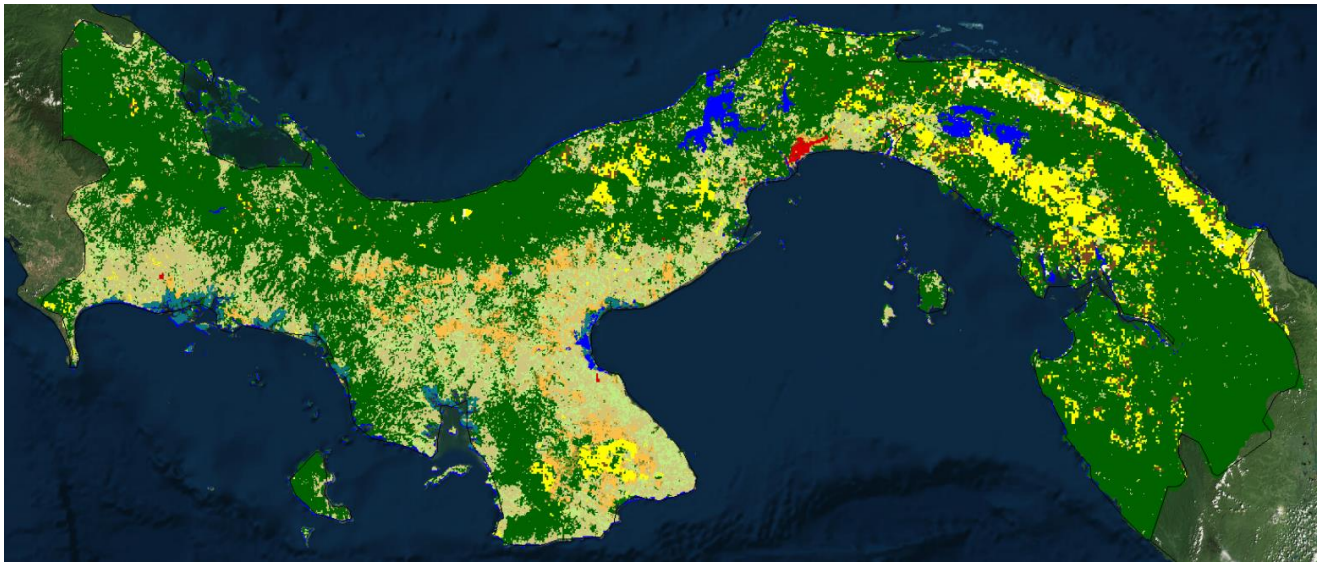
Temperature anomaly
This map shows where earth's temperatures were warmer or cooler in the daytime for the past month than the average temperatures for the same month from 2001-2010. Updated monthly.
-NASA Earth Observations



Land Surface Temperature
This map shows the temperature of the earth's lands during the daytime. Updated monthly.
-NASA Earth Observations

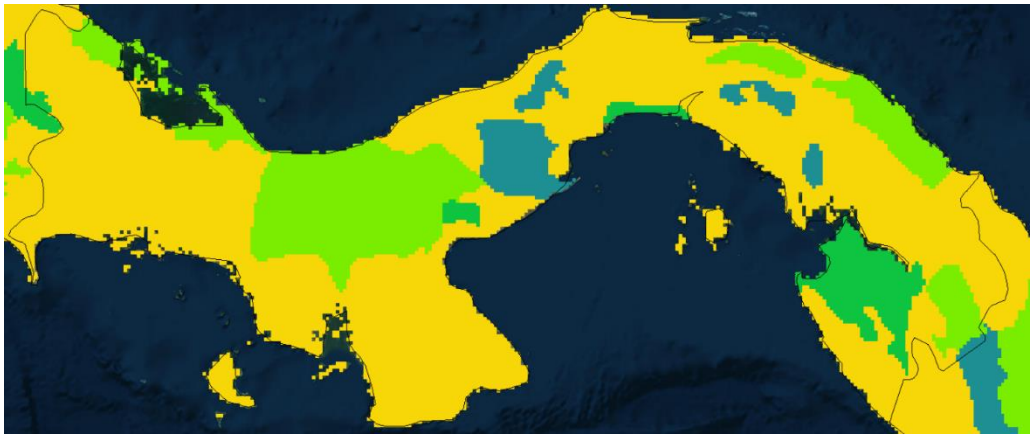
Land Cover/ Use Impacting Vector-borne Disease Transmission

Panama: Land Cover (FAO 2005)

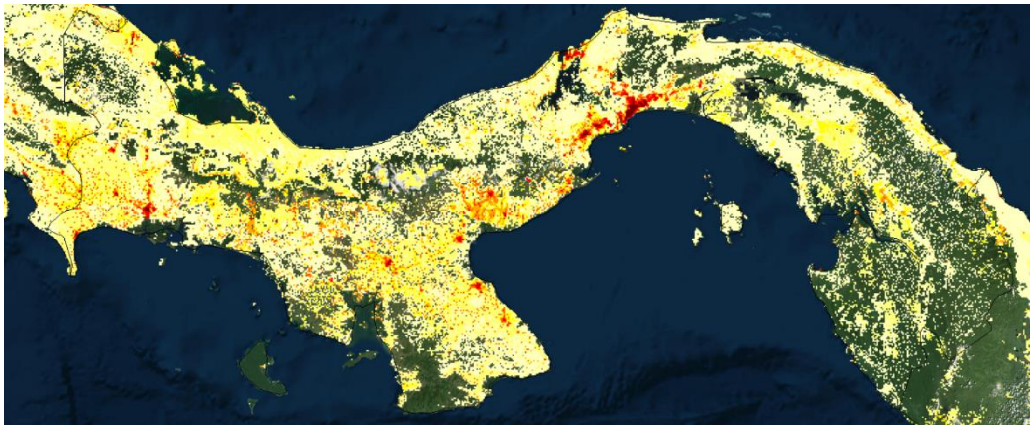


- 11 - Irrigated croplands
- 14 - Rainfed croplands
- 20 - Mosaic Croplands/Vegetation
- 30 - Mosaic Vegetation/Croplands
- 40 - Closed to open broadleaved evergreen or semi-deciduous forest
- 50 - Closed broadleaved deciduous forest
- 60 - Open broadleaved deciduous forest
- 70 - Closed needleleaved evergreen forest
- 90 - Open needleleaved deciduous or evergreen forest
- 100 - Closed to open mixed broadleaved and needleleaved forest
- 110 - mosaic Forest - Shrubland/Grassland
- 120 - Mosaic Grassland/Forest - Shrubland
- 130 - Closed to open shrubland
- 140 - Closed to open grassland
- 150 - Sparse vegetation
- 160 - Closed to open broadleaved forest regularly flooded (fresh-brackish water)
- 170 - Close broadleaved forest permanently flooded (saline-brackish water)
- 180 - Closed to open vegetation regularly flooded
- 190 - Artificial area
- 200 - Bare areas
- 210 - Water Bodies
- 220 - Permanent Snow and Ice
- 230 - No data

Soil Drainage and Human Population



Soil Drainage (Harmonized World Soil Database 1.1; 0.02 Deg resolution)



LandScan 2011, Human population per square km.

Malaria Risk Maps

Malaria in Panama

Source: CDC: Travelers advice for Panama

Malaria Risk Maps

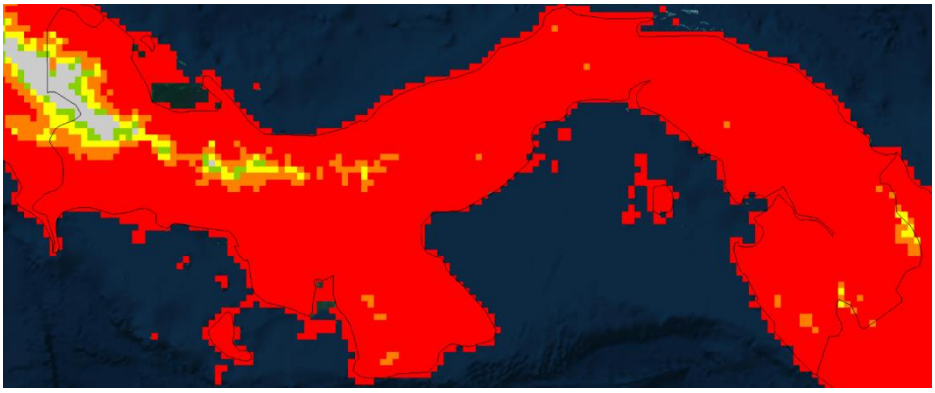
The number of infectious days (by month) in which the annual temperature regime could support malaria infection.
Gething et al. 2011

Plasmodium falciparum

Plasmodium vivax

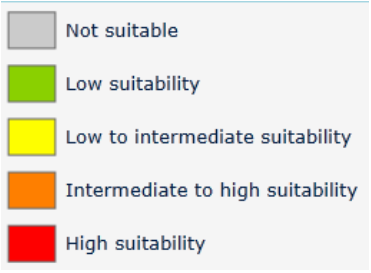
Malaria Risk Maps

The normalized Z(T) index of temperature suitability that incorporates the duration and degree of suitability across an average year
Gething et al. 2011

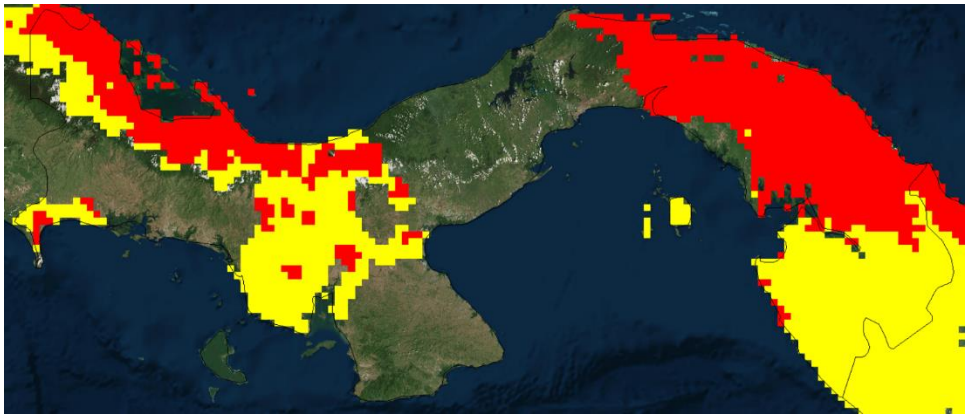


Plasmodium falciparum

Plasmodium vivax



Malaria Risk Maps



Lower risk (PR<1%)
Intermediate risk (PR 1-5%)
Higher risk (PR >5%)

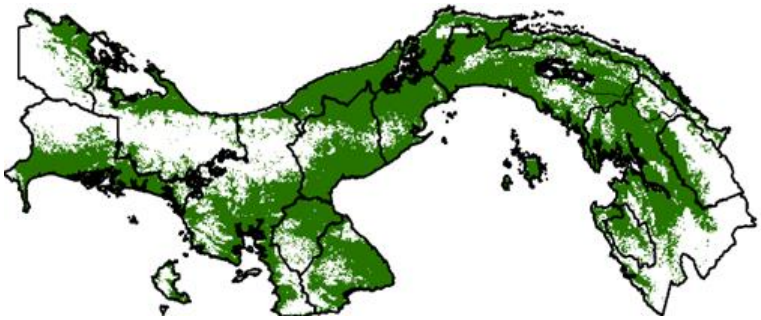
Stratified estimate proportion of the general population that are infected with *P. vivax* at any one time averaged over the 12 months of 2010. -Malaria Atlas Project

Lower risk (PR <5%)
Intermediate risk (PR 5-40%)
Higher risk (PR >40%)

Stratified estimate proportion of 2-10 year olds in the general population that are infected with *P. falciparum* at any one time averaged over the 12 months of 2010. -Malaria Atlas Project

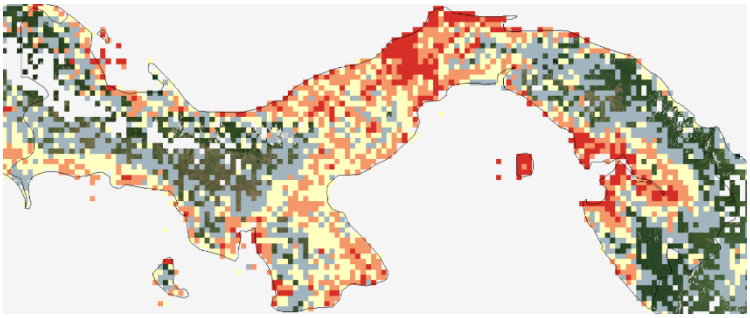
Malaria Vectors of Panama: Habitat Suitability Models

Anopheles albimanus



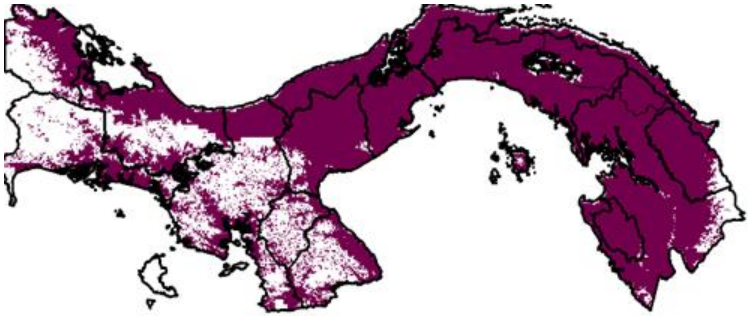
Suitable Habitat

Maxent model of *An. albimanus*, Lainhart, W. 2016



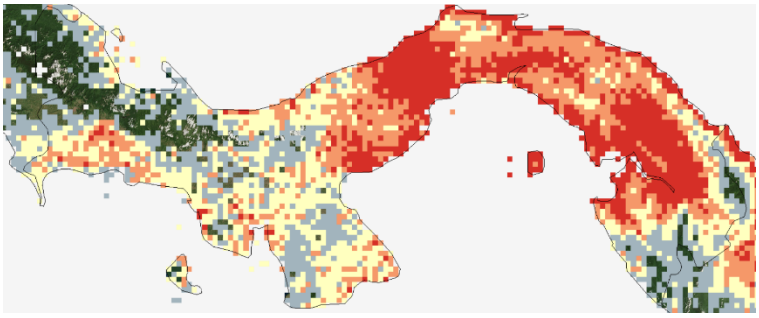
Maxent model of *An. albimanus*, Nyari, A. 2011

Anopheles punctimacula



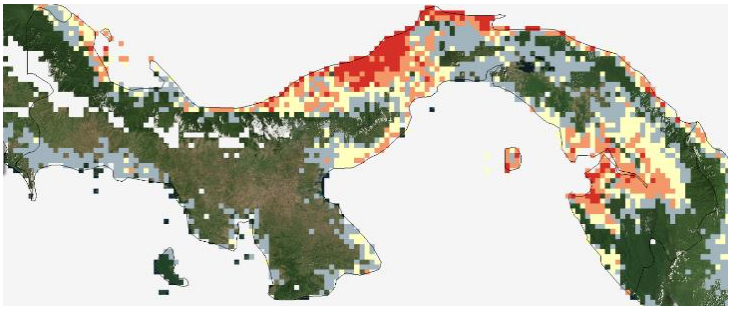
Suitable Habitat

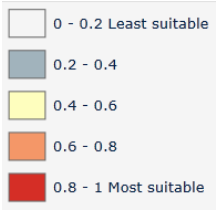
Maxent model of *An. punctimacula*, Lainhart, W. 2016



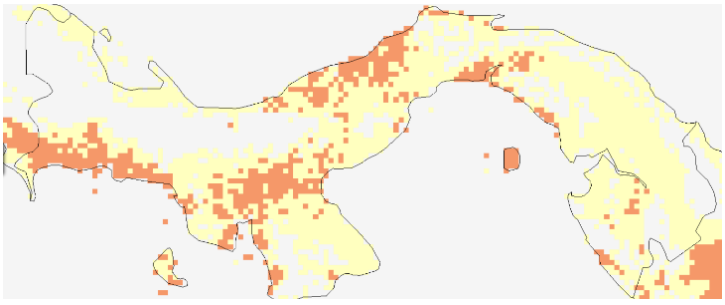
Maxent model of *An. punctimacula*, Nyari, A. 2011

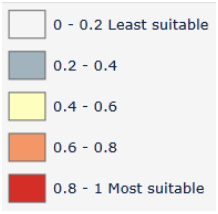
Secondary Malaria Vectors



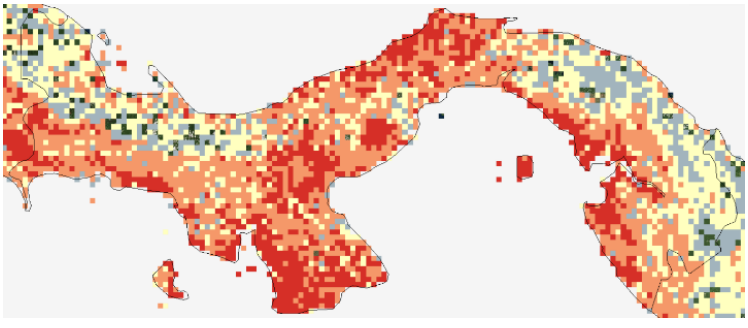


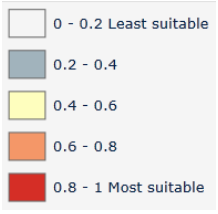
Maxent model of *An.aquasalis*, Nyari, A. 2011





Maxent model of *An. darlingi*, Nyari, A. 2011





Maxent model of *An. pseudopunctipennis*,Nyari, A. 2011

Malaria Vectors of Panama: Bionomics and Medical Importance

Background

Anopheles albimanus and *Anopheles punctimacula* s.l. are considered the primary vectors of Malaria in Panama. Malaria transmission occurs throughout the country (Lainhart, et al. 2016). Insecticide resistance to organophosphate, carbamate, and pyrethroid insecticides has also been reported from Panama in *Anopheles albimanus* specimens (Cáceres, et al. 2011).

Anopheles (Nys.) albimanus Wiedemann, 1820

Bionomics:

Larvae of *An. albimanus* are found in a wide variety of permanent water habitats. They are salt tolerant. Habitats are usually in full sunlight or partial shade containing abundant floating, emergent vegetation and floating scum and algae. Habitats frequently have muddy bottoms and turbid or polluted water.

Medical Importance:

In 17 of 20 Caribbean region countries, *An. albimanus* is the principal malaria vector.

WRBU Species Page

Anopheles (Ano.) punctimacula Dyar and Knab, 1906

Bionomics:

Larvae of *An. punctimacula* were taken in deep or sometimes partial shade in the following types of water: stream pool with clear water, in grass along a clear slow-moving stream with abundant vegetation, along a swamp margin, and in deep water of a large swamp. Adult females bite man and domestic animals and have been collected in Shannon traps, stable traps, horse traps, in corrals, and from human bait. (Wilkerson 1990:235)

Medical Importance:

An. punctimacula is a confirmed malaria vector (pers. comm. Wilkerson 2009)

WRBU Species Page

Anopheles (Nys.) aquasalis Curry, 1932

Bionomics:
An. aquasalis is the only species primarily restricted to the coast. This species primarily occurs in brackish water such as in mangrove swamps and coastal ground pools. However, aquasalis is capable of living in fresh water and is often collected several kilometers from the coast. (Faran and Linthicum 1981:8)

Medical Importance:
An. aquasalis is a primary vector of malaria in the Lesser Antilles, and in Trinidad and Tobago. Along the coast of Brazil, the Guianas and possibly Venezuela, it is always a potential vector but usually only important when it occurs in large numbers. *An. aquasalis* feeds readily on man and is commonly collected in houses. In the past it has been an important vector of malaria in coastal Brazil. (Faran and Linthicum 1981:9)

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Anopheles (Nys.) darlingi Root, 1926

Bionomics:

The immatures of *An. darlingi* have been collected in streams and ponds with mud bottoms, ground pools, and swamps. Most of the immatures were in partially shaded areas. All the sites contained grassy or floating vegetation and sometimes green algae. The water was clear, never turbid or polluted. The sites were usually in areas of secondary growth such as plantations or cultivated fields. *An. darlingi* is definitely an endophilic species. A number of workers have verified that when a bait animal is used as a form of mosquito control outside houses, more specimens of darlingi are still found inside the houses than on the bait animal. (Faran and Linthicum 1981:36)

Medical Importance:

An. darlingi is a very efficient vector of malaria in northern and northeastern Brazil as well as in numerous other areas in South America. Wherever this species occurs along with malaria, darlingi females are almost always found naturally infected. An. darlingi is highly endophagous and anthropophilic. In addition to malaria, this species has also been suspected of being a vector of human filariasis. It has transmitted Wuchereria bancrofti (Cobbold) in the laboratory and has been collected naturally infected with this parasite. (Faran and Linthicum 1981:9)

WRBU Species Page

Anopheles (Cel.) pseudopunctipennis Theobald, 1901

Bionomics:

The larvae are found in sunny habitats including stream pools and margins. Females feed at night and will enter houses to take a blood meal.

Medical Importance:

This species is considered an important vector of malaria in Central America.

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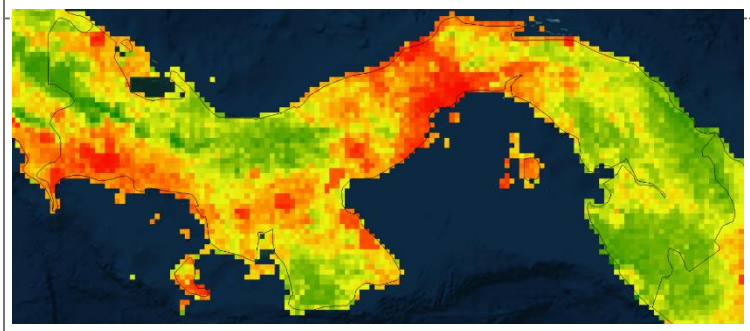
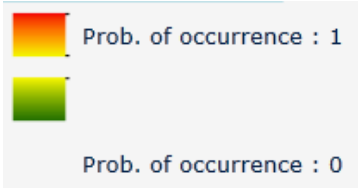
Dengue, Yellow Fever and Zika Virus Risk Maps and Vector Distribution Models

The primary vectors for Dengue, Yellow Fever, Chikungunya and Zika Viruses are Aedes aegypti and Aedes albopictus.
Estimation of Aedes aegypti (Diptera: Culicidae) population size and adult male survival in an urban area in Panama (Neira et al. 2014).

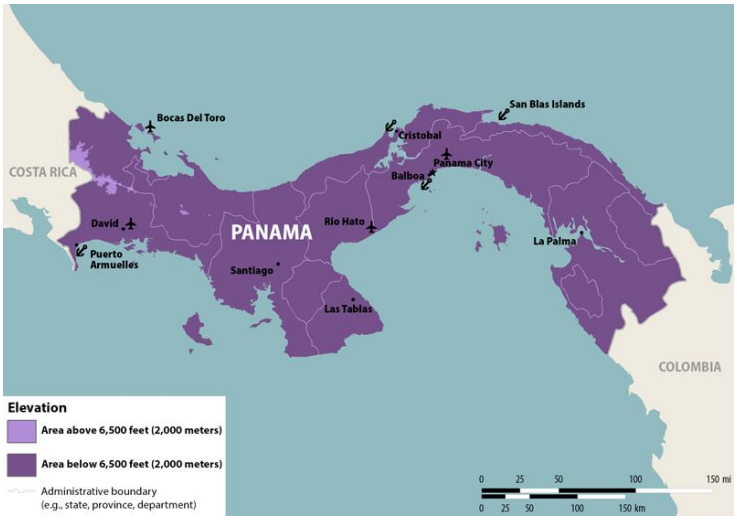
Top: *Aedes aegypti*, Bottom: *Aedes albopictus* (Photo Source: James Gathany, CDC)

Aedes Arbovirus Distributions





Dengue Prediction Model
Bhatt, S. et al. 2013

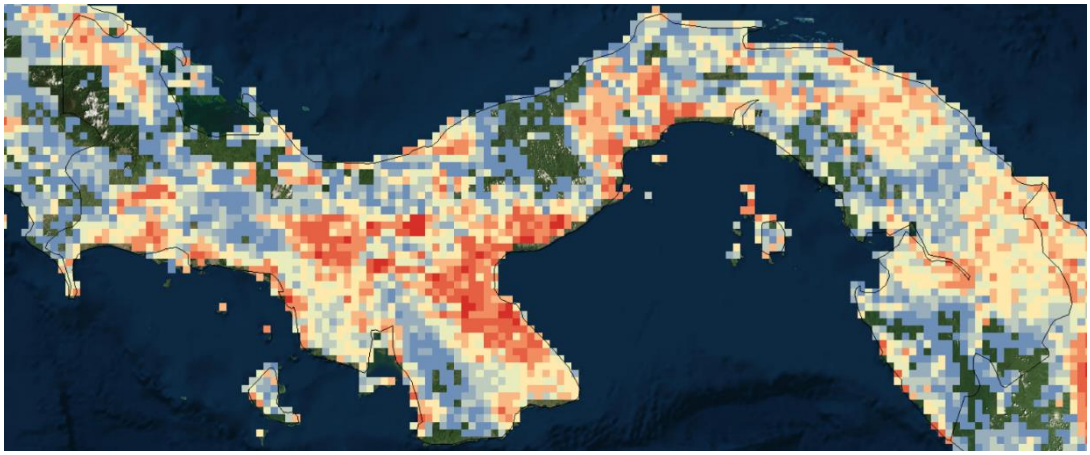


Map sourced from TravelPro.org and confirmed by CDC

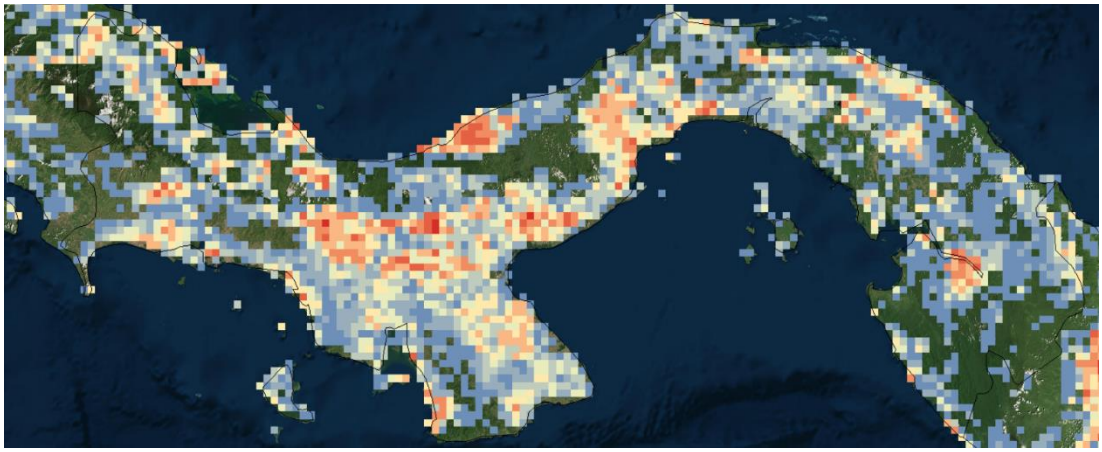
CDC: Recommendations for Yellow Fever Vaccinations in Panama

Aedes Arbovirus Vector Habitat Suitability Model

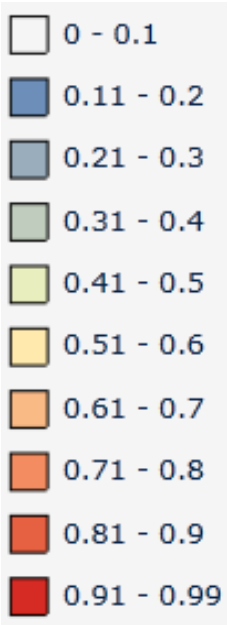
Kraemer, et al. 2016



Aedes aegypti



Aedes albopictus



Aedes Arbovirus Vectors of Panama: Bionomics and Medical Importance

Aedes (Stg.) aegypti (Linnaeus, 1762)

Bionomics:
In association with man, aegypti will use any and all natural and artificial containers. Away from urban areas this species tends to favor pools in river beds, tree stumps, tree holes and natural containers. Females are primarily day biters and readily enter buildings to feed. They have also been taken in lesser numbers at night (Christophers 1960).

Medical Importance:
Ae. aegypti is a primary vector of dengue, chikungunya virus and yellow fever (Christophers 1960).

WRBU Species Page

Aedes (Stg.) albopictus (Skuse, 1894)

Bionomics:
Immatures are found in natural containers, including tree holes, bamboo stumps, coconut shells, rock holes, palm fronds, and leaf axils. They are also found in all varieties of artificial containers and will breed indoors. Females readily bite man (Huang 1972).

Medical Importance:
Vector of dengue and yellow fever in the wild. Under laboratory conditions: bird malarias, Eastern and Western equine encephalitis, West Nile, chikungunya and Japanese encephalitis viruses (Huang 1972).

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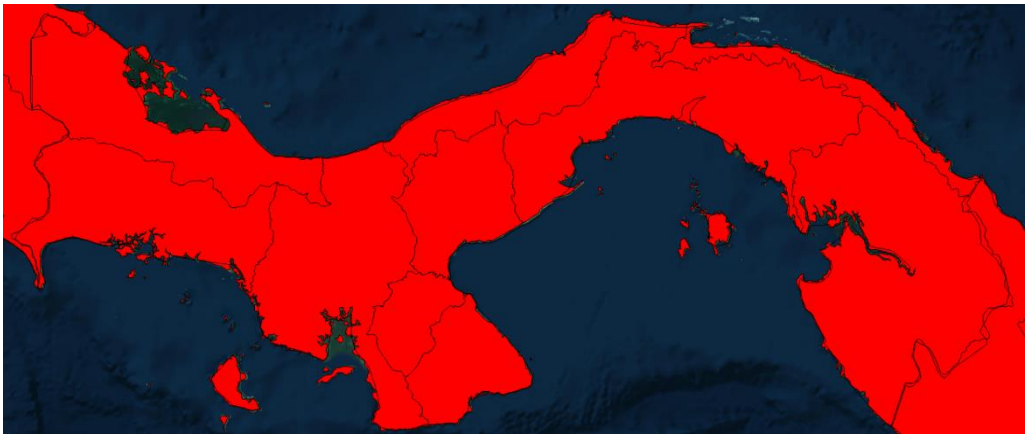
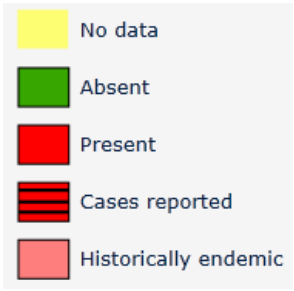
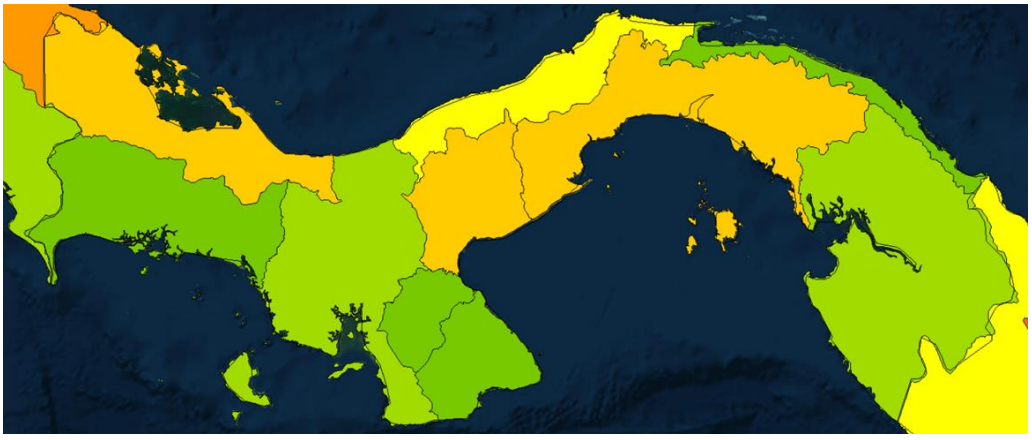
Leishmaniasis Risk Maps

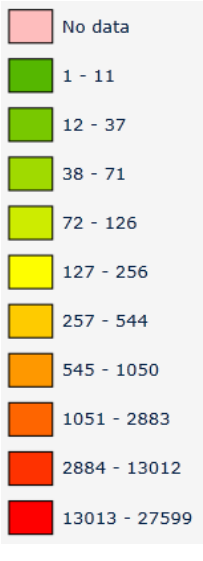
Leishmaniasis Risk Maps





Cutaneous Leishmaniasis presence/ absence 2012
Alvar J. et al. 2012.

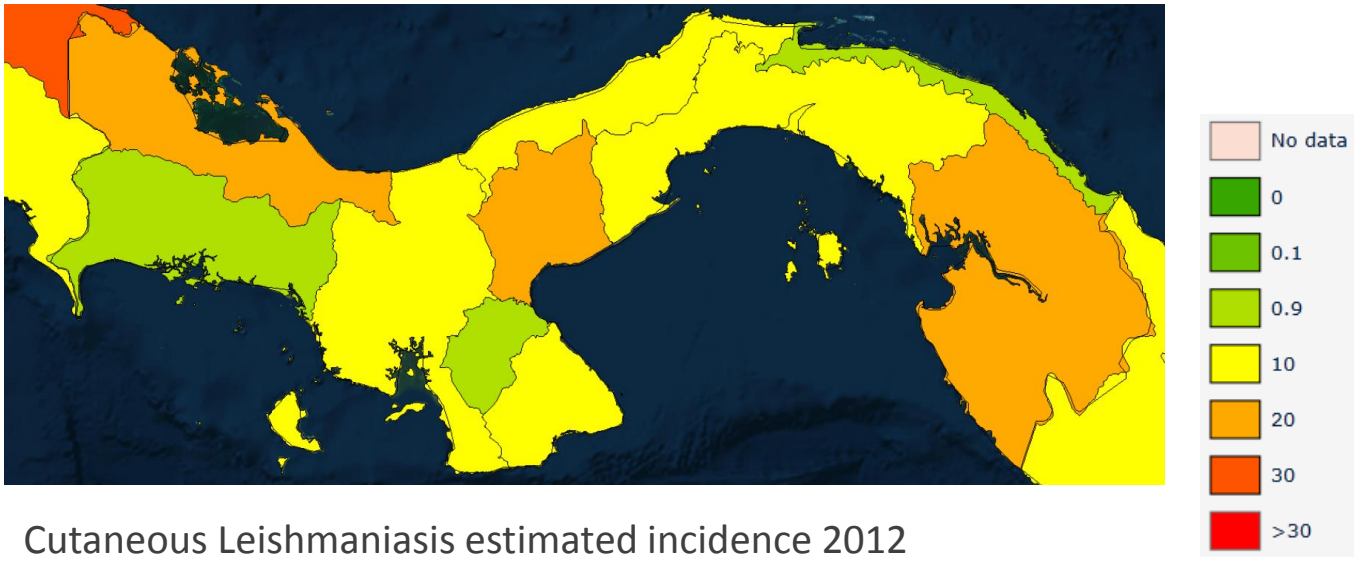




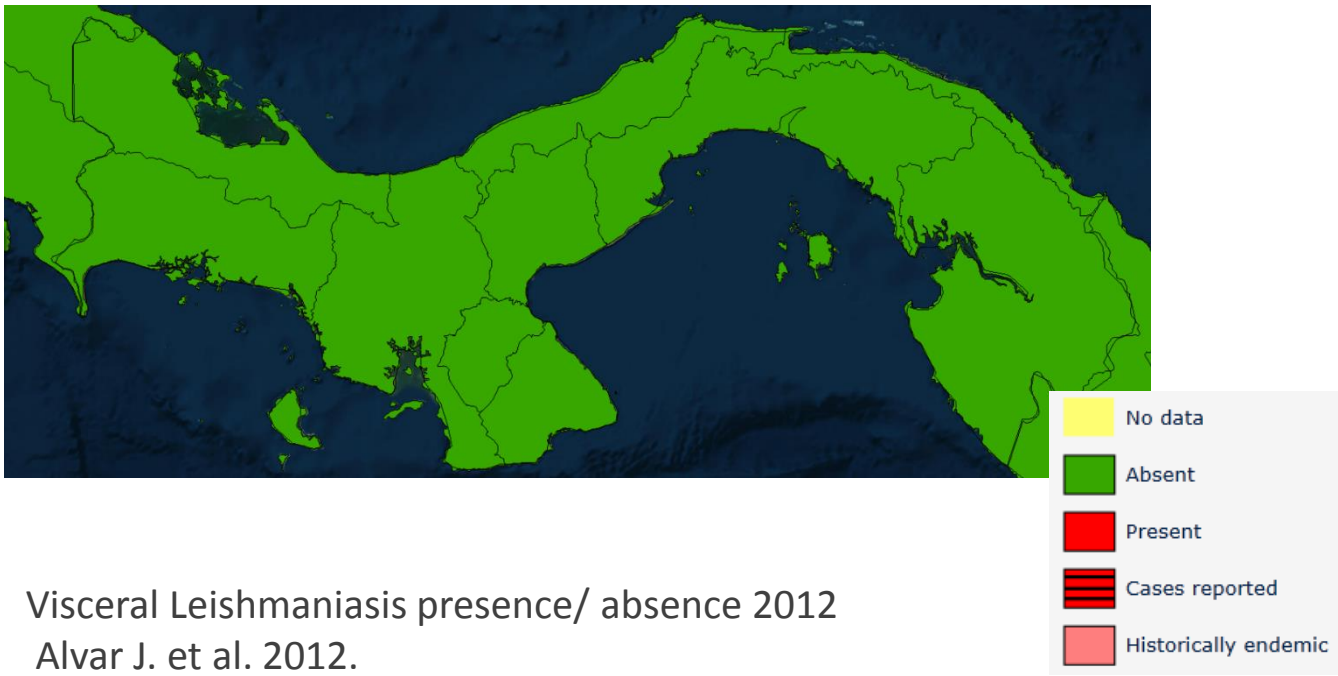
Cutaneous Leishmaniasis estimates of the maximum number of cases, 2012
Alvar J. et al. 2012.

Leishmaniasis Risk Maps

Leishmaniasis Risk Maps



Cutaneous Leishmaniasis estimated incidence 2012
Alvar J. et al. 2012.

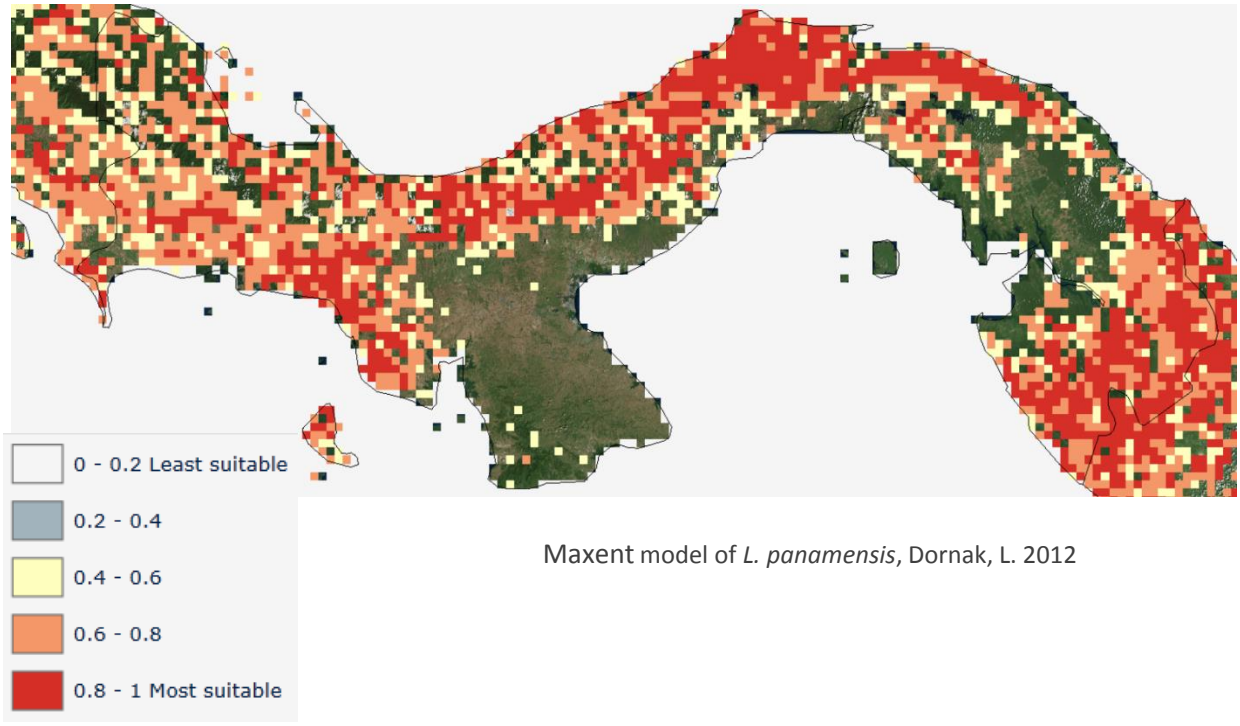


Visceral Leishmaniasis presence/ absence 2012
Alvar J. et al. 2012.

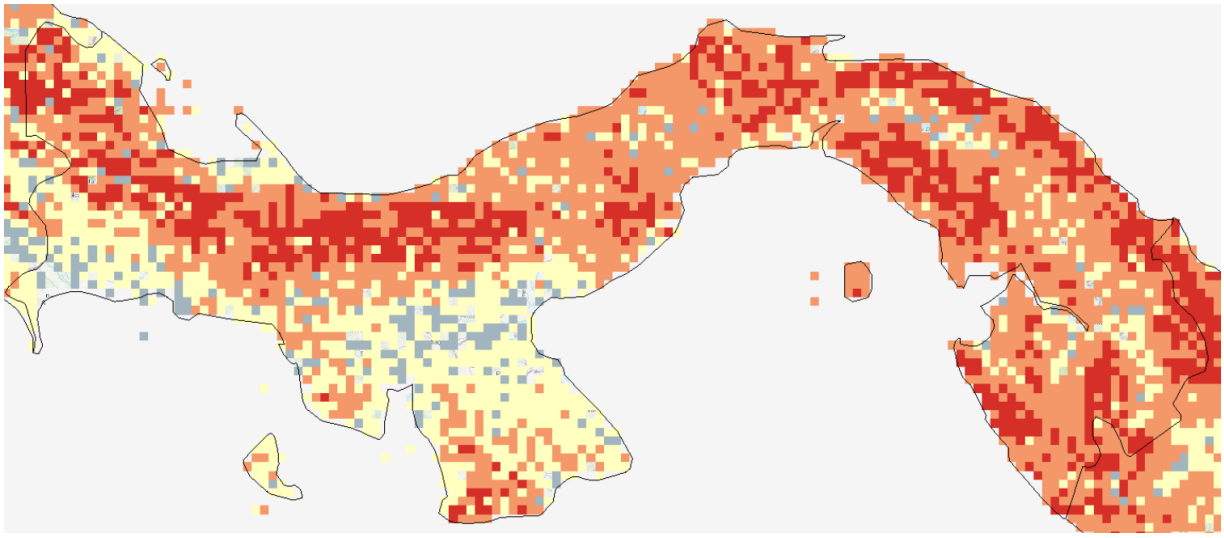
Photo Source: University of Pennsylvania

Leishmaniasis Vectors of Panama: Habitat Suitability Models

Lutzomyia panamensis and Lu. gomezi

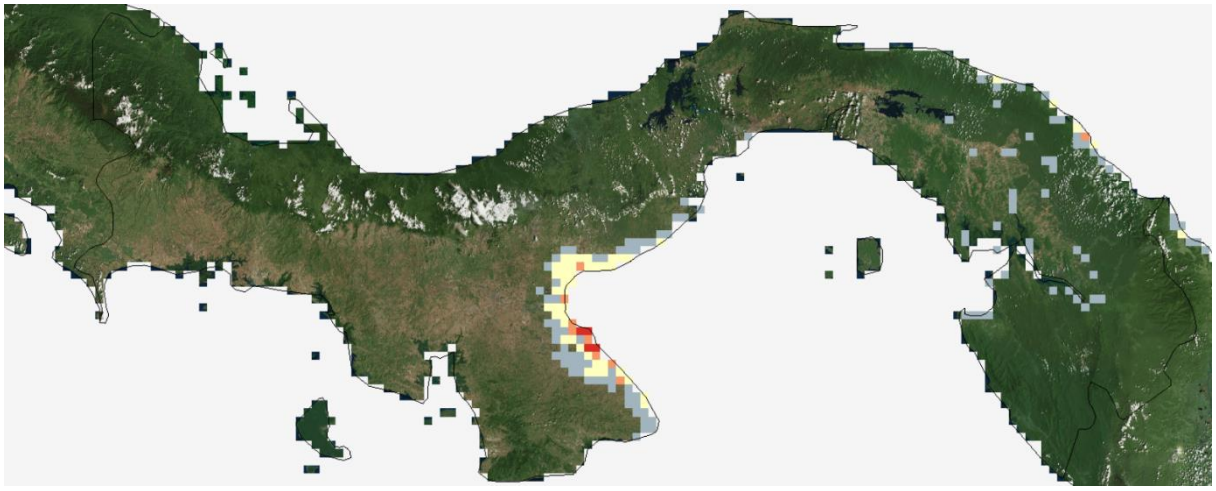


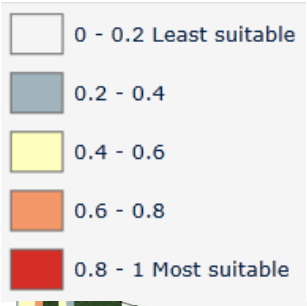
Maxent model of *L. panamensis*, Dornak, L. 2012



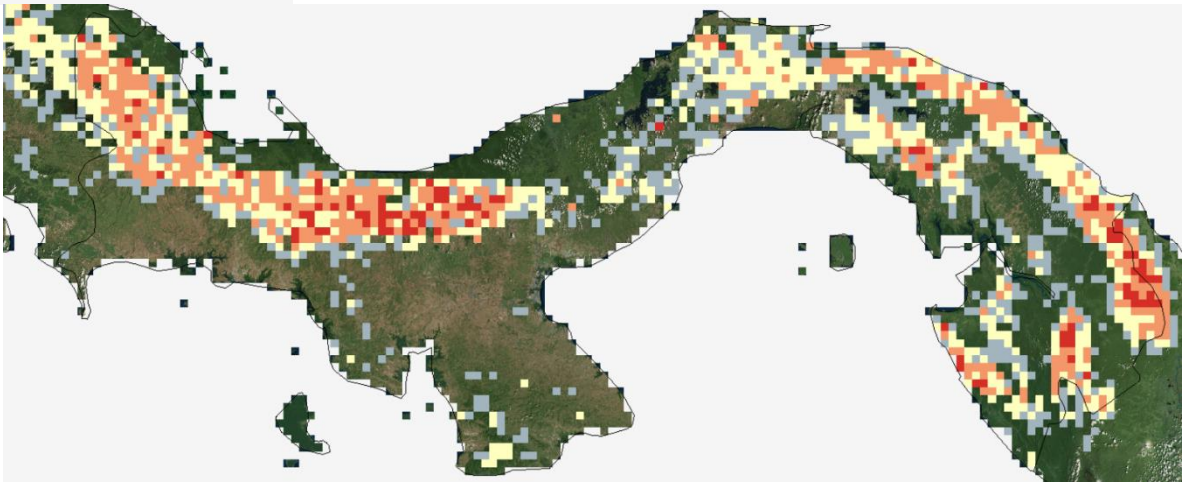
Maxent model of *L. gomezi*, Dornak, L. 2012

Lutzomyia longipalpis and *Lu. ovallesi*





Maxent model of *L. longipalpis*, Dornak, L. 2011



Maxent model of *L. ovallesi*, Dornak, L. 2012

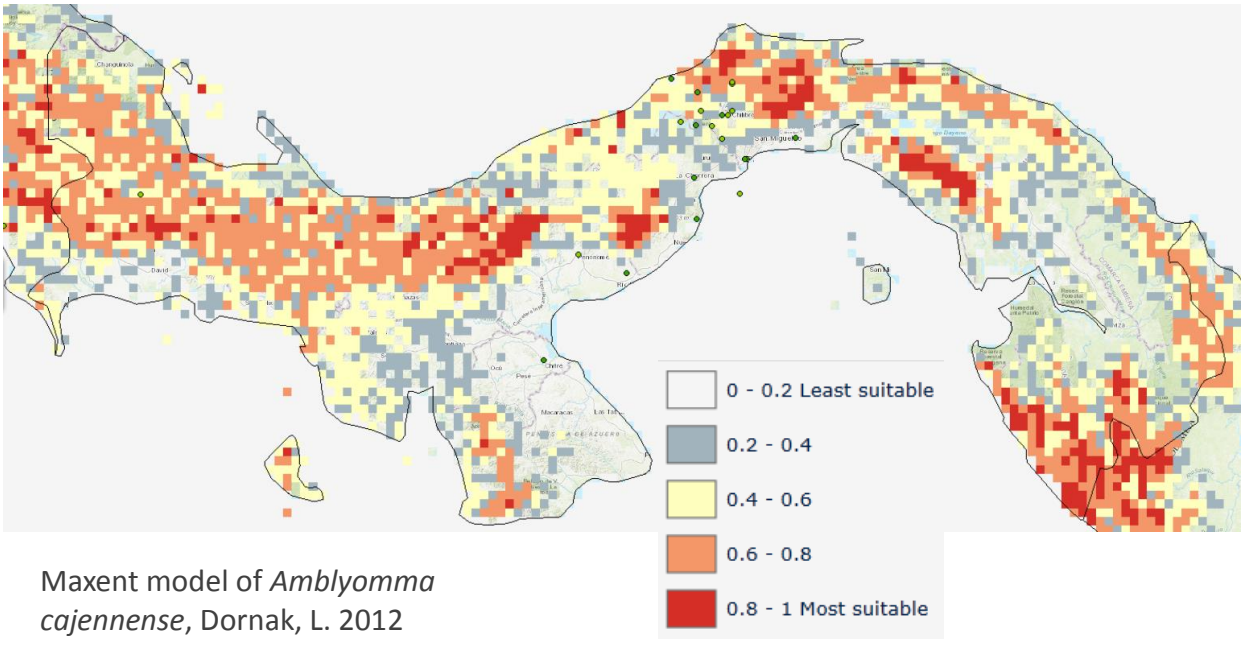
Sand Fly Vectors: Medical Importance

Maroli, M. et al 2012

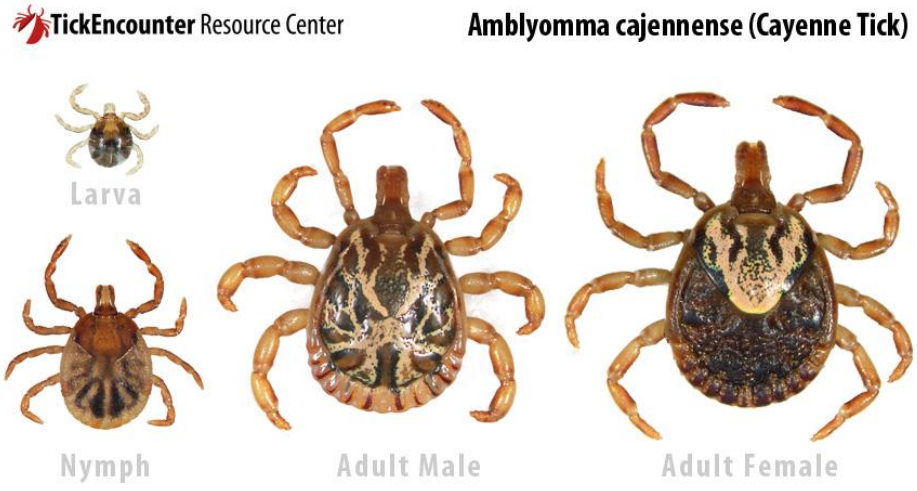
- *Lutzomyia panamensis:* A suspected vector of *Leishmaniasis braziliensis* and *Leishmaniasis panamensis* which can cause localized cutaneous leishmaniasis in humans.
- *Lutzomyia trapidoi:* A suspected vector of *Leishmaniasis braziliensis* which can cause localized cutaneous leishmaniasis in humans.
- *Lutzomyia gomezi*: A known vector of Leishmaniasis panamensis which can cause localized cutaneous leishmaniasis in humans.
- *Lutzomyia cruciata*: A known vector of Leishmaniasis panamensis which can cause localized cutaneous leishmaniasis in humans.
- *Lutzomyia longipalpis:* A proven vector of *Leishmaniasis infantum* which can cause visceral leishmaniasis in humans.
- *Lutzomyia ovallesi:* A suspected vector of *Leishmaniasis braziliensis* which can cause localized cutaneous leishmaniasis in humans.
- *Lutzomyia ylephiletor:* A suspected vector of *Leishmaniasis braziliensis* and *Leishmaniasis panamensis* which can cause localized cutaneous leishmaniasis in humans.

Ticks and Tick-Borne Disease Hazards of Panama

Amblyomma cajennense (Fabricius, 1787)



Maxent model of *Amblyomma cajennense*, Dornak, L. 2012



Life stages of the RMSF vector Amblyomma cajennense, sourced from TickEncounter.org

Triatomines and Chagas Disease Hazards of Panama

Photo Source: Vectors of Chagas: https://sites.google.com/site/triatominae/rhodnius-genus/r-pallescens

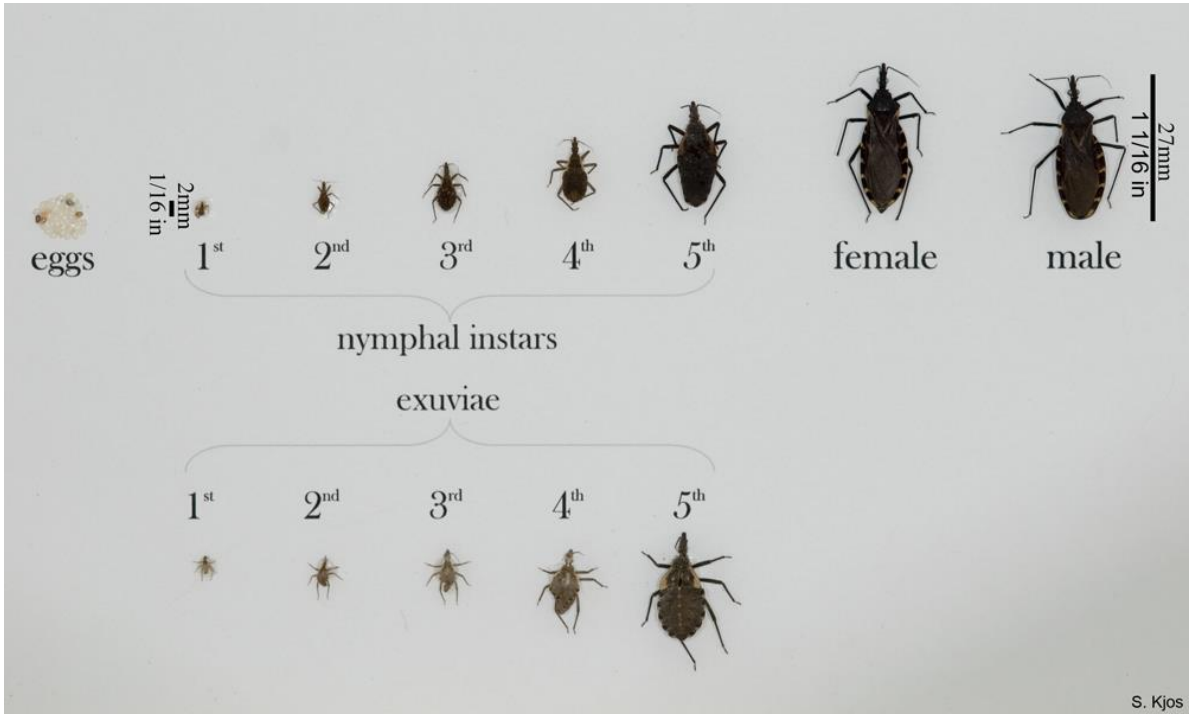
Background

Triatomines vector *Trypanosoma cruzi* (causative agent of Chagas Disease) to humans via their feces. They may acquire the parasite through a blood-meal taken from an infected mammal reservoir (CDC, 2017). The primary vector of T. cruzi in Panama is *Rhodnius pallescens*. In a recent study examining domesticated dogs for the presence of T. cruzi, investigators found a strong correlation between infection and proximity to Royal Palms (Attalea butyracea) (Saldana, 2015). Another study examined these palm trees across five different habitats representing a gradient of human disturbance. Their findings suggest that there is a significant increase in *Rhodnius pallescens* abundance in royal palm trees found in areas of high disturbance (Gottdenker, et al. 2011). Further studies have shown that there is an increased risk of human infection within homes that are less than 300 m from these palm trees (Pineda et al. 2008).

Additional Resources:

A full list of vertebrate hosts and reservoirs for trypanosome species in Panama can be found here.

A checklist of the Triatominae species including distributions and taxonomic notes can be found here.



Life stages of Triatomines. Source: CDC

Distribution of Chagas Disease Vectors

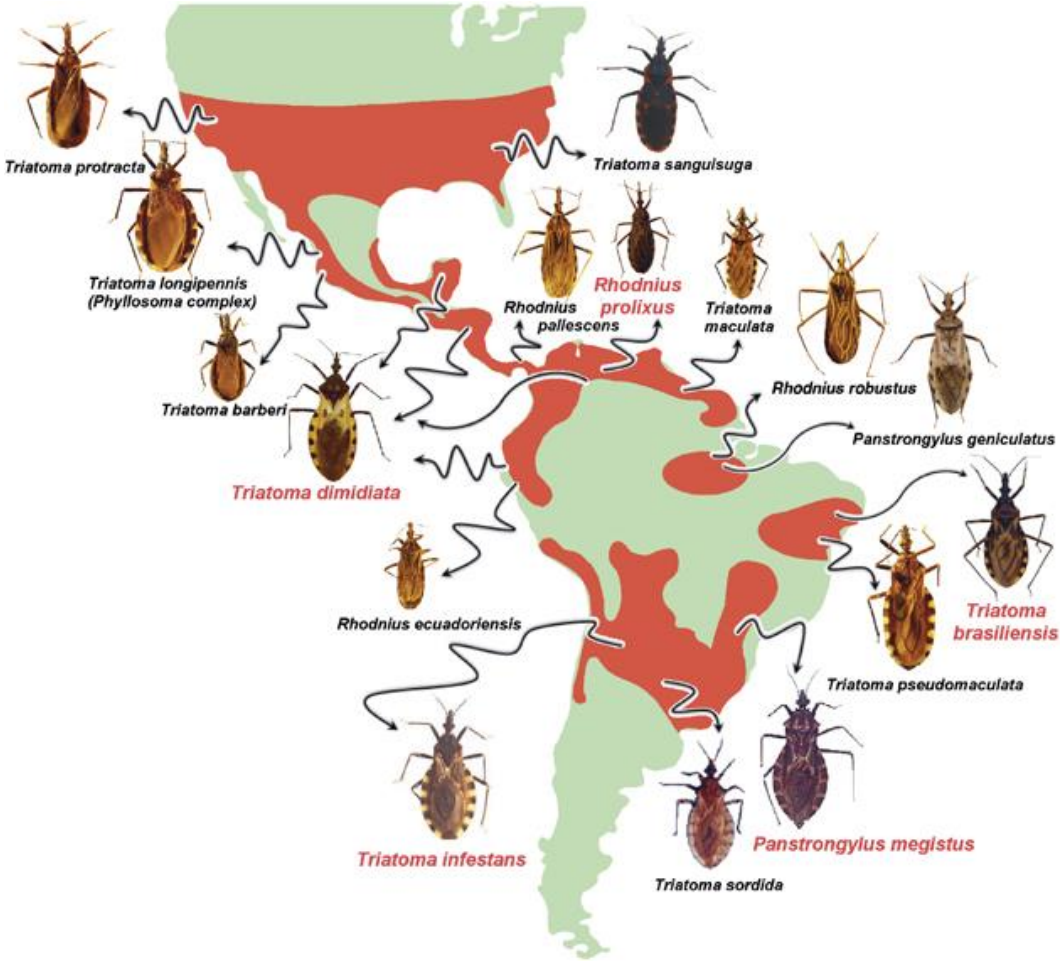


Figure Source: Genetics and evolution of triatomines: From phylogeny to vector control:DOI: 10.1038/hdy.2011.71

Distribution of triatomine species of medical importance. There are 20 species known to vector *T. cruzi* to humans. The areas in red are the estimated distribution for each species. Species highlighted in red are considered the most important vectors of the parasite. In Panama, *Rhodnius prolixus* is considered the primary Chagas vector (Gourbière, et al. 2012).

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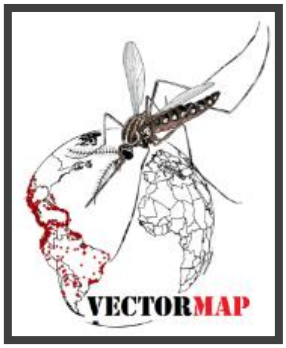
Vector Hazard Report:
Request a Report by Contacting the WRBU

WRBU
WALTER REED BIOSYSTEMATICS UNIT
Know the vector, know the threat

The Walter Reed Biosystematics Unit is part of the Walter Reed Army Institute of Research and is based at the Smithsonian Institution Museum Support Center. To access taxonomic keys, the Systematic Catalog of Culicidae or to learn more about WRBU visit wrbu.si.edu



VectorMap is only as good as the data you provide. If you have collection records, models or pathogen testing results please contact the VectorMap team to learn how to contribute data at mosquitomap@si.edu

Vector Photos Provided by Judith Stoffer, Walter Reed Biosystematics Unit