



# Climate Change and Vector-borne diseases

**Sherine Huntley Jones**  
**Medical Entomologist**

**Pesticide Control Week**  
**September 29<sup>th</sup>, , 2016**

**University of the West Indies**

# Presentation Outline

---



- ▶ General Overview
- ▶ Definitions
- ▶ Emerging and Re-emerging Diseases
- ▶ Factors affecting Disease Emergence
- ▶ Impact/Effects of climate on diseases
- ▶ Vector-borne Diseases
- ▶ Case Studies
  - ▶ Malaria
  - ▶ Dengue
- ▶ Vector-borne Diseases in Jamaica
- ▶ Way Forward



# Overview 1

---



- ▶ The last 200 years have seen greater environmental changes than the previous 2000 years
- ▶ The last 20 years have seen greater changes than the last 200 years
  - ▶ (Myers and Tickell, 2001)



# Definition of Emerging Disease

---

- ▶ *“Emergency of a pathogen in human or animal population which is related to the increase in distribution, increase in incidence or increase in virulence or other factors” (Jones, 2008)*



# Definition of Emerging Disease

---

- ▶ Since 1980, a new disease has emerged on an average of 7 months (Climate change Initiatives, 2008)

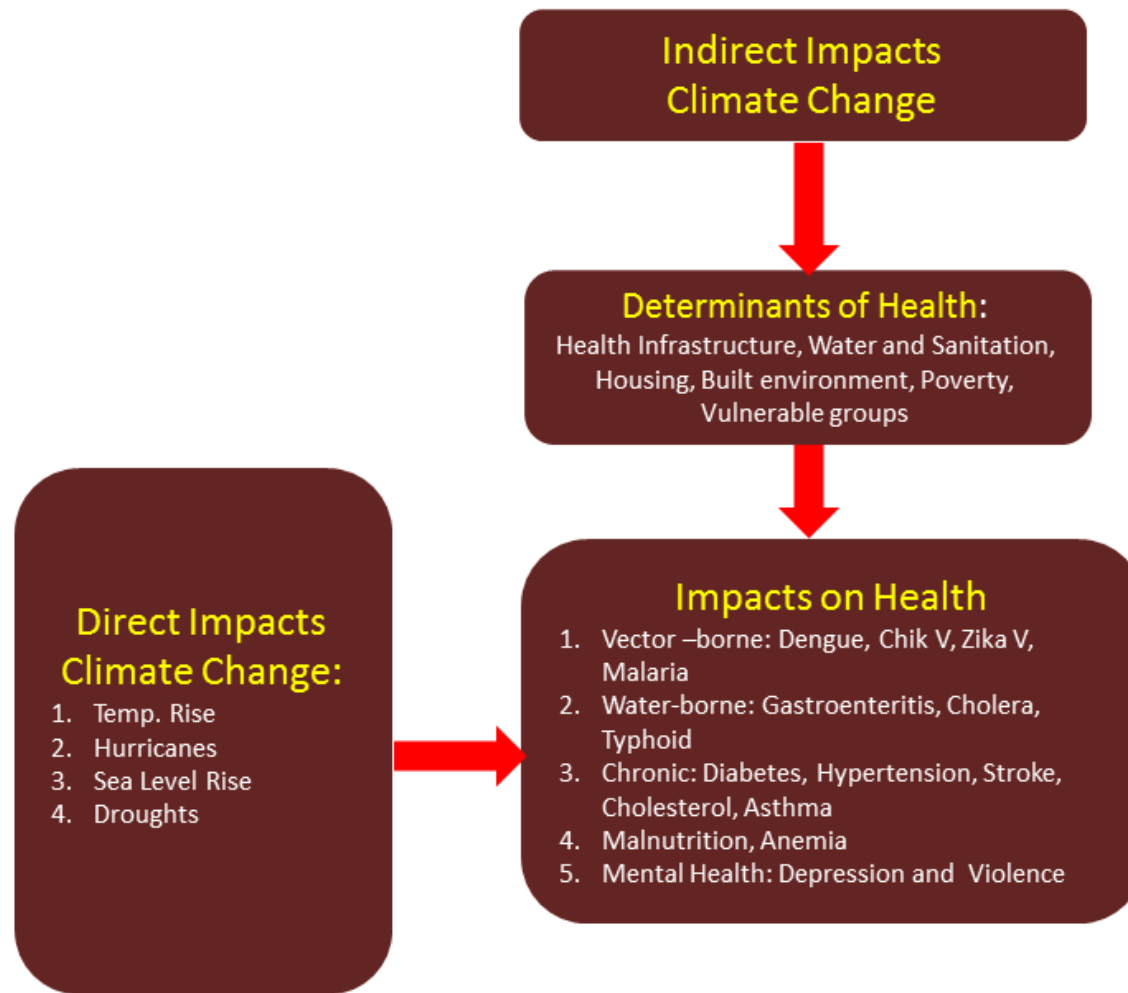


# Factors affecting emergency and re-emergency

## ► Include genetical, biological, social, political and economical

1. Human Susceptibility
2. Climate and weather
3. Changing ecosystems
4. Human demography and behaviour
5. Economical development and land use
6. Poverty and social inequalities
7. Altered landscape that brings people into contact with the vector
8. Faster longer distant travel and trade
9. Climate change

Figure Direct and Indirect Impacts on Health and Its determinants



Source: Homero Silva 2016

# Vector-borne Diseases of Concern

Disease	Pathogen	Vector	Transmission
Protozoan			
<b>Malaria</b>	<b><i>Plasmodium falciparum, vivax, ovale, malariae</i></b>	<b><i>Anopheles</i> spp. Mosquitoes</b>	<b>Anthroponotic</b>
<b>Leishmaniasis *</b>	<b><i>Leishmania</i> spp.</b>	<b><i>Lutzomyia</i> &amp; <i>Phlebotomus</i> spp. Sandflies</b>	<b>Zoonotic</b>
<b>Trypanosomiasis *</b>	<b><i>Trypanosoma brucei gambiense, rhodesiense</i></b>	<b><i>Glossina</i> spp. (tsetse fly)</b>	<b>Zoonotic</b>
<b>Chagas disease *</b>	<b><i>Trypanosoma cruzi</i></b>	<b><i>Triatomine</i> spp.</b>	<b>Zoonotic</b>

\* WHO neglected tropical disease

Hill et al., 2005





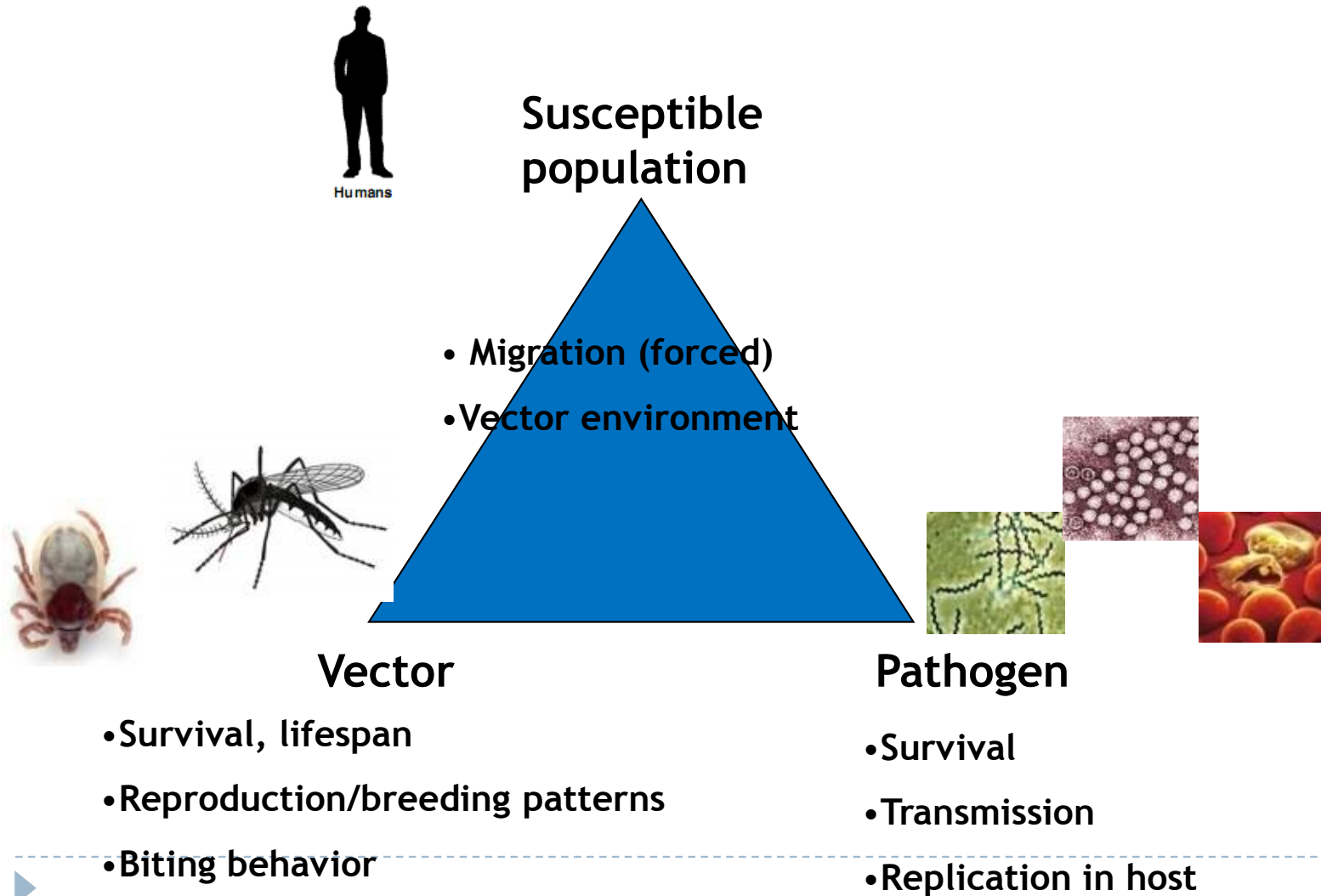
# Vector-borne Diseases of Concern (cont.)

Disease	Pathogen	Vector	Transmission
Viral			
<b>Dengue *</b>	<b><i>DEN-1,2,3,4 flaviviruses</i></b>	<b><i>Aedes aegypti</i> mosquito</b>	<b>Anthroponotic</b>
<b>Yellow fever</b>	<b><i>Yellow fever flavivirus</i></b>	<b><i>Aedes aegypti</i> mosquito</b>	<b>Anthroponotic</b>
<b>Encephalitis (West Nile, Lyme, etc.)</b>	<b><i>Flavi-,alpha- and bunyaviruses</i></b>	<b>Mosquitoes and ticks</b>	<b>Zoonotic</b>
Filarial nematodes			
<b>Lymphatic filariasis *</b>	<b><i>Brugia malayi, timori, Wuchereria bancrofti</i></b>	<b>Anopheles, Culex, Aedes mosquitoes</b>	<b>Anthroponotic</b>
<b>Onchocerciasis *</b>	<b><i>Onchocerca volvulus</i></b>	<b><i>Simulium</i> spp. blackflies</b>	<b>Anthroponotic</b>



# Vector-borne Disease Dynamics

---



---

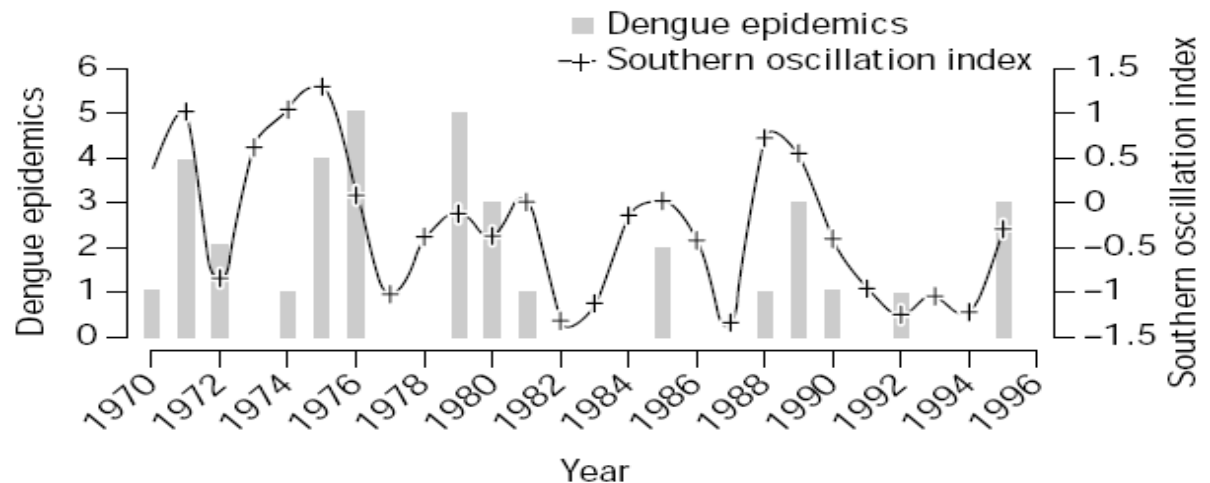
▶ **HOW WILL CLIMATE CHANGE AFFECTS  
THE TRANSMISSION DYNAMICS OF  
VECTOR-BORNE DISEASES**



# Example of Weather Effects: El Niño

- ▶ Global warming intensify El Niño
- ▶ Several studies found relationships between dengue epidemics and ENSO (El Niño Southern Oscillation)
- ▶ Drought conditions: increase water storage around houses → elevated *Aedes aegypti* populations
- ▶ Enhanced breeding opportunities when rainfall accumulates following drought (Kuno et al., 1995)

*ENSO= global scale pattern of climate variation accounting for up to 40% of temperature and rainfall variation in Pacific*



# Direct Effects of Climate Change on Vector-borne Disease

---

- ▶ **Climate change has the potential to**
  - ▶ Increase range or abundance of animal reservoirs and/or arthropod vectors
    - ▶ (e.g., Lyme, Malaria, Schistosomiasis)
  - ▶ Enhance transmission by affecting seasonality
    - ▶ (e.g., West Nile virus and other arboviruses)
  - ▶ Increase likelihood of successful importation of disease vector and host



# Vector and Host Seasonality (cont.)

---

► For e.g.

► Dengue high transmission in Jamaica is usually between October –February

► In the rainy season following the warm summer months



# Temperature Effects on Vectors and Pathogens

---

## ▶ Vector

- ▶ Survival decrease/increase depending on the species
- ▶ Changes in the susceptibility of vectors to some pathogens
- ▶ Changes in rate of vector population growth
- ▶ Changes in feeding rate and host contact

## ▶ Pathogen

- ▶ Decreased extrinsic incubation period of pathogen in vector at higher temperatures
- ▶ Changes in the transmission season
- ▶ Changes in geographical distribution
- ▶ Decreased viral replication



# Precipitation Effects on Vectors

---



## ► Vector

- Survival: increased rain may increase larval habitat
  - Excess rain can eliminate habitat by flooding
- Low rainfall can create habitat as rivers dry into pools (dry season malaria)
- Decreased rain can increase container-breeding mosquitoes by forcing increased water storage
- Heavy rainfall events can synchronize vector host-seeking and virus transmission
- Increased humidity increases vector survival and vice-versa



# Vector Activity

- ▶ Increased relative humidity increases activity, heavy rainfall decreases activity
- ▶ Increased activity increases transmission rates



National Geographic

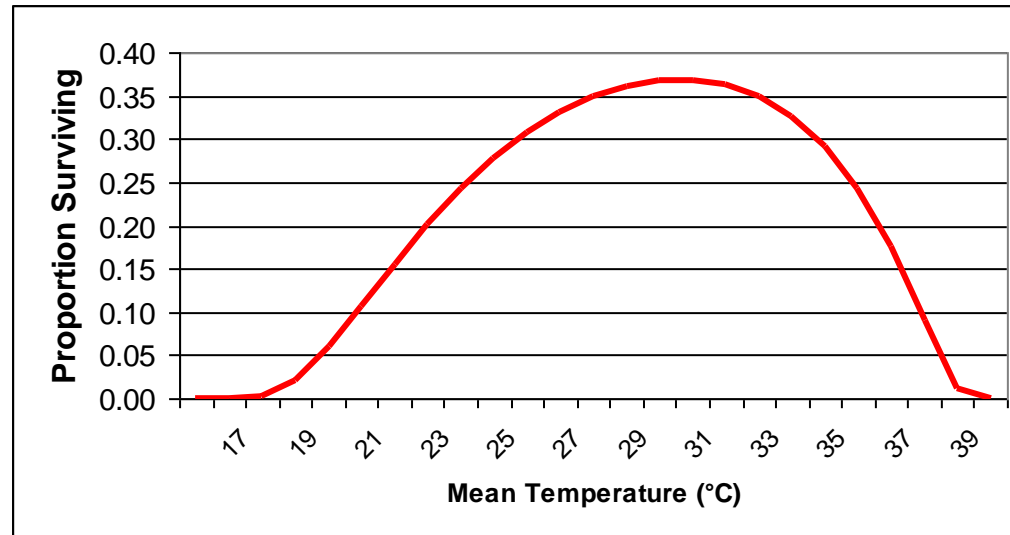


Ranger DJ

Ogden et al., 2005;  
Vail and Smith, 1998

# Proportion of Vectors Surviving Time Required for Parasite Development

---



# Vector and Host Seasonality

---

- ▶ Vectors and their hosts are subject to seasonal variations that are climate related (e.g., temperature) and climate independent (e.g., day-length)
- ▶ Seasonal variations affect abundance and demographic processes of both vectors and hosts



# Evidence Reviewed by the IPCC

---

- ▶ Emerging evidence shows that climate change has:
  - ▶ Altered the distribution of some infectious disease vectors (*medium confidence*)
  - ▶ Altered the seasonal distribution of some allergenic pollen species (*high confidence*)

IPCC AR4, 2007



# Jamaican Vectors – Major Public Health concerns

---

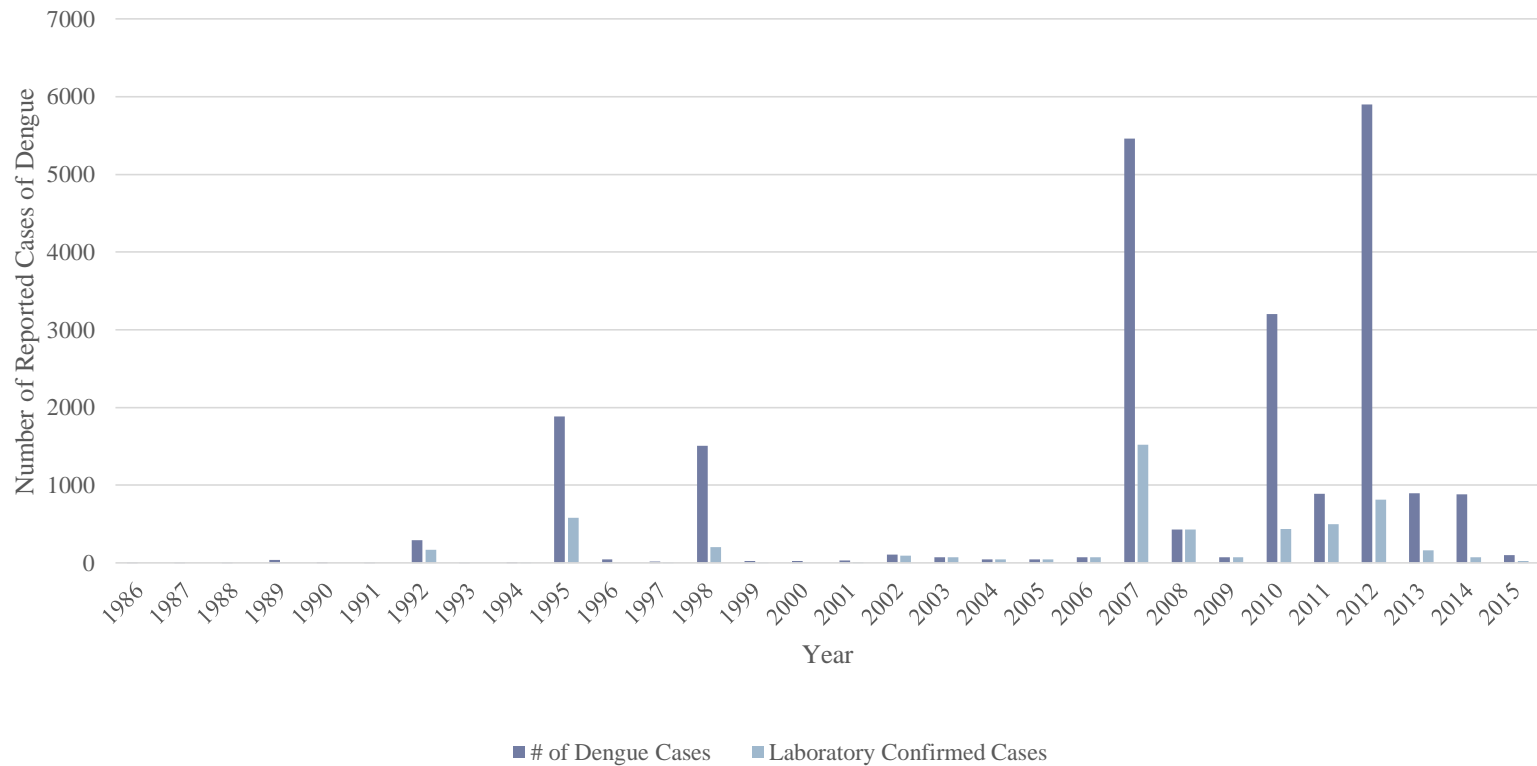
- ▶ **Dengue**, which is endemic,
- ▶ **Chik V**
- ▶ **Zika V**
- ▶ **Malaria (currently not endemic)**
- ▶ Epidemiological data showed that **leptospirosis** is a serious health problem, both in the human and animal population . Jamaica maintains its rabies-free status



(Ref PAHO country profile data)



Reported Dengue Cases and Laboratory Confirmed Cases, Jamaica, 1986-2015

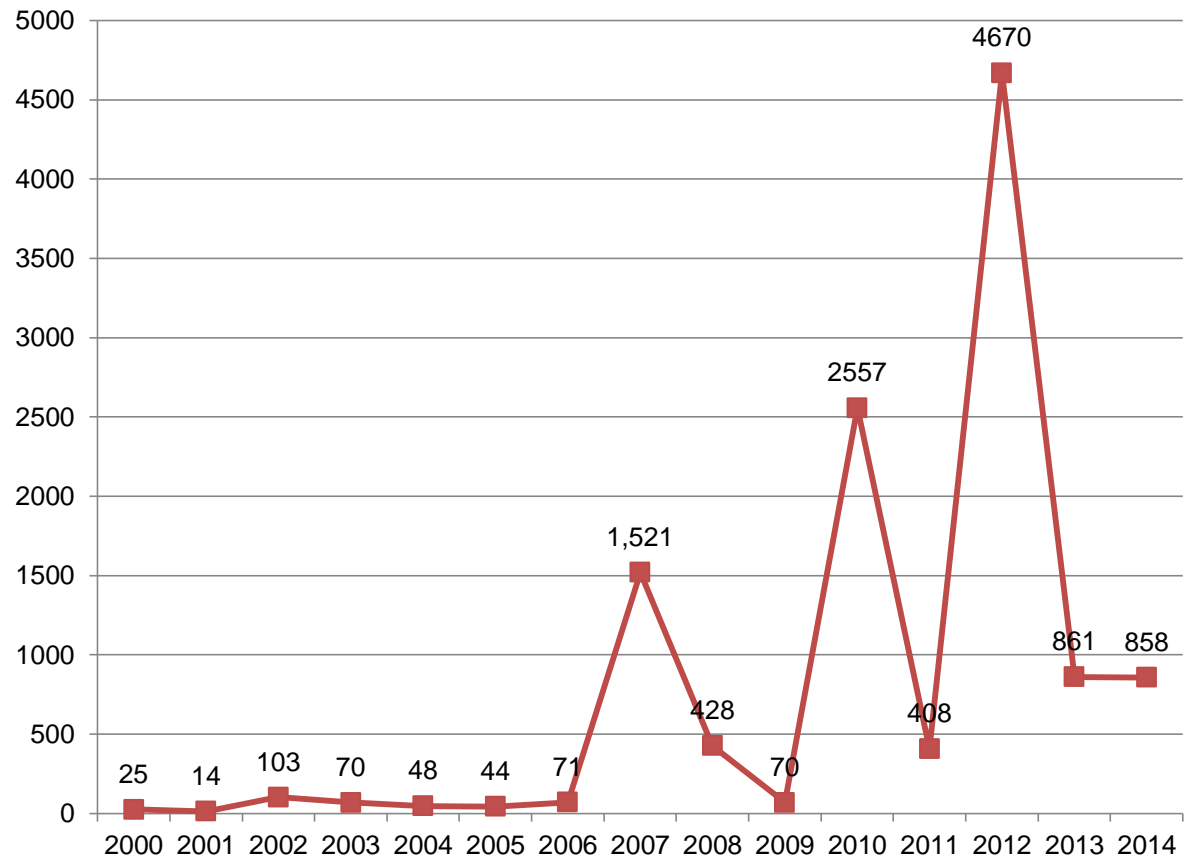


# Dengue in Jamaica



Year	Clinical Cases
2000	25
2001	14
2002	103
2003	70
2004	48
2005	44
2006	71
2007	1,521
2008	428
2009	70
2010	2557
2011	408
2012	4670
2013	861
2014	858

**Dengue Clinical Cases**



# Climate Variability and Dengue Incidence

## *Aedes* mosquito breeding

- ▶ Highest abundance mean temp. 20°C ↑ accumulated rainfall (150 mm)
- ▶ Decline egg laying monthly mean temperature <16.5°C
- ▶ No eggs temp. <14.8°C

## Other studies:

- ▶ Virus replication increases ↑ temperature<sup>2</sup>
- ▶ Transmission of pathogen >12°C<sup>3</sup>
- ▶ Biological models: small ↑ temperature in temperate regions → increases potential epidemics<sup>4</sup>

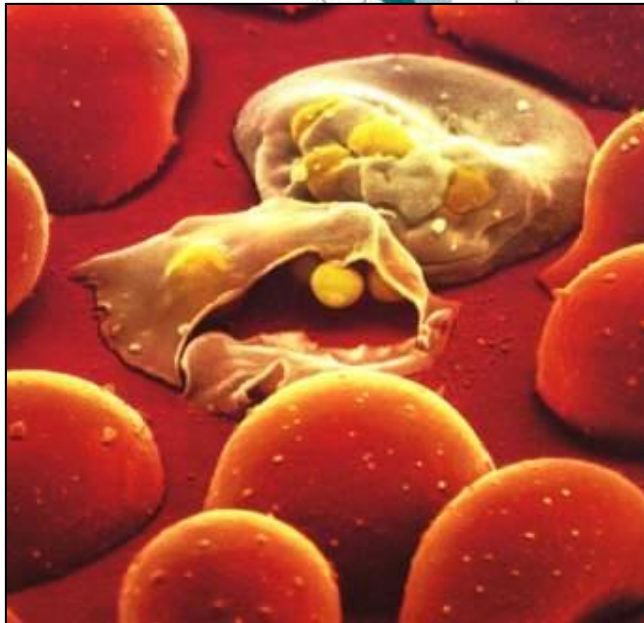
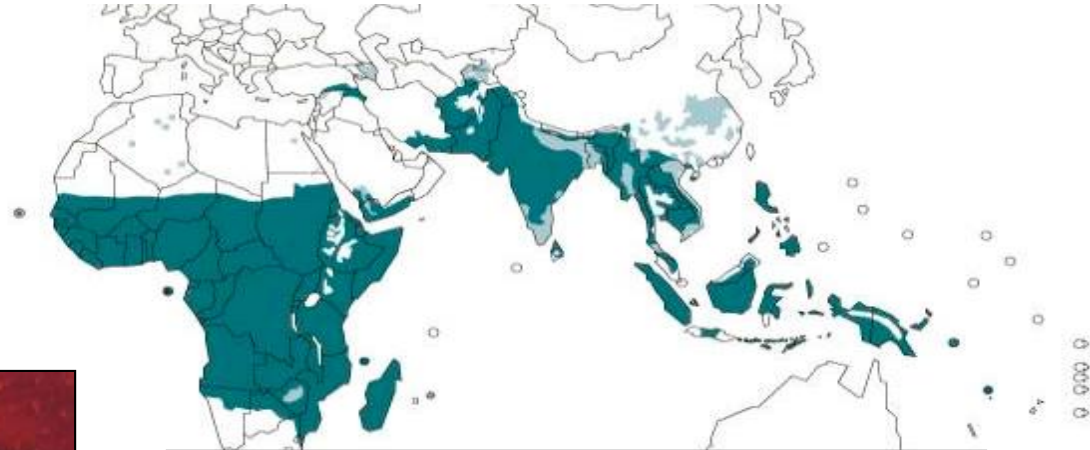


---

<sup>1</sup>Vezzani et al., 2004; <sup>2</sup>Watts et al., 1987; <sup>3</sup>Patz et al., 2006; <sup>4</sup>Patz et al., 1998



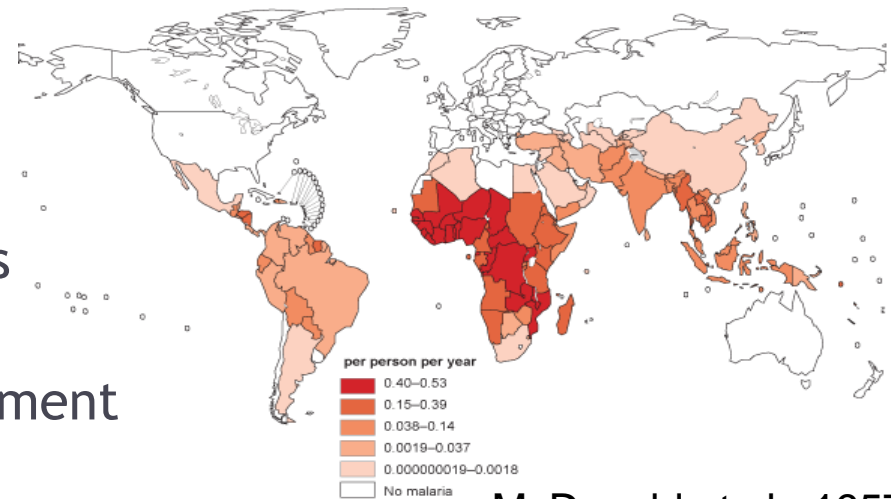
# Case Study I: Malaria



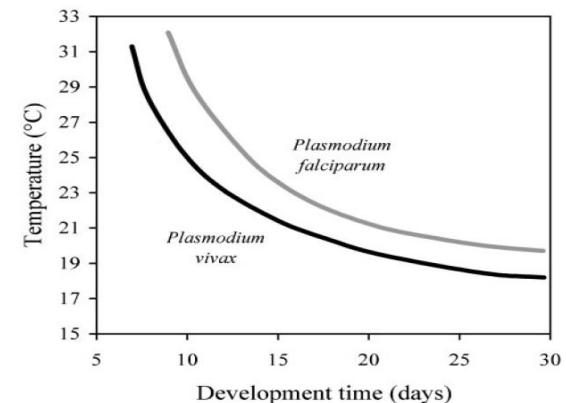
# Case Study I: Malaria (cont.)

- ▶ 40% world population at risk
- ▶ 500 million severely ill
- ▶ Climate sensitive disease<sup>1</sup>
  - ▶ No transmission where mosquitoes cannot survive
  - ▶ *Anopheles*: optimal adult development 28-32°C
  - ▶ *P falciparum* transmission: 16-33°C
- ▶ Highland malaria<sup>2</sup>
  - ▶ Areas on the edges of endemic regions
- ▶ Global warming → El Niño<sup>3</sup>
  - ▶ Outbreaks

Estimated incidence of clinical malaria episodes (WHO)

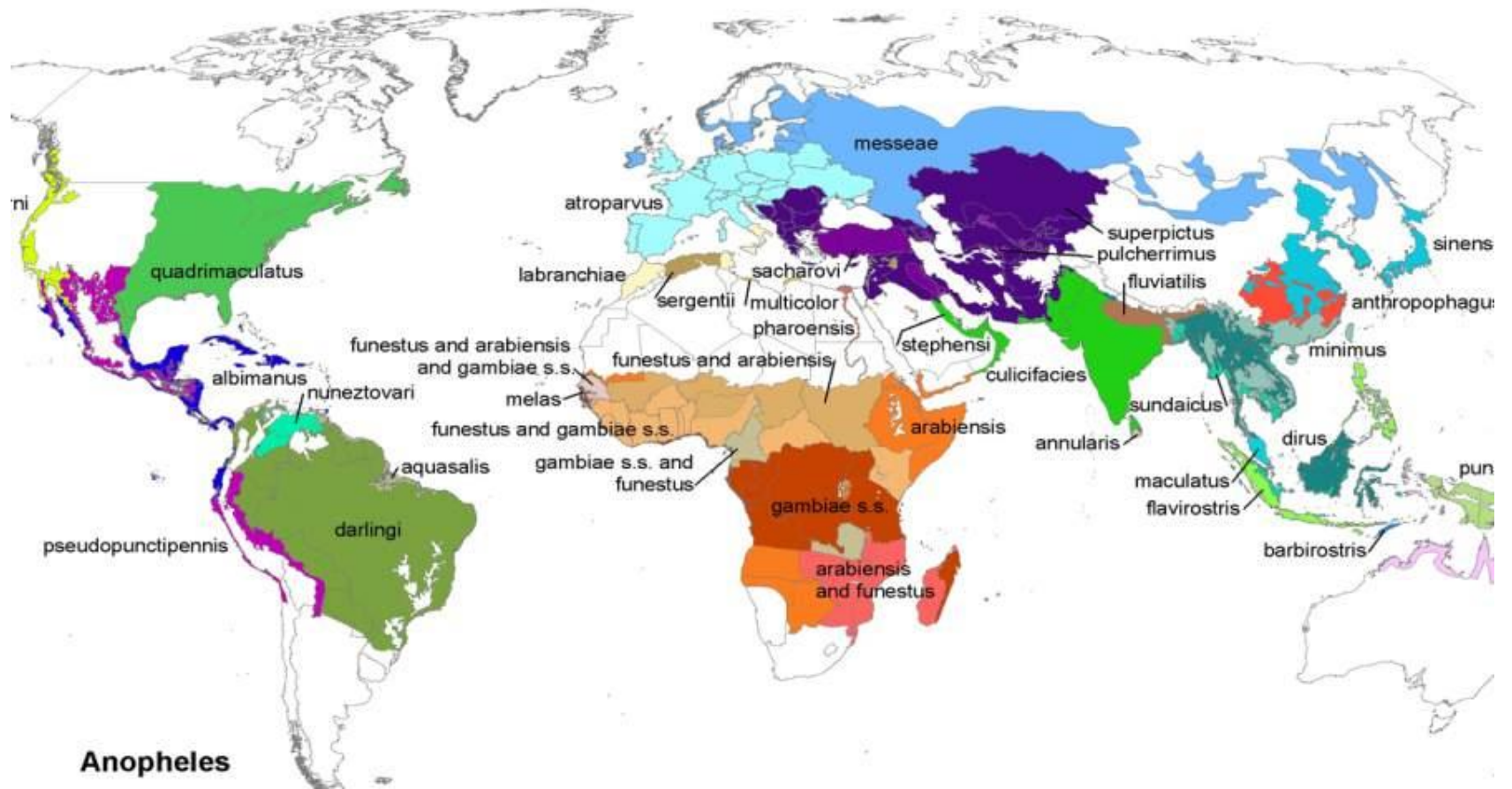


McDonald et al., 1957



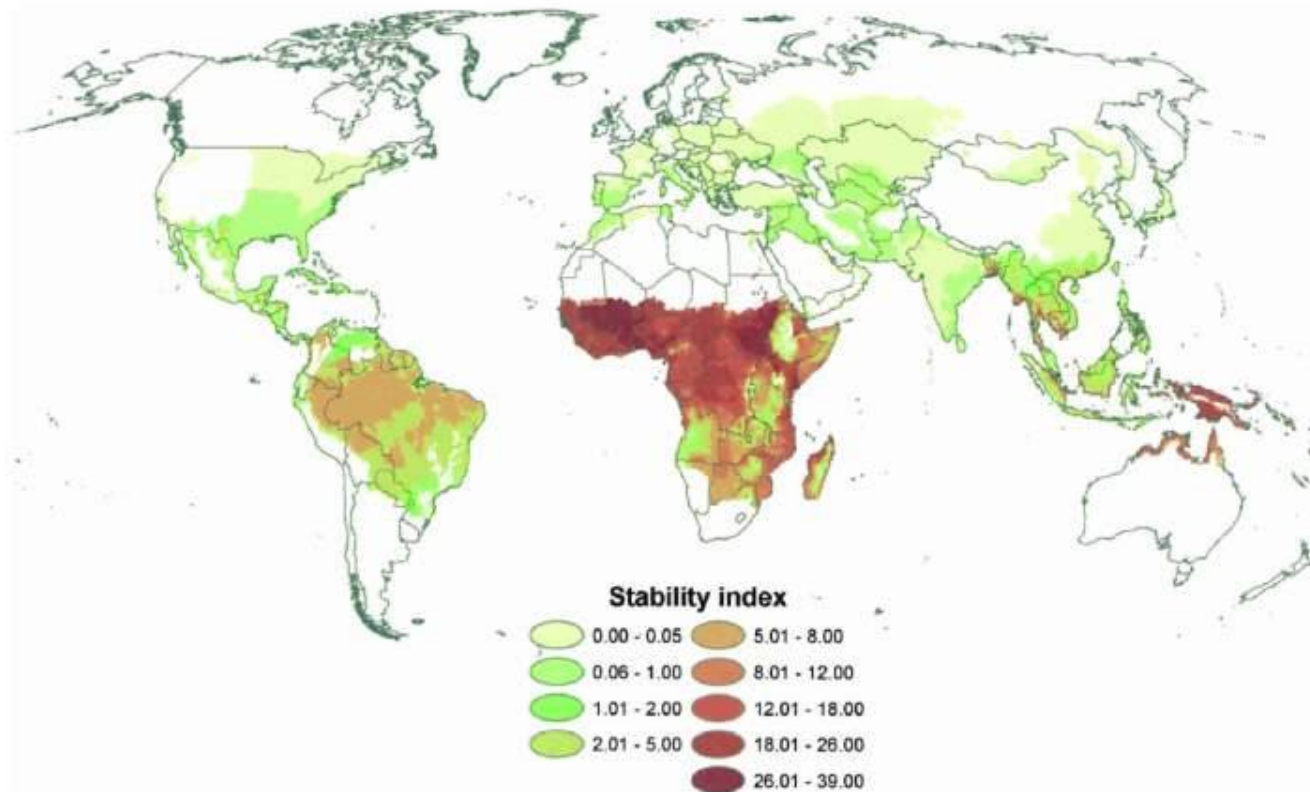
<sup>1</sup> Khasnis and Nettleman 2005; <sup>2</sup> Patz and Olson 2006; <sup>3</sup> Haines and Patz, 2004

# Competent Vectors



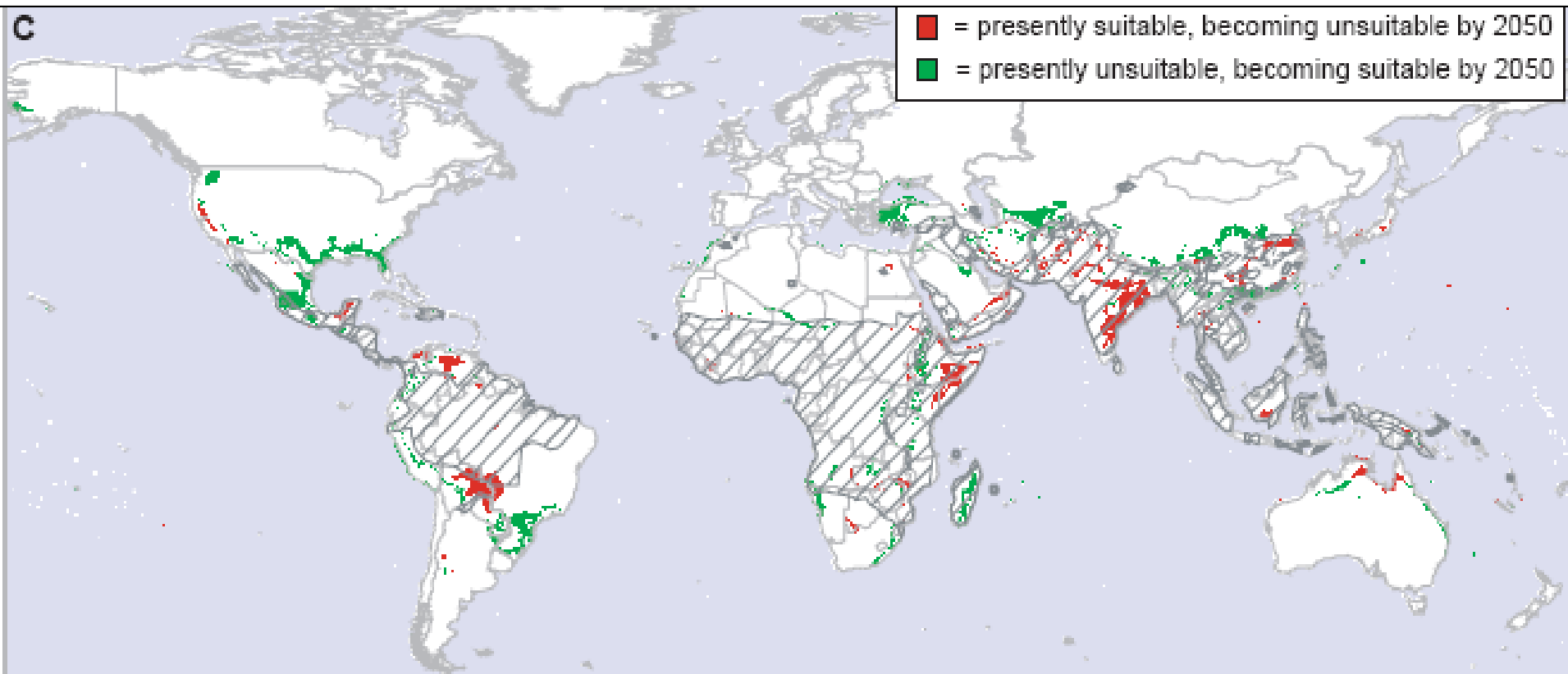
Kiszewski et al., 2004

# Malaria Endemicity



“Climate change related exposures... will have mixed effects on malaria; in some places the geographical range will contract, elsewhere the geographical range will expand and the transmission season may change (*very high confidence*).”

# Malaria Projection: 2050



# Malaria in Jamaica



Year	Malaria (imported)	Malaria (locally transmitted)	Total
2000	7	0	7
2001	6	0	6
2002	7	0	7
2003	9	0	9
2004	141	0	141
2005	88	0	88
2006	8	186	194
2007	8	191	199
2008	4	18	22
2009	7	15	22
2010	7	2	9





# Evidence of Climate Change Effects

---

- ▶ Some specific disease examples:
  - ▶ Malaria — East African highlands
  - ▶ Lyme disease — Canada
  - ▶ Schistosomiasis — China
  - ▶ Bluetongue Europe

Source: CDC



Source: USDA



Source: Davies Laboratory



Source: DEFRA



# Way Forward

---



- ▶ Research on the impact of climate change on vector ecology
- ▶ Building Resilience
- ▶ Enhance the implementation of Integrated Vector Management Approach (IVM)
  - ▶ Less dependency on the use of chemicals





# Way Forward

---



- ▶ Enforcement
- ▶ Addressing Crucial Contributing Factors
  - ▶ Solid Waste Management
  - ▶ Frequency of piped water supply
  - ▶ Behaviour
    - ▶ Getting persons to be responsible and to take the appropriate actions



## KEY MESSAGE

---



- ▶ **ONCE A WEEK LOOK FOR  
AND DESTROY THE  
BREEDING SITE OF THE  
AEDES AEGYPTI MOSQUITO**

