VECTOR-BORNE DISEASES IN A CHANGING CLIMATE

James Dunford, Ph.D.

Medical Entomologist

Adjunct Assistant Professor

Old Dominion University

OUTLINE

- ‘Global warming’ and using entomological studies as indicators
- Climate change, vectors, and vector-borne disease
- Current projects
- Closing remarks

‘GLOBAL WARMING’ AND ENTOMOLOGICAL INDICATORS

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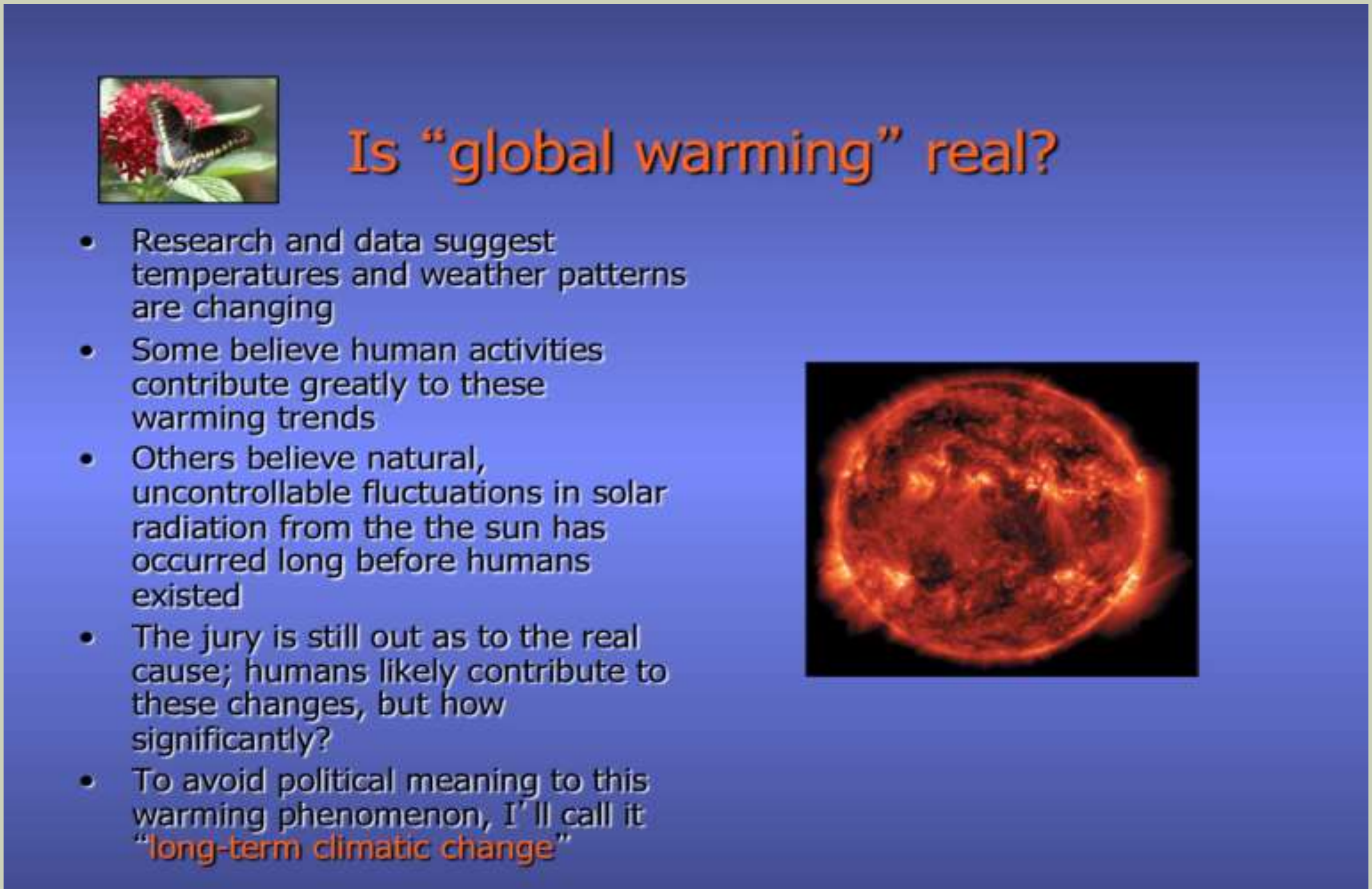
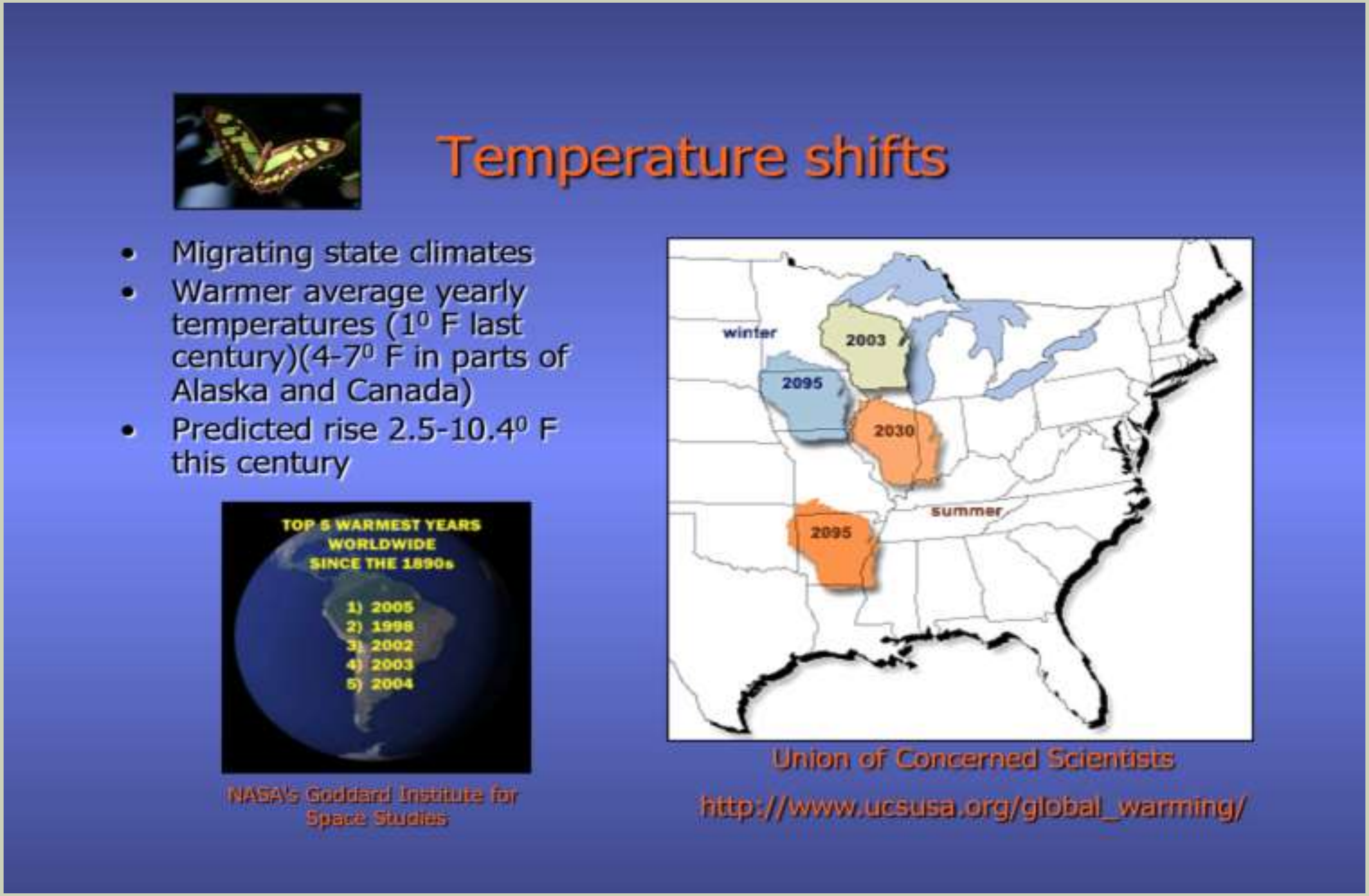
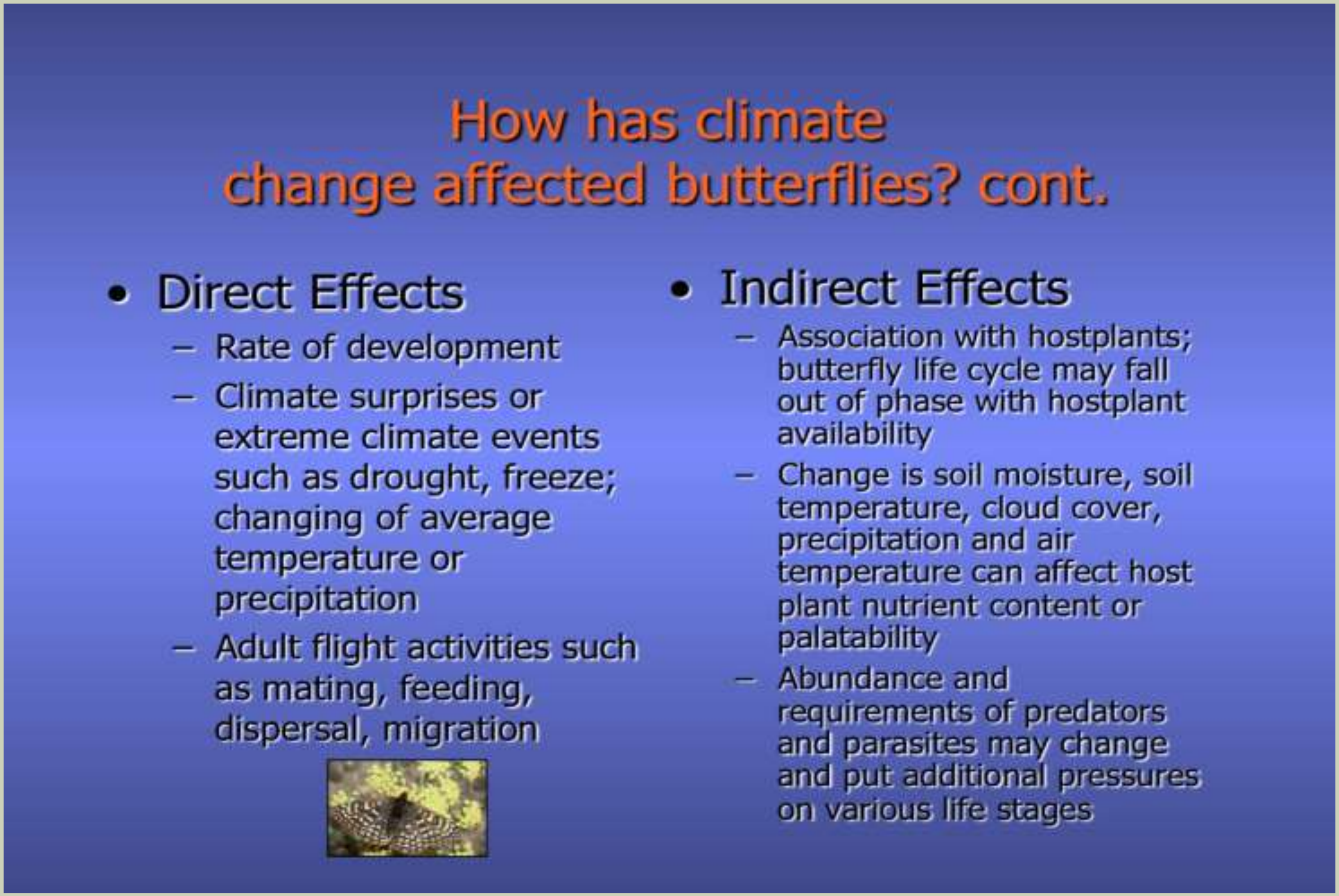


‘GLOBAL WARMING’ AND ENTOMOLOGICAL INDICATORS



‘GLOBAL WARMING’ AND ENTOMOLOGICAL INDICATORS



CLIMATE CHANGE AND VECTORS

- CDC: Public Health Response to a Changing Climate
  https://www.cdc.gov/features/changingclimate/


CDC Centers for Disease Control and Prevention

Public Health Response to a Changing Climate

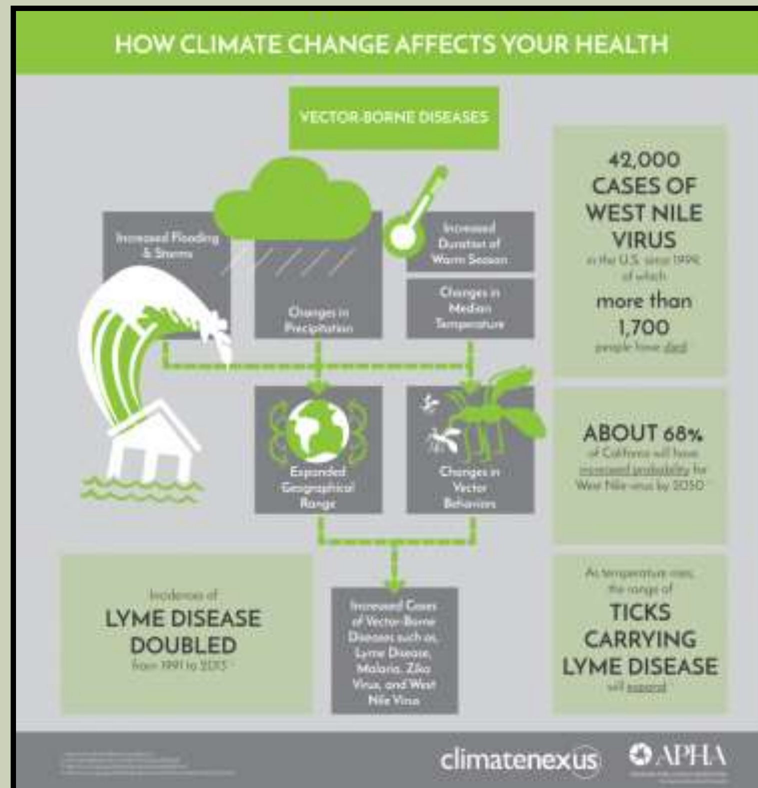
Climate change threatens human health and well-being in many ways. Learn what CDC is doing to prevent and adapt to the health effects of climate change.

- heat waves,
- heavy precipitation events and flooding,
- droughts,
- more intense hurricanes and storms,
- sea level rise, and
- air pollution.

- **Step 1: Anticipate Climate Impacts and Assessing Vulnerabilities**
- **Step 2: Project the Disease Burden**
- **Step 3: Assess Public Health Interventions**
- **Step 4: Develop and Implement a Climate and Health Adaptation Plan**
- **Step 5: Evaluate Impact and Improve Quality of Activities**

CDC Climate Ready States and Cities Initiative

https://climatenexus.org

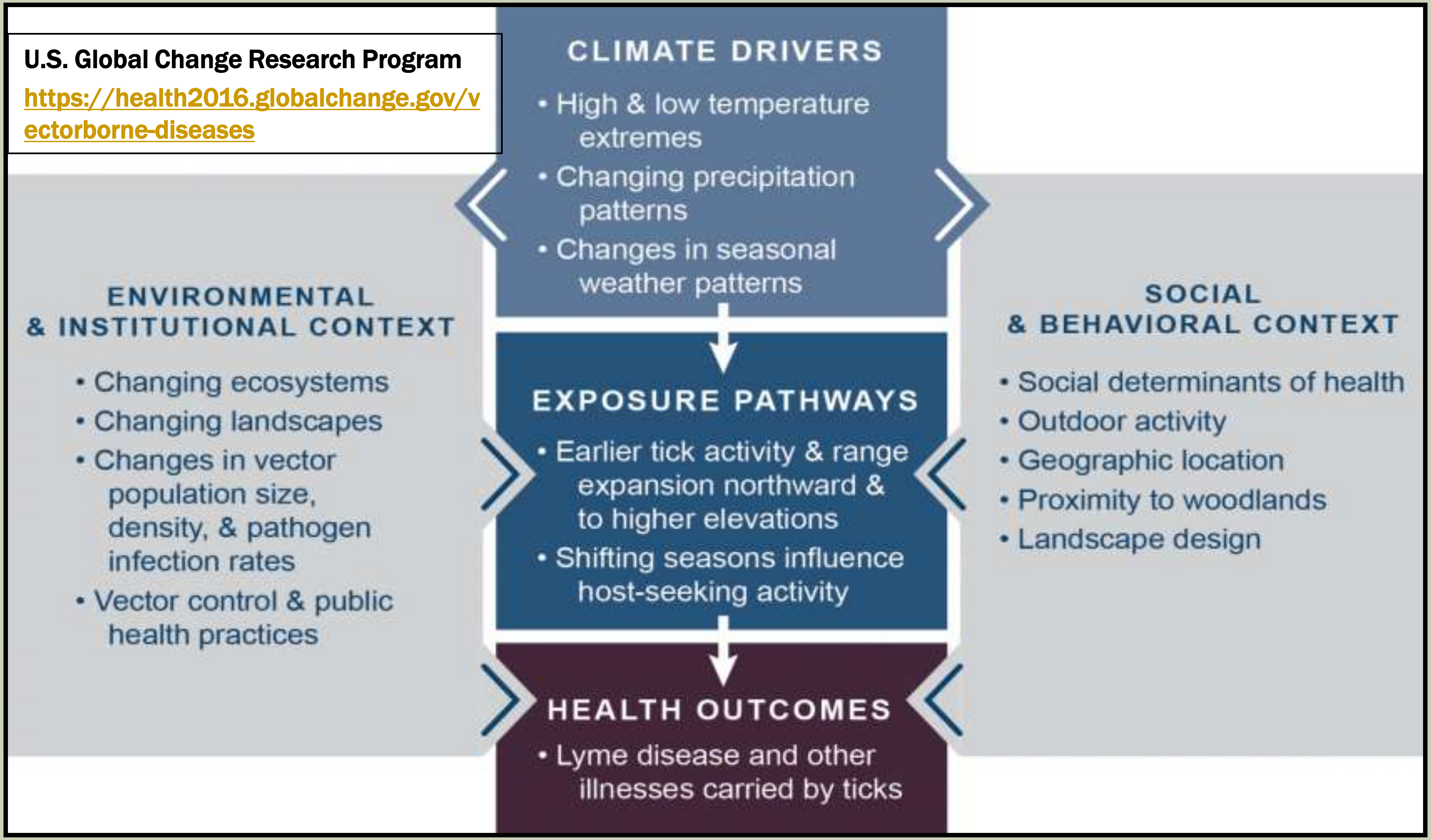


CLIMATE CHANGE AND VECTORS

- Many interacting determinants of vector-borne disease, to include climate
- Vector-borne diseases amongst the most well studied diseases associated with climate change; but reliable data? Still poorly understood?
- Climate and weather patterns exert range of physiological, behavioral affects on vectors and in turn disease prevalence
- Influence on disease transmission from shorter (annual) to longer (decadal) time scales
- Climate variables account for geographical distribution of vectors/disease
- Relatively stable historic vector/disease distributions now changing
- Vector distributions extending into higher altitudes/northern latitudes
- Decreasing ranges in Equatorial regions; movement into to new areas; species dependent

CLIMATE CHANGE AND VECTORS

U.S. Global Change Research Program
https://health2016.globalchange.gov/vectorborne-diseases



RECENT STUDIES

- Disease prevalence/new regions:
  - Malaria, + precip/temps-Kenya (Githeko & Ndegwa 2001)
  - Hantavirus, + precip-SW U.S. (Yates et al. 2002); Paraguay (Williams et al. 1997); Panama (Ruedas et al. 2004)
  - Dengue and chikungunya, + temps-Europe (Tomasello & Schlagenhauf 2013)
- Range shifts:
  - *Ixodes ricinus* (Lyme, TBE)-Europe (Gage et al. 2008)
  - *Ixodes scapularis* (Lyme, babesiosis)-NA (Ogden et al. 2006, 2010)
  - *Anopheles darlingi* (malaria)-SA (Escobar et al. 2016)
  - *Aedes aegypti* and *Ae. albopictus*-Europe (Tomasello & Schlagenhauf 2013); U.S. (Armstrong et al. 2017); LA/C (Chadee and Martinez 2016)

RECENT STUDIES

- Mills et al. 2016

(National Center for Emerging and Zoonotic Infectious Diseases, CDC)

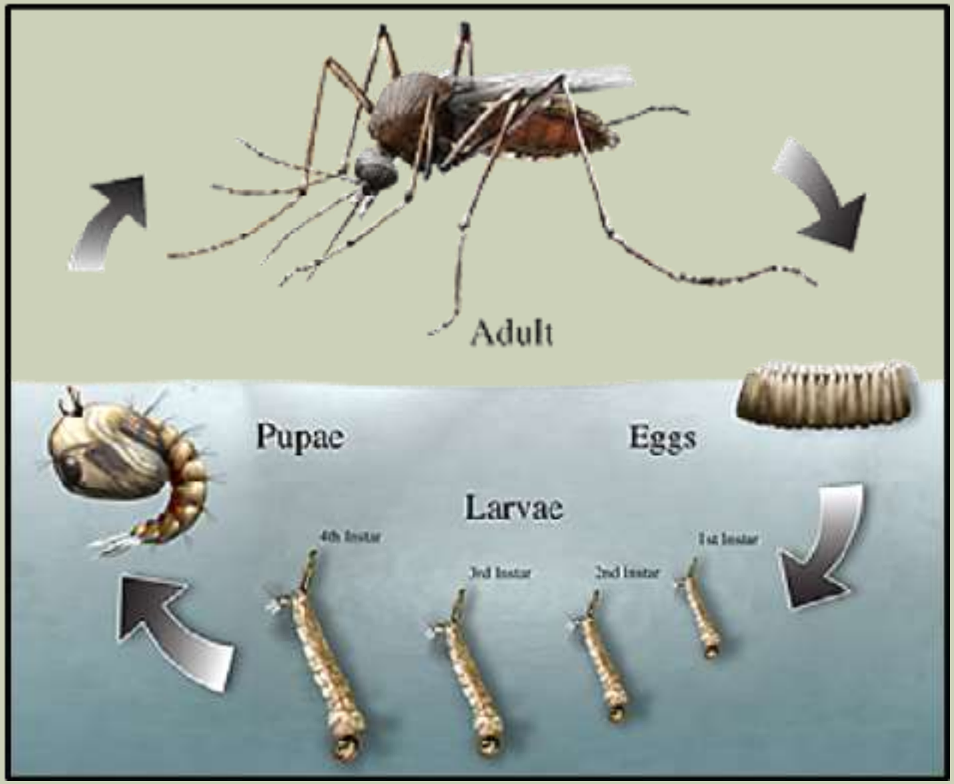
  - Pathogen identification and characterization
  - Baseline data on geographic and habitat distributions
  - Longitudinal/altitudinal monitoring programs
  - Predictive modeling of changes in zoonotic disease risk and the projected distributions and abundance of major hosts and vectors
  - Track data on the geographic distribution, severity, and frequency of outbreaks of wildlife diseases and VBZDs in humans
  - Conduct experimental laboratory and field studies of effects of climate change on hosts and vectors and their abilities to maintain and transmit pathogens

MOSQUITOES AS VECTORS

- Vector: Any agent that carries and transmits an infectious pathogen into another organism
- Over 3,000 known species
- Widely distributed
- #1 human disease vector:
  - malaria, dengue, yellow fever, Zika, chikungunya, RVF, WNV, SLE, EEE, WEE, VEE, LaCrosse, filariasis, etc…

MOSQUITOES AS VECTORS

- Eggs in or near water
- Larvae and pupae aquatic stages
- Adult females seek blood meals to reproduce; the vector stage



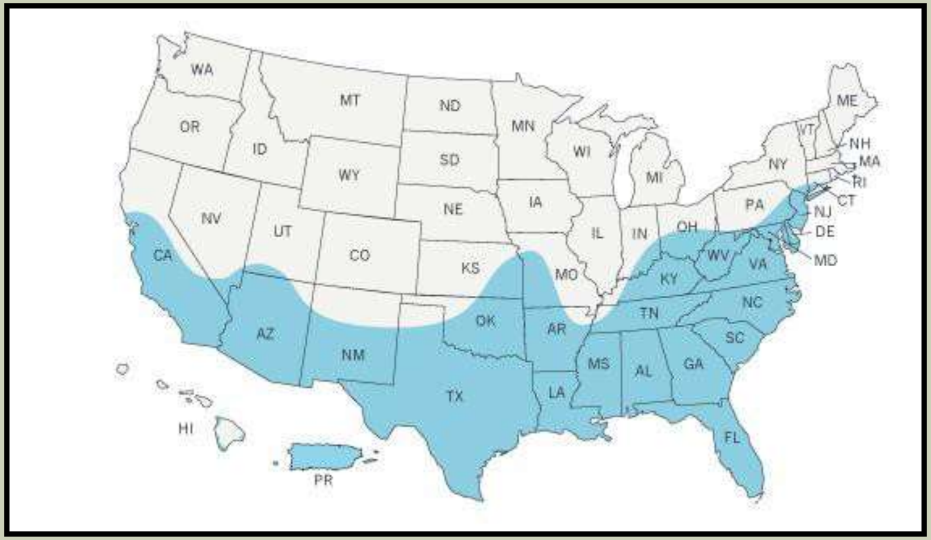
MOSQUITOES AS VECTORS

- Host selection
- Longevity
- Abundance
- Vector competence

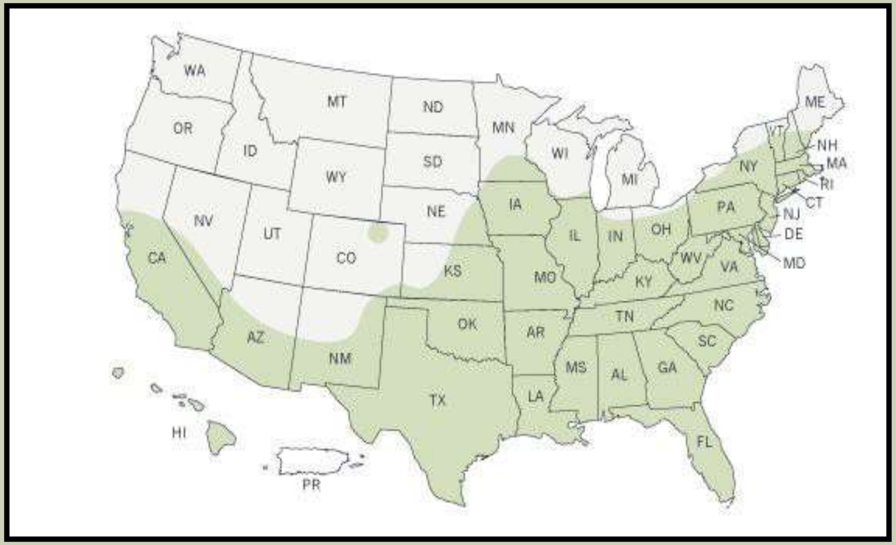
AEDES AEGYPTI AND *AEDES ALBOPICTUS*

- Occupy urban/peri-urban areas
- Bite during daytime
- Breed inside human-made containers in or near homes
- Lay eggs indoors and outdoors
- Bites often unnoticed; bites and rests indoors/outdoors

ESTIMATED RANGES OF *AEDES AEGYPTI* AND *AEDES ALBOPICTUS* IN THE UNITED STATES (CDC-2016)



Aedes aegypti



Aedes albopictus

MOSQUITO SPECIES IN VIRGINIA

Aedes aegypti (L.)
Aedes albopictus (Skuse)
Aedes vexans (Meigen)
Anopheles atropos (Dyar & Knab)
Anopheles barberi (Coquillett)
Anopheles bradleyi (King)
Anopheles crucians (Wiedemann)
Anopheles punctipennis (Say)
Anopheles quadrimaculatus (Say)
Anopheles smaragdinus (Reinert)
Anopheles walkeri (Theobald)
Coquillettidia perturbans (Walker)
Culex territans (Walker)
Culex salinarius (Coquillett)
Culex restuans (Theobald)
Culex quinquefasciatus (Say)
Culex pipiens (L.)
Culex peccator (Dyar & Knab)
Culex erraticus (Dyar & Knab)
Culex tarsalis (Coquillett)
Culiseta inornata (Williston)
Culiseta melanura (Coquillett)
Ochlerotatus grossbecki (Dyar & Knab)
Ochlerotatus hendersoni (Cockerell)
Ochlerotatus dupreei (Coquillett)
Ochlerotatus trivittatus (Coquillett)
Ochlerotatus triseriatus (Say)
Ochlerotatus tormentor (Dyar & Knab)
Ochlerotatus thibaulti (Dyar & Knab)
Ochlerotatus taeniorhynchus (Wiedemann)
Ochlerotatus stimulans (Walker)
Ochlerotatus sticticus (Meigen)
Ochlerotatus sollicitans (Walker)
Ochlerotatus mitchellae (Dyar)
Ochlerotatus japonicus (Theobald)
Ochlerotatus infirmatus (Dyar & Knab) Orthopodomyia alba (Baker)
Orthopodomyia signifera (Coquillett)
Psorophora columbiae (Dyar & Knab)
Psorophora ciliata (Fabricius)
Psorophora cyanescens (Coquillett)
Psorophora discolor (Coquillett)
Psorophora ferox (von Humboldt)
Psorophora horrida (Dyar & Knab)
Psorophora howardii (Coquillett)
Psorophora mathesoni (Belkin & Heinemann)
Toxorhynchites rutilus septentrionalis (Dyar & Knab)
Uranotaenia sapphirina (Osten Sacken)
Wyeomyia smithii (Coquillett) (Say)

DENGUE IN THE U.S.

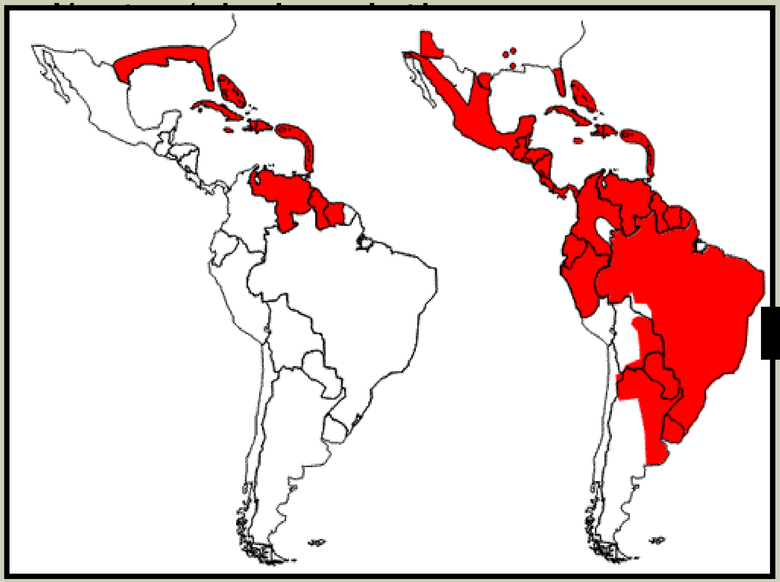
- Historical dengue outbreaks in the U.S.
  - 1780: Philadelphia, PA
  - 1826-8: Savannah, GA
  - 1850-1: Charleston, SC, Savannah, GA, New Orleans, LA, Mobile, AL, Galveston, TX, Augusta, GA
  - 1922: Texas, Savannah, GA
  - 1934: Florida
  - 1945: New Orleans

DENGUE IN THE U.S.

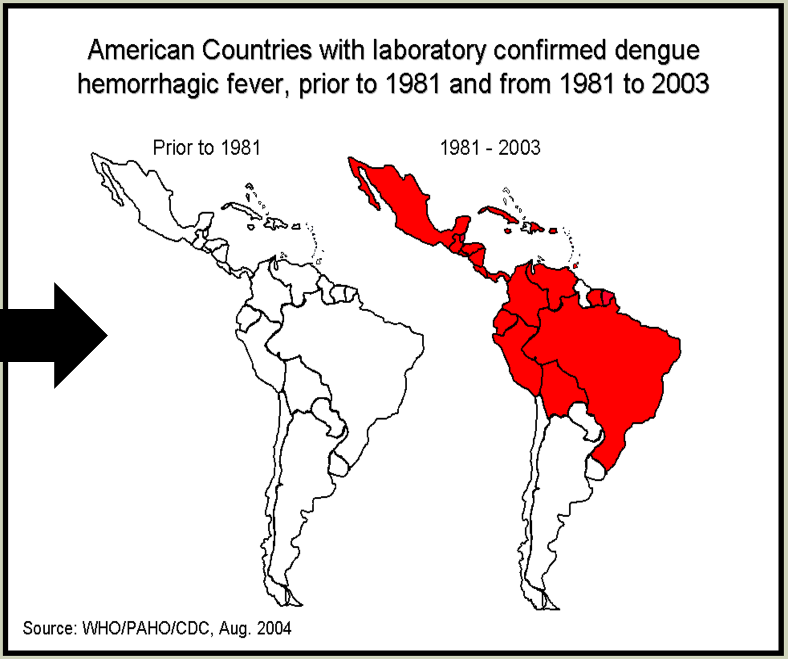
- Recent local transmission
  - Texas:
    - 1980: 23 cases, first locally acquired since 1945
    - 1980-1999: 64 cases (lab-documented)
    - 2005: DEN-2 epidemic in Brownsville; estimated incidence of recent dengue infection (4% of population)
  - Hawaii:
    - 2001-2002: 122 cases (first since 1944)
    - 2015 (146 locally acquired cases)
  - Florida (also Puerto Rico/U.S. Virgin Islands):
    - 2009-2011: 93 cases

RESURGENCE OF DENGUE

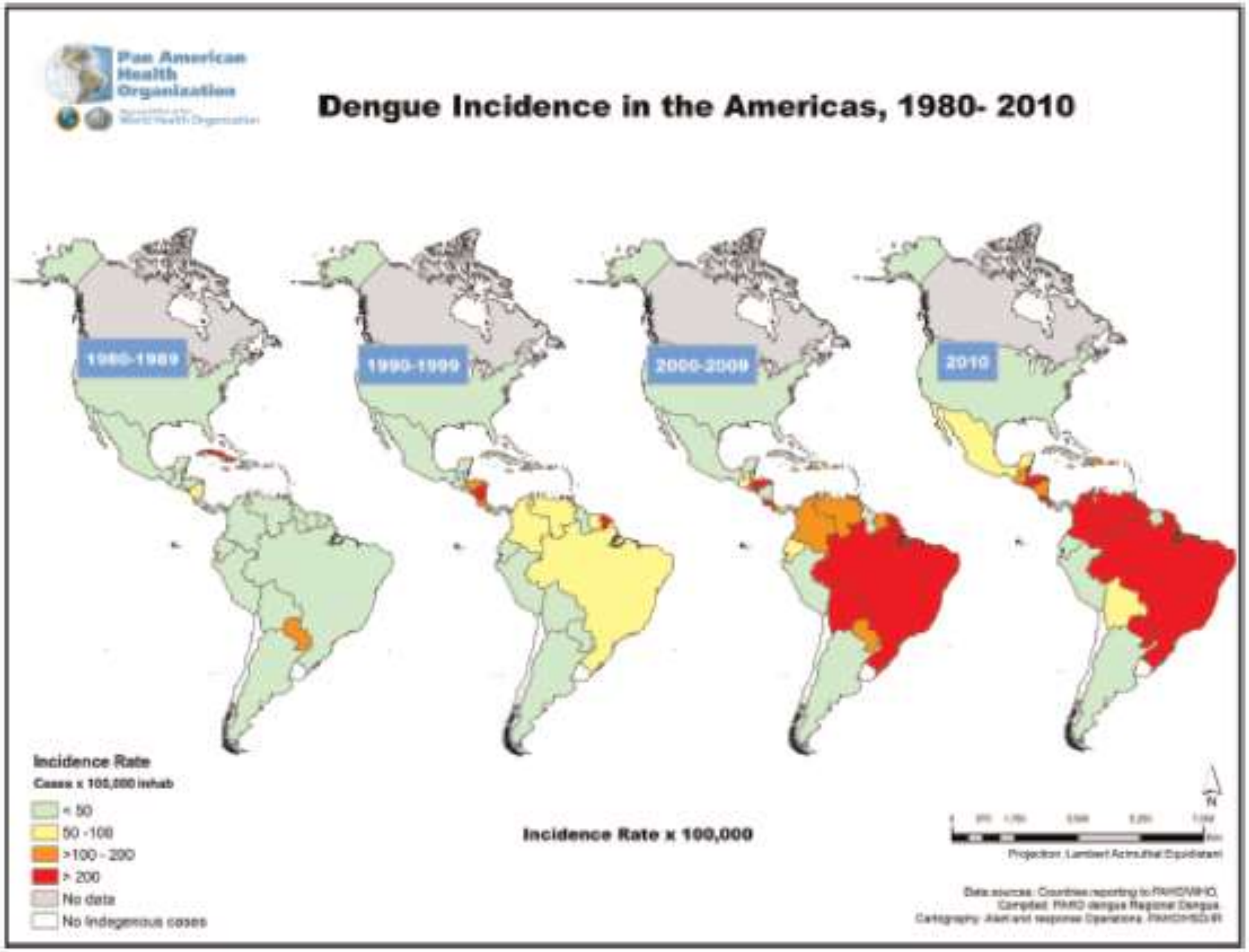
- Unprecedented global population growth
- Unplanned and uncontrolled urbanization
  - More human-made breeding grounds (waste)
  - Decay in public health infrastructure
- Lack of effective mosquito vector control
- Increased international air travel
- Globalization of trade
- Ecological changes; climate change



Aedes aegypti in the Americas (1970), at the end of the mosquito eradication program, and in 2002



RESURGENCE OF DENGUE



SUPPORTING PROJECTS/SURVEILLANCE

- Awarded $450K across 2016-2017 from Armed Forces Health Surveillance Branch-Global Emerging Infections Surveillance and Response System (GEIS) to initiate mosquito/disease surveillance in Central America/Caribbean

  - Collaborators include:
    - **University of Florida, Emerging Pathogens Institute**
    - National Vector Borne Disease Lab-Haiti
    - University of West Indies-Trinidad and Tobago
    - National Center for the Control of Tropical Diseases-Dominican Republic
    - Currently developing collaborations:
      - Izabal Vector Control Program-Guatemala
      - Roseau Environmental Health Department-Dominica
      - Saint Georges University-Grenada
      - Saint James School of Medicine-Anguilla

SUPPORTING PROJECTS/SURVEILLANCE

- Objectives:
  - Improve disease risk data, track changes in vector and associated disease distributions/ecologies (VectorMap: http://vectormap.si.edu)
  - Host feeding behaviors (determine origin of blood meal)
  - Assess association of climate and vector/disease distributions
  - Caribbean Vector Surveillance Network; public health partnerships

SUPPORTING PROJECTS/SURVEILLANCE

- **Results to date-Haiti** (White et. al.-University of Florida):
  - Over 10,000 mosquitoes collected; ~2,000 mosquitoes tested
  - First detection of chikungunya in *Ae. albopictus* and *Culex quinquefasciatus* [Manuscript under review: A new "American" subgroup of African-lineage Chikungunya virus detected in and isolated from mosquitoes collected in Haiti, 2016]
    - East-Central-South African (ECSA) chikungunya lineage
  - First detection in Western Hemisphere of Spondweni virus in *Ae. aegypti* [Manuscript under review: Detection and Sequencing of *Spondweni virus* in field-caught *Culex quinquefasciatus* mosquitoes, Haiti 2016]
  - Detection of Zika in male (germline transmission?) and female *Ae. aegypti*
  - First detection of Zika in *Cx. quinquefasciatus* (competent vector?)
  - Detection of dengue type 3 in *Ae. aegypti*

SUPPORTING PROJECTS/SURVEILLANCE

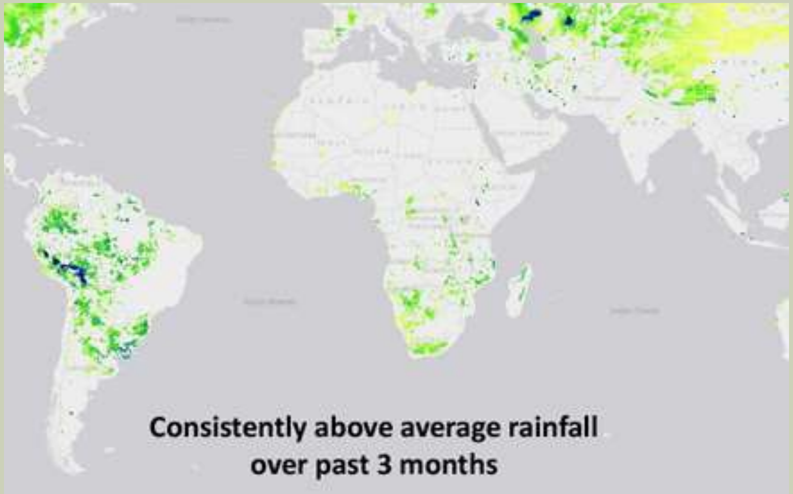
VectorMap

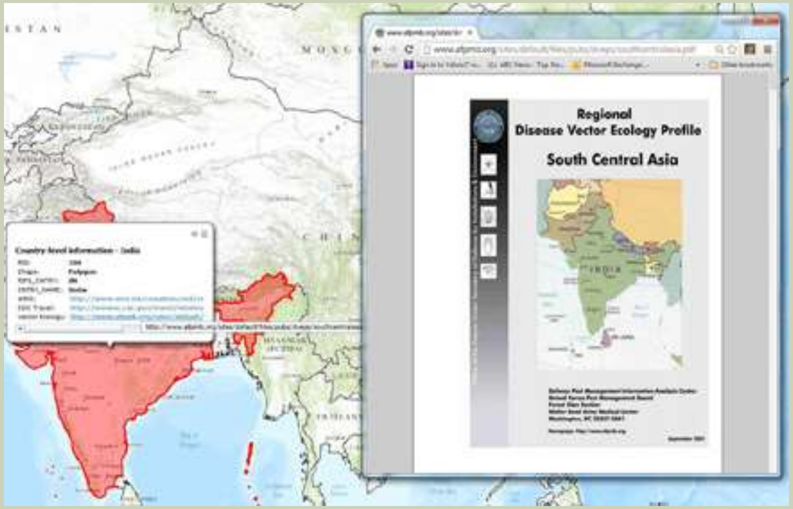
Know the vector, know the threat

Aedes aegypti **habitat suitability**

SUPPORTING PROJECTS/SURVEILLANCE

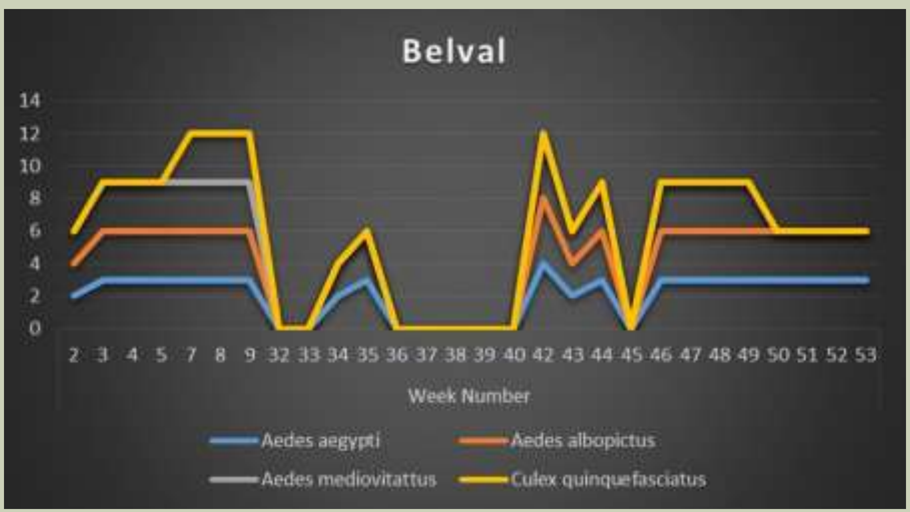
Aedes aegypti habitat suitability

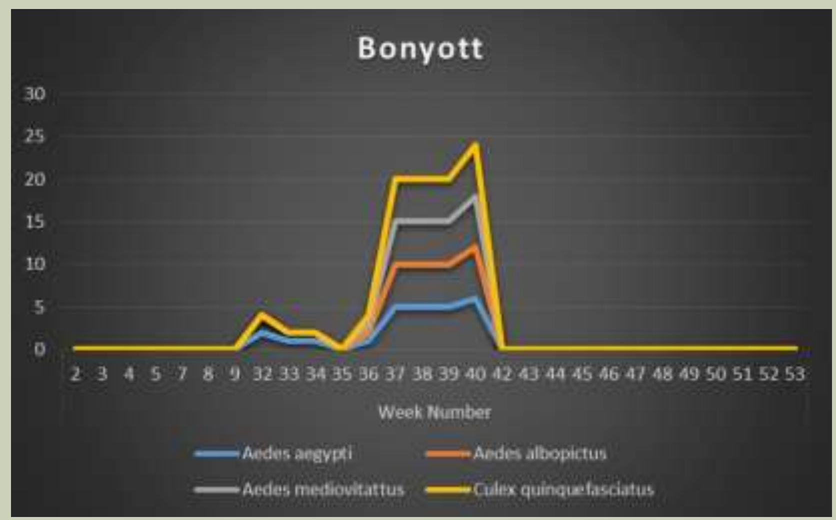




SUPPORTING PROJECTS/SURVEILLANCE

Collection Site	Week Number																												
	1	2	3	4	6	7	8	32	33	34	35	36	37	38	39	40	42	43	44	45	46	47	48	49	50	51	52	53	Total Hours	Average Hours per Week
Belval	24	36	36	36	36	36	36	0	0	12	48	0	0	0	0	0	36	24	36	0	36	36	36	36	36	36	48	24	684	24.42857143
Bonyott	0	0	0	0	0	0	0	12	24	12	0	12	60	60	60	60	0	0	0	0	0	0	0	0	0	0	0	0	300	10.71428571
Calra, Leogane	24	36	36	36	36	36	36	0	0	0	0	0	0	0	0	0	36	24	36	0	36	36	36	36	36	36	48	24	624	22.28571429
Gressier FLM #3	24	36	36	36	36	36	36	24	24	24	36	24	36	36	36	36	36	24	36	12	36	36	36	36	12	0	0	0	780	27.85714286
Jan Jan	0	0	0	0	0	0	0	12	24	24	0	24	60	60	60	60	0	0	0	0	0	0	0	0	0	0	0	0	324	11.57142857
Marechal Cavales #2	24	36	36	36	36	36	36	24	12	24	36	24	36	36	36	36	36	24	36	12	36	36	36	36	72	0	36	0	864	30.85714286
Marechal Grand Riviere #1	24	36	36	36	36	36	36	24	36	24	36	24	36	36	36	36	36	24	36	12	36	36	36	36	72	0	36	0	888	31.71428571
Sigueneau, Leogane	24	36	36	36	36	36	36	0	0	0	0	0	0	0	0	0	36	24	36	0	36	36	36	36	36	36	48	24	624	22.28571429





SUPPORTING PROJECTS/SURVEILLANCE

- Current/Future:
  - Blood meal analyses to determine host preference
  - Utilize viral isolation techniques to reveal unknown viruses (e.g., Mayaro virus, Spondweni virus)
  - Identify new mosquito records
  - Identify new distributional records
  - Predictive modeling

GLOBAL HEALTH ENGAGEMENTS

- Subject Matter Expert Exchanges (SMEEs):
  - Didactic and field curriculum:
    - Mosquito Biology, Surveillance, and Control
    - Mosquito Surveillance and Disease Monitoring using VecTest Kits: Tools for Optimizing Vector Control Programs
    - Tactical Insecticide Resistance Using the CDC Bottle Assay
- Evaluate capacity to collaborate long term
- Build dialogue on vector issues on an international scale; to include issues potentially associated with climate change

GLOBAL HEALTH ENGAGEMENTS

GLOBAL HEALTH ENGAGEMENTS

GLOBAL PUBLIC HEALTH AND CLIMATE CHANGE

- Entomology/vector programs excellent platform to analyze the affects of climate change on vectors/vector-borne diseases

- Public health personnel skillset should include ability to engage with:
  - HN health sector agencies (MoH)
  - Multiple U.S. agencies
  - NGOs
  - HN military medical departments

- Establish and maintain relationships across borders

- International partners required more than ever for vector surveillance/control due to international travel, increased urbanization, climate change (=synergistic increase in disease burden)

IMPACTS OF CLIMATE CHANGE/VECTOR-BORNE DISEASE

- Increased emphasis on vector surveillance and control
- Greater need to combine and better analyze clinical, vector/pathogen, zoonotic vector-borne disease surveillance data
- More focus on research/scenario modeling in climate change/vector-borne disease arena
- Increased morbidity and mortality
- Whether concerned about butterflies or vectors/vector-borne disease, entomological indicators of climate change will likely play a role in modifications to policy/guidance and disease risk management approaches








QUESTIONS?