Center for
VECTOR BIOLOGY
RUTGERS

VECTORS CHANGE CLIMATE CHANGE AND HEALTH

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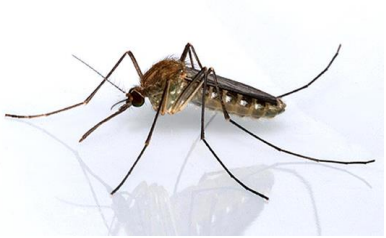
ENTOMOLOGY, ECOLOGY & EVOLUTION, MICROBIOLOGY, PUBLIC HEALTH

SEBS, RUTGERS UNIVERSITY

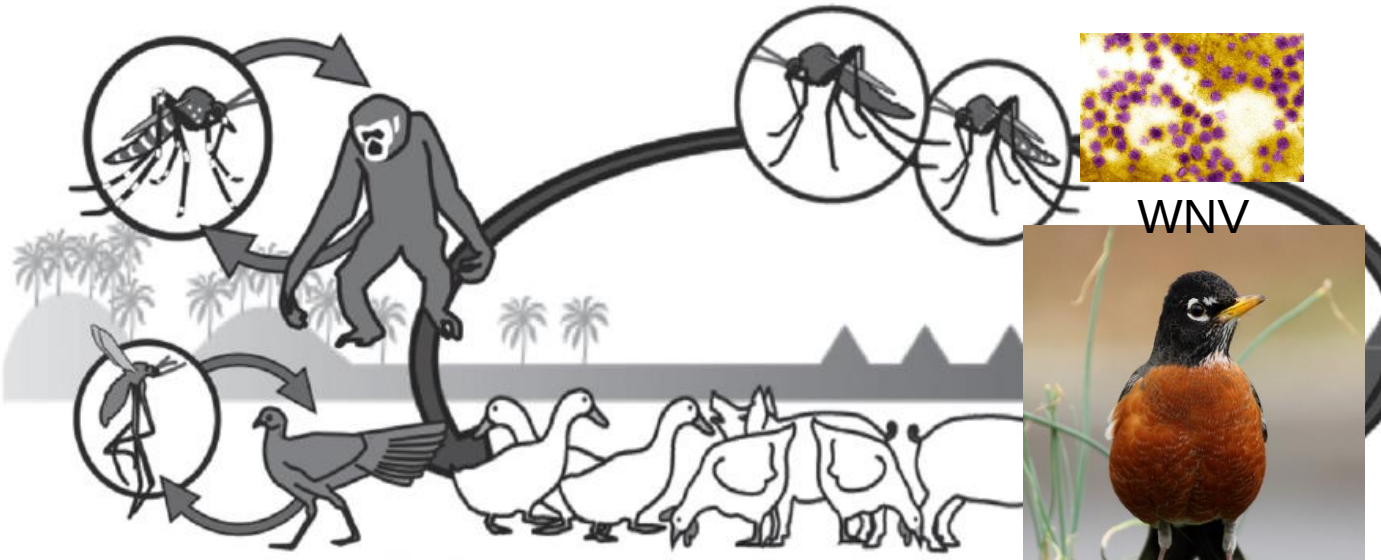
MOSQUITO-BORNE DISEASES

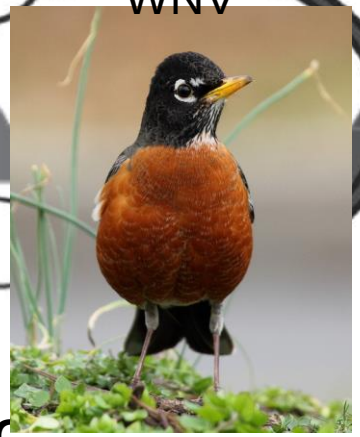


Culex

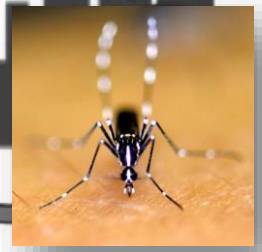
ZIKV

WNV





American robin



Aedes

ENZOOTIC CYCLE

EPIZOOTIC CYCLES

EPIDEMIC CYCLES

Ellis, B. R. and Wilcox, B. A. 2009 The ecological dimensions of vector-borne disease and control. Cad. Saúde Pública, 25 Sup 1:S155-S167, 2009

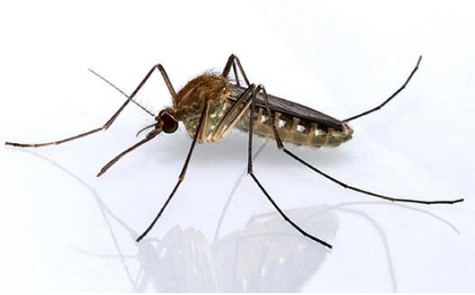
VECTORS CHANGE

1. Become “domestic”

Culex pipiens

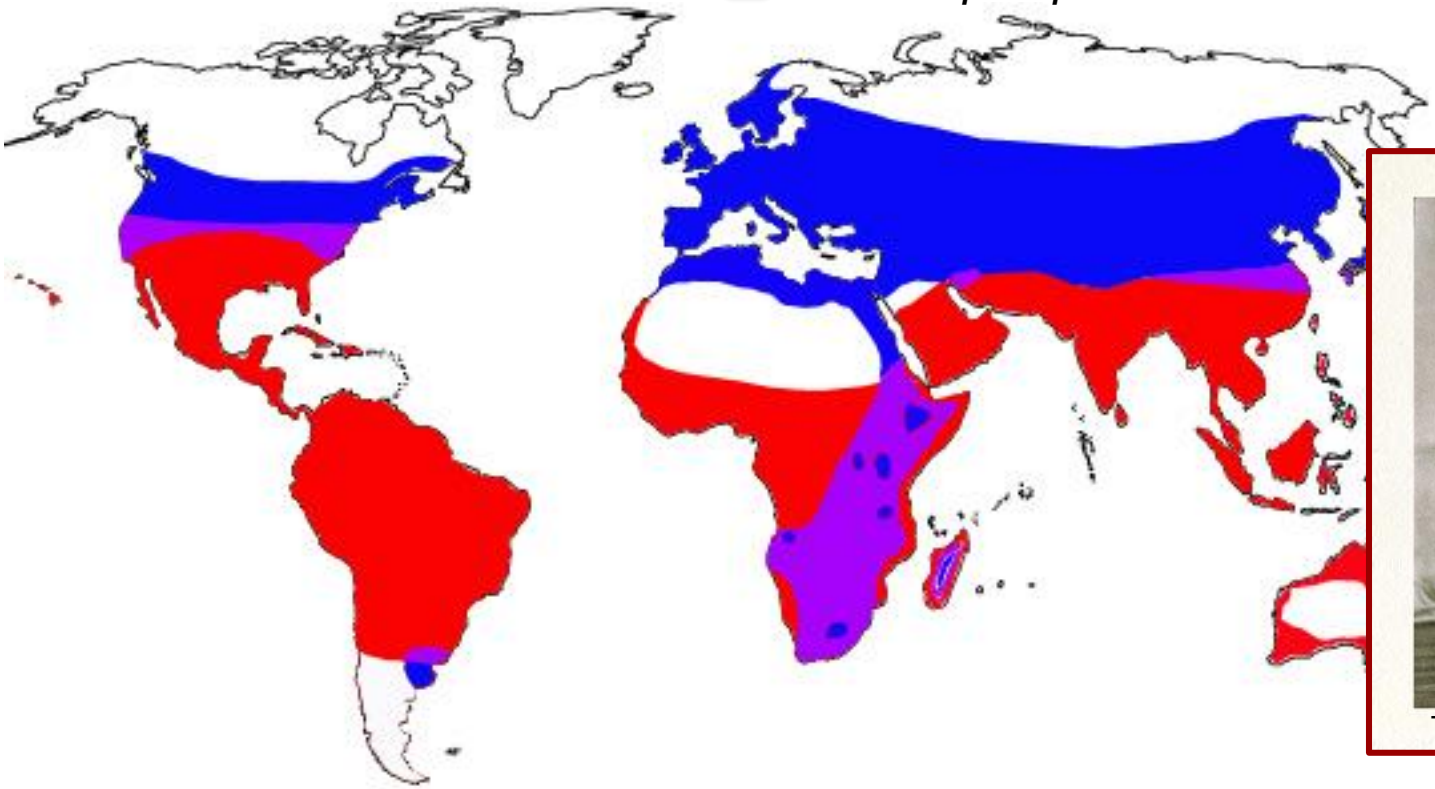
Aedes aegypti

VECTORS CHANGE



2. Become invasive

Culex pipiens f. pipiens f. molestus
Culex quinquefasciatus




The Bellevue Venus

Lymphatic filariasis (*Wuchereria bancrofti)*
St. Louis encephalitis (SLEV); West Nile virus (WNV); Dog heartworm (*Dirofilaria immitis)*

Yellow fever
Dengue
Chikungunya
Zika
Next?

VECTORS CHANGE

Invasive *Aedes*

Aedes aegypti

Tropical, expanded worldwide after the 1500's

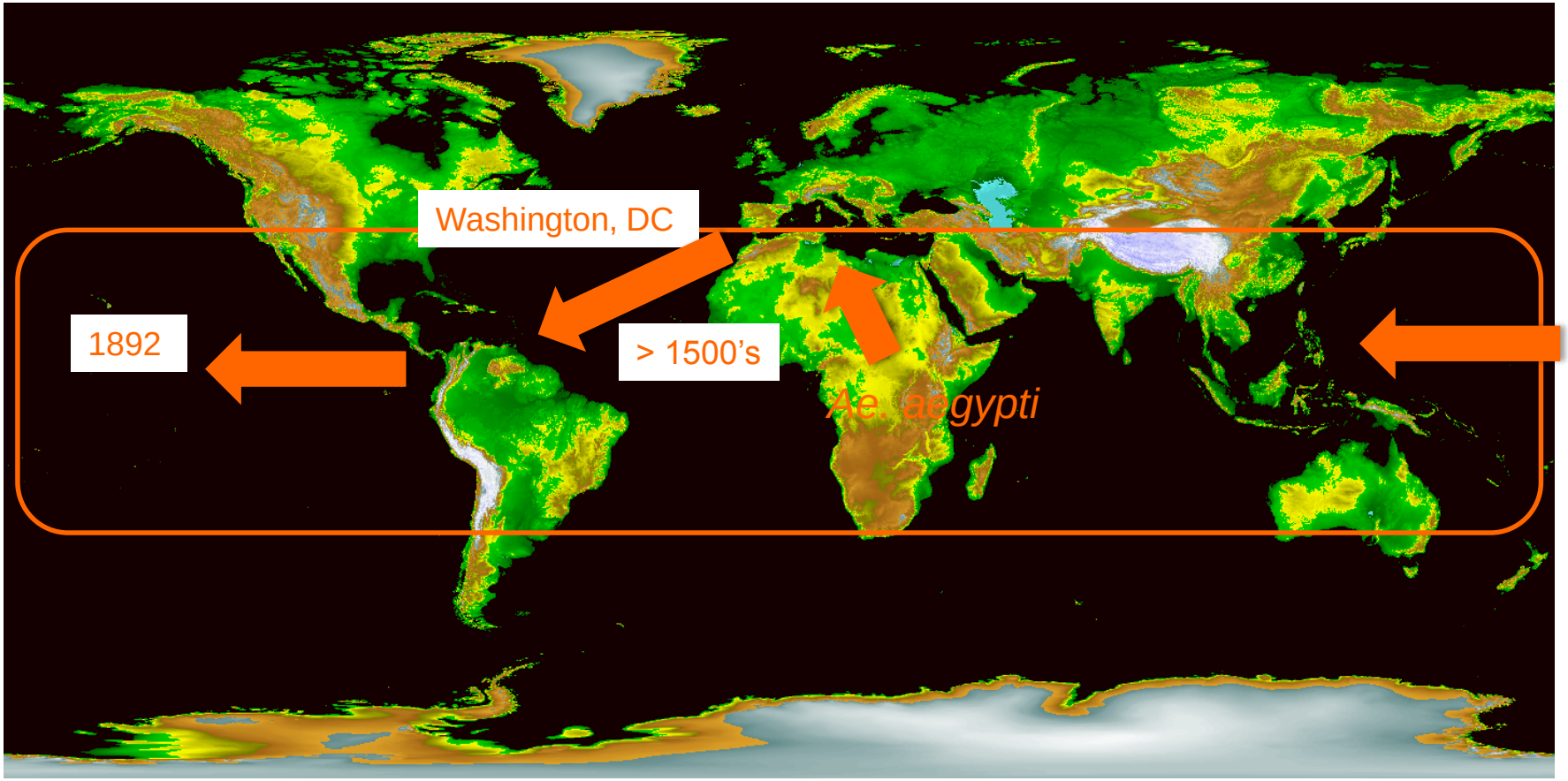
Tropical & temperate, after 1960's

Aedes albopictus

Aedes j. japonicus

Cold temperate, after 1990's

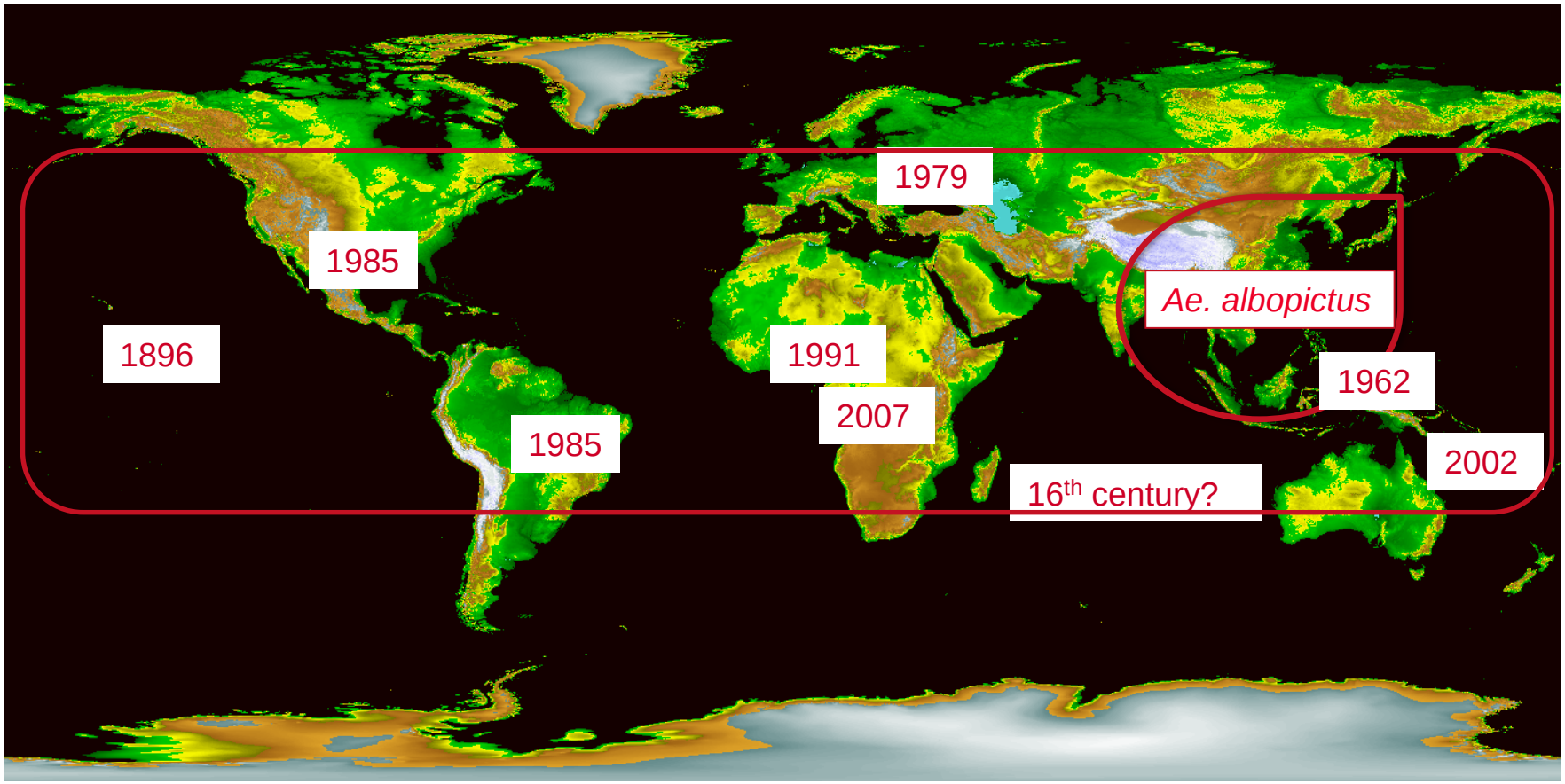
Aedes aegypti L, yellow fever mosquito



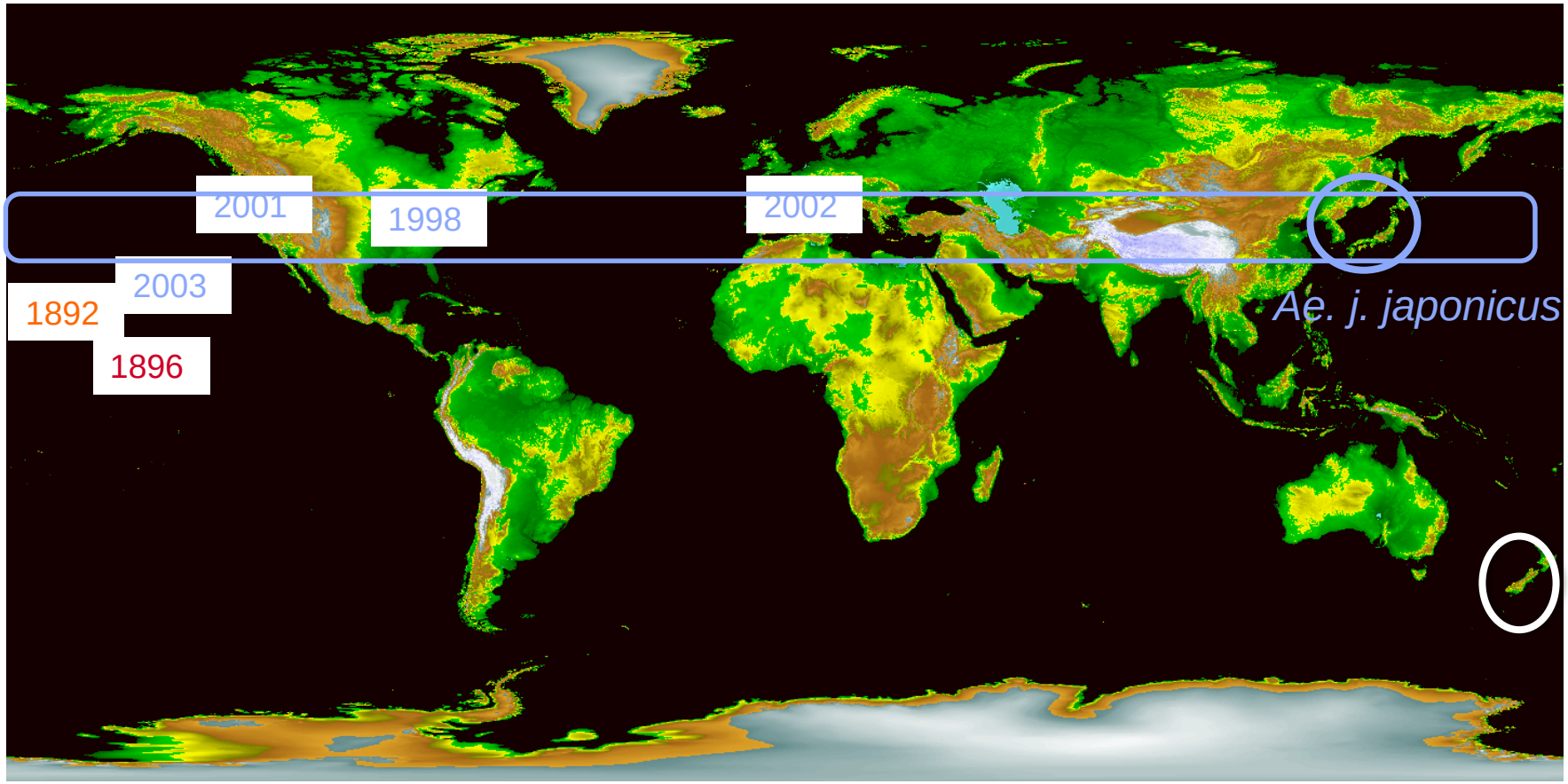
Brown et al. 2011 Worldwide patterns of genetic differentiation imply multiple 'domestications' of *Aedes aegypti*, a major vector of human diseases. Proc. Biol. Sci. 278(1717):2446-54

Brown JE, Evans BR, Zheng W, Obas V, Barrera-Martinez L, Egizi A, Zhao H, Caccone A, Powell JR 2014 Human impacts have shaped historical and recent evolution in *Aedes aegypti*, the dengue and yellow fever mosquito Evolution. 68(2):514-25

Aedes albopictus, Asian tiger mosquito



Aedes j. japonicus, Asian bush mosquito



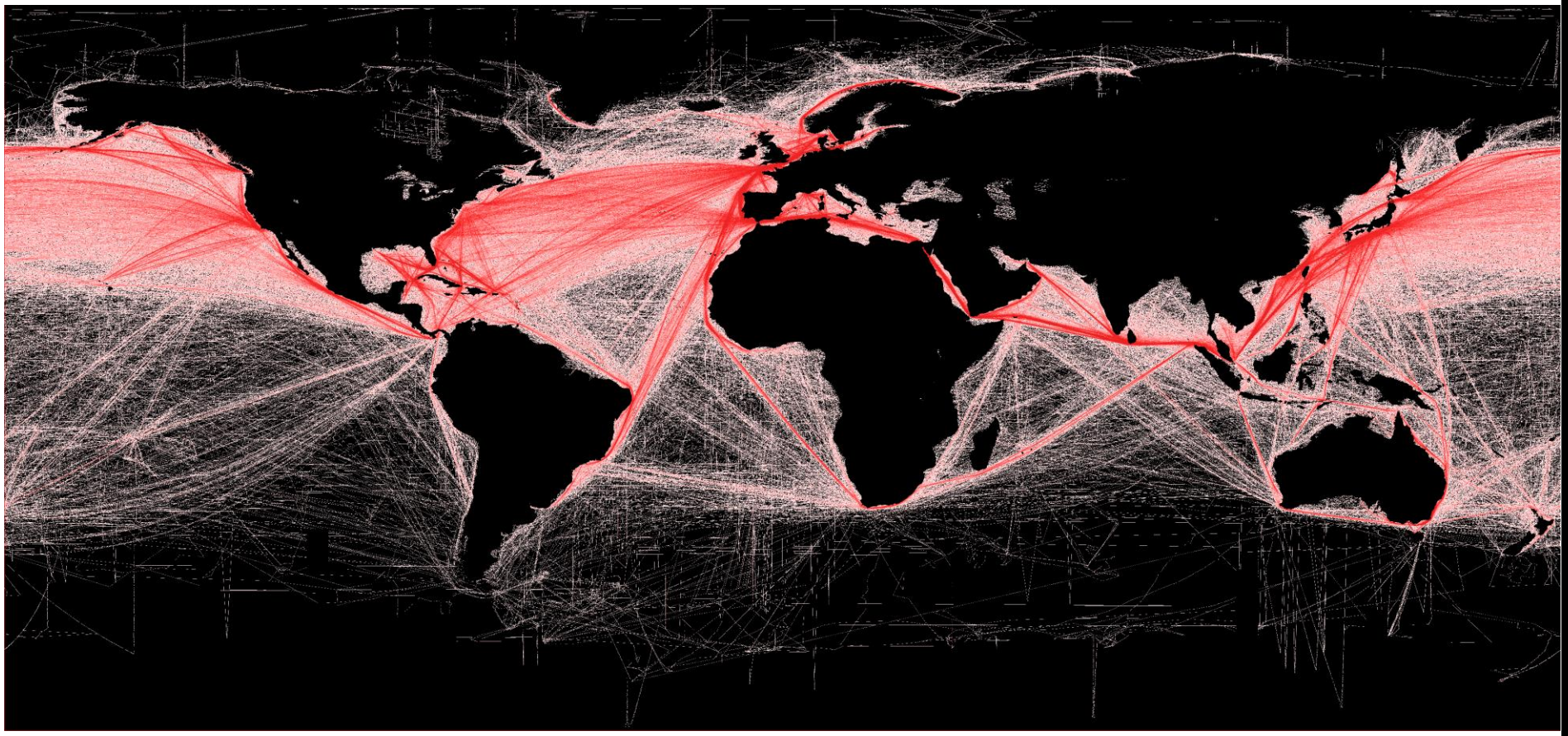
The Hawaiian islands have been colonized by *Ae. aegypti*, *Ae. albopictus* and *Ae. j. japonicus*, as well as *Culex quinquefasciatus* (1826).

Fonseca et al. 2010. **Molecular Ecology.** 19(8): 1559-72.
Cameron et al. 2010 **Journal of Medical Entomology** 47(4):527-35.
Huber et al. 2014 **Parasitology Research** 113(9): 3201-10.
Egizi et al. 2015 **Biological Invasions** 17(1): 123-132.
Egizi et al 2016 **Molecular Ecology** *online early*

BECAUSE OF THIS

Global aviation network

AND THIS



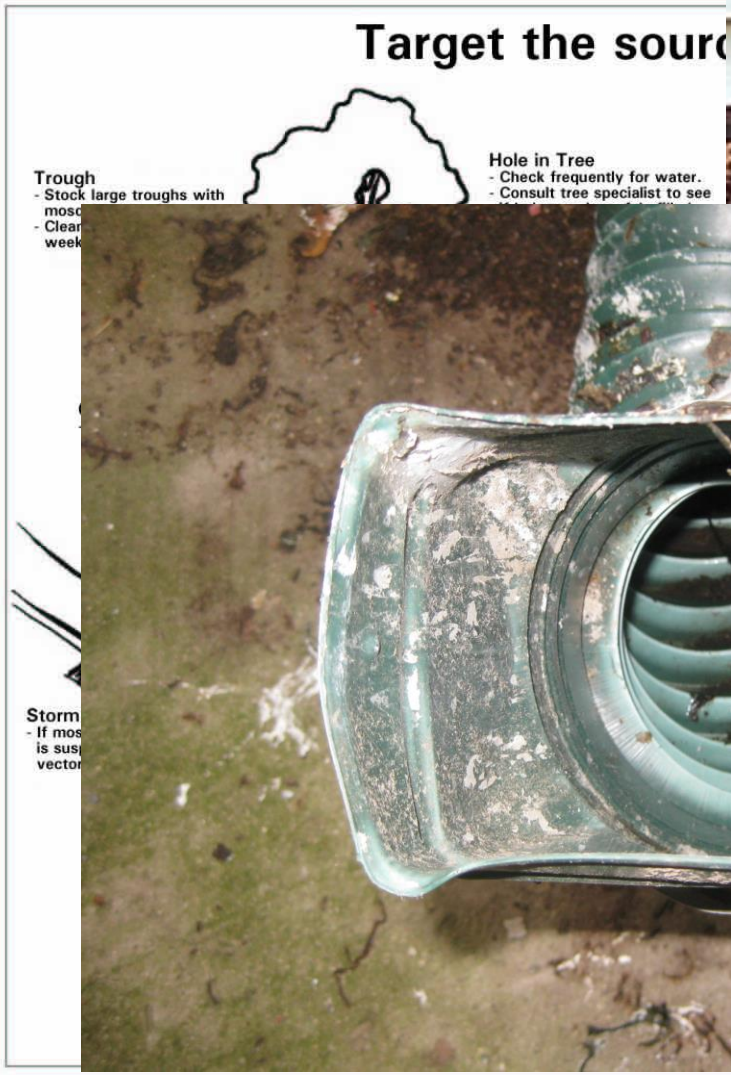
Worldwide ship traffic

BUT ALSO BECAUSE OF THIS

3. Vectors become resistant to control

Mutations in *acetylcholinesterase,* the target of organophosphates (OPs)

Mutations in the Sodium channels, the target of DDT and



Unlu I, Farajollahi A, Indelicato N, Fonseca DM 2014 The hidden world of Asian tiger mosquitoes: immature *Aedes albopictus* (Skuse) dominate in corrugated rainwater extension spouts. **Transactions of the Royal Society of Tropical Medicine and Hygiene** 108(11): 699-705.

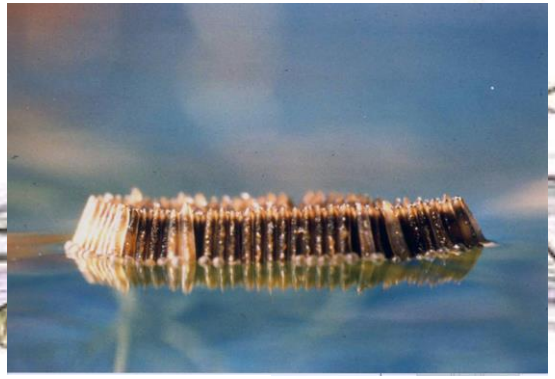
CLIMATE CHANGE

Anticipated trends:

- **Longer and warmer summers**
- **Shorter and milder winters**
- **Increased frequency of severe and unpredictable weather events (storms, heat waves, droughts)**
- **Sea level rise**

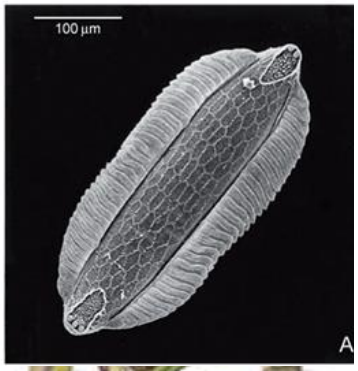
Egizi A, Fefferman NH, Fonseca DM 2015 Evidence that implicit assumptions of “no evolution” of disease vectors in changing environments can be violated on a rapid timescale. **Philosophical Transactions of the Royal Society Series B** 370(1665)

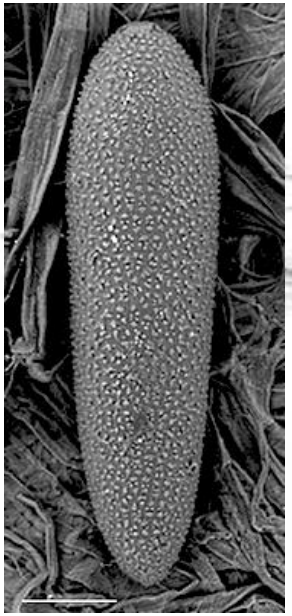
MOSQUITO LIFE-CYCLE



Culex egg raft

Anopheles egg

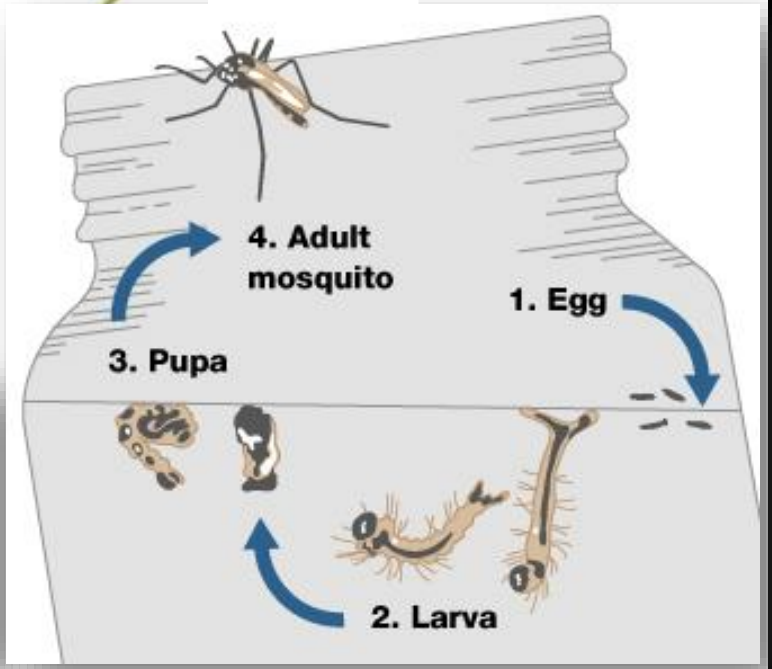




Aedes egg

Aedes eggs

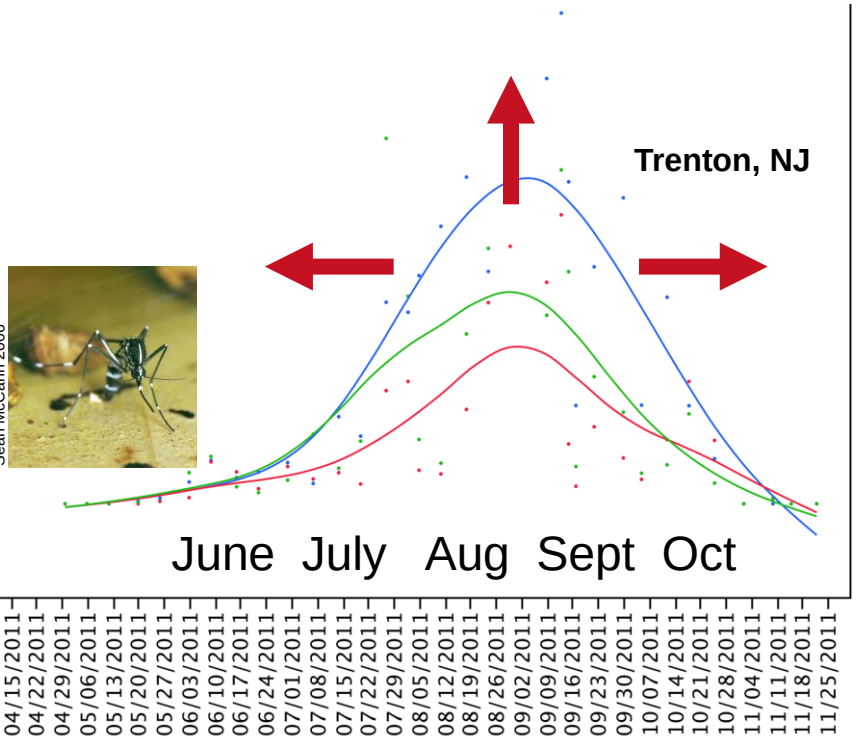
Aedes



WHAT DO MILDER TEMPERATURES DO?

Ary Faraji

Aedes albopictus,
Asian tiger mosquito



Sean McCann 2006

Aedes eggs

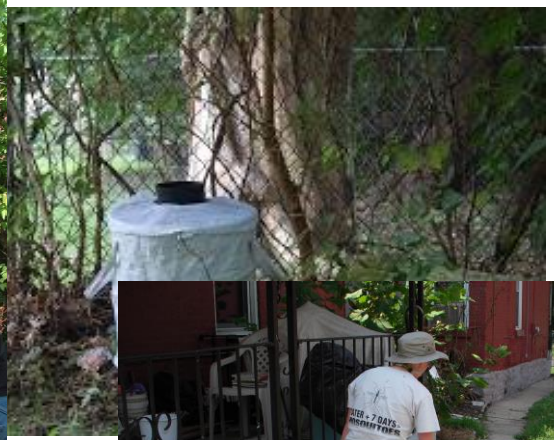
Dina Fonseca

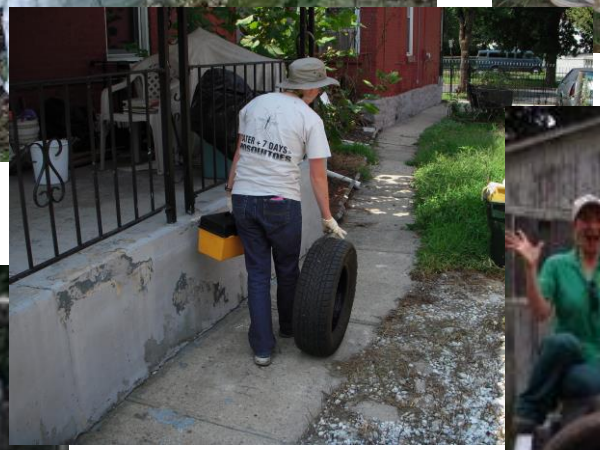
SEVERE WEATHER

- Increased habitat
- Increased availability of blood hosts
- Breakdown of control

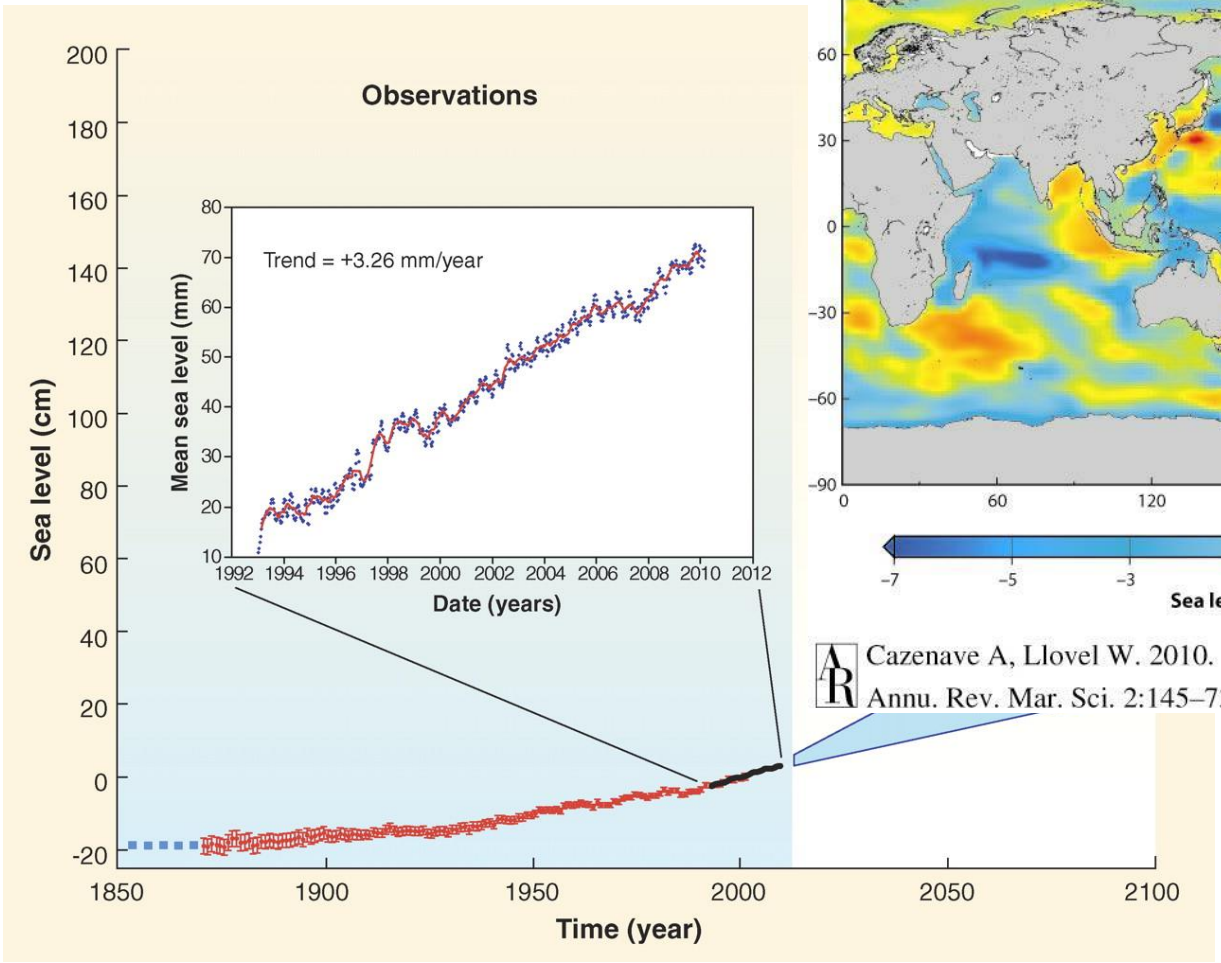
George Armstrong/FEMA

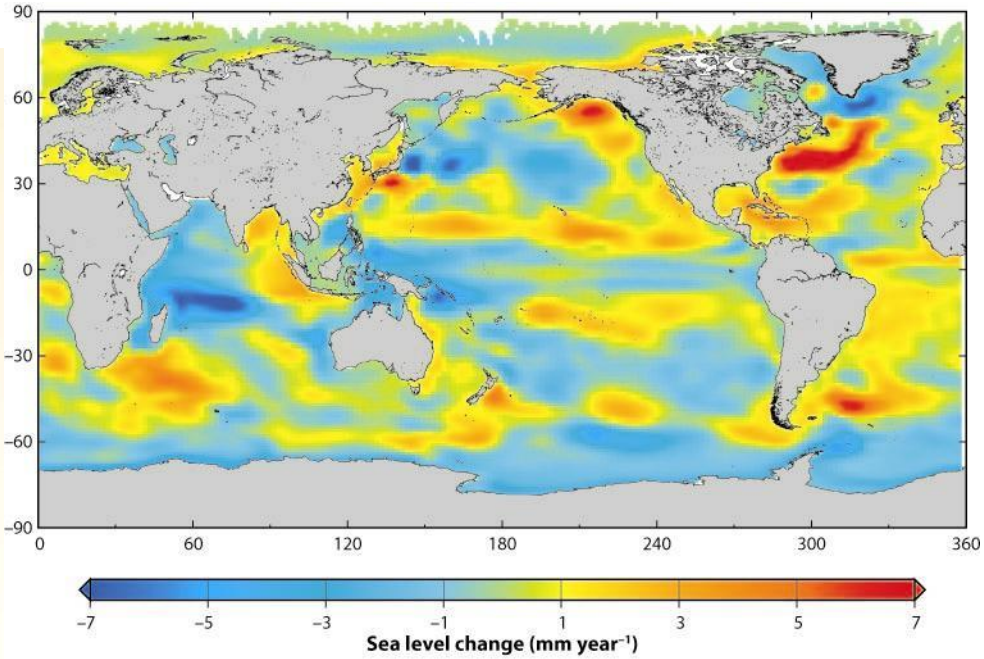
ORGANIZED MOSQUITO CONTROL





CHANGES IN SEA LEVEL





Nichells R. J. and Cazenave A. 2010. Sea-level rise and its impact on coastal zones. Science 328: 1517-1520

“Early colonists reported seeing clouds of salt marsh mosquitoes that would block out the sun. European settlers may have enjoyed a bounty of fish, waterfowl, and game but life in the unspoiled wilderness had its drawbacks. Salt marsh mosquitoes swarmed so ferociously that few American Indians chose to live on barrier islands. The ones that lived there were likely forced to the seaside by bigger, stronger tribes they feared.”

MOSQUITOES

John B. Smith
(1858-1912)

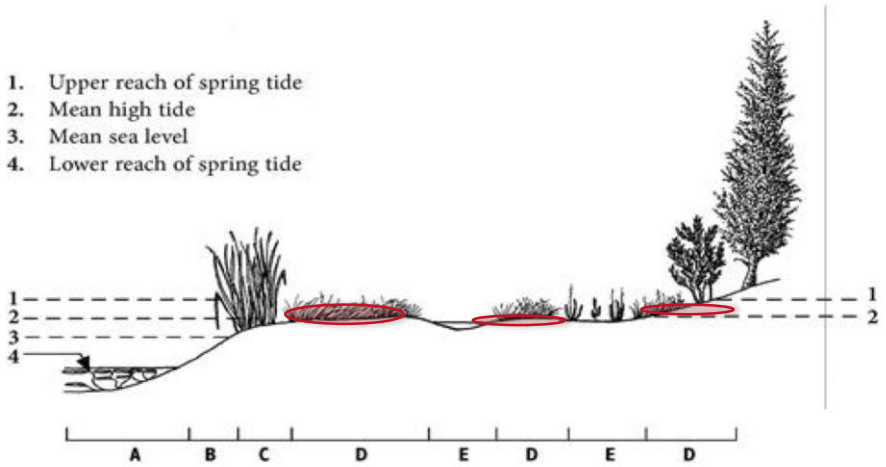
Freshwater swamp (tussocks)

Brackish water swamp

John B. Smith, NJAES entomologist worked to pass laws through the NJ legislature to provide support for mosquito control, both by empowering local Health Boards and eventually creating county Mosquito Extermination Commissions (after his death in 1912).

CATCHING THE TIDE

Aedes sollicitans



Habitat floods only during very high tides (“spring” tides) once or twice a month = predictable (!)

Eggs hatch, temperature determines development rates

Organized mosquito control applies larvicides PREVENTIVELY

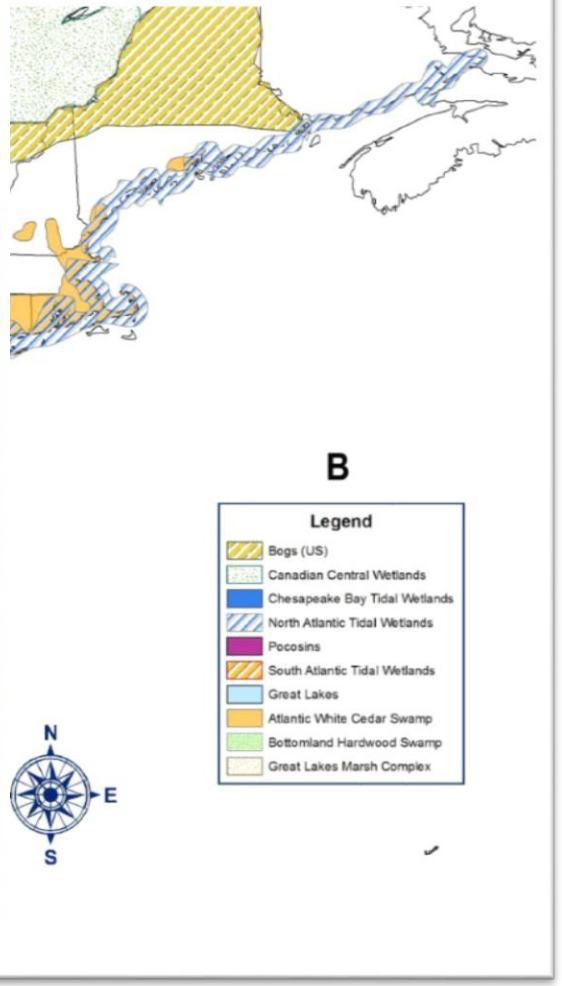
INTEGRATED PEST MANAGEMENT

PREVENTION

SURVEILLANCE

CONTROL

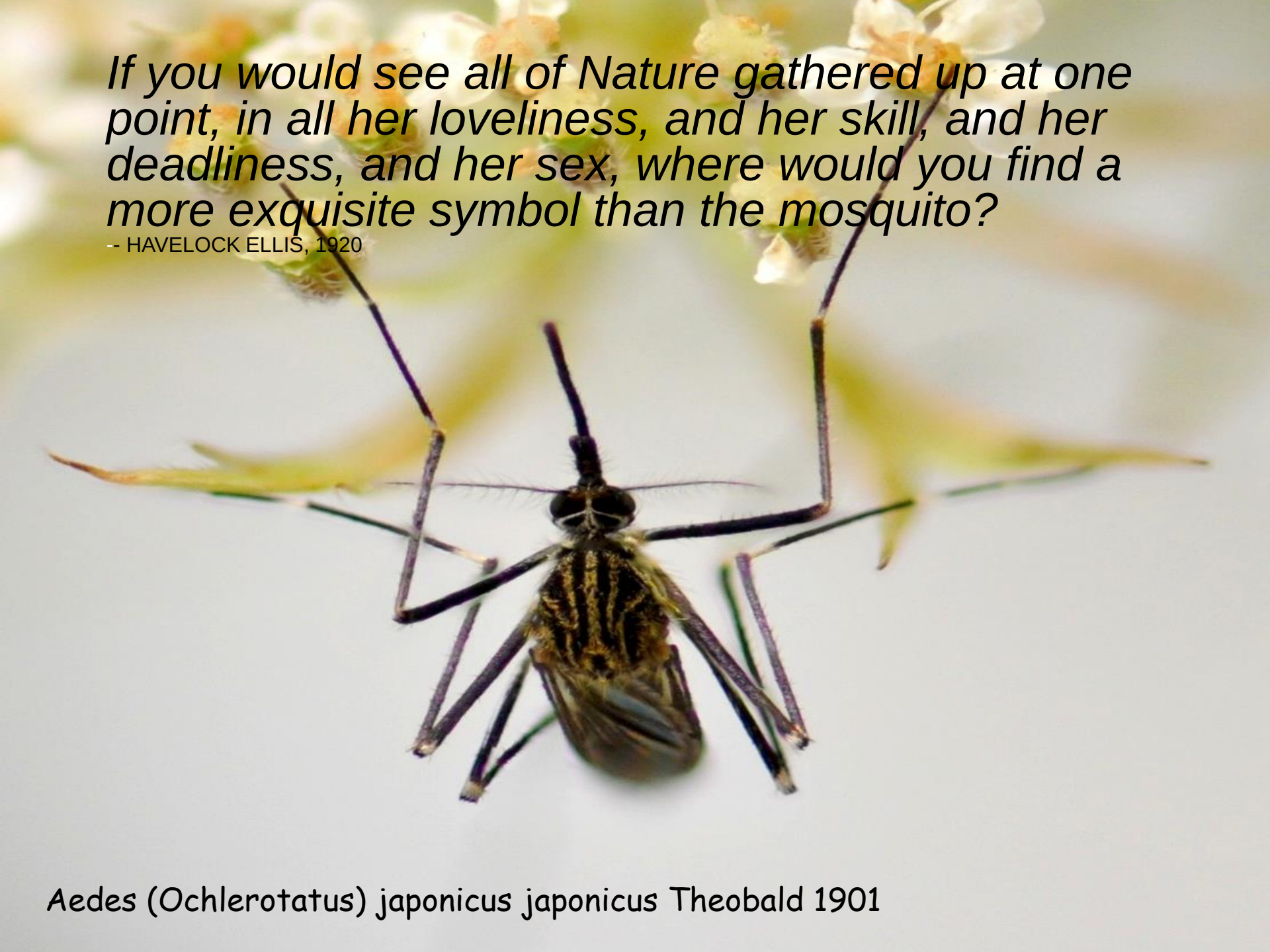
GLOBAL CLIMATE CHANGE = UNPREDICTABILITY



Rey et al 2012 *Int. J. Environ. Res. Public Health* **2012**, *9*(12), 4537-4605

If you would see all of Nature gathered up at one point, in all her loveliness, and her skill, and her deadliness, and her sex, where would you find a more exquisite symbol than the mosquito?

-- HAVELOCK ELLIS, 1920



Aedes (Ochlerotatus) japonicus japonicus Theobald 1901