Climate Change and Vector-borne Disease in the Northeastern US

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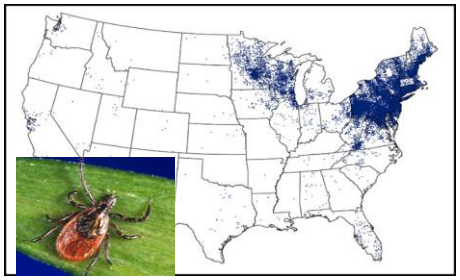
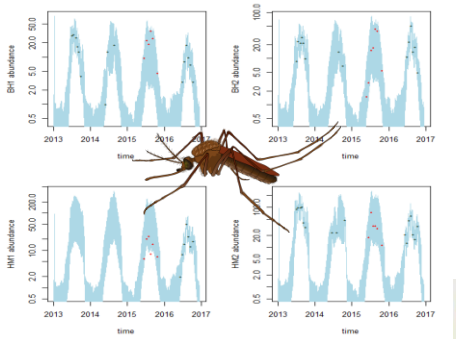
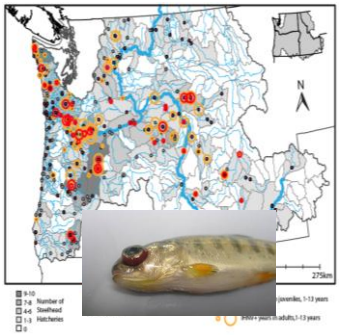
[the science behind environmental solutions]

- 12-15 PhD scientists engaged in ecosystem science research
- Institute prioritizes science translation

LaDeau Lab: Disease Ecology





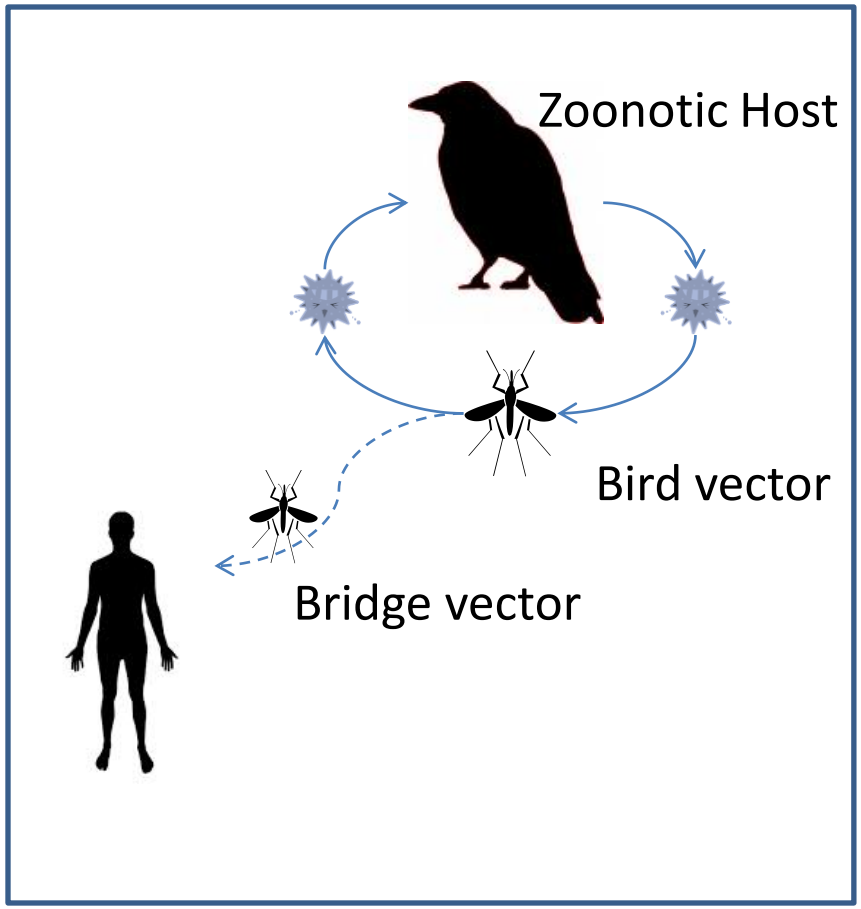


What are vector borne diseases (of concern in northeastern US)?

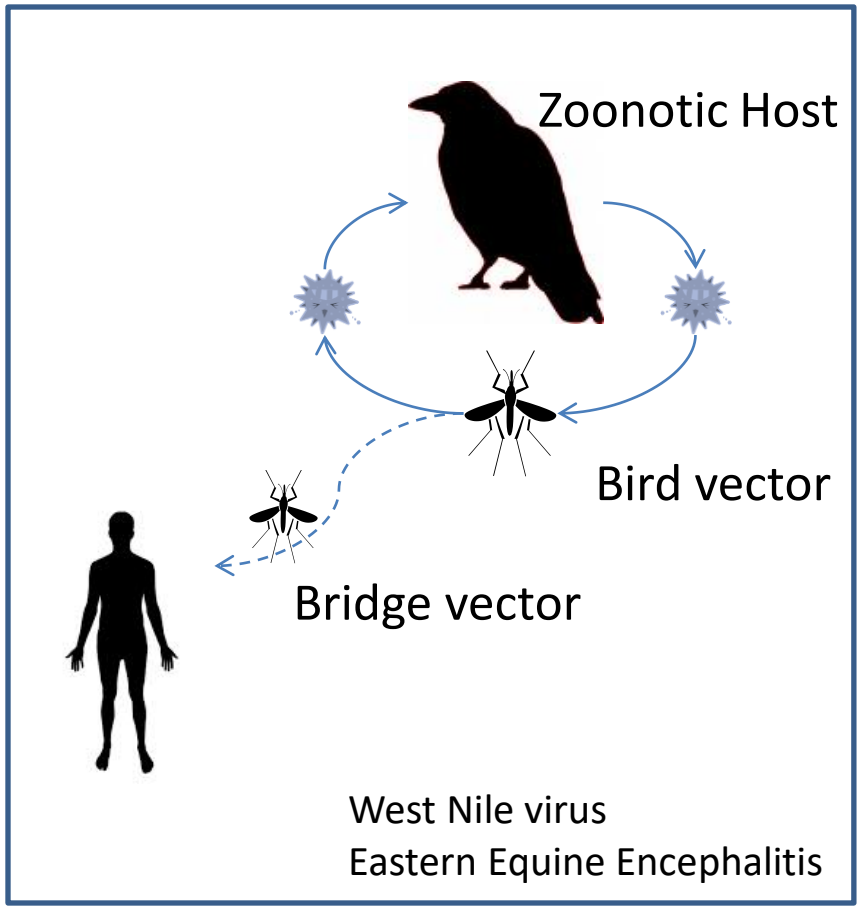
- Vector-borne diseases (VBDs) are caused by pathogens transmitted to humans through the bite of an arthropod (e.g., mosquitoes, ticks, fleas, triatomines,…).

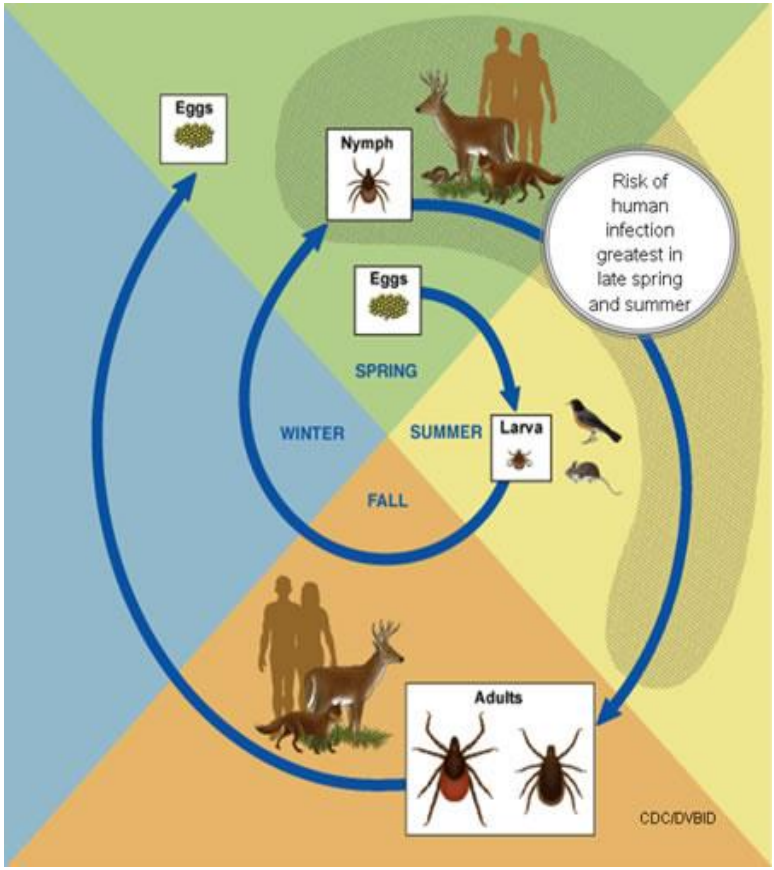
- VBDs have **zoonotic** origins.

Zoonotic Origins



Zoonotic Origins





What are vector borne diseases (of concern in northeastern US)?

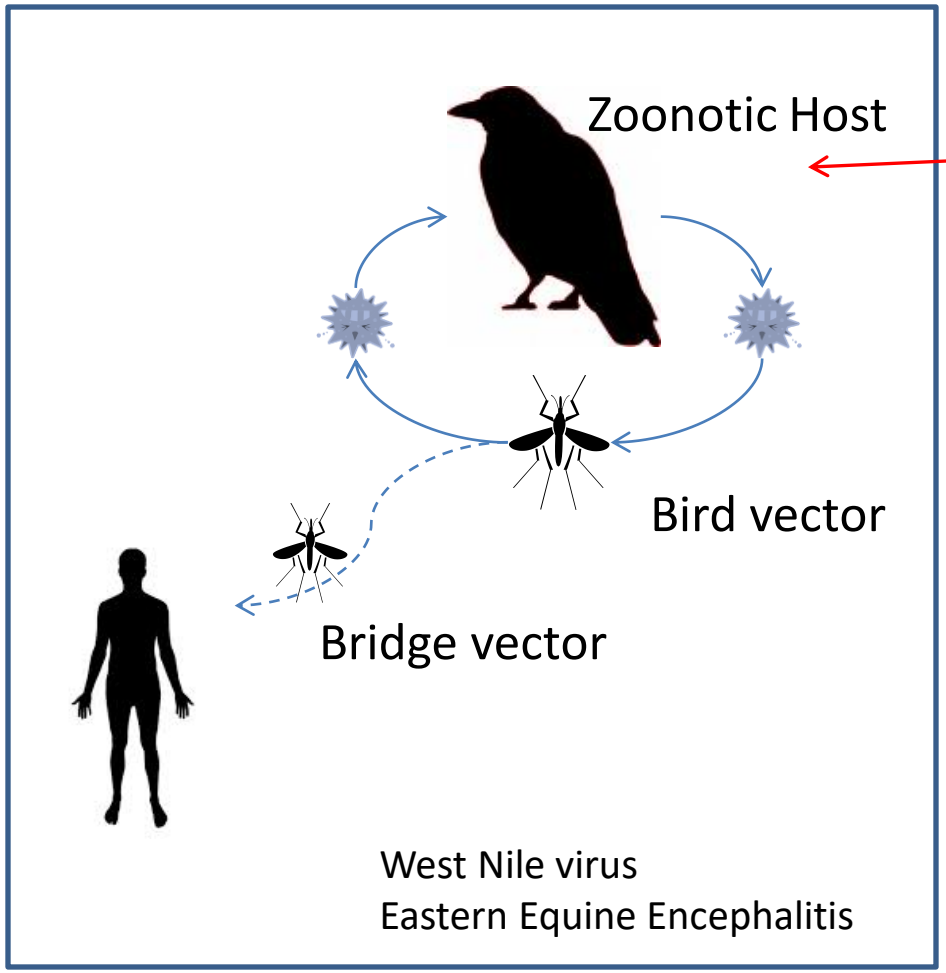
- VBDs are caused by pathogens transmitted to humans through the bite of an arthropod.

- VBDs that infect humans have **zoonotic** origins.

- Some continue to require non-human animals to persist.
  *Less epidemic potential – but difficult to manage.

- Some have adapted to human hosts.
  *Higher epidemic potential – but can be eradicated.

Transmission



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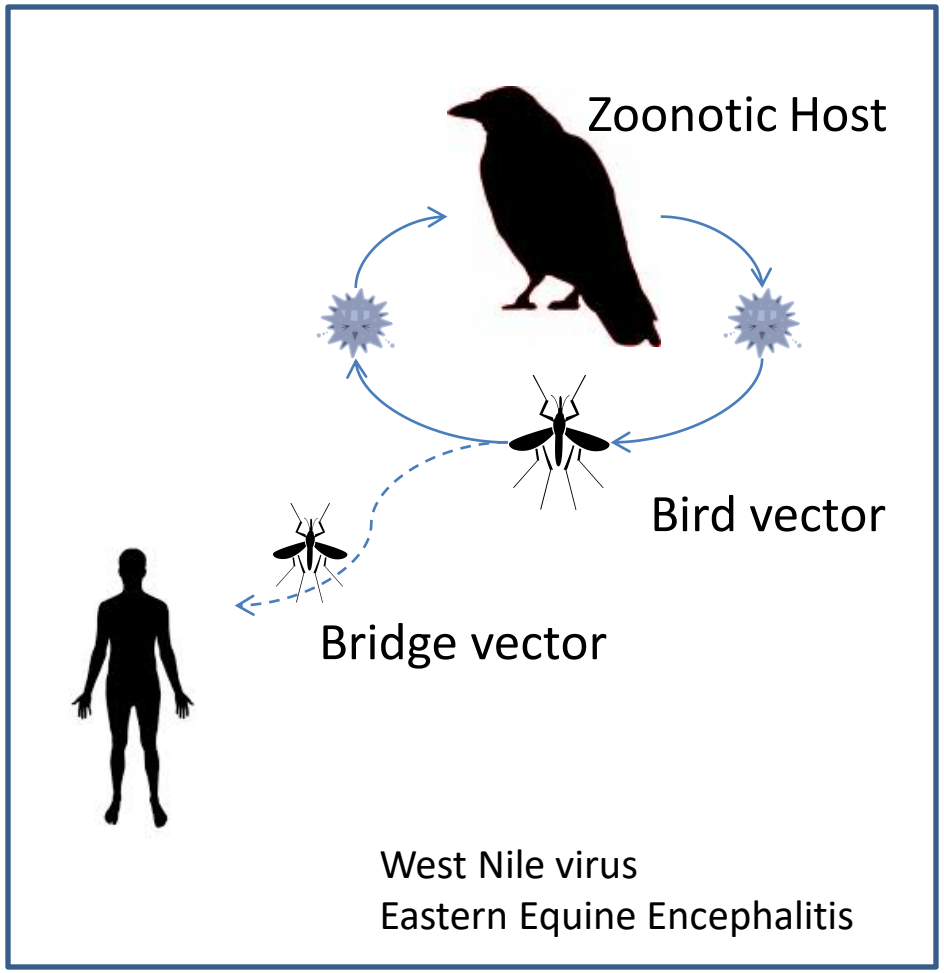

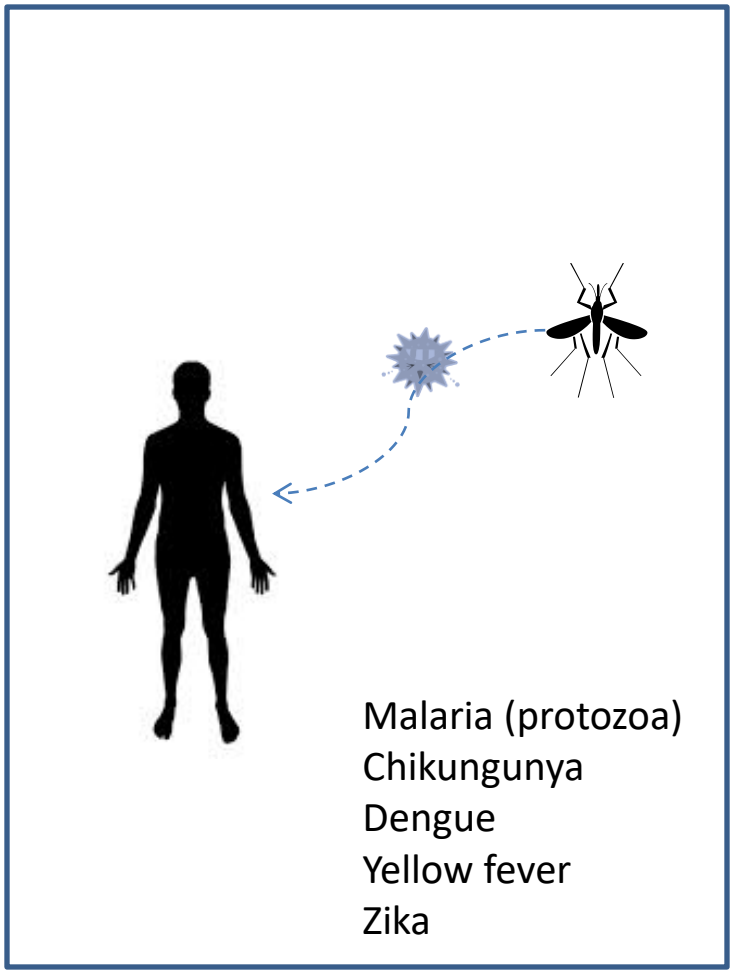

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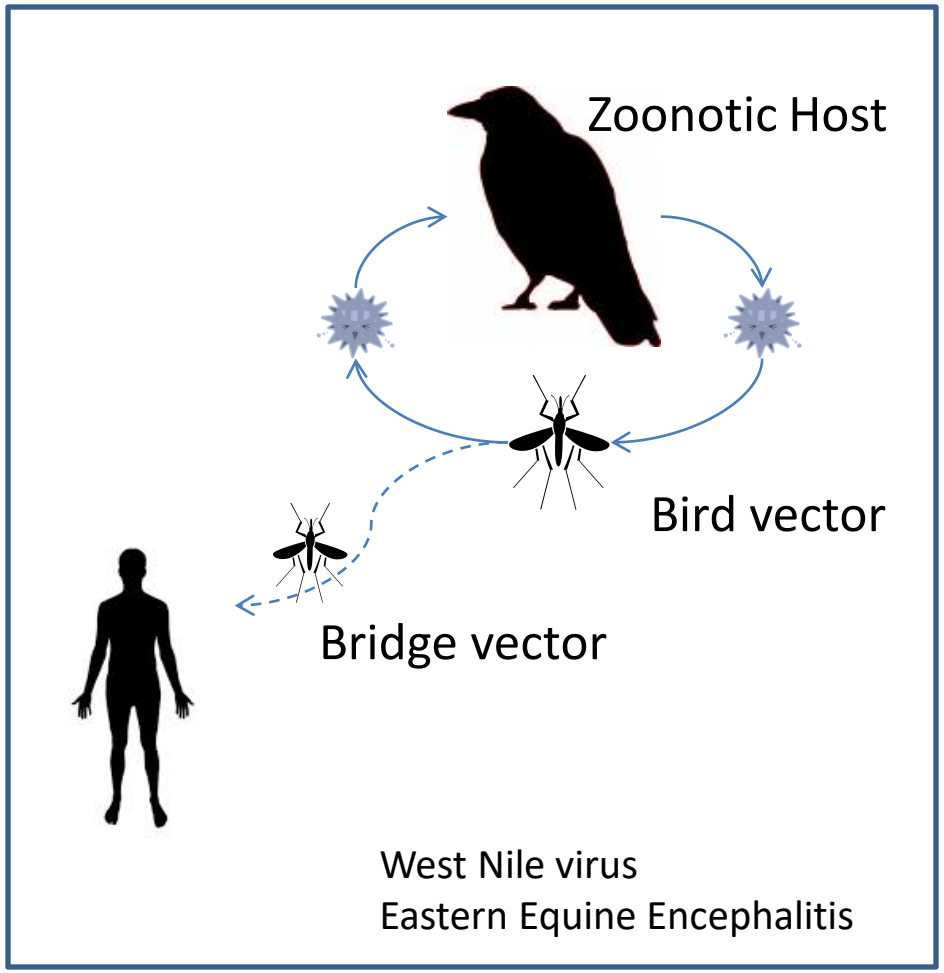
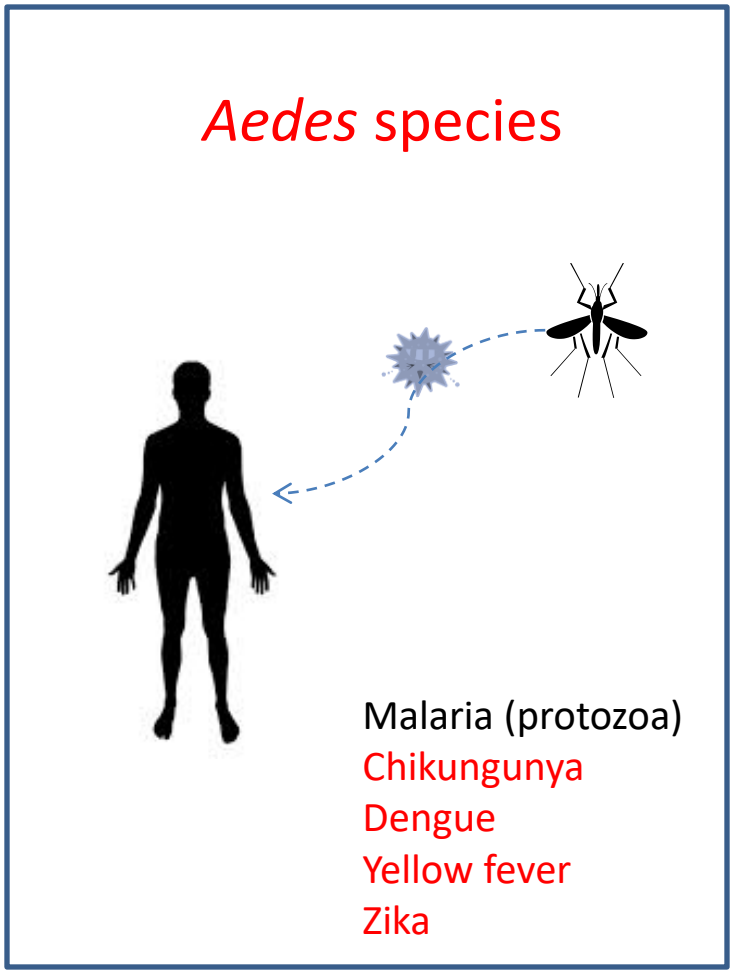
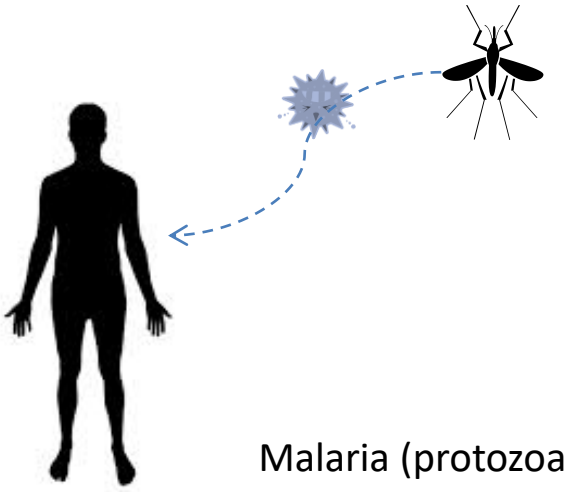




Transmission

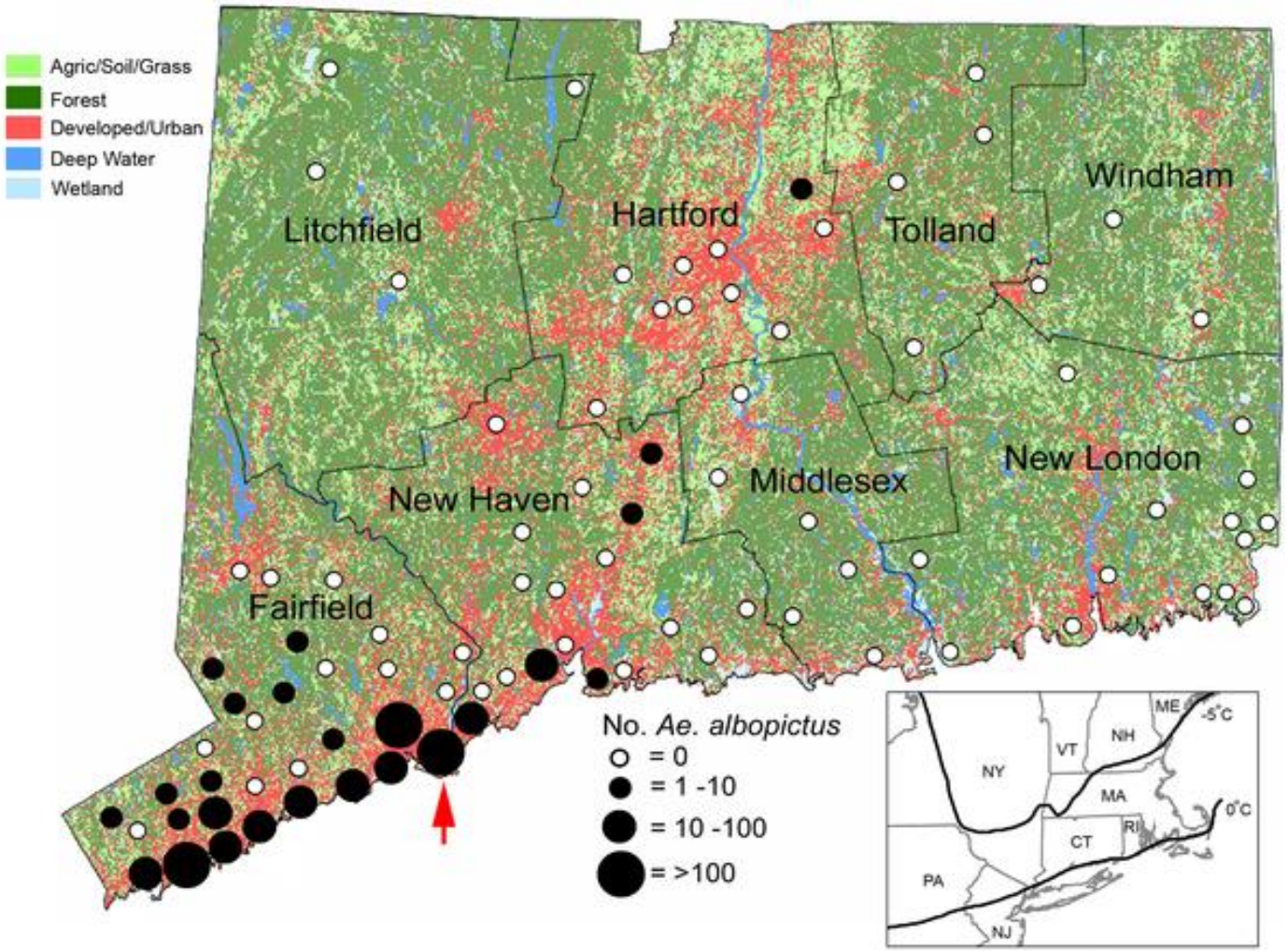
Aedes albopictus (tiger mosquito)

Aedes species



Malaria (protozoa)
Chikungunya
Dengue
Yellow fever
Zika

Fig 1. County map of Connecticut showing geographic distribution of mosquito trapping sites and land use characteristics.



Armstrong PM, Andreadis TG, Shepard JJ, Thomas MC (2017) Northern range expansion of the Asian tiger mosquito (Aedes albopictus): Analysis of mosquito data from Connecticut, USA. PLOS Neglected Tropical Diseases 11(5): e0005623. https://doi.org/10.1371/journal.pntd.0005623 https://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0005623

Why is climate an important factor in vector-borne disease risk?

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- Arthropods are ectotherms.
- Warmer temperatures generally speed up growth.

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  * Juveniles grow to adult stages more rapidly.
  * More population growth per season.

Mosquitoes may grow to adult stages in less than a week.

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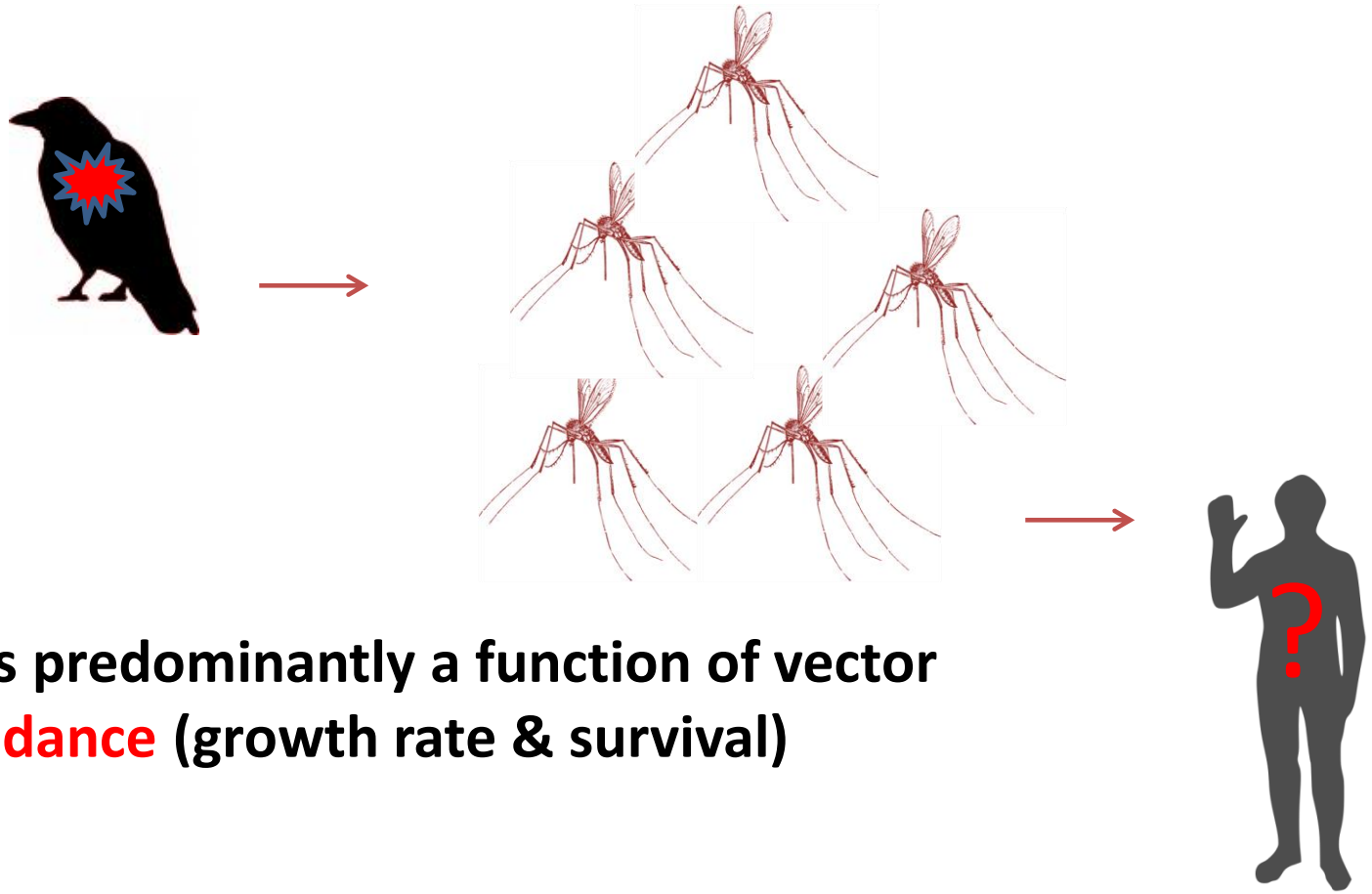
Mosquitoes may grow to adult stages in less than a week.

Risk of human exposure to VBD is directly related to the SIZE of the vector population in habitats where people are present.

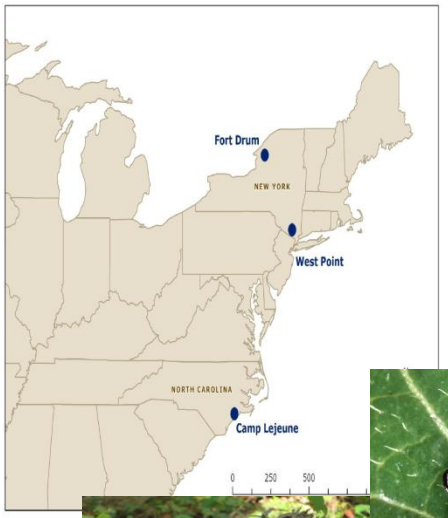
IF an infected host is present….



risk is predominantly a function of vector abundance (growth rate & survival)

Why is climate an important factor in vector-borne disease risk?

- Ticks…



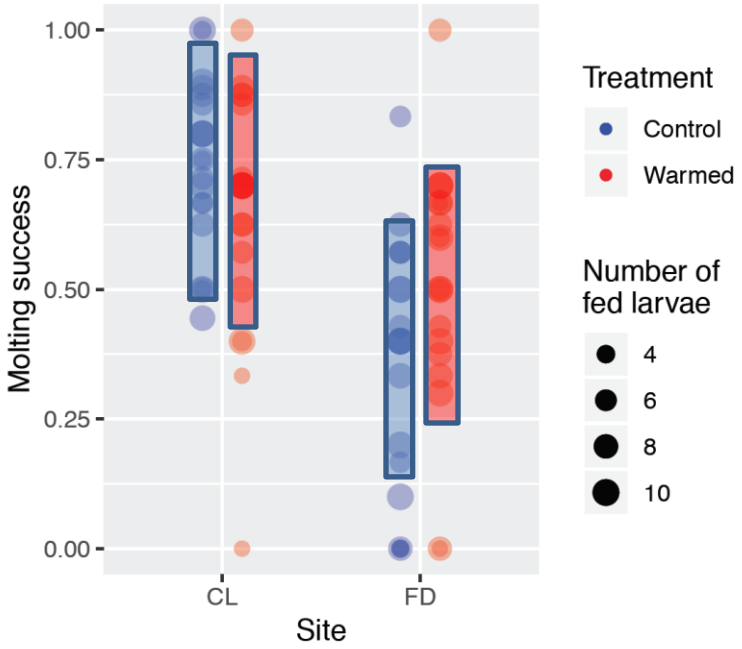

S. Bauer, PD-USGov-USDA-ARS


Soil Core Habitat


Percival Environment Chamber

Fed larval ticks (*Ixodes scapularis*) experienced:

- Reduced molting (survival) in north (p=0.002).
- Warming (3°C) increased molting success at FD only (p=0.044).



Killilea, Brunner, LaDeau, McGovern & Ostfeld unpub

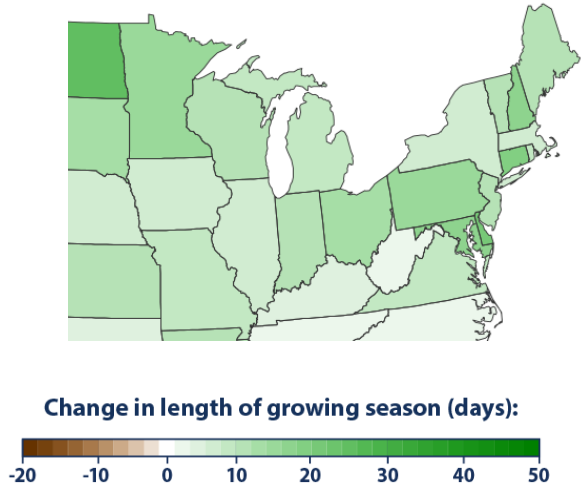
Funded by

SERDP
DOD • EPA • DOE

Why is climate an important factor in vector-borne disease risk?

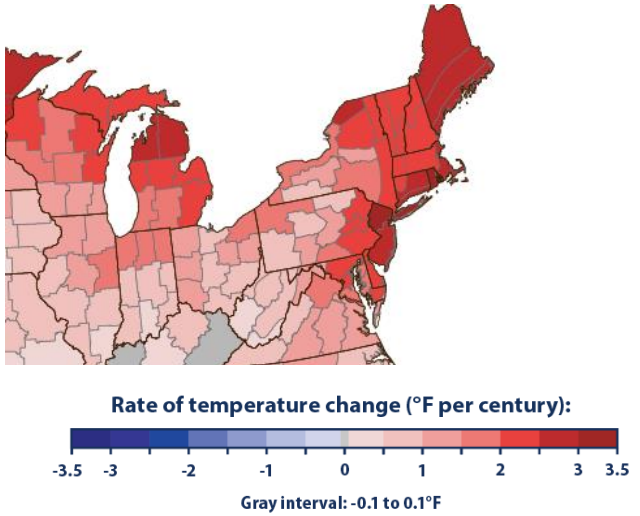
Warmer = greater growth & winter survival rates.

Longer growing seasons (shorter winter) = more time for population growth and more time to feed on infected hosts.



Data source: Kunkel, K.E. 2016 expanded analysis of data originally published in: Kunkel, K.E., D.R. Easterling, K. Hubbard, and K. Redmond. 2004. Temporal variations in frost-free season in the United States: 1895–2000. Geophys. Res. Lett. 31:L03201.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.



*Alaska data start in 1925.

Data source: NOAA (National Oceanic and Atmospheric Administration). 2016. National Centers for Environmental Information. Accessed February 2016. www.ncei.noaa.gov.

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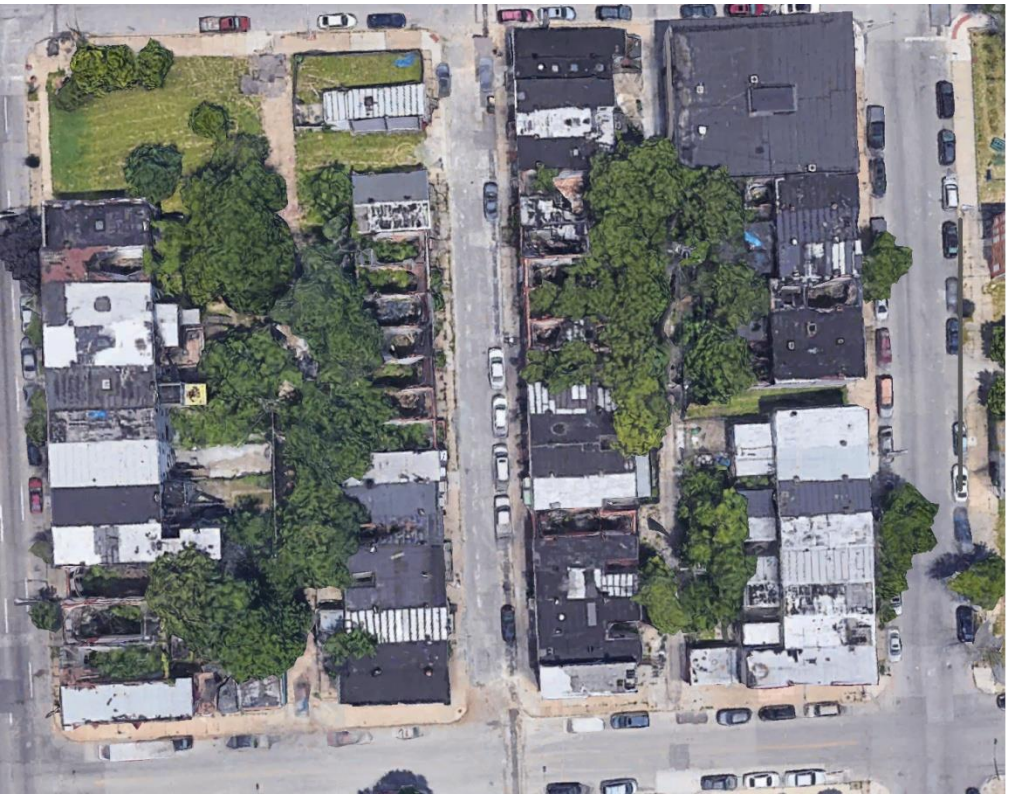
How does the northeastern landscape support VBDs?

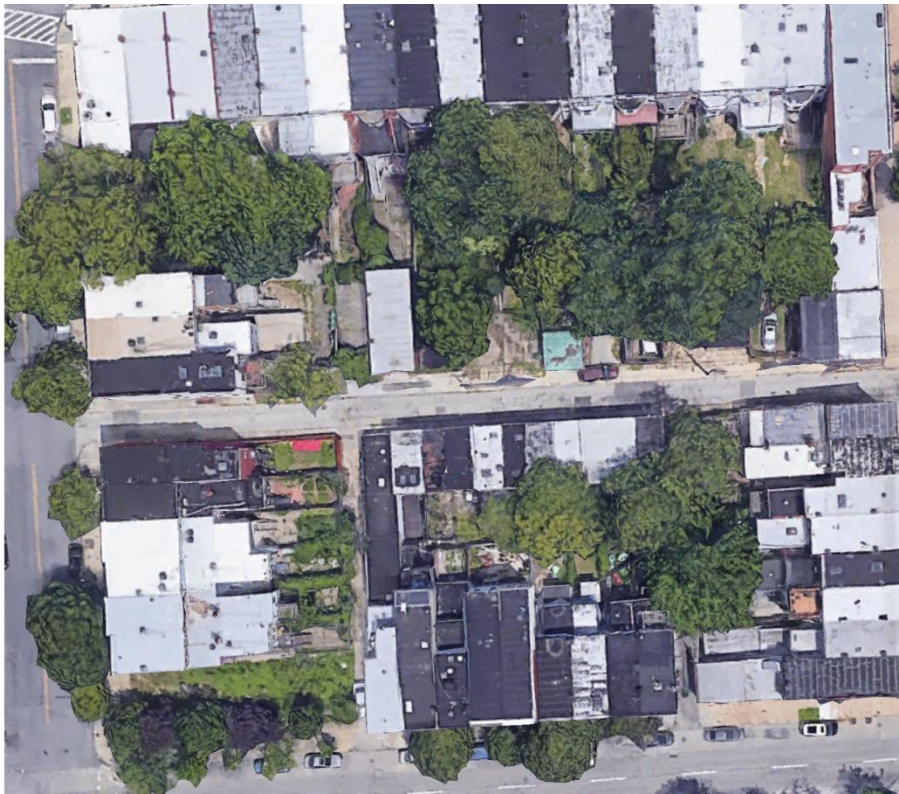
How does the northeastern landscape support VBDs?

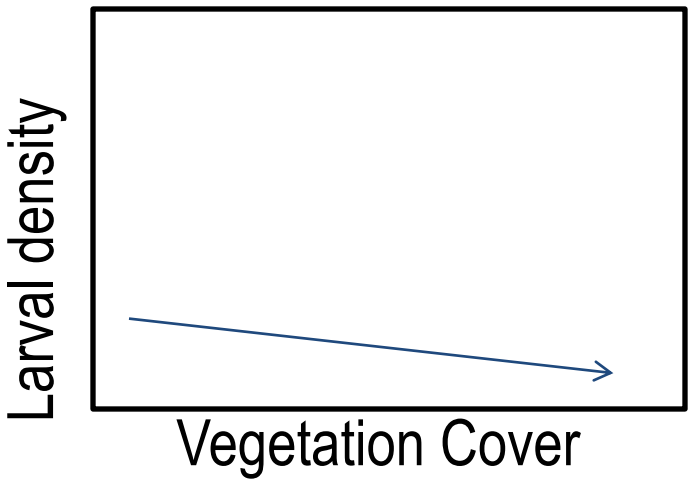
- Arthropod (mosquito & tick) vectors in the northeastern US need vegetation for food and to maintain habitat humidity.
- Northeastern cities and suburbs are mix of high human population density and ‘green’ habitat.
- Human-vector contact depends on shared space.

Urban Mosquito Habitat

- High urban vegetation cover (Baltimore, MD)

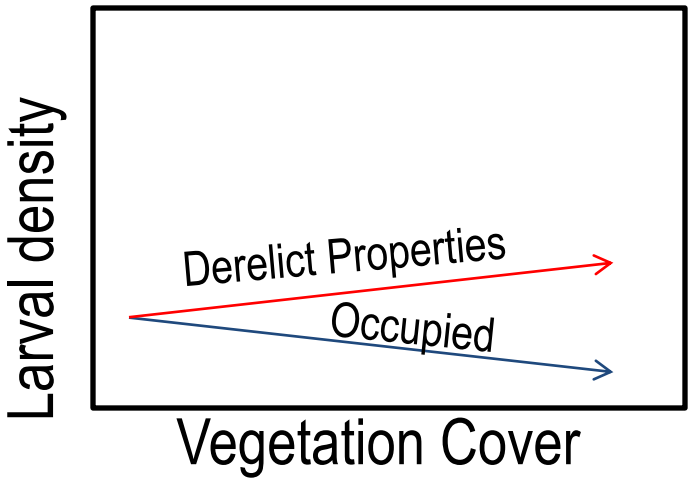






Vegetation cover a negative predictor of juvenile mosquito density.

Little E., Biehler D., Leisnham P.T., Jordan R., Wilson S. & LaDeau S.L. (2017).. *Journal of Medical Entomology*, 54, 1183-1192.

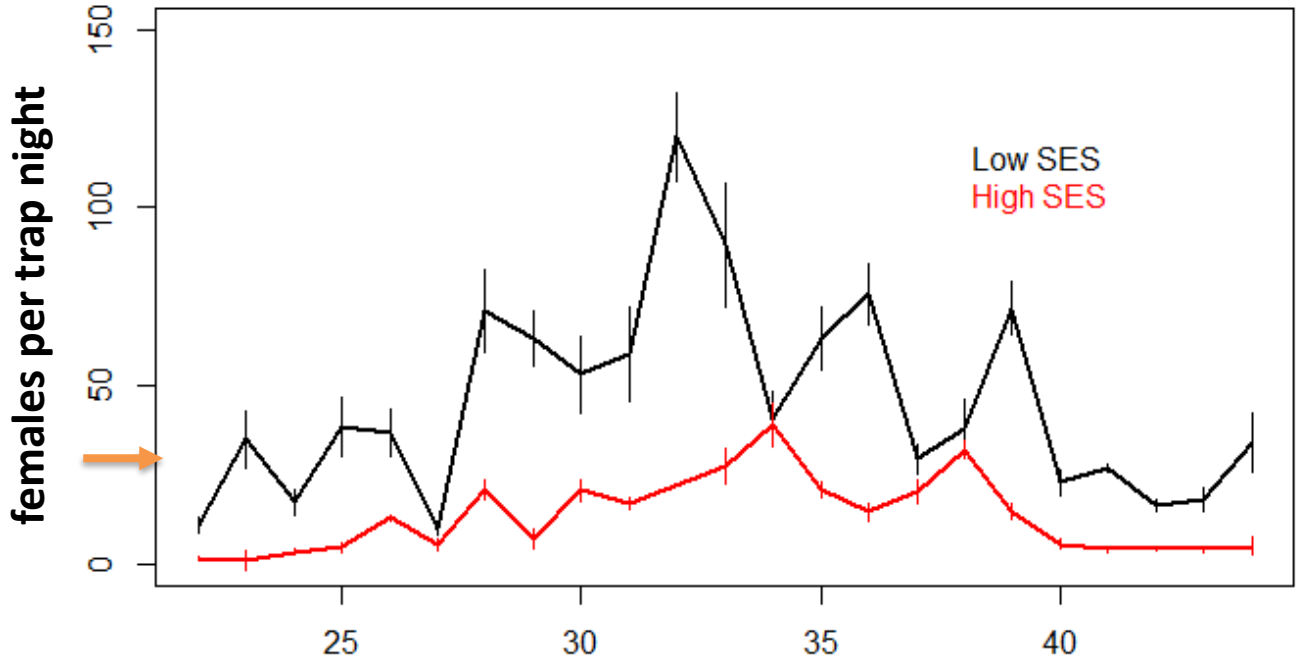


Vegetation cover a negative predictor of mosquito density EXCEPT on blocks with abandoned/vacant properties.

Little E., Biehler D., Leisnham P.T., Jordan R., Wilson S. & LaDeau S.L. (2017).. *Journal of Medical Entomology*, 54, 1183-1192.

Urban Mosquito Habitat

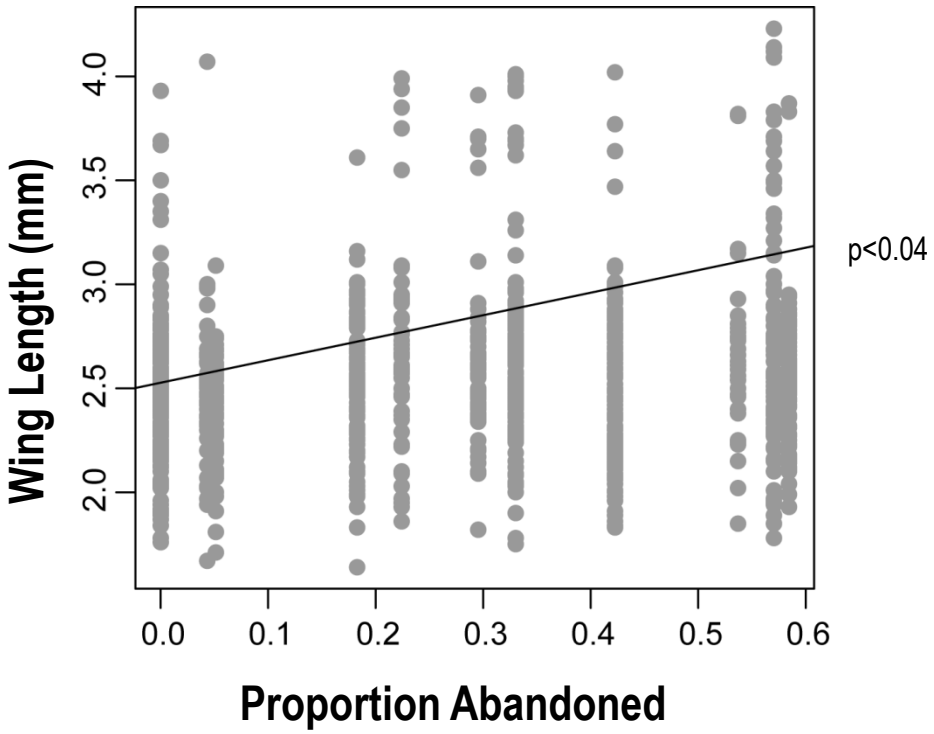
More tiger mosquitoes (*Ae. albopictus)* in low income neighborhoods (Baltimore MD)



Mean and SE shown for AEAL females per nbhd (2013-2016)

Bodner D., LaDeau S.L. & Leisnham P.T. (2019). *Journal of Medical Entomology*, 56, 192-198.
Little E., Biehler D., Leisnham P.T., Jordan R., Wilson S. & LaDeau S.L. (2017).. *Journal of Medical Entomology*, 54, 1183-1192.

Bigger mosquitoes in low income neighborhoods



Bigger mosquitoes may transmit virus more effectively…

Katz G, Leisnham PT, LaDeau SL. (2019) *Journal of Medical Entomology.* 57, 615-619.

What can we do to manage risk?

Challenges:

Changing climate & growing urban landscapes likely to support greater vector populations AND contact rates.

Actions:

Surveillance. Know what species are abundant and when.
Community engagement.
Manage container habitat (garbage!) and vegetation.

Acknowledgments

Paul Leisnham, Dawn Biehler, Rebecca Jordan, Sacoby Wilson, Dina Fonseca, Parks & People Foundation, Baltimore City DPW (Mosquitoes)
Mary Killilea, Jesse Brunner, Rick Ostfeld, Elizabeth McGovern, Megan Schierer(Ticks)

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