Urban Ecology of WNV in Atlanta Georgia, 2008-2013

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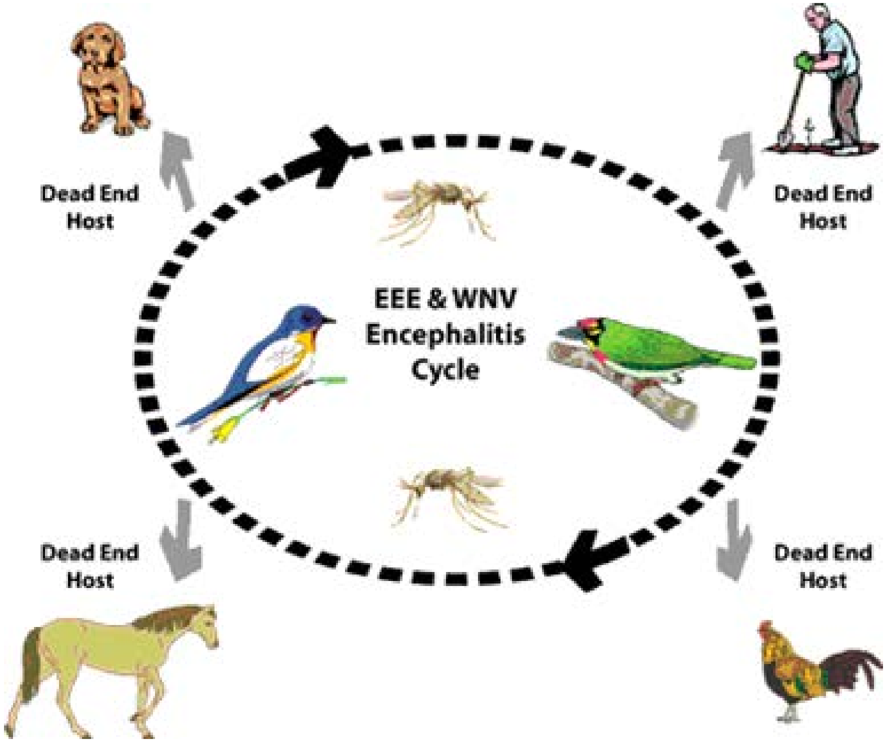
GEORGIA MOSQUITO CONTROL ASSOCIATION

GMCA Meeting, Oct 2013

Urban Ecology of West Nile virus in Atlanta, GA



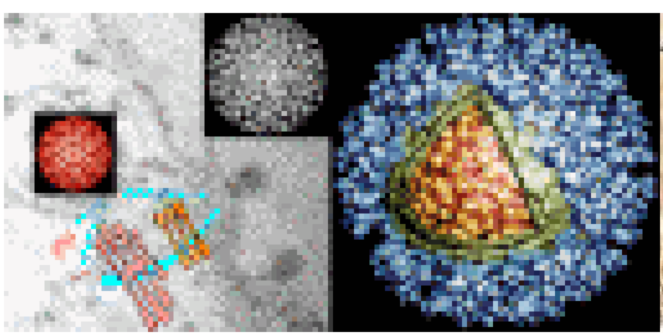
Collaborators

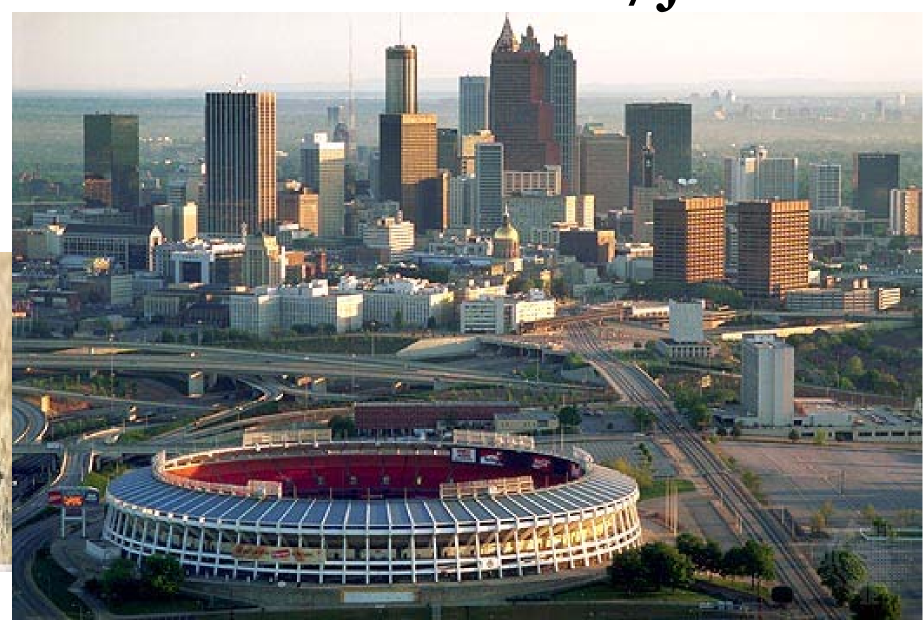
Gonzalo Vazquez-Prokopec, Luis Chaves, Rebecca Levine, Donal Bisanzio, Uriel Kitron - **Emory**

Danny Mead – **UGA**

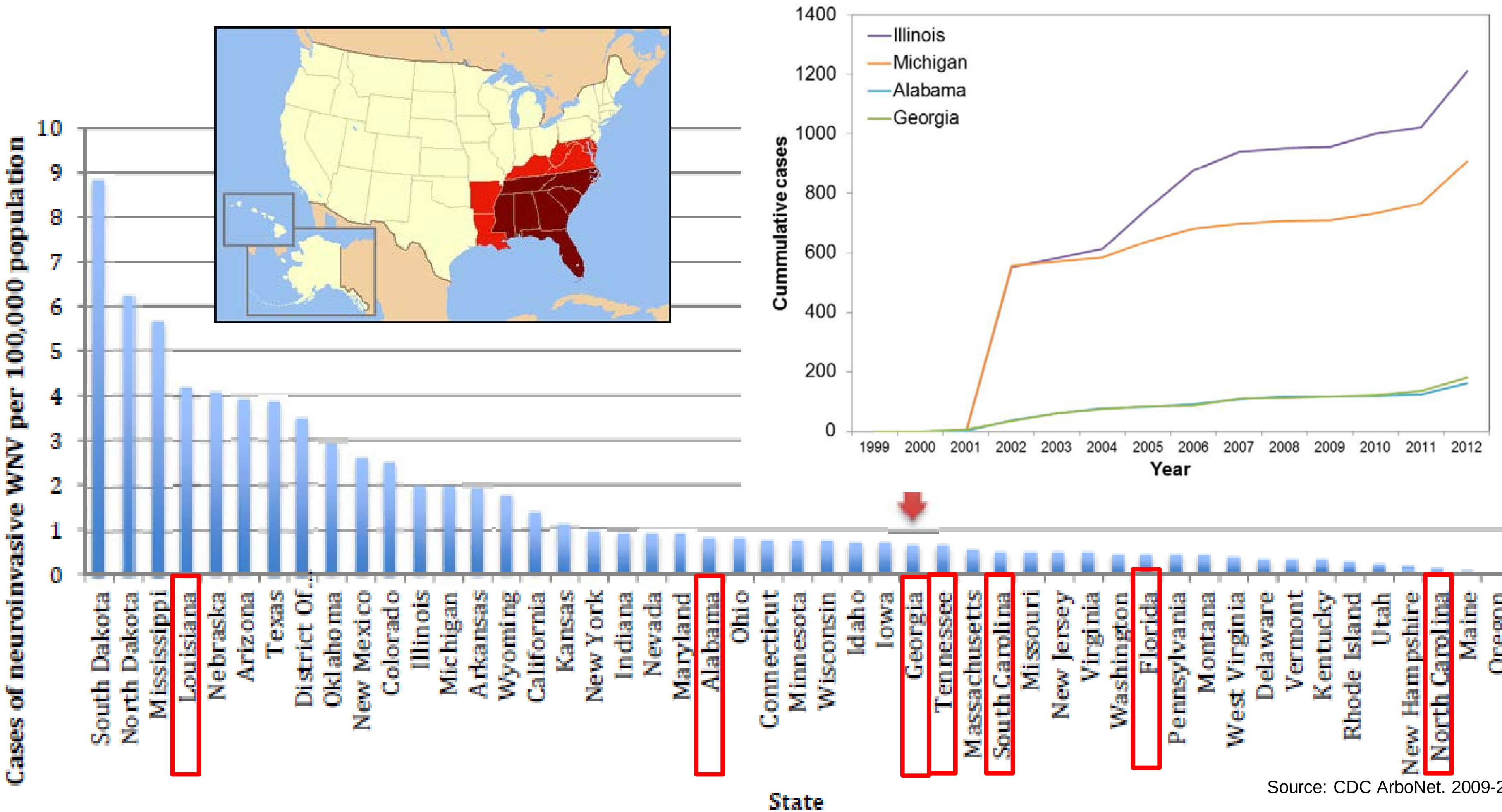
Rosmarie Kelly – **GA-DPH**

Thomas Burkot – **CDC/JCU**





Neuro-invasive WNV cases significantly lower in GA and most SE States



Source: CDC ArboNet. 2009-2012

Why WNV spill-over in Georgia (and the SE) is that low ?

Why is WNV spill-over that low?

Low mosquito abundance?

Absence of transmission hot-spots?

Low enzootic transmission?

Absence of competent reservoir hosts?

Complex bird community “dilutes” transmission?

Different viruses?

Low human exposure?

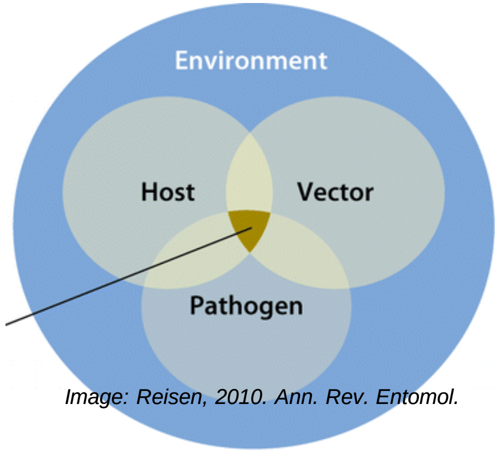
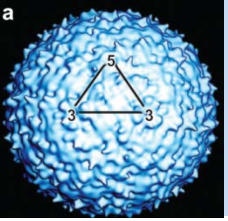


Image: Reisen, 2010. Ann. Rev. Entomol.



Vectors and WNV infection

Mosquitoes

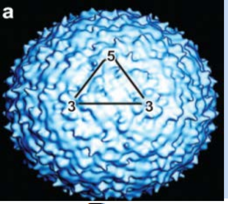
- *Culex quinquefasciatus* the most important Vector. Found in >84% of WNV+ tested pools.

<u>Common urban habitats for *Cx quinquefasciatus*</u>:

* unmanaged residential pools and containers
* catch basins
* **Wastewater treatment facilities**

Mosquito Surveillance (positive pools)		
14-Sep-07		
2007	EEE*	0
	Hart Park	0
	Flanders	93
	WNV*	64
5-Sep-06		
2006	EEE*	0
	Flanders	24
	WNV*	51
	Highlands J	0
6-Sep-05		
2005	EEE*	8
	Flanders	100
	WNV*	31
	Highlands J	6
8-Sep-04		
2004	EEE*	2
	Flanders	56
	WNV*	100
	Highlands J	0

Source: R. Kelly



Hot-spots of transmission

Research

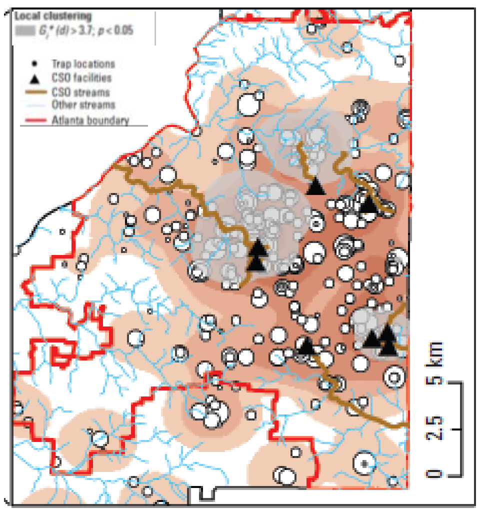
VOLUME 118 | NUMBER 10 | October 2010 • ehp ENVIRONMENTAL HEALTH PERSPECTIVES OPEN ACCESS

The Risk of West Nile Virus Infection Is Associated with Combined Sewer Overflow Streams in Urban Atlanta, Georgia, USA

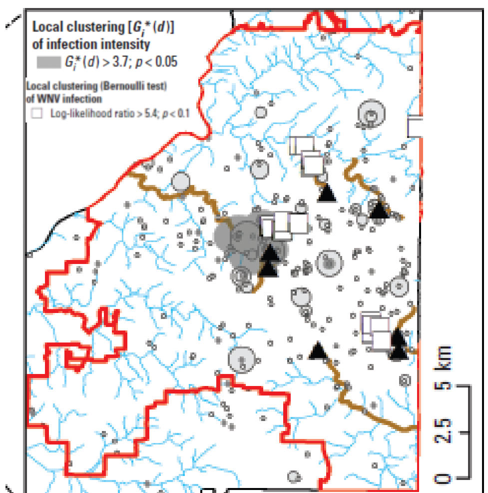
Gonzalo M. Vazquez-Prokopec,[1] Jodi L. Vanden Eng,[2] Rosmarie Kelly,[3] Daniel G. Mead,[4] Priti Kolhe,[5] James Howgate,[5] Uriel Kitron,[1,6] and Thomas R. Burkot[2]

[1]Emory University, Atlanta, Georgia, USA; [2]Centers for Disease Control and Prevention, Atlanta, Georgia, USA; [3]Georgia Division of Public Health, Atlanta, Georgia, USA; [4]University of Georgia, Athens, Georgia, USA; [5]Fulton County Department of Health and Wellness, Atlanta, Georgia, USA; [6]Fogarty International Center, National Institutes of Health, Bethesda, Maryland, USA

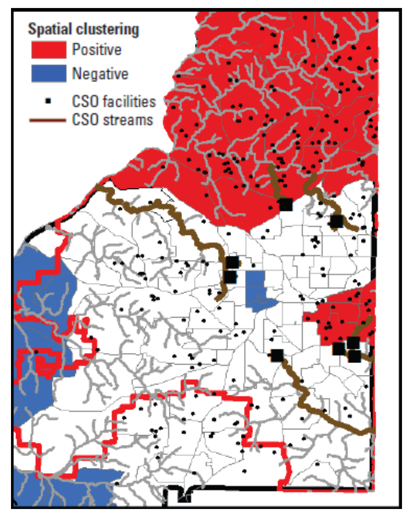
Cx. quinquefasciatus **abundance**



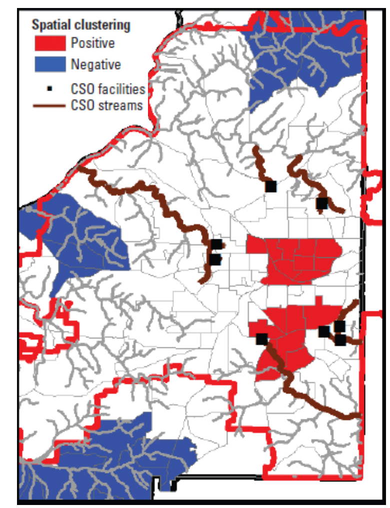
WNV infection in ***Cx. quinquefasciatus***



WNV infection in dead corvids

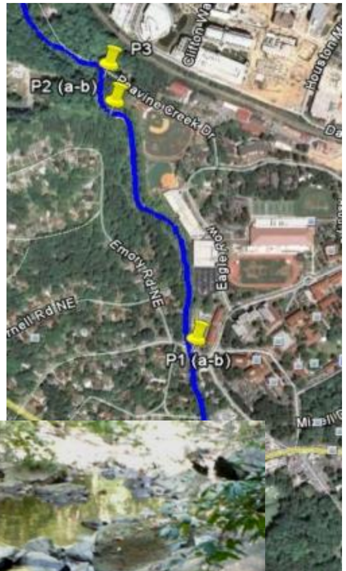


WNV infection in humans



WNV infection in mosquitoes, birds and humans clustered in close proximity to CSO streams.

Role of CSOs in mosquito ecology and population dynamics.

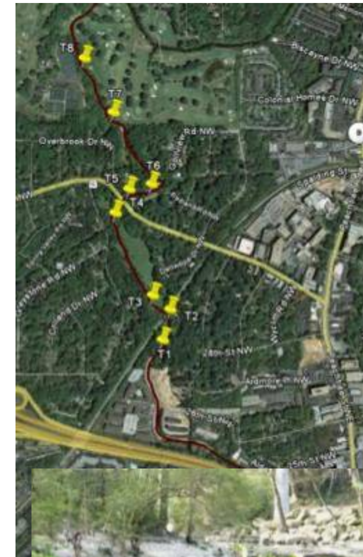


Peavine creek
Non-CSO

Observational, laboratory, and semi-natural experiments

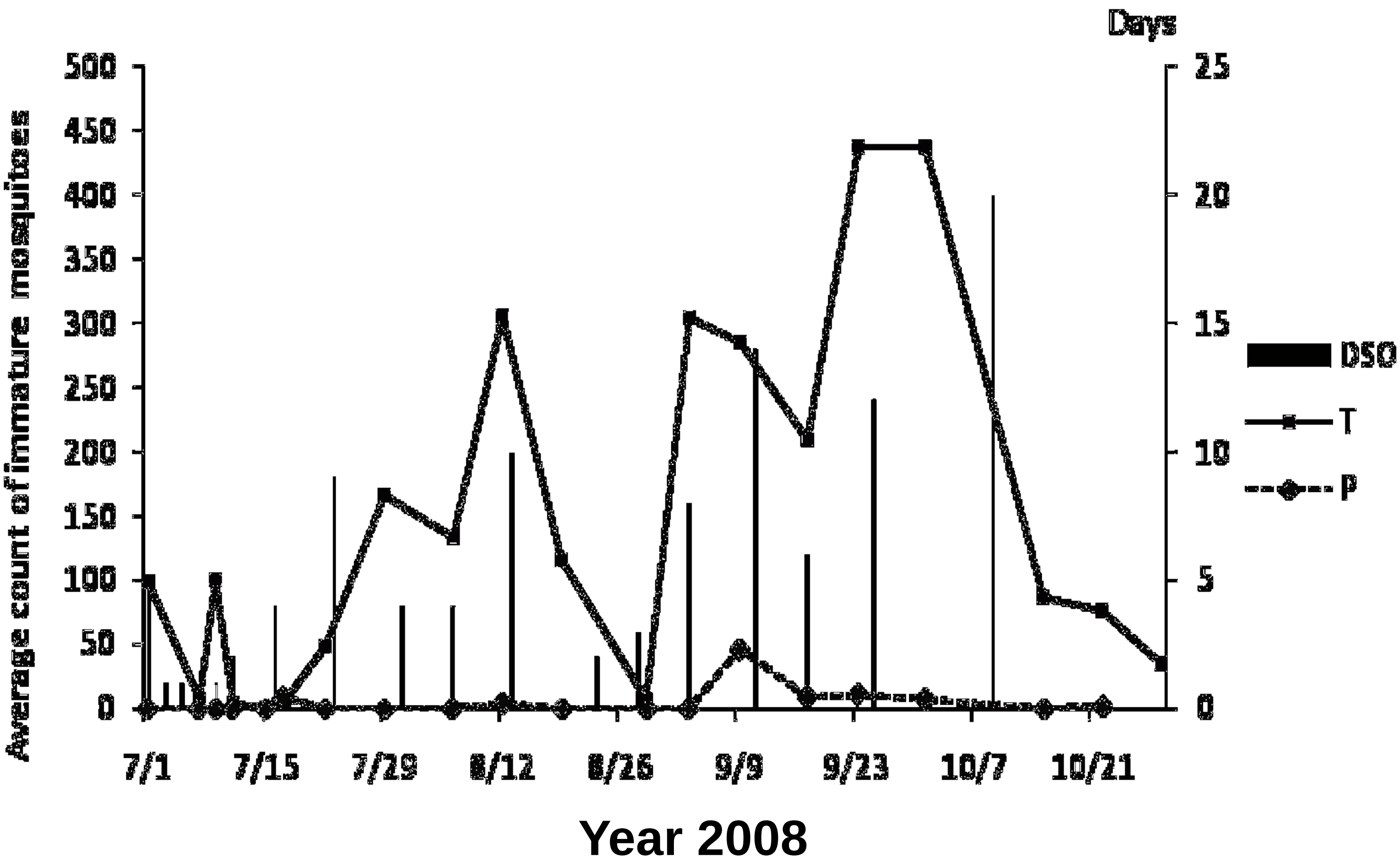
Oviposition preference
Fitness and behavior
Density dependence

CDC insectary



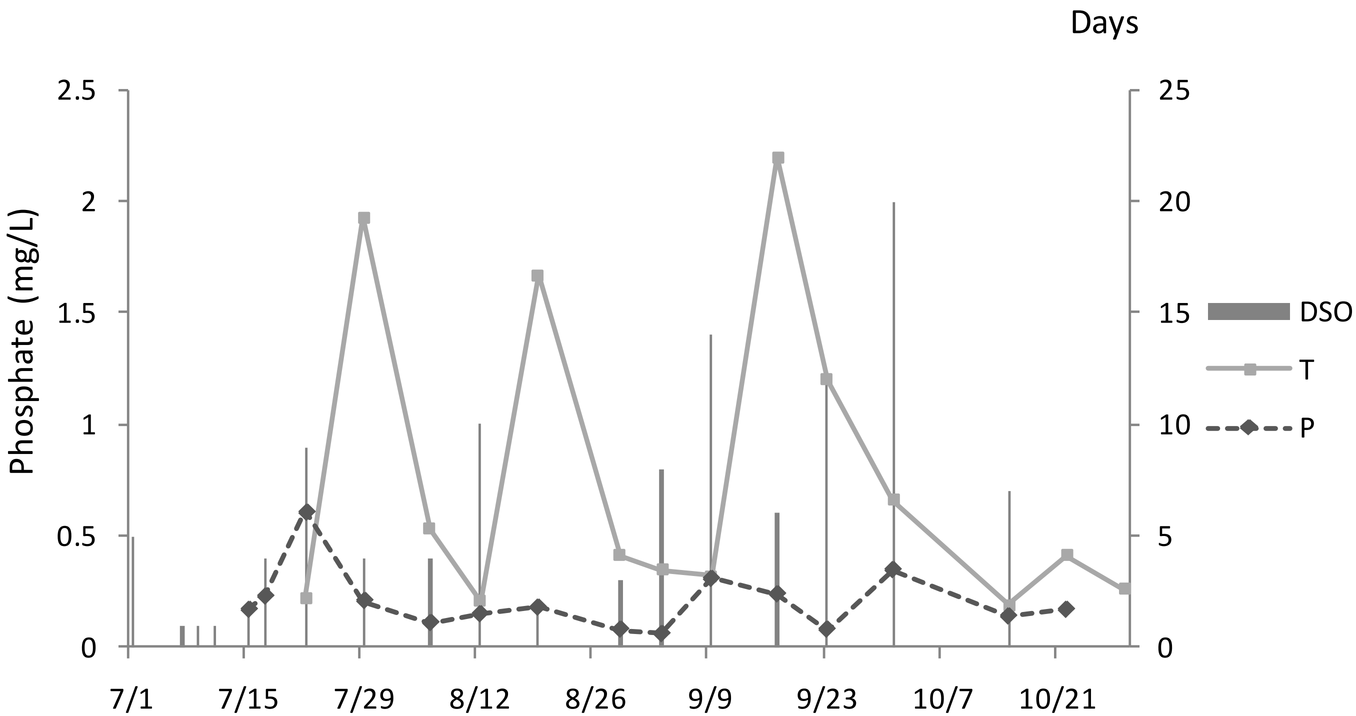
Tanyard creek
CSO

Monitoring CSO (T) and non-CSO (P) streams



Lund et al. submitted

Water quality and vector productivity



↑ ***Cx quinquefasciatus***

↑ **Ammonia and Phosphate**

↓ **Dissolved oxygen**

Lund et al. submitted

CSOs and mosquito oviposition

- Experimental work in semi-natural conditions

Combined Sewage Overflow Enhances Oviposition of *Culex quinquefasciatus* (Diptera: Culicidae) in Urban Areas

LUIS FERNANDO CHAVES,[1] CAROLYN L. KEOGH, GONZALO M. VAZQUEZ-PROKOPEC, AND URIEL D. KITRON

Combined sewage overflow accelerates immature development and increases body size in the urban mosquito *Culex quinquefasciatus*

L. F. Chaves[1], C. L. Keogh[2], A. M. Nguyen[3], G. M. Decker[1], G. M. Vazquez-Prokopec[1] & U. D. Kitron[1,4]

Weather variability impacts on oviposition dynamics of the southern house mosquito at intermediate time scales

L.F. Chaves* and U.D. Kitron

Tap	Tap	Tap	Tap	Tap +
CSO	CSO +	CSO +	CSO +	CSO +

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Absence of competent reservoir hosts?

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Different viruses?

Low human exposure?

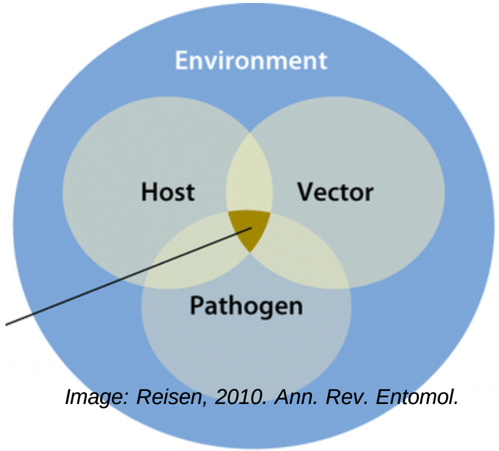
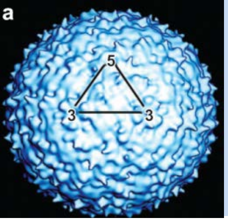


Image: Reisen, 2010. Ann. Rev. Entomol.

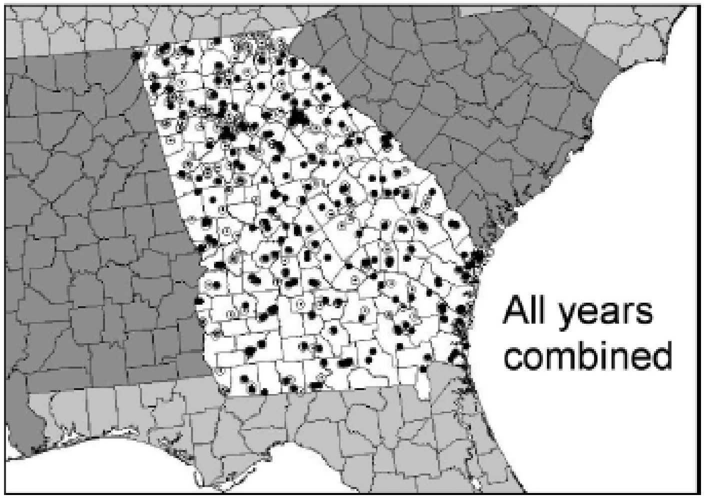


Enzootic Transmission

Infection in birds

- 2001-2007 dead bird surveillance: 1,884 (+) **/** 7,396 tested (25%). Most (89%) infected dead birds were crows and blue Jays.

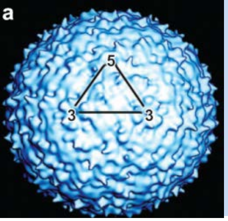
- Northern cardinals, rock pigeons and ground doves seem to play a significant role in virus amplification.



● WNV pos ⊙ WNV neg

	Total		
Species	n	*No. pos*	*% pos*
Rock pigeon *(Columba livia)*	847	155	18.0
Northern Cardinal *(Cardinalis cardinalis)*	3000	443	14.8
Common ground dove *(Columbina passerina)*	61	15	24.6
Gray catbird *(Dumetella carolinensis*	264	25	9.5
Northern mockingbird *(Mimus polyglottos)*	329	32	9.7
Brown thrasher *(Toxostoma rufum)*	327	12	3.7
House finch *(Carpodacus mexicanus*	979	19	1.9
House sparrow *(Passer domesticus)*	1057	18	1.7
Tufted titmouse *(Baeolophus bicolor)*	489	3	0.6
Canada goose *(Branta Canadensis)*	2609	8	0.3
All species tested ($n = 83$)[a]	14077	868	6.2

Source: Gibbs et al. 2006



Enzootic Transmission

Monitoring residential and recreational areas in Atlanta, GA (work led by Rebecca Levine)

Performing comprehensive avian sampling, serology and virus isolation (at UGA)

Mist-netting

Blood sampling

Limited Spillover to Humans from West Nile Virus Viremic Birds in Atlanta, Georgia

VECTOR-BORNE AND ZOONOTIC DISEASES
Volume 13, Number 11, 2013

Rebecca S. Levine,[1] Daniel G. Mead,[2] and Uriel D. Kitron[1]

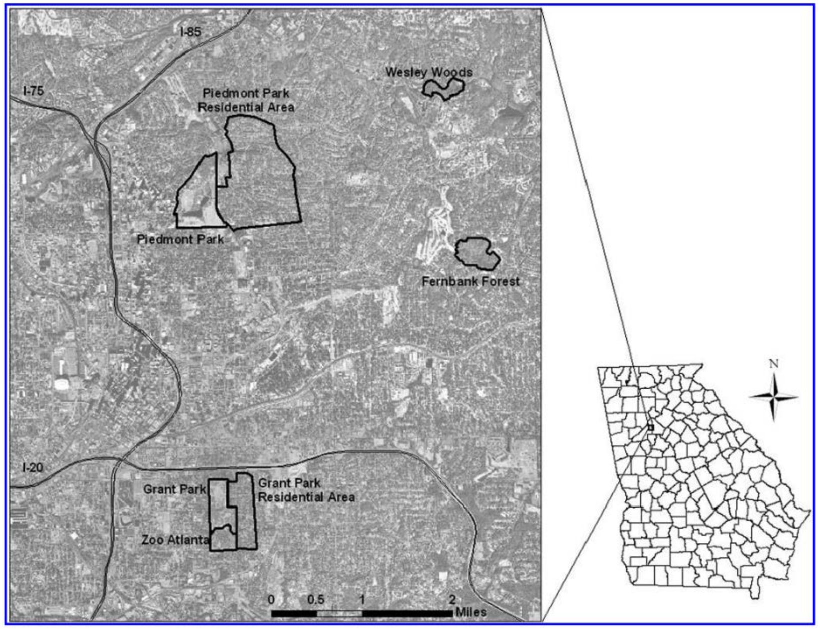


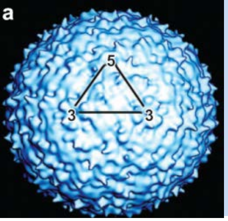
Table 1. Avian Species and the Number of Unique Individuals Sampled in Urban Atlanta, GA, 2010–2012

Species common name	*Species name*	*Number of samples*
Northern Cardinal	*Cardinalis cardinalis*	156
American Robin	*Turdus migratorius*	131
Carolina Wren	*Thryothorus ludovicianus*	47
Northern Mockingbird	*Mimus polyglottos*	44
Brown Thrasher	*Toxostoma rufum*	41
Gray Catbird	*Dumetella carolinensis*	37
European Starling	*Sturnus vulgaris*	26
Swainson's Thrush	*Catharus ustulatus*	17
Common Grackle	*Quiscalus quiscula*	16
Blue Jay	*Cyanocitta cristata*	14
Eastern Towhee	*Pipilo erythrophthalmus*	14
Tufted Titmouse	*Baeolophus bicolor*	11
Wood Thrush	*Hylocichla mustelina*	11
Song Sparrow	*Melospiza melodia*	9
Eastern Bluebird	*Sialia sialis*	6
Gray-Cheeked Thrush	*Catharus minimus*	5
Hooded Warbler	*Setophaga citrina*	5
White-Breasted Nuthatch	*Sitta carolinensis*	5
Brown-Headed Cowbird	*Molothrus ater*	3
Eastern Phoebe	*Sayornis phoebe*	3
Great-Crested Flycatcher	*Myiarchus crinitus*	3
House Finch	*Haemorhous mexicanus*	3
Ovenbird	*Seiurus aurocapilla*	2
Red-Bellied Woodpecker	*Melanerpes carolinus*	2
White-Throated Sparrow	*Zonotrichia albicollis*	2
Yellow-Shafted Flicker	*Colaptes auratus*	2
Black-and-White Warbler	*Mniotilta varia*	1
Chestnut-Sided Warbler	*Setophaga pensylvanica*	1
Downy Woodpecker	*Picoides pubescens*	1
House Sparrow	*Passer domesticus*	1
House Wren	*Troglodytes aedon*	1
Indigo Bunting	*Passerina cyanea*	1
Kentucky Warbler	*Geothlypis formosa*	1
Magnolia Warbler	*Setophaga magnolia*	1
Mourning Dove	*Zenaida macroura*	1
Northern Waterthrush	*Parkesia noveboracensis*	1
Rose-Breasted Grosbeak	*Pheucticus ludovicianus*	1
Red-Eyed Vireo	*Vireo olivaceus*	1
Red-Winged Blackbird	*Agelaius phoeniceus*	1
Veery	*Catharus fuscescens*	1
Yellow-Bellied Sapsucker	*Sphyrapicus varius*	1
Total		630

Table 2. West Nile Virus Viremia Titers in Wild Passerines Sampled in Atlanta, GA, 2010–2012

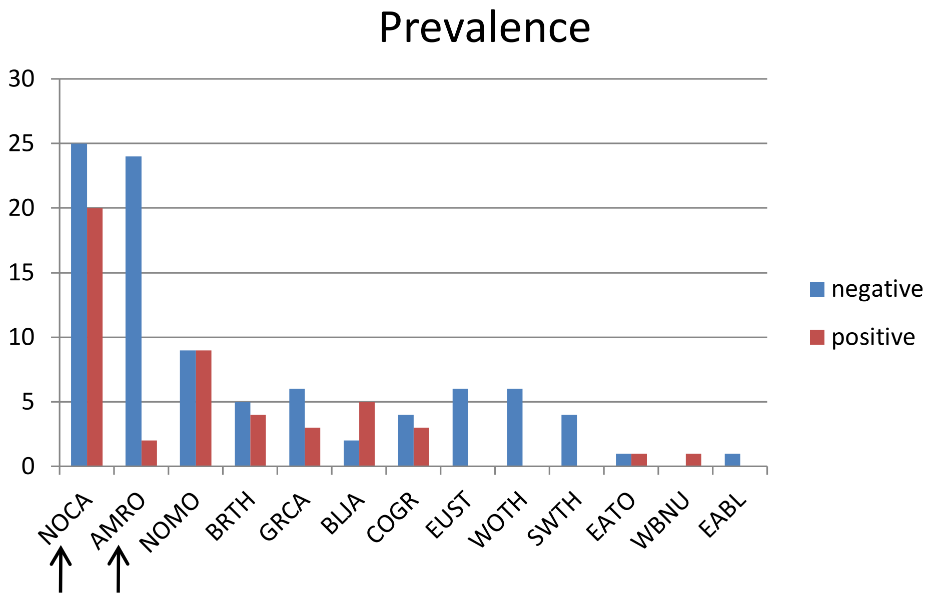
Species common name	*Species name*	*Age*	*Location captured*	*Sample year*	*Sample month and day*	*Virus titer (log_{10} pfu/mL)*
Northern Cardinal	*Cardinalis cardinalis*	Hatch-year	Park–Woods	2010	August 13	3.74
American Robin	*Turdus migratorius*	Hatch-year	Park–Woods	2010	September 1	Below detectable levels
Northern Cardinal	*Cardinalis cardinalis*	Hatch-year	Residential	2011	July 28	3.47
Northern Cardinal	*Cardinalis cardinalis*	Hatch-year	Zoo Atlanta	2011	August 3	1.69
Carolina Wren	*Thryothorus ludovicianus*	After Hatch-Year	Zoo Atlanta	2011	August 3	4.69
Northern Cardinal	*Cardinalis cardinalis*	Hatch-year	Park–Water	2011	August 9	3.87

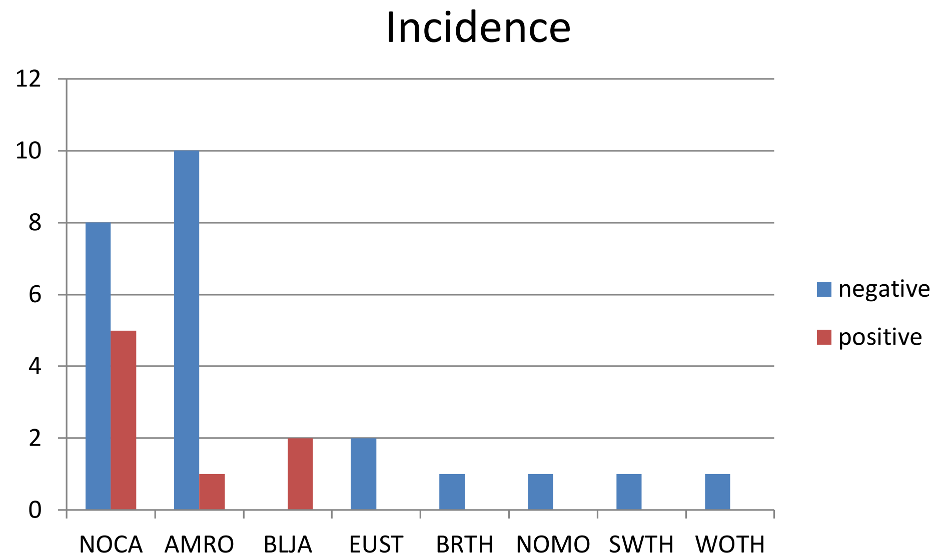
pfu, plaque-forming units.

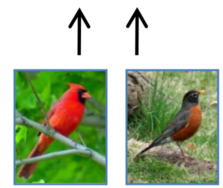


Enzootic Transmission

- 48 out of 141 samples WNV seropositive (34%)







Levine et al. VBZD 2013

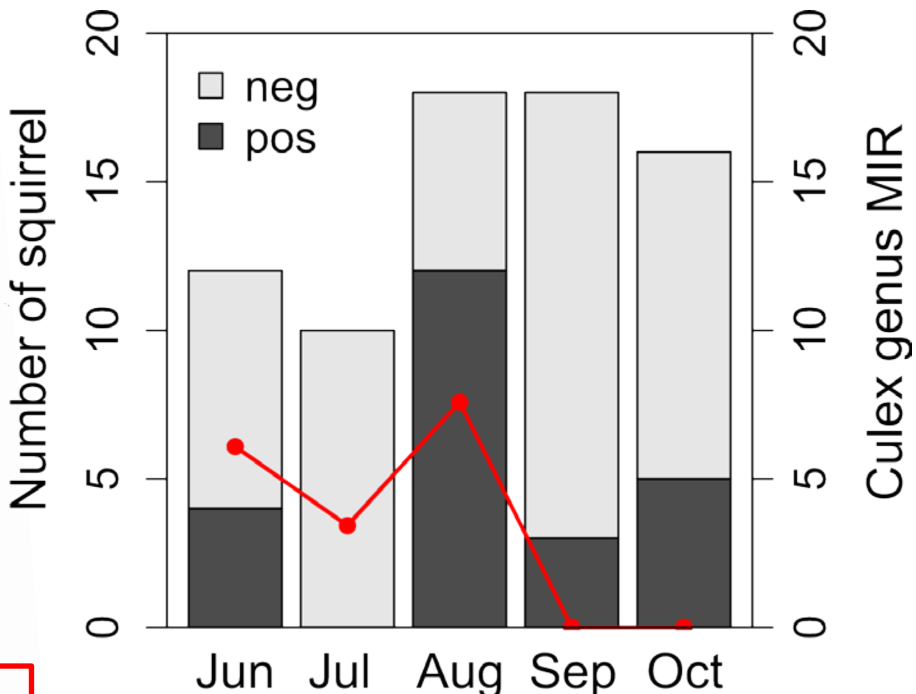
2011 followed a similar trend

Northern Cardinal: a competent reservoir host in the SE

Other contributors to virus amplification

- Work led by Donal Bisanzio (DVM,PhD).
- Work done in Grant Park. Bi-weekly squirrel sampling

Site	Tested pool of *Culex* genus N pools (N mosquitoes)	MIR (N positive pools) [95% CI]	Captured Squirrel (Density/ha)	Seroprevalemce % (N positive) [95% CI]
Site A	17 (102)	9.8 (1) [0.2; 53.4]	11 (22.0)	45.5% (5) [16.8- 76.6%]
Site_B	40 (558)	7.1 (4) [1.9; 18.2]	10 (16.5)	30.0% (3) [6.7- 65.2%]
Site_C	26 (243)	4.1 (1) [0.1; 22.7]	9 (20.6)	33.3% (3) [7.4- 70.1%]
Site D	44 (561)	8.9 (5) [2.9; 20.6]	3 (14.8)	100% (3) [29.2- 100%]
Site E	31 (323)	6.1 (2) [0.7; 22.2]	3 (21.2)	33.3% (1) [0.8- 90.5%]
Site F	30 (351)	2.8 (1) [0.1; 15.7]	18 (20)	38.9% (7) [17.3- 64.3%]
Site G	120 (1850)	2.7 (5) [0.8; 6.2]	15 (19.5)	13.3% (2) [1.6- 40.4%]
All sites	308 (3988)	4.7 (19) [2.8; 7.4]	69 (18.9)	34.7% (24) [23.7- 47.2%]



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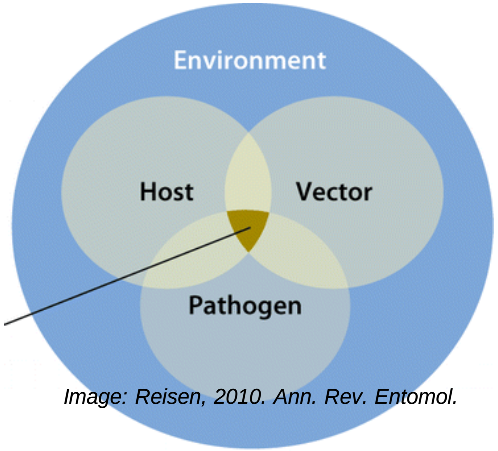
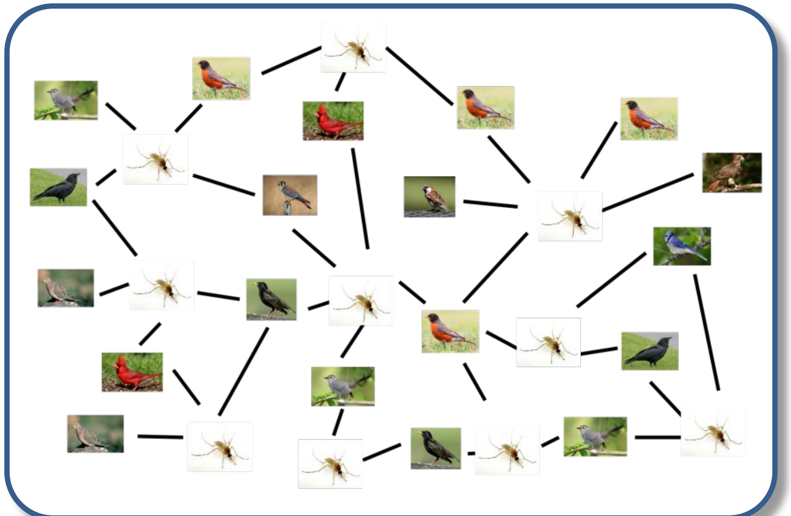
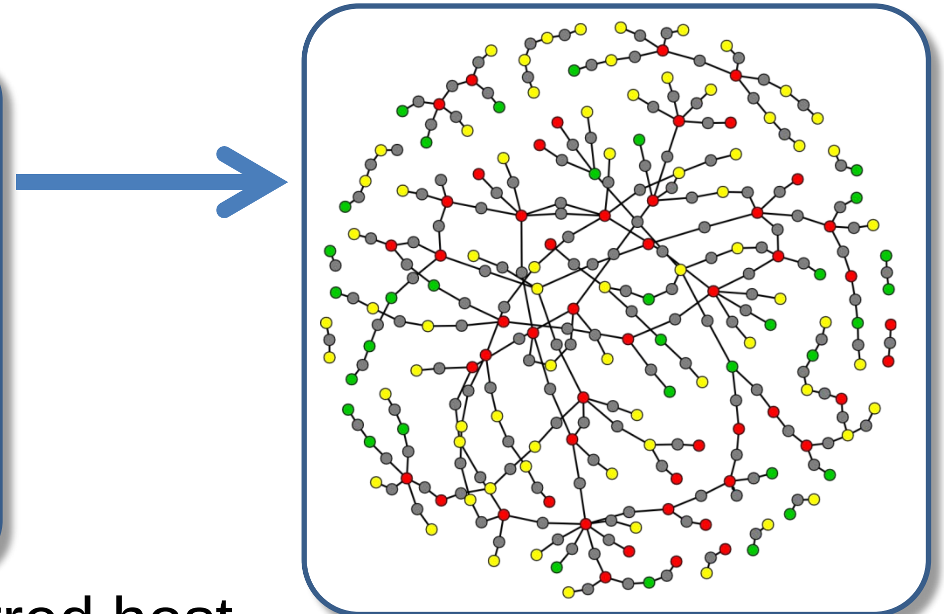


Image: Reisen, 2010. Ann. Rev. Entomol.

Bird – Mosquito Contact network

Simulation models to assess interaction between bird and mosquito communities.

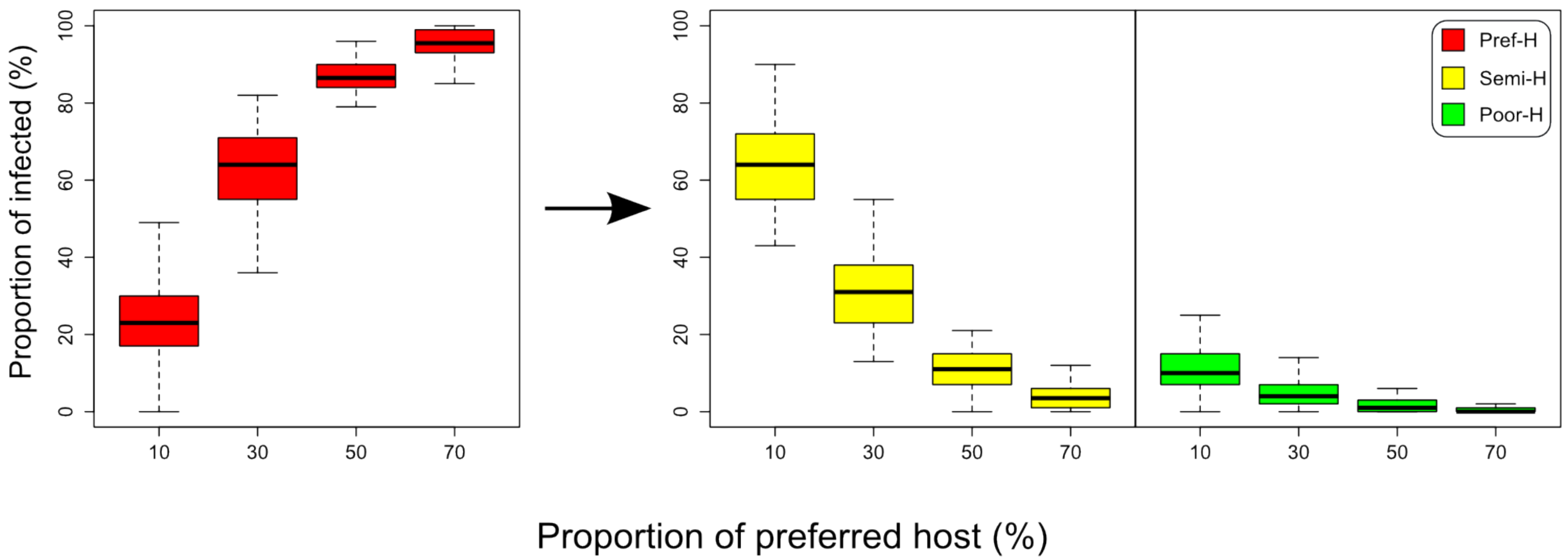




- Pref-H: highly preferred host
- Semi-H: moderately preferred host
- Poor-H: low preference host
- Mosquito

Bisanzio et al. in prep.

Bird community composition affects WNV amplification



- Increasing the proportion of Pref-H reduces the number of birds infected in the other two groups
- Bird population composition has more impact on WNV prevalence within bird groups than in the overall population

Bloodmeal ID from field-caught mosquitoes

Species	Common name	Blood meals	% of group	% of total (n=86)
Avian				
Cardinalis cardinalis	Northern Cardinal	9	24%	10%
*Chrysomus thilius**	*Blackbird*	8	22%	9%
Turdus migratorius	American Robin	8	22%	9%
Sturnus vulgaris	Common Starling	2	5%	2%
Dumetella carolinensis	Gray Catbird	1	3%	1%
Troglodytes aedon	House Wren	1	3%	1%
Baeolophus bicolor	Tufted Titmouse	1	3%	1%
Accipiter cooperii	Cooper's Hawk	1	3%	1%
Hylocichla mustelina	Wood Thrush	1	3%	1%
Carpodacus mexicanus	House Finch	1	3%	1%
Meleagris gallopavo	Wild Turkey	1	3%	1%
Poecile carolinensis	Carolina Chickadee	1	3%	1%
Gallus gallus	Chicken	1	3%	1%
Toxostoma rufum	Brown Thrasher	1	3%	1%
Total Avian		37	100%	43%
Mammalian				
Homo sapiens	Humans	32	84%	37%
Sciurus carolinensis	Eastern Gray Squirrel	1	3%	1%
Lasiurus borealis	Eastern Red Bat	1	3%	1%
Procyon lotor	Common raccoon	1	3%	1%
Odocoileus virginianus	White-tailed Deer	1	3%	1%
Didelphis virgiana	Virginia Oppossum	1	3%	1%
Canis lupus familiaris	Dog	1	3%	1%
Total Mammalian		38	100%	44%

Table 5. Mixed blood meals in mosquitoes caught in Atlanta, Georgia 2010-2011

Avian species	Mammalian species	Mosquitoes, n
Dumetella carolinensis	*Lasiurus borealis*	1
Cardinalis cardinalis	*Homo sapiens*	3
*Chrysomus thilius**	*Homo sapiens*	2
Meleagris gallopavo$	*Homo sapiens*	1
Turdus migratorius	*Homo sapiens*	1

* Sequences matched over >95% to *Chrysomus thilius* species, but it is not found in Georgia

$ The *Meleagris gallopavo* sequence was shorter than other matched sequences- 171/172 nucleotides

Cardinals represent 24% of all bird sources and humans 37% of total samples.

Evidence of human-bird mixed feeds!

Karen Wu et al. Unpublished

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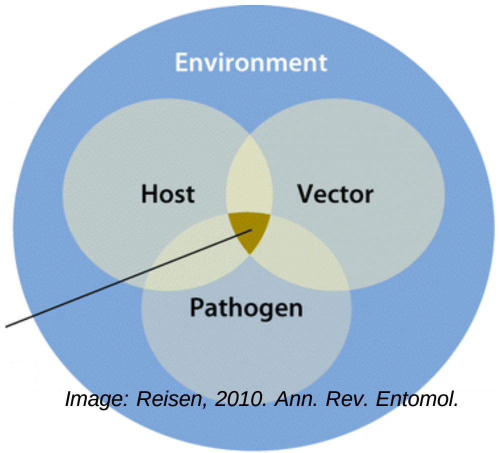


Image: Reisen, 2010. Ann. Rev. Entomol.

Some thoughts

Low spill-over in GA not associated with low virus amplification or availability of competent hosts.

All data indicates more virus spill-over into humans should be occurring.

Is the low human infection rate confounded by low reporting (in all SE states?). How do we explain low neuro-invasive WNV?

We need to learn more about contact rates between **humans-mosquitoes** and birds-mosquitoes.

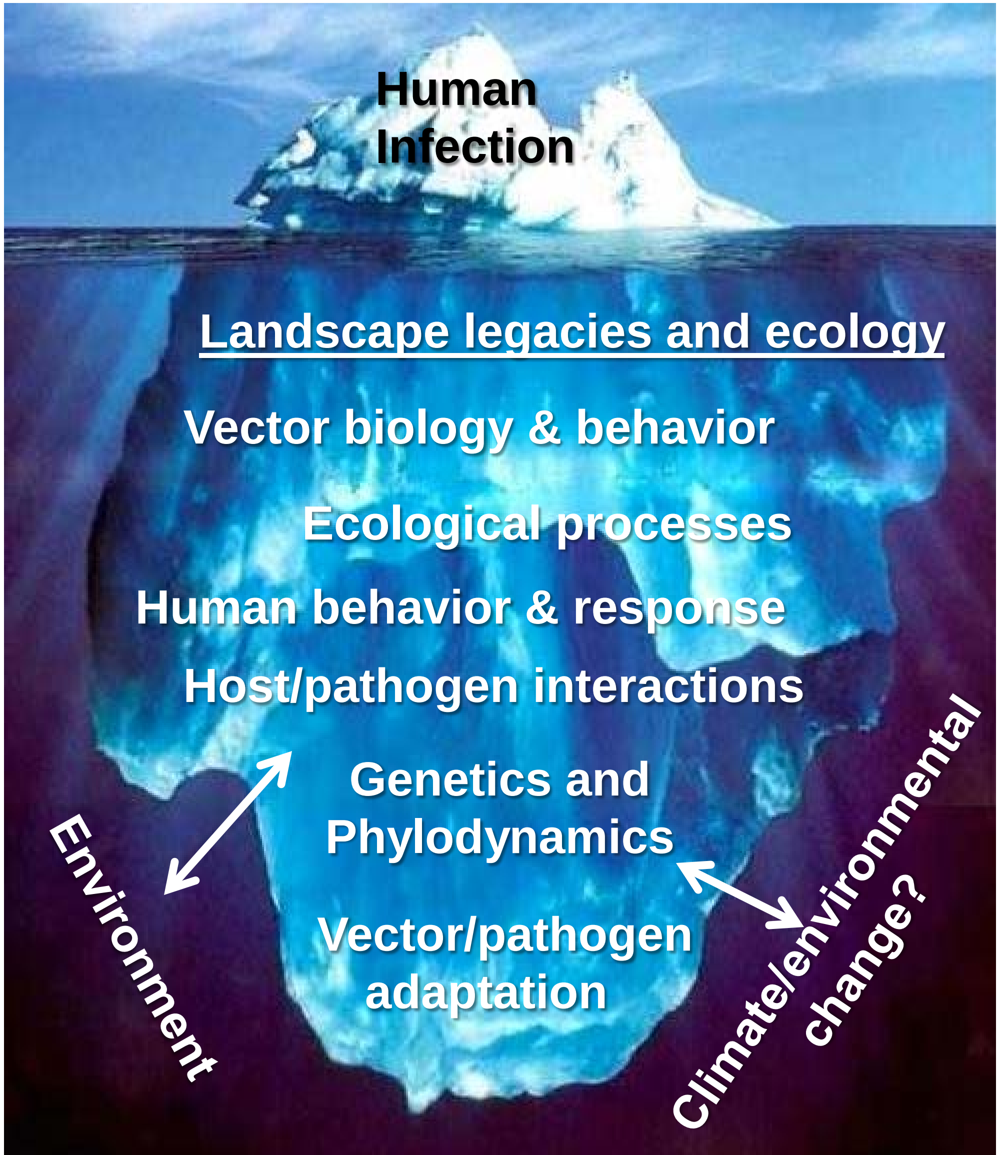
“Let me tell you the secret that has led me to my goal. My strength lies solely in my tenacity.” (Louis Pasteur)

Understanding linkages between vectors, hosts and built environment

"Much remains to be discovered about the complex biological and ecological relationships that exist among pathogens, vectors, hosts, and their environments."

"Such knowledge is essential to the development of novel and more effective interventions"

Forum on Microbial Threats – US Institute of Medicine. 2007.



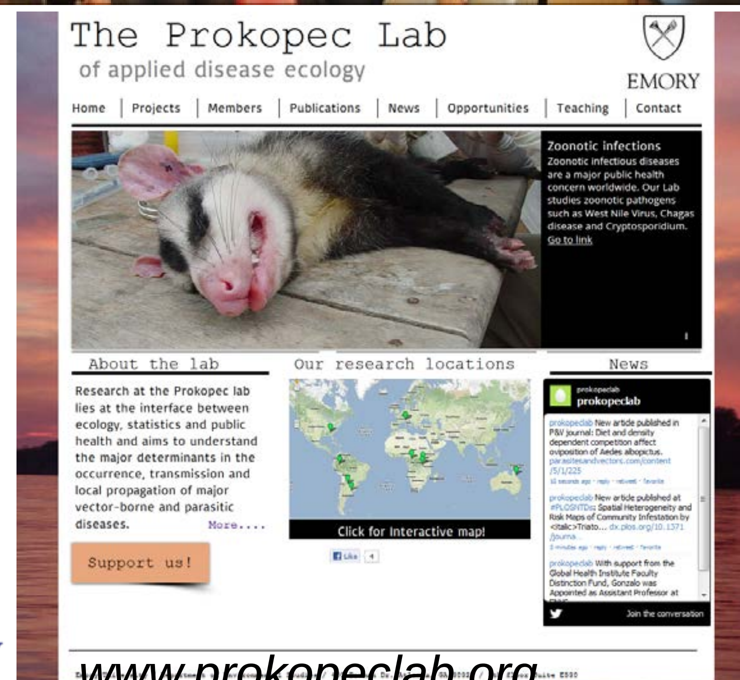
Acknowledgements

Emory students who participate in all field and lab activities.

Danny Mead for helping with sample processing at UGA.

Rosemarie for her constant support.

Emory University for continued support to undergraduate and graduate students involved in the lab.



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Questions?