Nothing Compares
NORTH CAROLINA

New Collaborations for Zika Surveillance, Risk, and Mosquito Control

May Communicable Disease Webinar

May 18, 2017

Same Time, Same Place, New Participants

Monthly Communicable Disease (CD) Webinar

- Normally joined by CD Nurses representing all 100 NC Counties, covering health topics

- For the first time, 115 NC personnel involved with mosquito education, surveillance, and control invited:

  - 37 Counties, 56 Towns, 2 Villages, 1 MC Districts

  - Several types of Departments represented:

    - ✓ Health
    - ✓ Environmental Health
    - ✓ Public Works/Services/Utilities
    - ✓ Community Code Enforcement
    - ✓ Emergency Management
    - ✓ Maintenance
    - ✓ Streets
    - ✓ Town Admin.
    - ✓ Water
    - ✓ Mosquito Control

Purpose of Combining Nurses and MC Staff

- Local Health Department and Vector Control gets to know one another - before a crisis occurs
- Zika provided the chance to review and improve disease vector management
- Modeling a new interface to provide better routine prevention, response, and Communicable Disease surveillance*

*"Surveillance" -- Human Surveillance or Mosquito Surveillance?

What is Surveillance?

*”Surveillance” -- Human Surveillance or Mosquito Surveillance?

Today's Topics

1. Introduction to the Vector-borne Disease Program within the Comm. Disease Branch Human
2. Zika Transmission Overview
3. Human Zika Surveillance Process in NC
4. Ecological context required for local mosquito-borne Zika transmission
5. Deficiencies in NC local mosquito surveillance programs
6. Deficiencies in NC local mosquito suppression programs
7. Progress NC and Univ. Partners have made in the past year to understand mosquito surveillance and response:
    - Survey of NC Mosquito Programs
    - 2016 Container-inhabiting Aedes survey
    - AA 908 program
    - Insecticide Resistance Program

Today's Topics

8. NC Capacity for Zika (and the next disease)
    - New entomologists
    - Zika Pregnancy Registry coordinator
    - University partners

9. DHHS Resources for local Health and Vector Control needs
    - Laboratory Diagnostics
    - Zika Pregnancy Registry
    - Integrated Mosquito Management

10. 2017-18 Plans

What is the DHHS Vector-borne program?

1. Human Surveillance of vector-borne disease (e.g., NCEDSS)

2. Mosquito/Tick Surveillance - data collection and reporting (e.g., CDC's ArboNet, MosquitoNet)

3. Standardization of mosquito and tick mapping and data amongst Counties and Municipalities

Who are the DHHS Vector-borne staff?

Carl Williams
State Veterinarian

Michael Doyle
State PH Entomologist

Alexis Barbarin
State Entomologist

Ronna Chan
Zika Pregnancy Registry

Autumn Locklear
Zika Screening Coordinator

Open
Vector-borne Nurse Consultant
(formerly Jodi Reber)

For our Non-Communicable Disease Partners…

What is human surveillance?

Why do we do it?

Public Health Surveillance

The ongoing, systematic collection, analysis, interpretation and dissemination of data about a health-related event for use in public health action to reduce morbidity and mortality and to improve health.

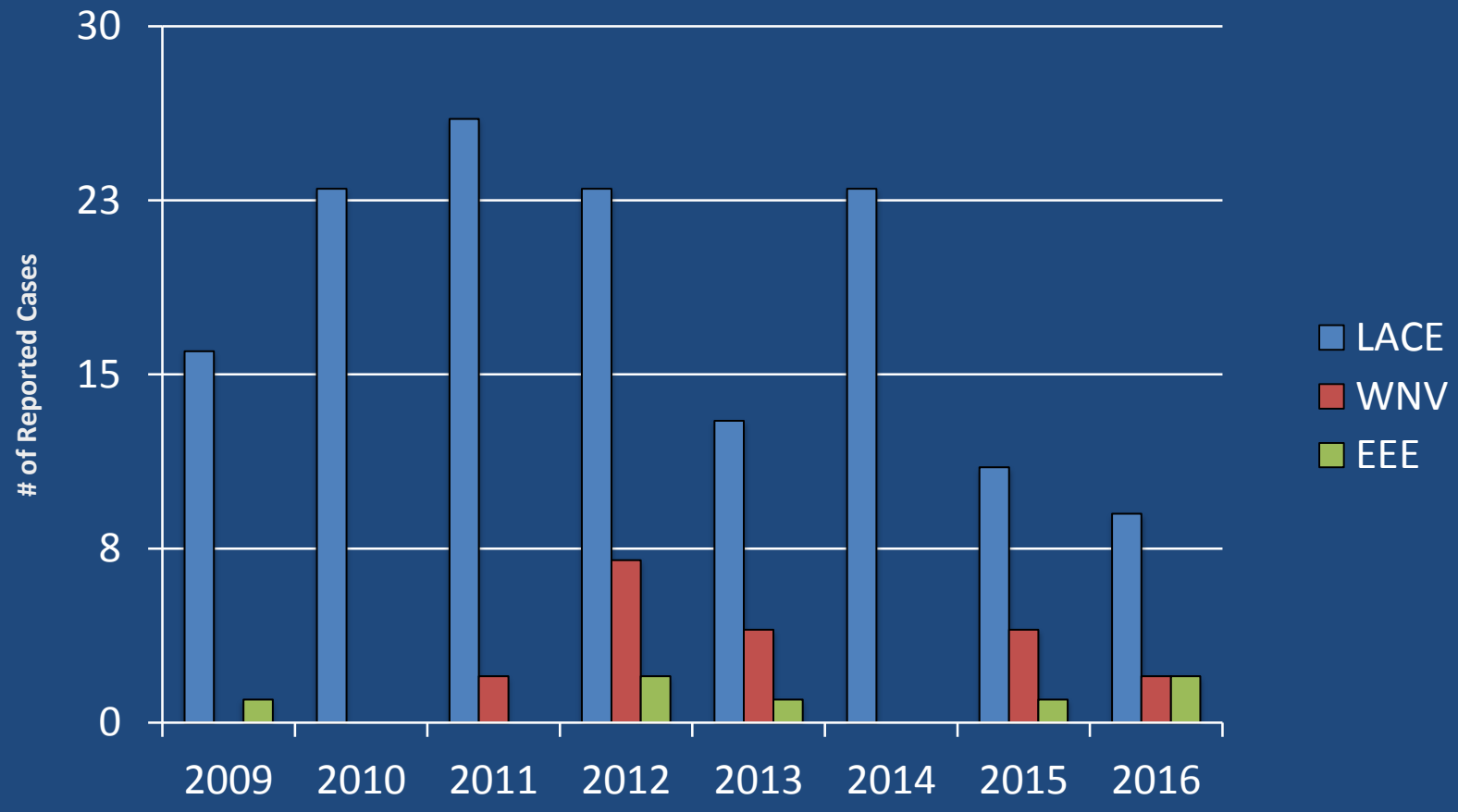
CDC. Updated guidelines for evaluating public health surveillance systems: recommendations from the guidelines working group. MMWR 2001;50(No. RR-13).

Neuroinvasive Arboviral Infections

	Reportable	1° Vector	Geography	Genus	Reservoir
La Crosse	Y*	*Aedes* spp	Western NC	Bunyavirus	Small rodents
Eastern Equine Encephalitis	Y*	*Culex* spp	Piedmont and Coastal NC	Alphavirus	Birds
West Nile	Y*	*Culex* spp	Statewide	Flavivirus	Birds
Powassan	Y* **	*Ixodes* spp	Upper Midwest & New England	Flavivirus	Small rodents
St. Louis	Y* **	*Culex* spp	Ohio-Mississippi River Basin	Flavivirus	Songbirds; blue jay, robin
Japanese Encephalitis	Y* **	*Culex* spp	Eastern Asia	Flavivirus	Pigs, wading birds

* Per 10A NCAC 41A .0101 arboviral encephalitis (neuroinvasive disease) is reportable
** Transmission not documented in NC

Confirmed and Probable Endemic Arboviral Conditions by Year Onset, NC

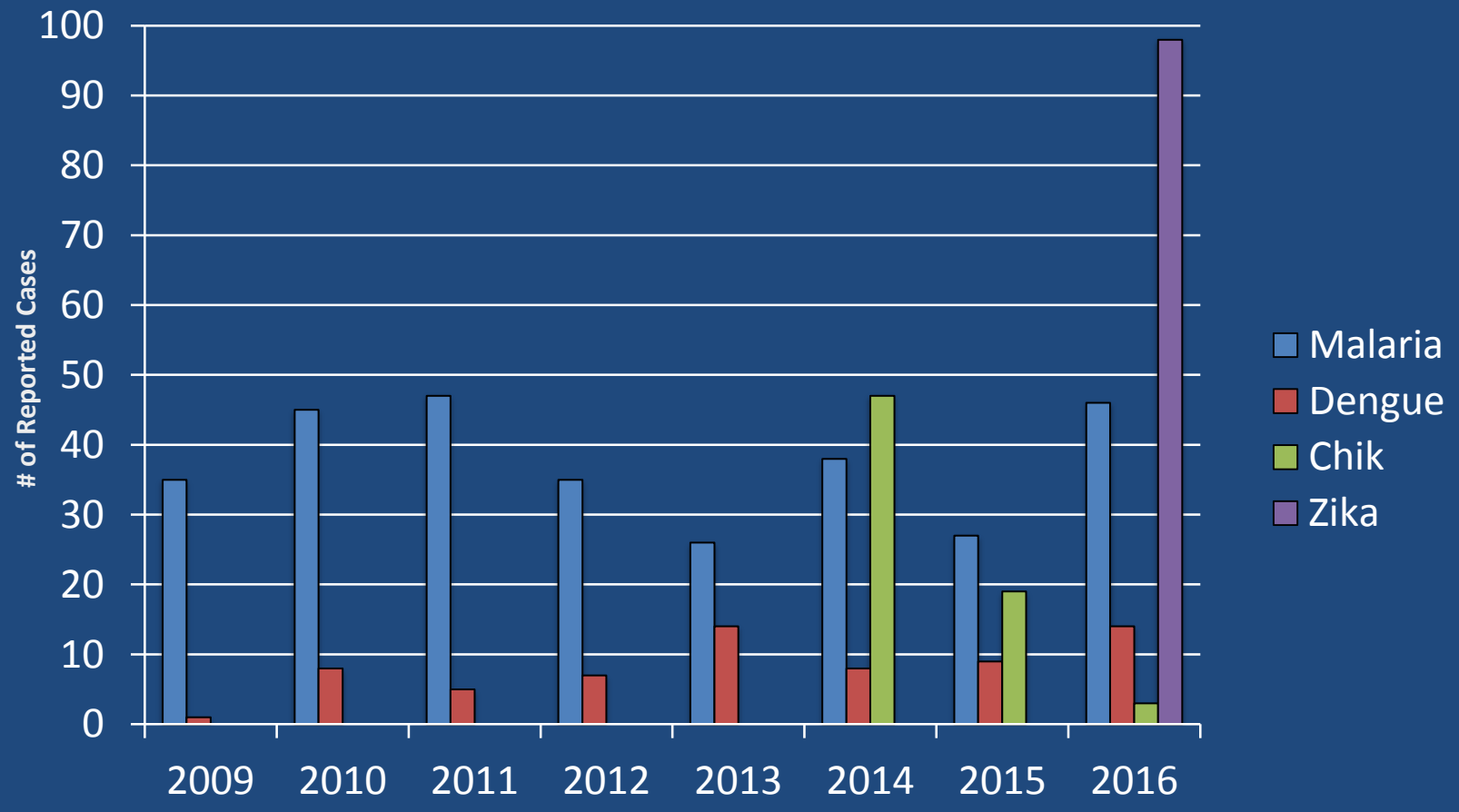


Other Mosquito Borne Infections

	Reportable	1° Vector	Geography	Genus	Reservoir
Dengue	Y* **	*Aedes* aegypti	Multiple Continents	Flavivirus	Human & NHP
Chikungunya	Y* **	*Aedes* aegypti	Multiple Continents	Alphavirus	Human & NHP
Zika	Y* **	*Aedes* aegypti	Multiple Continents	Flavivirus	Human & NHP
Yellow Fever	Y* **	*Aedes* aegypti	Multiple Continents	Flavivirus	Human & NHP
Malaria	Y* **	*Anopheles* spp	Multiple Continents	Plasmodium	Human

* Per 10A NCAC 41A .0101 each condition is individually reportable
** Transmission not documented in NC

Confirmed and Probable Travel Associated Mosquito Borne Disease Cases by Year Onset, NC



Surveillance Components

Data

- Collection
- Analysis
- Interpretation

Application

- Dissemination
- Action

"Action is what distinguishes surveillance from the task of simply monitoring events."

Surveillance Serves Public Health Function

- Supporting case detection and public health interventions
- Estimating the impact of a disease or injury
- Determining the distribution and spread of illness
- Generating hypotheses and stimulating research
- Evaluating prevention and control measures
- Facilitating planning

Teutsch SM, Churchill RE. Principles and practice of public health surveillance. 2nd ed. Oxford, New York: Oxford University Press, 2000.

Objectives of Surveillance

1. Descriptive Epidemiology of Health Problems
2. Links to Services
3. Links to Research
4. Evaluation of Interventions
5. Planning and Projections
6. Education and Policy

Rothman, K.J., Greenland, S., & Lash, T.L. (2008). Modern Epidemiology, 3rd Edition. Philadelphia, PA: Lippincott, Williams & Wilkins.

Human Zika Surveillance; Focus on Pregnant Women

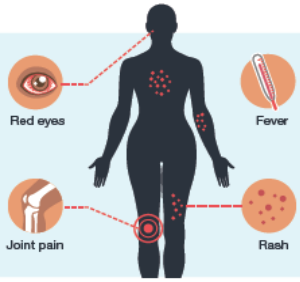
- On March 3rd the CDC released a report comparing data from birth defects surveillance programs both before and after the introduction of Zika virus into the Western Hemisphere.
  - After introduction of Zika virus, the proportion of infants and fetuses with birth defects born to mothers with laboratory evidence of possible Zika, was approximately 20 times higher than the prevalence of potentially Zika-related birth defects among pregnancies during the pre-Zika years. https://www.cdc.gov/mmwr/volumes/66/wr/mm6608a4.htm

- On April 7th the CDC released a report detailing Zika Virus–Associated Birth Defects.
  - In 2016, a total of 1,297 pregnancies with possible recent Zika virus infection were reported to the U.S. Zika Pregnancy Registry from 44 states. Additionally, approximately one in 10 pregnancies with laboratory-confirmed Zika virus infection resulted in a fetus or infant with Zika virus–associated birth defects. https://www.cdc.gov/mmwr/volumes/66/wr/mm6613e1.htm?s_cid=mm6613e1_w

CDC's Response to **Zika**

WHEN TO TEST FOR ZIKA VIRUS

As a healthcare provider, you decide if a patient should be tested for Zika virus infection. The algorithm below will help you determine whether or not to test your patient for Zika virus infection. For information on which test to use, see CDC's interim guidance.



If your patient is

- Experiencing or has recently experienced symptoms of Zika*
- An asymptomatic pregnant woman

Ask the following questions

Does the patient live in or has the patient recently traveled to an area with Zika?

- NO
- YES → **Test for Zika**

Has the patient had unprotected sex with a partner who has lived in or traveled to an area with Zika?

- NO → **Do Not Test for Zika**
- YES → **Test for Zika**

*Healthcare providers should review their local and state health jurisdiction guidelines regarding testing of patients with clinically compatible illness without known travel or sexual exposures.

CDC does not recommend Zika virus testing for asymptomatic

- Men
- Children
- Women who are not pregnant

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

CS268732A August 17, 2016

U.S. Zika Pregnancy Registry

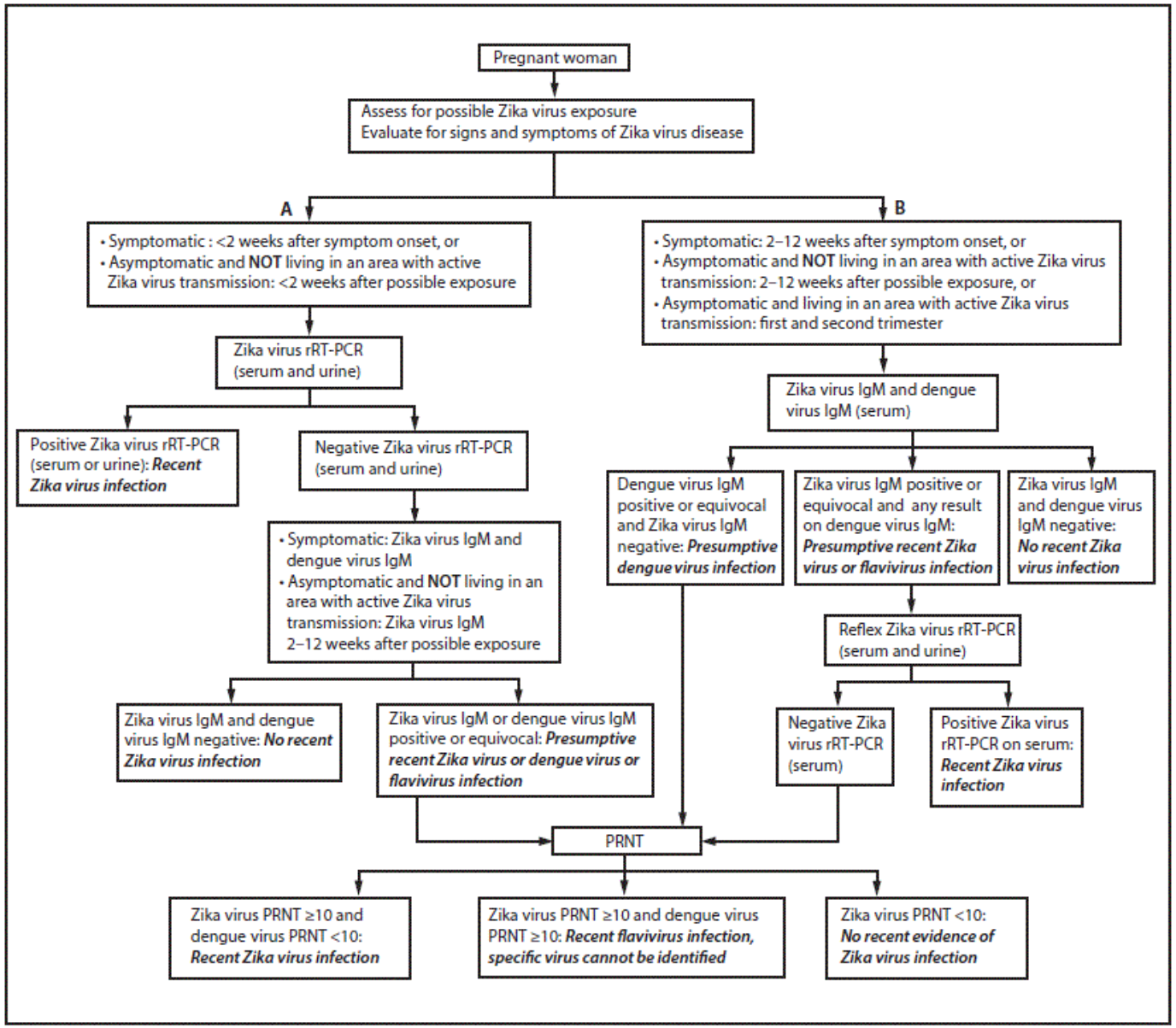
- Registry Eligible
  - Pregnant women in US with laboratory evidence of Zika virus infection
    - Positive or inconclusive
    - a/symptomatic
  - Prenatally or perinatally exposed infants born to registry-eligible women
  - Infants with laboratory evidence of congenital Zika virus infection
- Information collected from routine prenatal care and pediatric care
  - Maternal Health History
  - Neonate Assessment
  - Infant Follow-up
- Relies on effective partnership with all providers and DPH
- NC Birth Defects Monitoring Program, Early Intervention Branch notified of infant cases under investigation

Testing Pregnant Women

- MMWR
- Update: Interim Guidance for Health Care Providers Caring for Pregnant Women with Possible Zika Virus Exposure — United States, July 2016
- Weekly / July 29, 2016 / 65(29);739–744

- Slides 20 to 32 adapted from CDC Clinician Outreach and Communication Activity (COCA) call 9 Aug 16

Interim Guidance for Health Care Providers Caring for Pregnant Women with Possible Zika Virus Exposure



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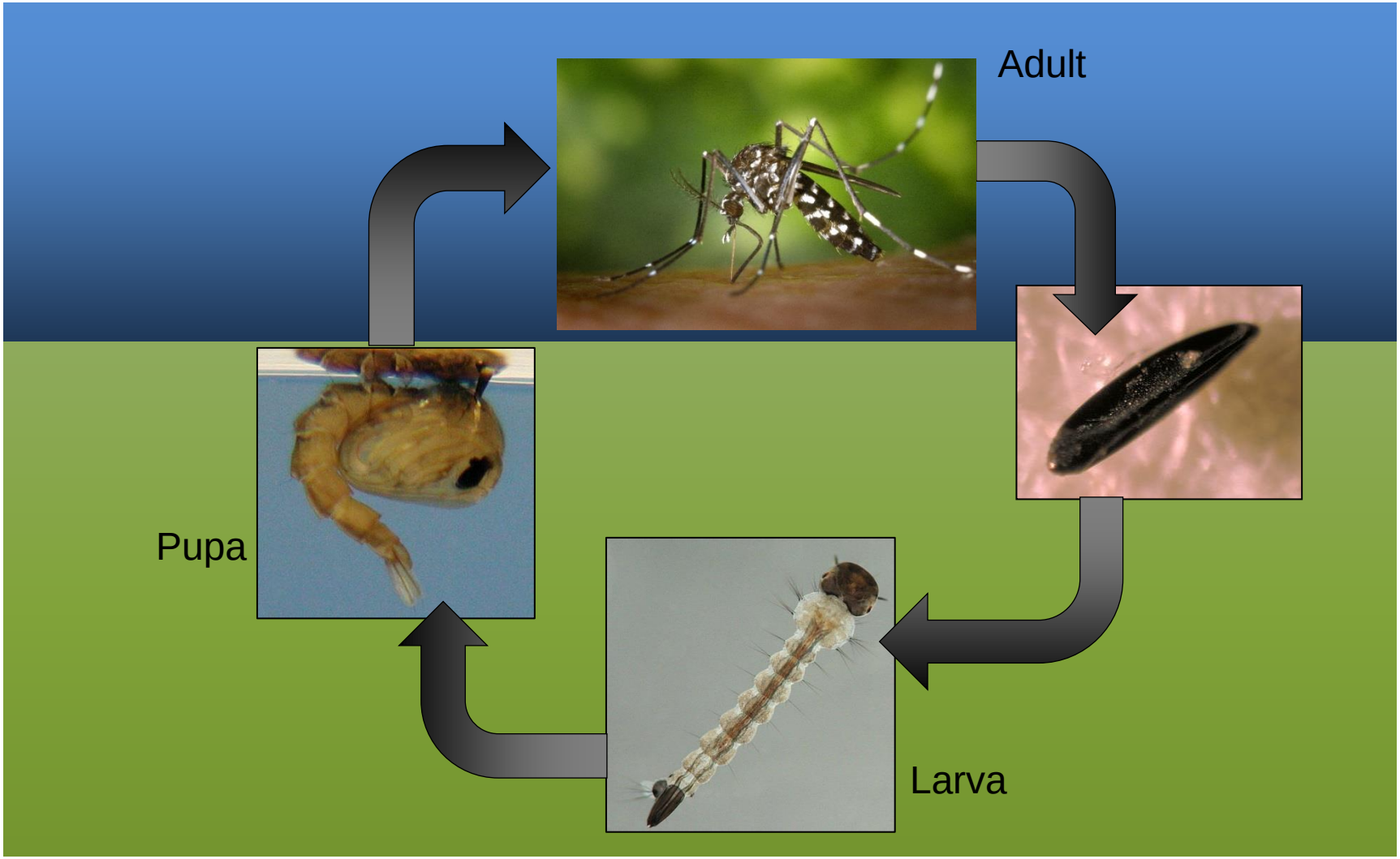
Mosquito Life Cycle



General NC Mosquito Types*

1. **Container-Inhabiting**
   - **Lay eggs on dry walls of small containers (i.e., bottle caps to rain barrels)**
   - **LaCrosse Encephalitis, Zika, Dengue, Chikungunya, Yellow Fever**
   - **Larvae grow in containers: natural (i.e., rock pools, holes in trees) and artificial (pop cans, Frito's bags, downspout drains)**
   - **Generally short flyers (feet to 100's of yards), and skittish**

2. **Floodwater**
   - **Lay eggs on dry soil, where flooding will eventually occur**
   - **Fewer diseases, but the main reason governmental mosquito control exists and continues – without them, we'd have no methods to suppress mosquitoes**
   - **Larvae grow in mostly natural areas (river bottoms, lake edges, woodland pools), but often found in man-made settings (i.e., suburban detention basins, farm fields, pastures, drainage swales)**
   - **Generally LONG distance flyers (miles), and "kamakaze" behavior**

3. **Standing Water**
   - **Lay eggs in standing water, and larvae hatch almost immediately**
   - **West Nile Virus, Eastern Equine Encephalitis (EEE)**
   - **Larvae grow in small or huge areas (tires to farm fields)**
   - **Generally medium–distance flyers (yards to a few miles)**

*These are not official taxonomic groupings, but are behavioral groupings that determine surveillance and control strategies.

Vector-borne Program Current Goals:

MOSQUITOES*

Train County personnel in:

- ❑ Adult and Egg Trapping protocols
- ❑ Mosquito preparation for testing

Provide Expertise for:

- ❑ Mosquito Program creation and improvement
- ❑ University-run mosquito ID courses in NC
- ❑ Annual County spray equipment calibration workshops (organized and run by Mosquito Product Suppliers)

Perform:

- ❑ Post-Hurricane organization (not actual Aerial Spraying)
- ❑ Evaluation of Appropriate control methods
- ❑ Standardization of mosquito surveillance data

*All recommendations per CDC/AMCA Guidelines

Like birds, all mosquito species are not the same… nor are the disease cycles

Photo credit: Dan Ripplinger

Each Disease has Particular Mosquito Species to Transmit it…

West Nile Virus (WNV)

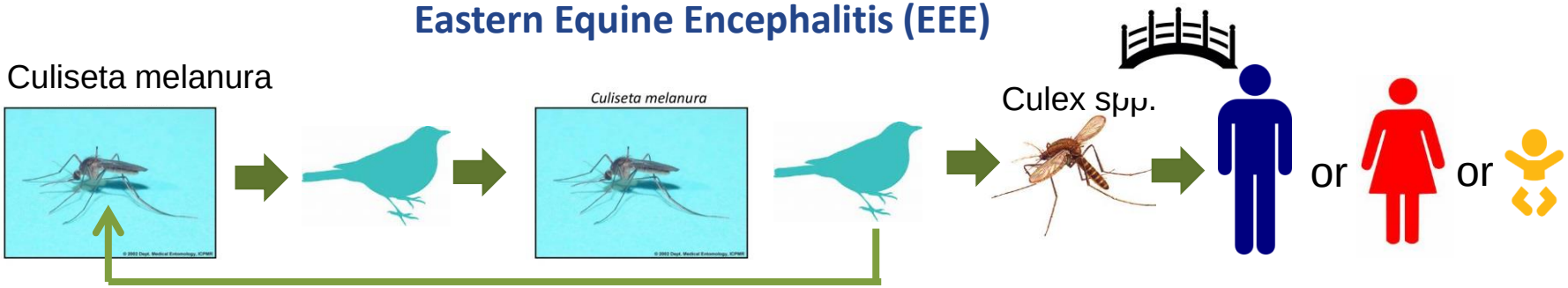
Culex spp.

LaCrosse Encephalitus (LAC)

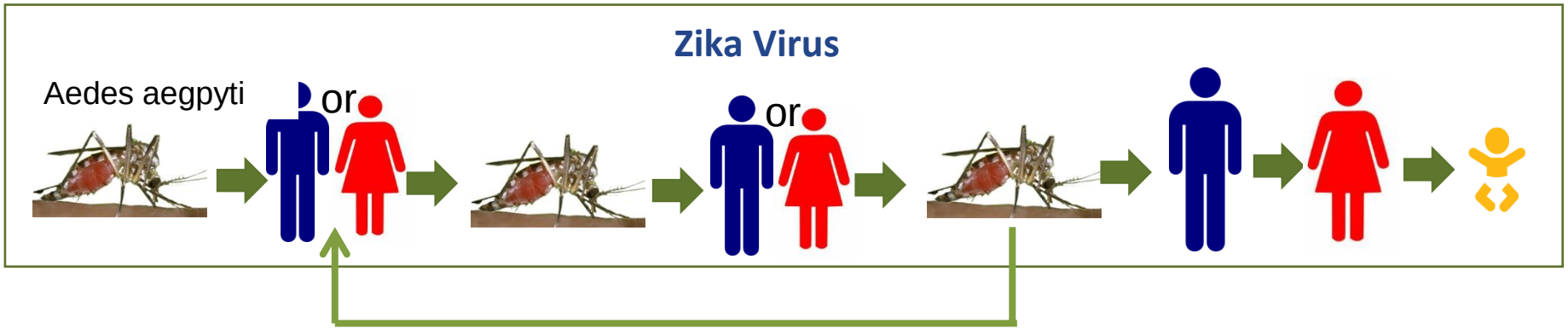
Aedes triseriatus

Eastern Equine Encephalitis (EEE)

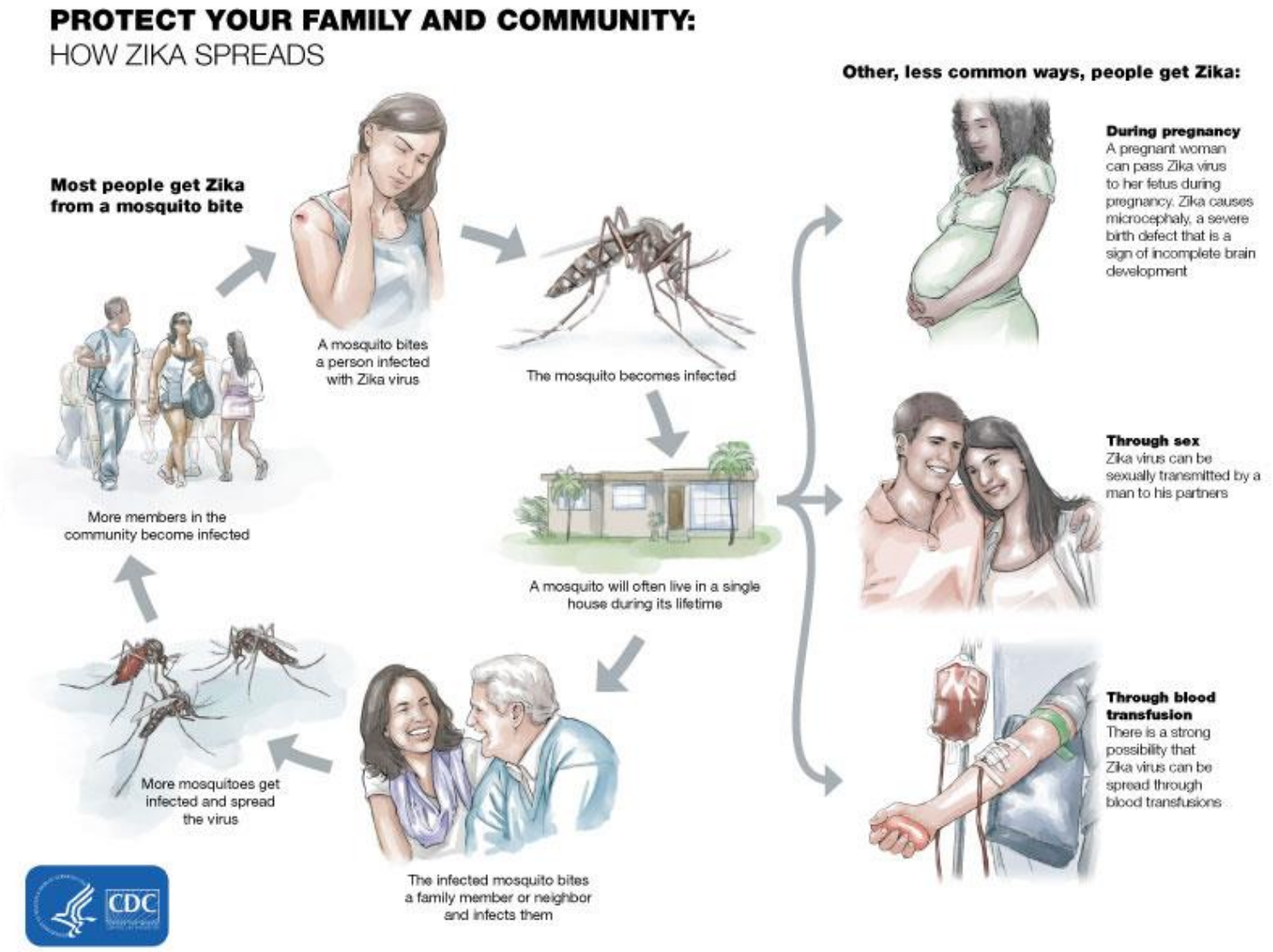
Culiseta melanura



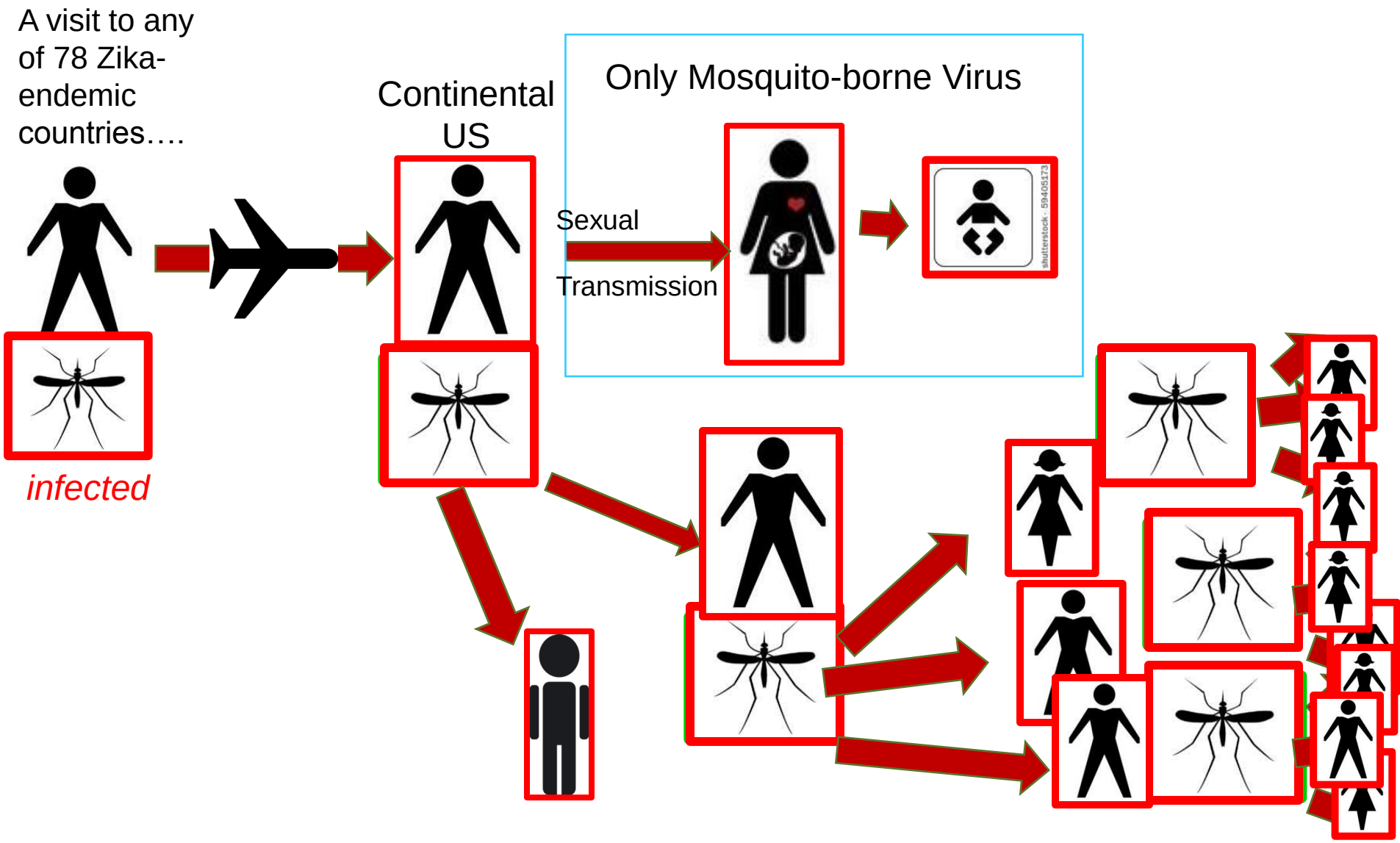
How Zika Spreads….compared to other mosquito viruses



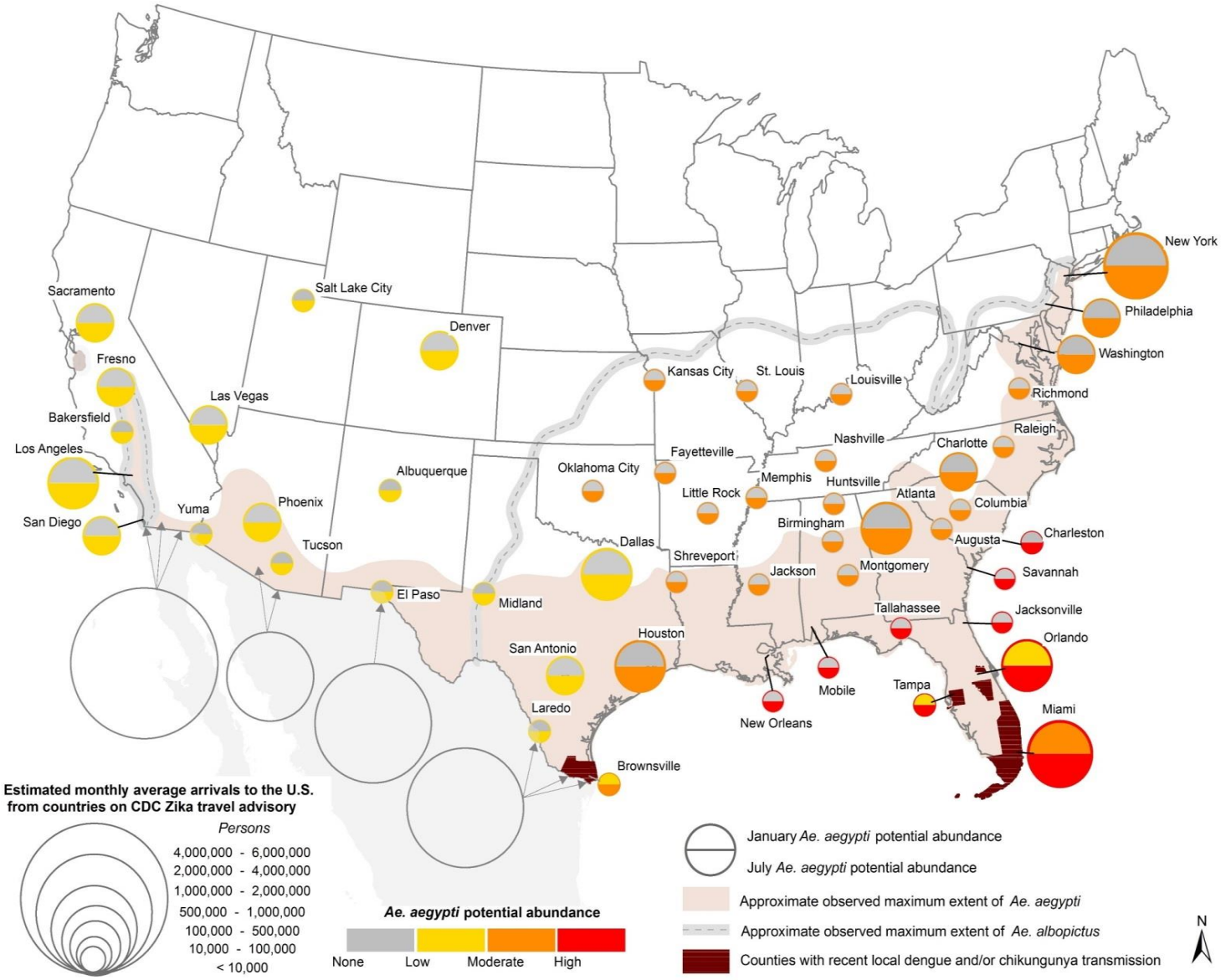
How Zika Spreads – First STD



Importation Route of Zika into US



National Risk of Zika Transmission – Spring 2016



www.cdc.gov

Ecologic Context Required for Local Zika Transmission

Mosquito-borne Transmission

1. **High number of vector mosquitoes (i.e., high temperatures and high rainfall – 3 to 4 summer months)**
2. **High number of "exposure" hours (i.e., hours humans are outside exposed to mosquitoes, or mosquitoes are inside with humans)**
3. **Infected traveler is bit in NC during the short time there is active virus in his/her blood***
4. **The infected mosquito lives long enough to grow virus within it (5+ days in warm weather), AND it bites another human**

***Sexual Transmission**

Infected male traveler spreads Zika sexually within 6 months of return

OR, less likely:

Infected female traveler spreads Zika sexually within a few weeks of return

What tools would Counties need to suppress a Zika (or Chik or Dengue) Outbreak?

Principles of Integrated Mosquito Management

THE AMERICAN MOSQUITO CONTROL ASSOCIATION

BEST PRACTICES FOR INTEGRATED MOSQUITO MANAGEMENT: A FOCUSED UPDATE

American Mosquito Control Association

January 2017

Outbreak Response (and Prevention)

Primary Goal:

Reduce contact between humans and infected mosquitoes IMMEDIATELY

- **Adulticiding**
- **Emergency Public Messaging**

Secondary Goal:

Reduce contact between humans and mosquitoes that may become infected in coming weeks

- **Larviciding**
- **Long-term Public Messaging**

Integrated Pest Management Methods

IMM uses a combination of methods to prevent and control mosquitoes that spread viruses, like Zika, dengue, and chikungunya. IMM is based on an understanding of mosquito biology, the mosquito life cycle, and the way mosquitoes spread viruses.

- https://www.cdc.gov/zika/vector/integrated_mosquito_management.html

Integrated Mosquito Management is a comprehensive mosquito prevention/control strategy that utilizes all available mosquito control methods singly or in combination to exploit the known vulnerabilities of mosquitoes in order to reduce their numbers to tolerable levels while maintaining a quality environment.

- American Mosquito Control Association 12-2-2009

1. Adult "Zika Mosquito" Surveillance Tools

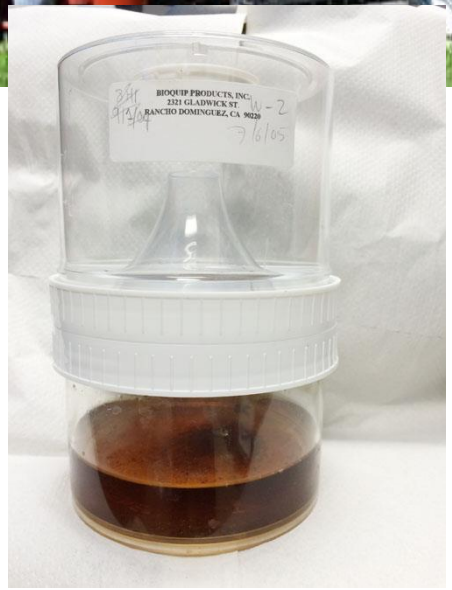
1. **CDC Light Traps? No.**
2. **Gravid Traps? No.**
3. **Landing Rate Counts? Yes and No.**
4. **Ovitraps? Yes.**
5. **BG Sentinel Traps? Yes.**
6. **BG Counters and Rotator Traps? No, but needed for pre-outbreak analysis of Ae. albopictus behavior**
7. **Dissecting Scopes and knowledge of Adult Mosquito Identification**

2. Adult Mosquito Suppression Tools

1. Truck/trailer-mounted Barrier Sprayer
2. Backpack Barrier Sprayers
3. Handheld ULV sprayer
4. Truck ULV Sprayer

3. Larval Mosquito Surveillance Tools

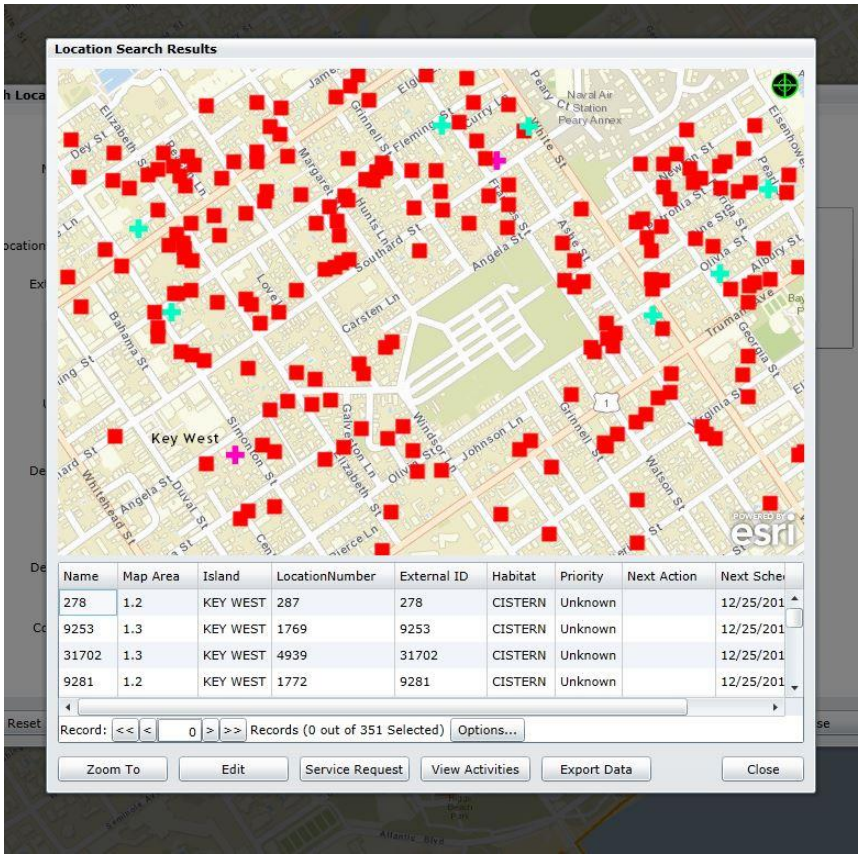
1. Dippers
2. Pipettes & Turkey Basters
3. Larval transport containers/bags
4. Emergence Containers
5. Dissecting scopes and knowledge of Larval ID



4. Database and Mapping Tools

1. **In-Field Data collection**

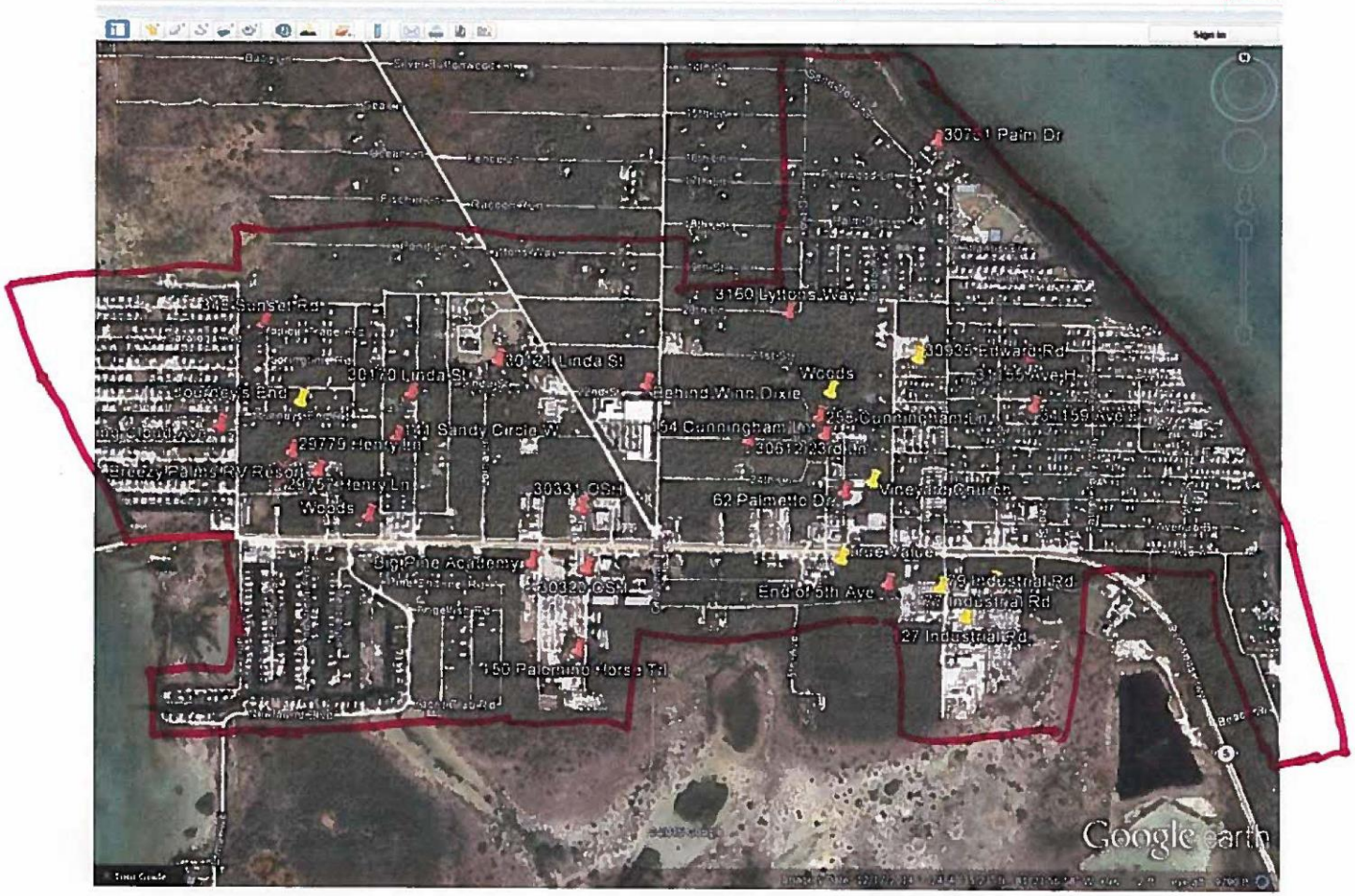
2. **Immediate mapping and printing capability**



Mapping of Storm Drains with Larvae

4. Database and Mapping Tools

12/15-18/2015 ★ Red pin = Ae. albopictus found — outside boundary of Big Pine Sweep



State of Mosquito Surveillance in NC

- **62 Counties with at least on person holding a Public Health Pesticide Applicator License**
- **17 Counties participated in Larval Mosquito Surveillance in 2016 (Container-Inhabiting Species)**
- **9 Counties with Known Adult Surveillance Activity (to date):**
  - **Currituck (by IMM Contractor)**
  - **Cabarrus**
  - **Pitt**
  - **Hyde (Ocracoke Only)**
  - **Brunswick**
  - **Beaufort**
  - **New Hanover**
  - **Onslow**
  - **Mecklenburg**
  - **Wake (developing program for 2018)**

State DHHS activities to Remedy the Deficiencies for Zika (and the next disease)

1. **2016 NCMVCA Survey of NC Mosquito Programs**

2. **Contracting with University Partners to have entomological expertise**
   - **Dr. Michael Reiskind, NC State Univ.**
   - **Dr. Stephanie Richards, East Carolina Univ.**
   - **Dr. Brian Byrd, Western Carolina Univ.**

3. **2016 Container-inhabiting Aedes survey**

4. **Insecticide Resistance Profiles for Ae. albopictus**

5. **Created positions:**
   - **Zika Pregnancy Registry**
   - **2 Entomologists (1 Mosquito, 1 Tick Specialty)**
   - **Vector-borne Nurse Consultant**

State DHHS activities to Remedy the Deficiencies for Zika (and the next disease)

6. **Emergency Vector Control Contract – Outside contractor with all of the best tools, equipment, and knowledge**

7. **AA 908 funding - 9 Counties at $27,000 in 2016-17**

8. **Ae. albopictus biology projects – to determine which chemicals, times, and dates are important for Ae. albopictus suppression**

Rotator Trap

BG Counter Trap

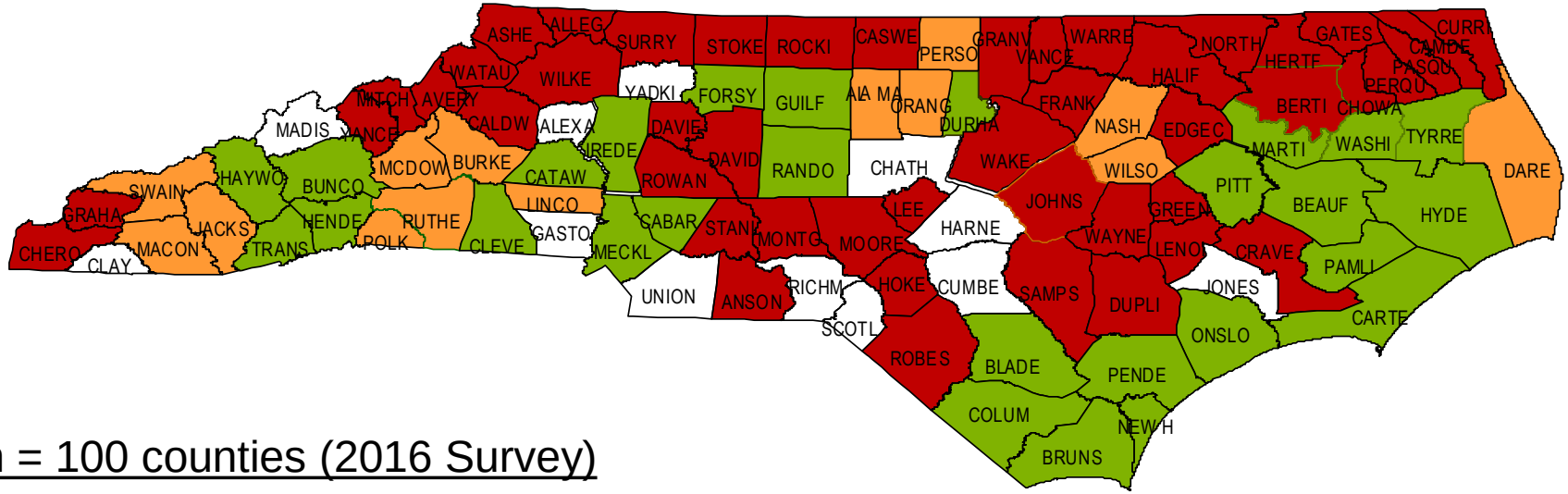
University Partners

Brian Byrd, PhD
Western Carolina University

Stephanie Richards, PhD
East Carolina University

Michael Reiskind, PhD
NC State University

State-wide Survey of Mosquito Services*



n = 100 counties (2016 Survey)

- No mosquito control programs (48%)
- Mosquito control programs (26%)
- Education only (14%)
- No response (12%)

*Survey directed by Jennifer Stewart, NC DHHS

2016 Insecticide Resistance Summary for NC Mosquitoes CDC Bottle Bioassays

Highest to lowest average (%) mortality at diagnostic time*

Purple = susceptible Orange = possible resistance Black = resistant

Ae. albopictus (N = 5 populations tested)

Permethrin	= Phenothrin	= Deltamethrin	= Etofenprox	≈ Deltamethrin	> Bifenthrin	> Malathion	≈ Malathion	> Etofenprox
(99)	(100)	(100)(10 µg/mL)	(100)(15 µg/mL)	(99)(5 µg/mL)	(97)	(92)(250µg/mL)	(89)(100µg/mL)	(33)(6µg/mL)

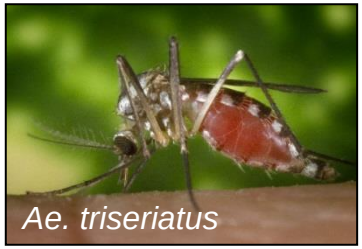
Cx. pipiens/quinquefasciatus (N = 2 populations tested)

Malathion	≈ Deltamethrin	> Deltamethrin	> Phenothrin	> Etofenprox	≈ Etofenprox	≈ Bifenthrin	> Malathion	≈ Permethrin
(75)(250µg/mL)	(73)(10 µg/mL)	(57)(5 µg/mL)	(44)	(39)(15 µg/mL)	(37)(6µg/mL)	(36)	(26)(100µg/mL)	(24)

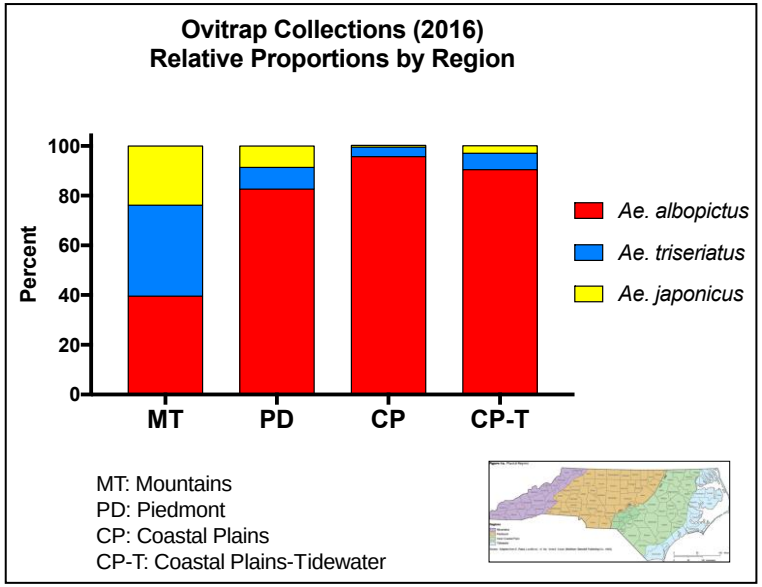
**Results in preparation for publication*

- Resistance to active ingredients was higher in *Culex* compared to *Aedes*
- Only the most effective insecticides should be used for targeted control
- Routine surveillance of insecticide resistance enhances the ability of control programs to protect public health.

2016 State-wide Survey of Container-Breeding Mosquitoes



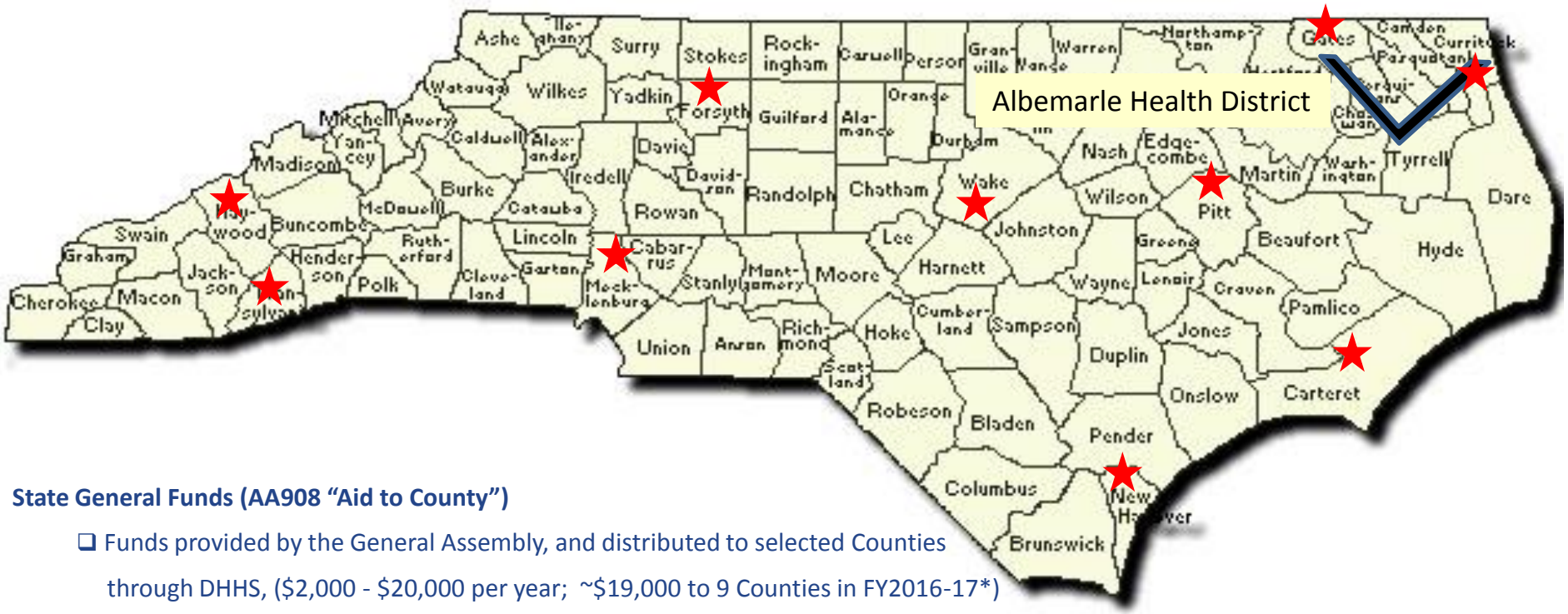
*Proportion of *Ae. hendersoni* not shown (<.1%)



- Survey conducted May-October 2016
- 18 Counties (Mountains-Coast) participated
- Universities processed egg collections (ovistrips)
- 3,609 ovistrips received (81% contained *Aedes* eggs)
- 293,701 eggs collected (66,126 reared and identified)
- Majority (99.9%) were three species (*Ae. albopictus*, *Ae. triseriatus*, and *Aedes japonicus*)

- **No *Aedes aegypti* (primary Zika vector) were identified in these efforts.**
- ***Aedes albopictus* remains a common peridomestic species throughout NC.**
- **The relative abundance of common container-inhabiting *Aedes* species vary regionally**
- ***Aedes japonicus* is more abundant in the mountains and piedmont regions of NC.**
- **The three common peridomestic *Aedes* species are of public health importance.**

2016-17 Counties Receiving AA 908 "Aid to County" Funds for Mosquito Programs



State General Funds (AA908 "Aid to County")

- ❑ Funds provided by the General Assembly, and distributed to selected Counties through DHHS, ($2,000 - $20,000 per year; ~$19,000 to 9 Counties in FY2016-17*)
- ❑ Use of funds is determined yearly by disease outlook and State Program needs
  - ❑Surveillance Equipment
  - ❑Control Tools (Spray Equipment, Mapping, Supplies)
  - ❑Data collection needs
- ❑ Available for counties to spend until May 31 each year

What are Plans for 2017?

1. Human Disease Surveillance

- ❑ NCEDSS investigation of human disease
- ❑ ArboNet reporting of arbovirus activity
- ❑ Coordinate Zika Pregnancy Registry

2. Mosquito Surveillance

- ❑ MosquitoNet – new CDC method for Counties to provide mosquito abundance and location data

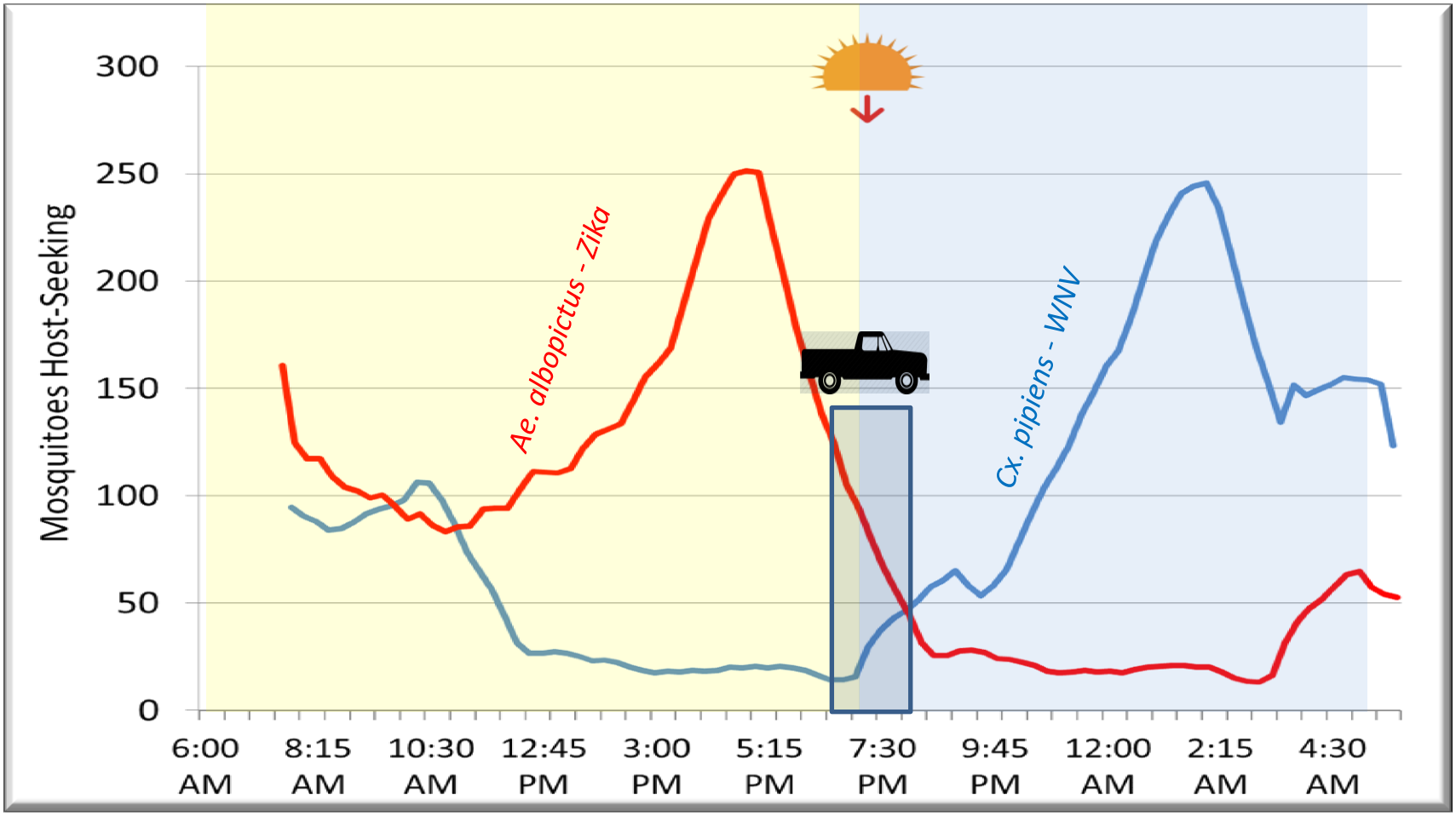
What are Plans for 2017?

3. Investigate Zika (and other) Disease Risk:

- ❑ Surveys regarding Ae. albopictus:
  - Preferred habitat (Urban/Suburban/Rural)
  - Seasonality (i.e., earliest to latest annual adult activity)
  - Daily host-seeking behavior
- ❑ Which chemicals do (or DO NOT) work against Ae. albopictus?

4. Zika Risk by NC Zip Code

Targeting Ae. albopictus correctly…



Note: Graphics above are representative only, not to be used for decision-making purposes

Support Available to County/Municipal Programs

State Entomologists (Michael Doyle and Dr. Alexis Barbarin)

- Expertise in mosquitoes, ticks, other vector arthropods
- Coordination of state-wide mosquito information
- Assistance with post-hurricane spraying
- Assistance with mosquito surveillance and control methods

State DHHS Staff

- Vectorborne Disease Nurse Consultant
- Zika Pregnancy Registry (ZPR) (Ronna Chang
- Zika Emergency Preparedness (Fred Philippe/Julie Casani)
- Media relations

University Services (Dr. Richards – ECU, Dr. Byrd – WCU, Dr. Reiskind – NCSU)

- Mosquito/Tick Identification assistance
- Evaluations of control and surveillance methodologies
- Studies of applied mosquito biology (i.e., disease risk and control improvement)
- MosquitoNet data input

NC Mosquito and Vector Association, Mosquito equipment vendors Universities

- Adult and Larval Mosquito ID Classes
- Equipment calibration

Questions?

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