Integrated Mosquito Management

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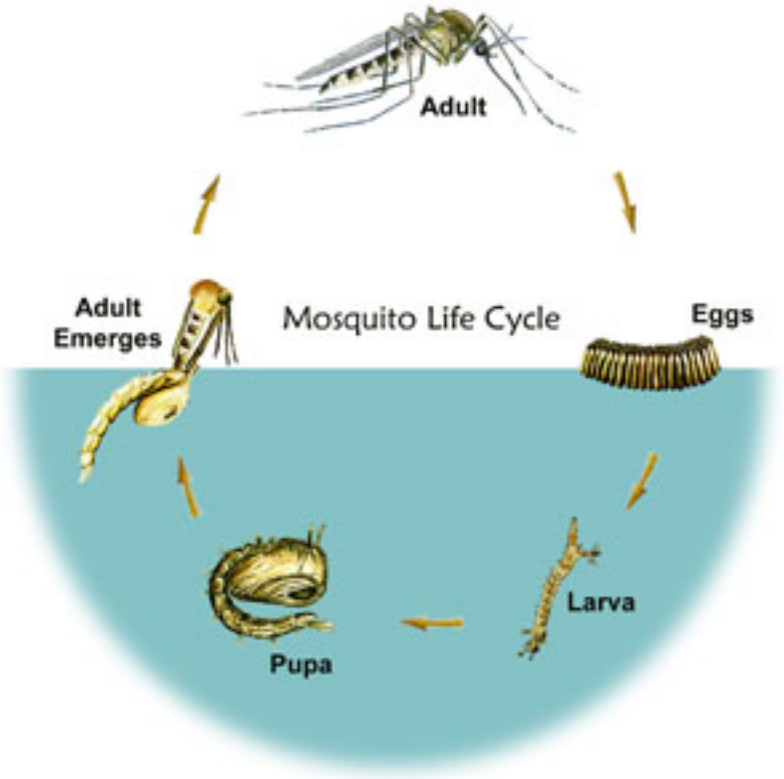
Mosquito Behavior



- Aquatic-breeders
- 4-14+ days from egg to adult
- Most important urban species breed in polluted stagnant water
- Active mostly in evenings and at night, adults rest in shady areas during the day

Mosquito Feeding

- Female (ONLY) takes a blood meal for egg development
- Vector by taking blood meal
- Life span
  - Males ~ 1 or 2 weeks
  - Females ~ up to a month

Mosquito diversity

- Two basic types
  - Floodwater mosquitoes
  - Standing water (container) breeders
    - natural sites
    - artificial sites

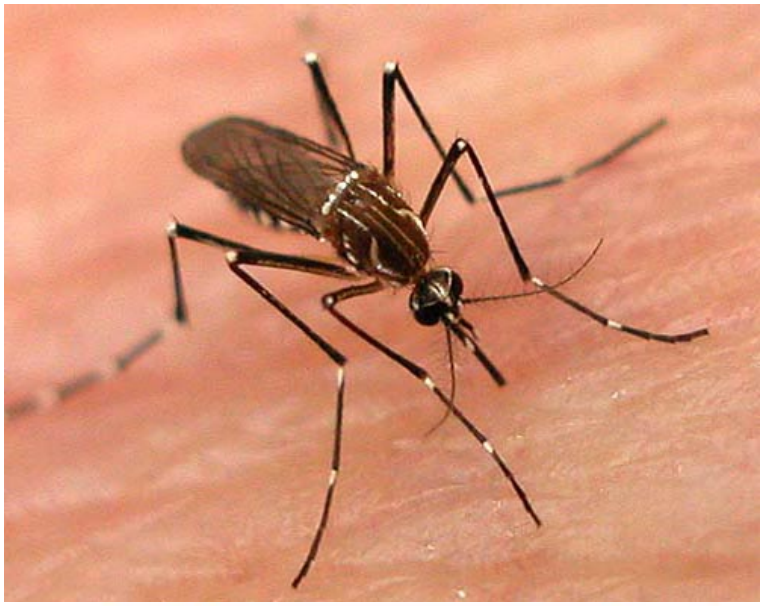
Photo: M. Merchant, Texas A&M AgriLife

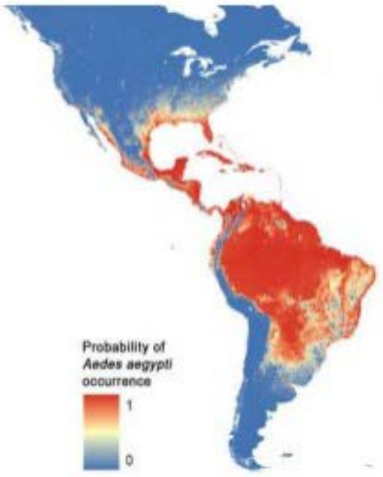
Culex quinquefasciatus
Southern house mosquito

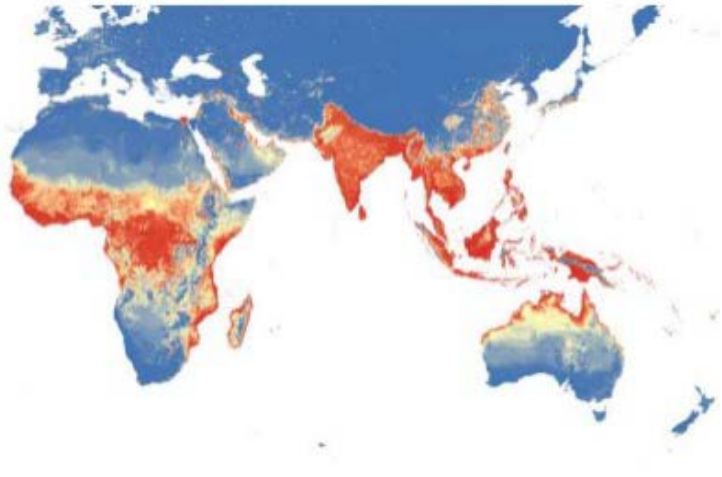
- Prefers polluted water in artificial containers or other standing water (ground water, sewer catch basins)
- Mostly feeds on birds, but thought to be principal vector of WNV to humans
- Also vectors of SLE, heartworm

Aedes aegypti
Yellow fever mosquito

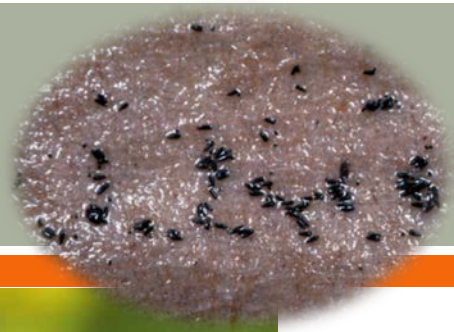
- Container breeder
- Daytime, evening biter
- Vector of yellow fever, Dengue fever, CHIK, Zika Virus
- Being replaced by tiger mosquito?



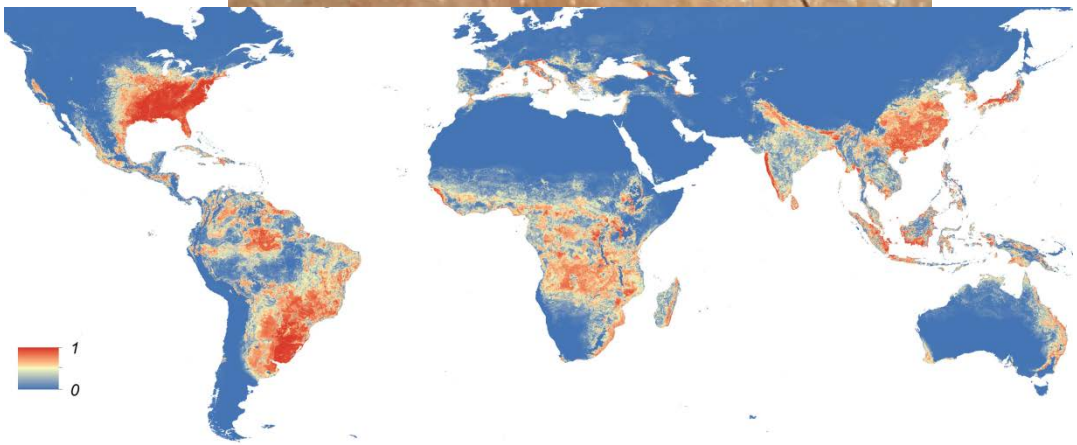




Aedes albopictus
Asian tiger mosquito



- Artificial container, treehole breeder
- Since early 1990s in eastern Texas
- Aggressive daytime biter
- Vector of CHIK, Dengue fever, Zika Virus



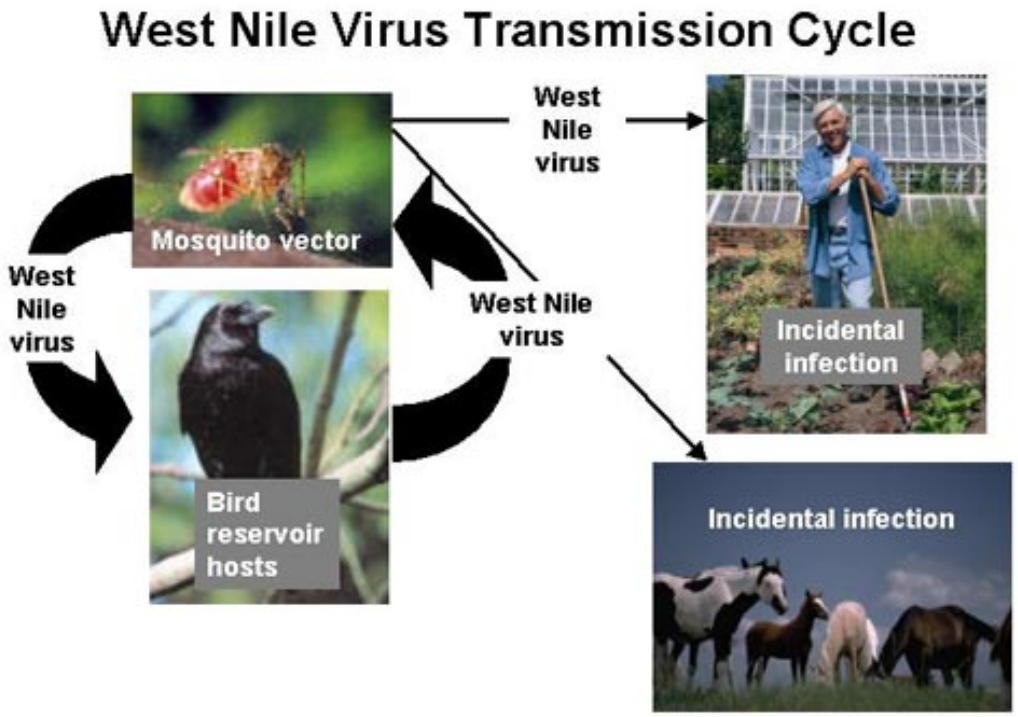
Disease Transmission

- West Nile virus
- Encephalitis
  - SLEV
  - EEEV
  - WEEV
  - LACV
- Dog heartworm
- Dengue Fever
- Chikungunyan
- Zika

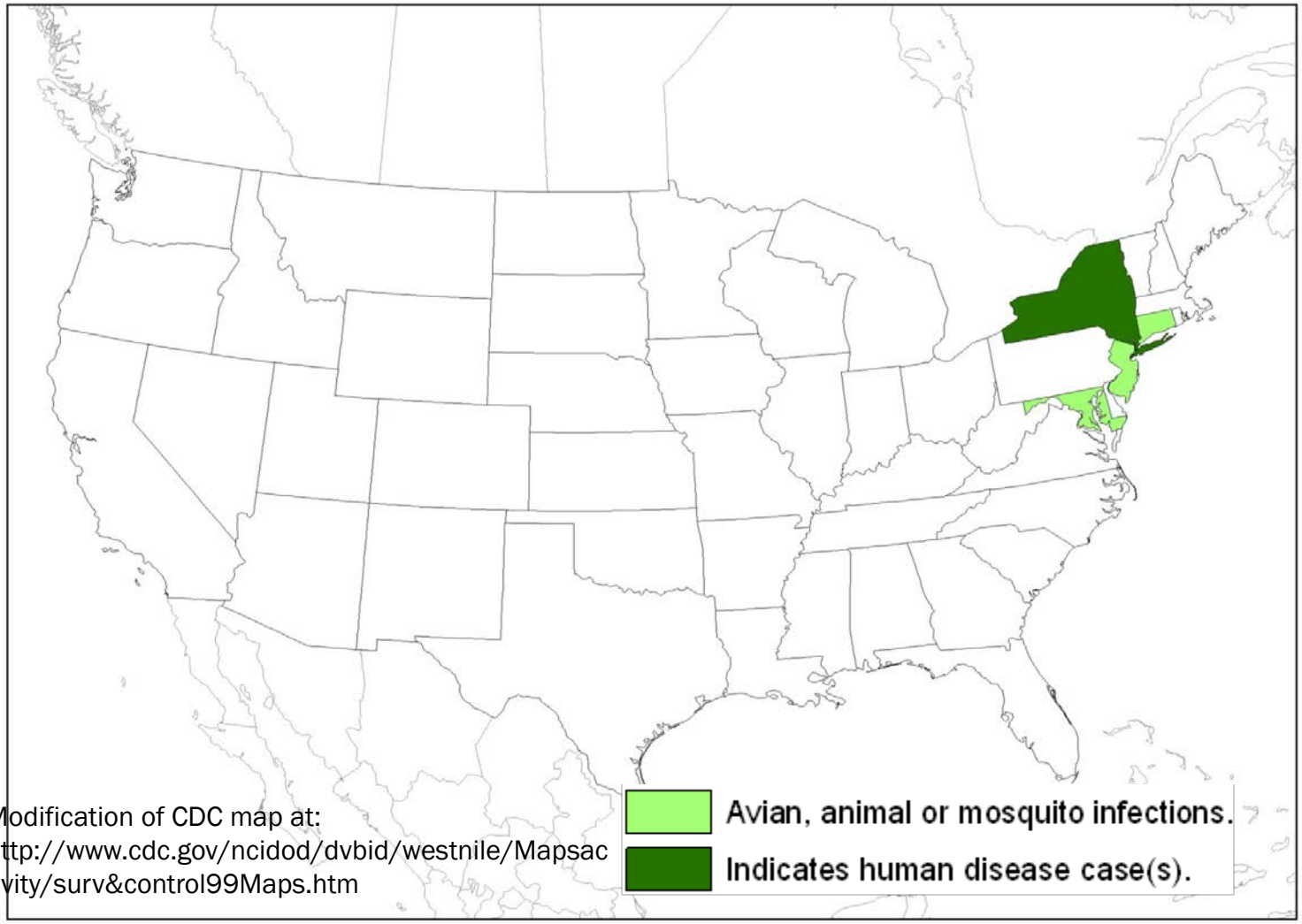
West Nile Virus

WNV Sylvatic Cycle

- Birds are amplifying hosts
  - Source of virus for feeding mosquitoes
  - Some species, e.g. crows, jays, experience high mortality rate (bird die off events)
- Humans are dead end hosts for the mosquito-vectored cycle
  - Low virus level in blood, so not a source of virus for feeding mosquitoes
  - HOWEVER, human to human transmission occurs without mosquito involvement
    - Blood product transfusion
    - Mother to fetus
    - Organ transplant
    - Occupational (lab)
    - Breast milk (1 probable case)
- Horses are dead end hosts

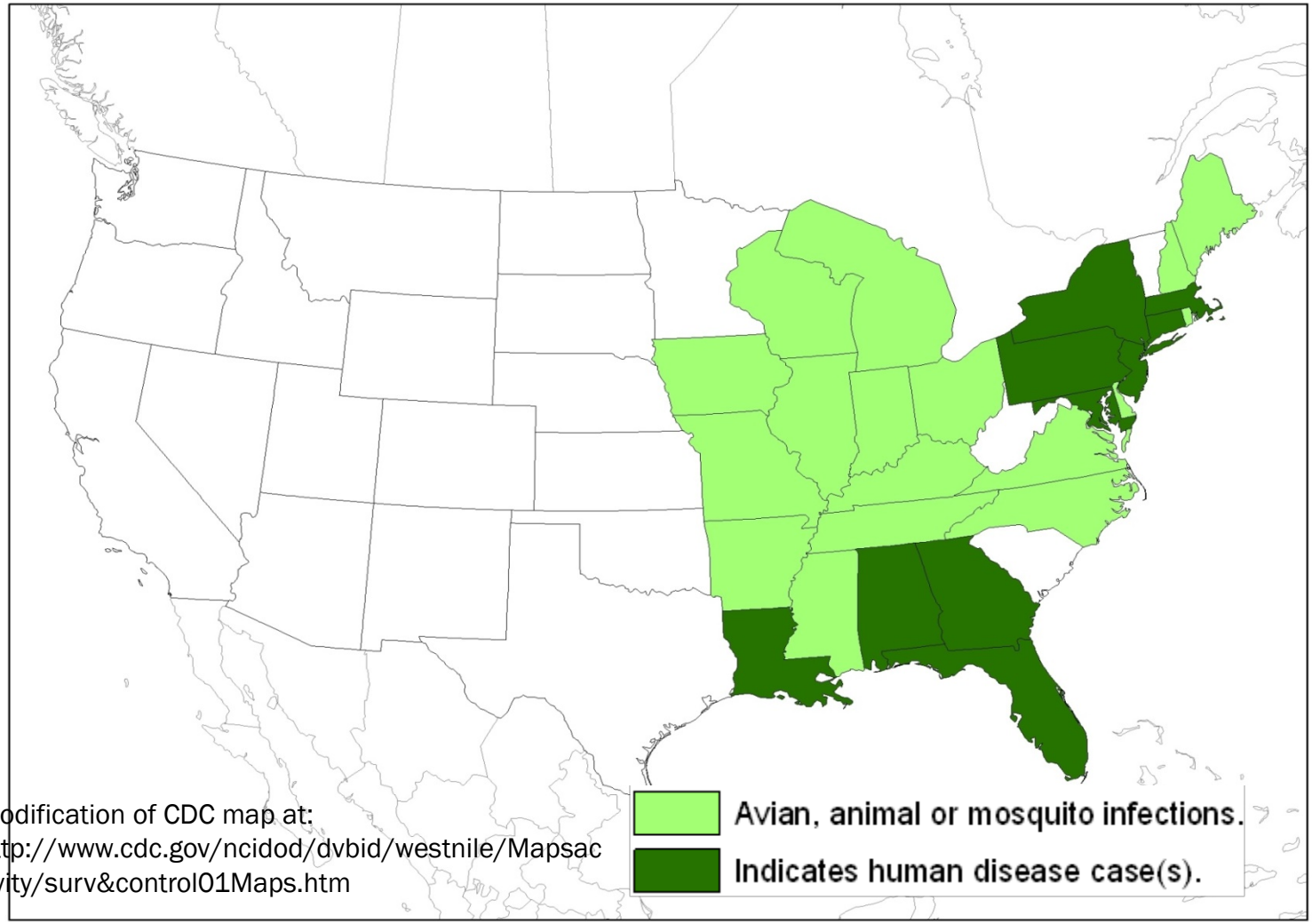


Virus Entry Into the USA - 1999



Modification of CDC map at:
http://www.cdc.gov/ncidod/dvbid/westnile/Mapsactivity/surv&control99Maps.htm

Virus Movement through 2001



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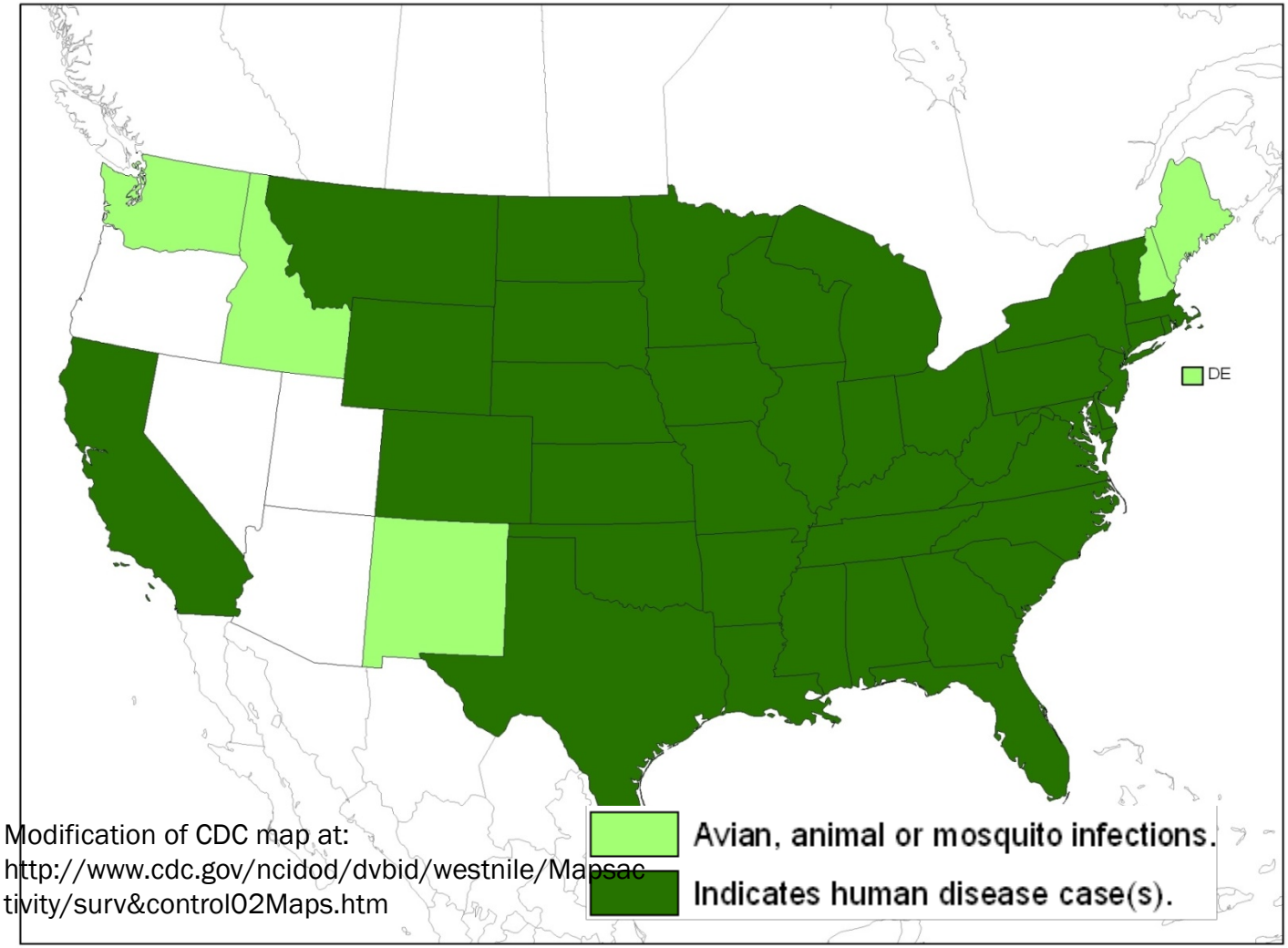
Rapid Spread of Virus - 2002



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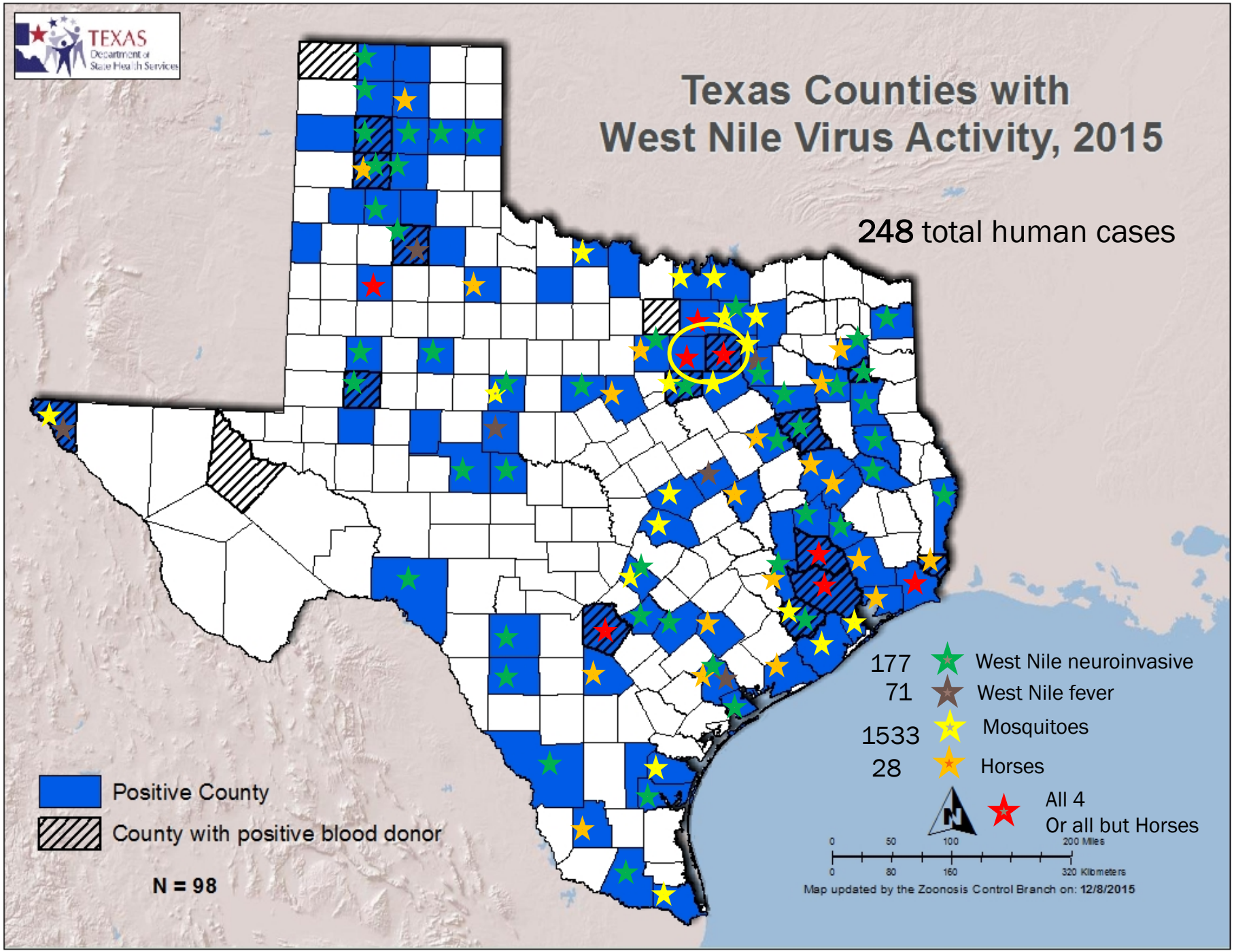
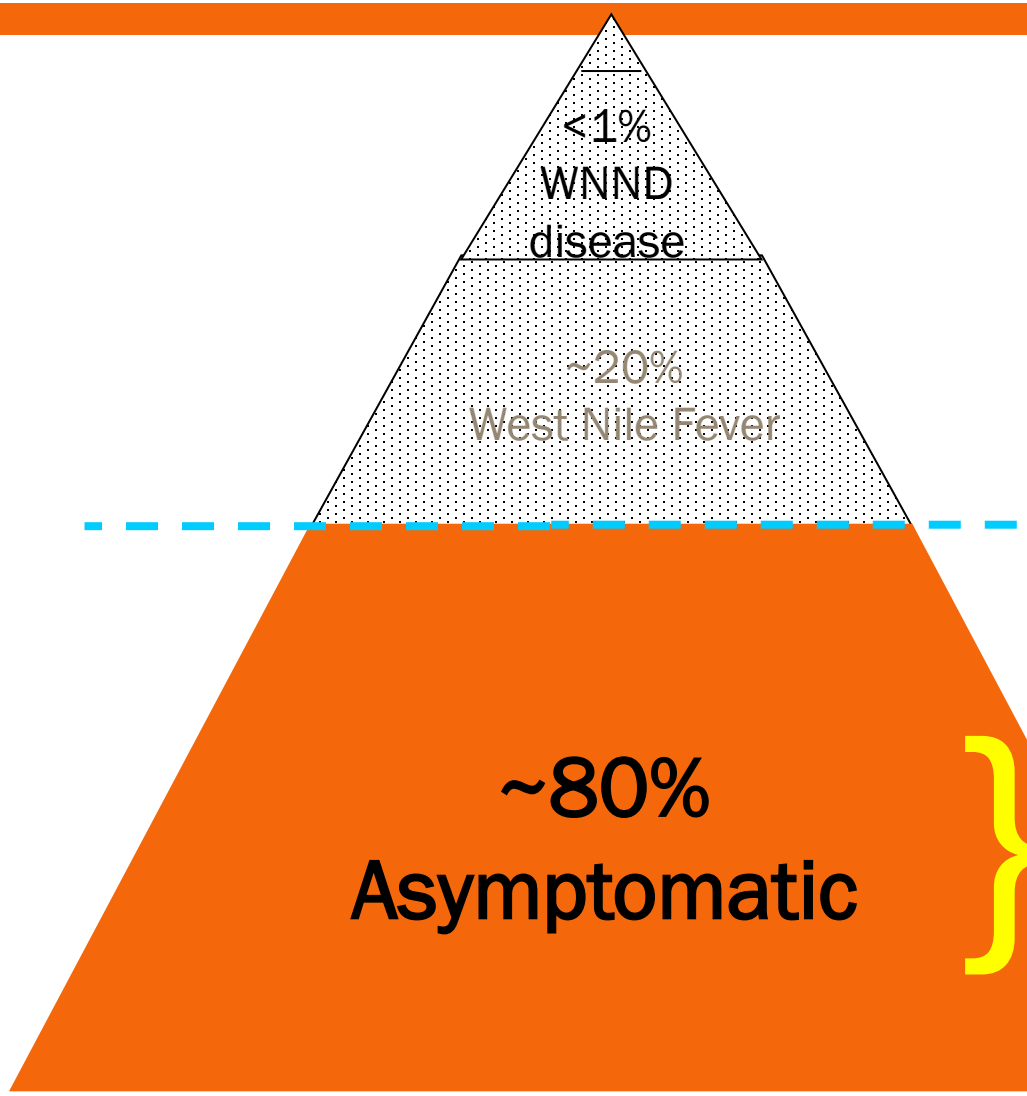

TEXAS
Department of State Health Services
Texas Counties with West Nile Virus Activity, 2015
248 total human cases
177 West Nile neuroinvasive
71 West Nile fever
1533 Mosquitoes
28 Horses
All 4
Or all but Horses
Positive County
County with positive blood donor
N = 98
0 50 100 200 Miles
0 80 160 320 Kilometers
Map updated by the Zoonosis Control Branch on: 12/8/2015

WNV Human Infection "Iceberg"

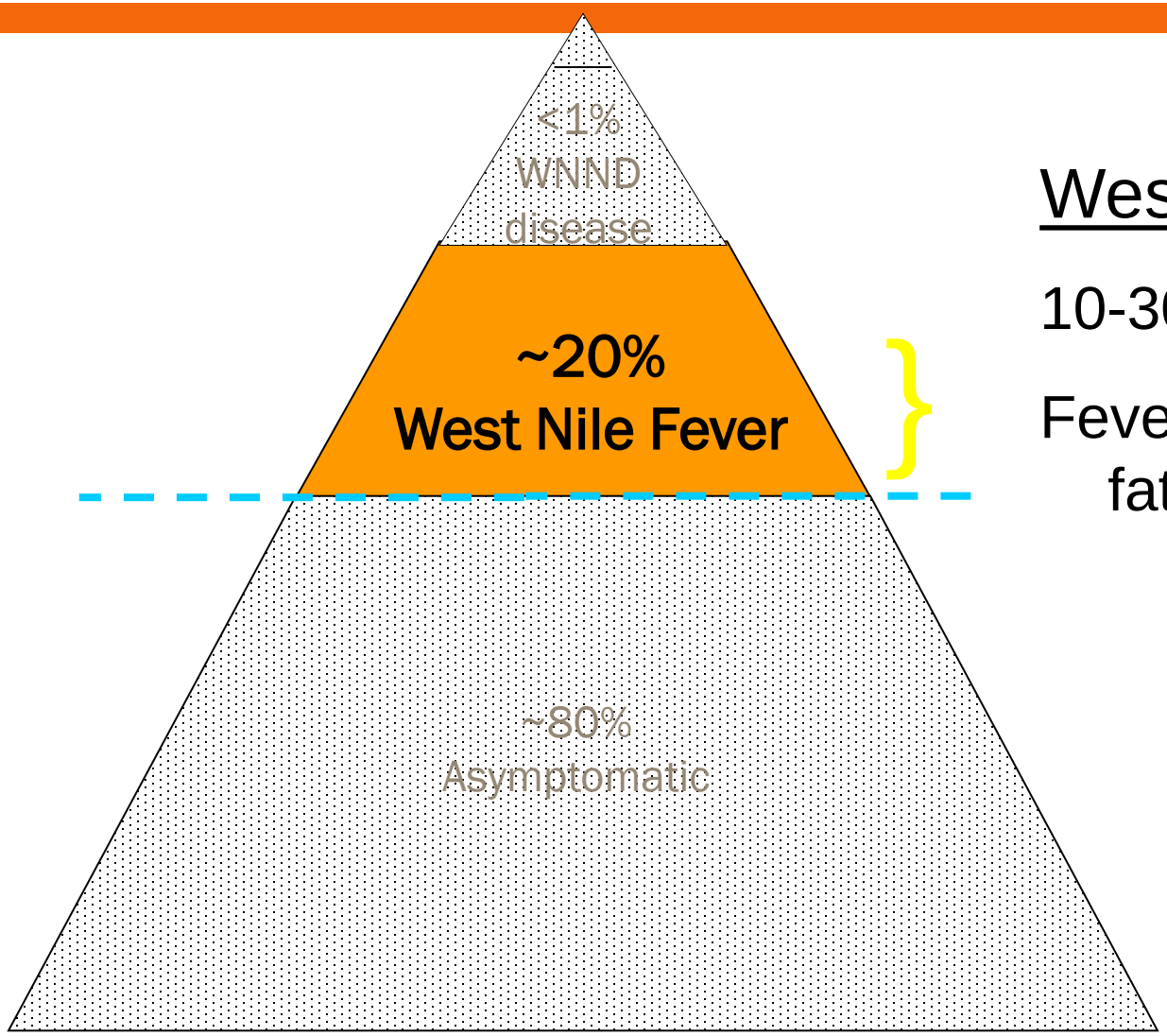


Asymptomatic Infection

~80% of infections

IgG can persist for many years

WNV Human Infection "Iceberg"

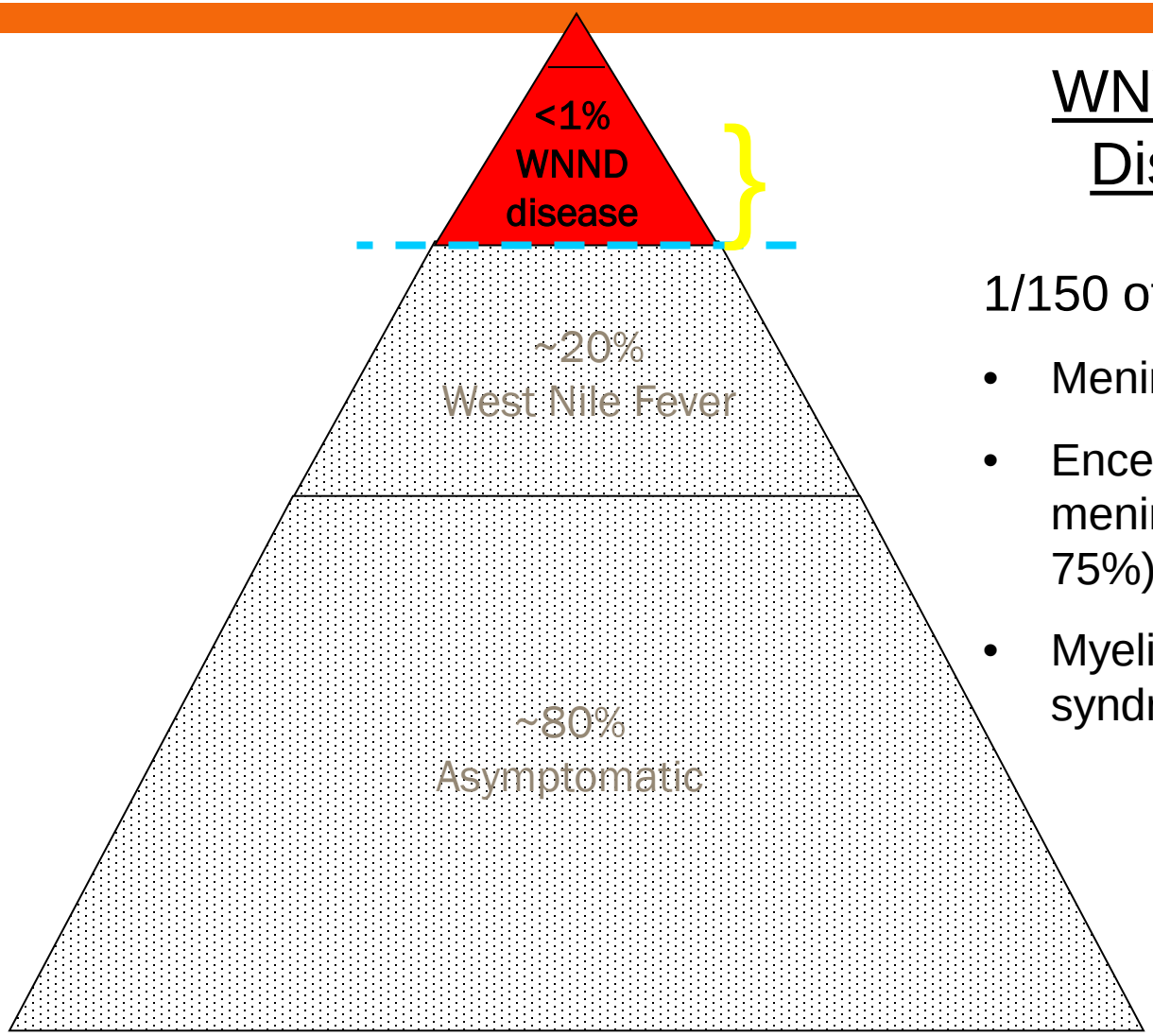


West Nile Fever

10-30% of infections

Fever, headache, rash, fatigue

WNV Human Infection "Iceberg"



WNV Neuroinvasive Disease (WNND)

1/150 of all infections

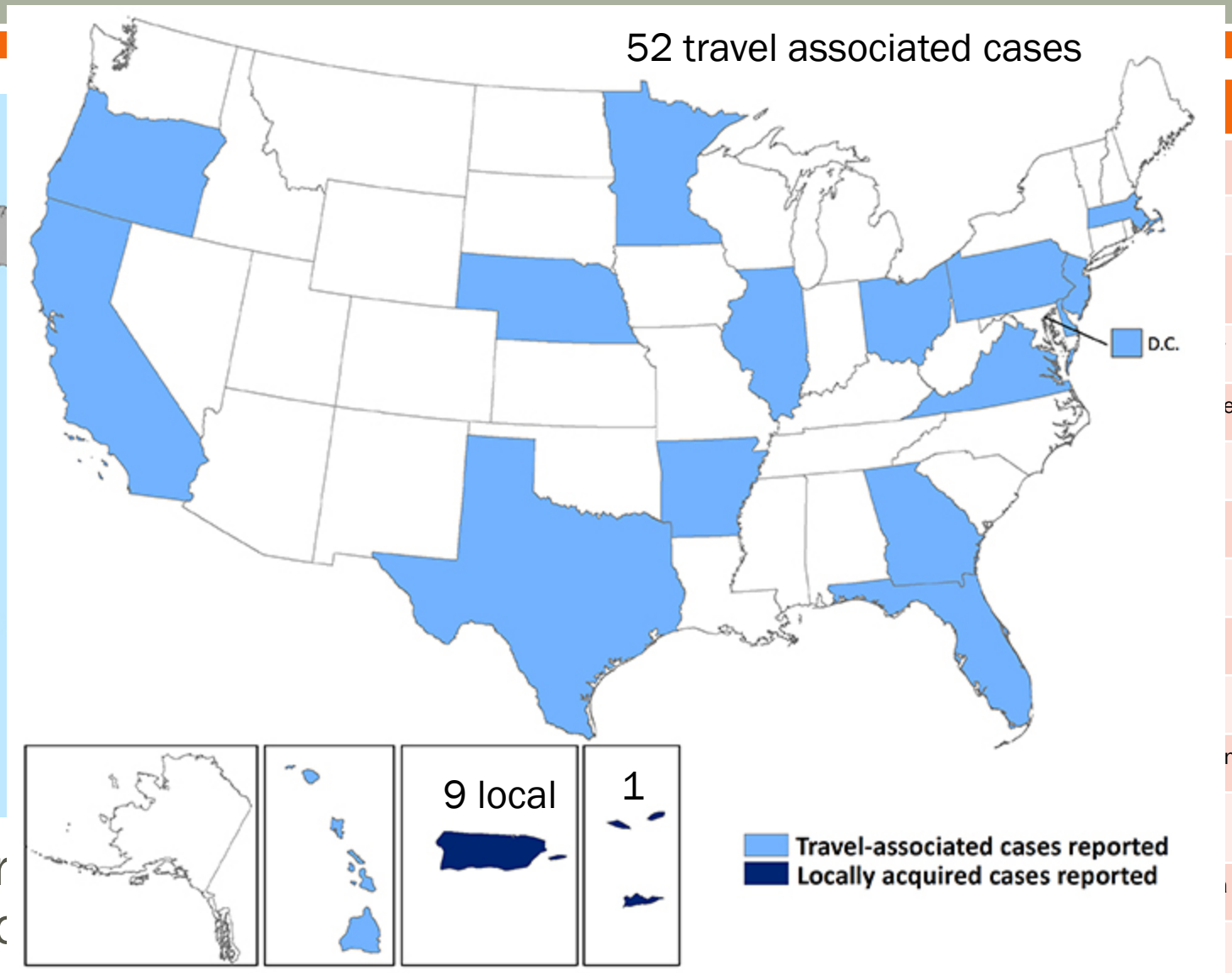
- Meningitis (25-35%)
- Encephalitis or meningoencephalitis (60-75%)
- Myelitis or flaccid paralysis syndrome (rare)

Zika Virus

Zika Virus

- Member of the Flavivirida virus family
  - Hundreds of Thousands! confirmed cases – 31,555 in Colombia (5,013 pregnant); 400,000 – 1.3 million in Brazil (estimated)
  - 10 in TX, 52 US
- Related to dengue, yellow fever, Japanese encephalitis and WNV
- Linked to microcephaly
  - 4,300 suspected cases in Brazil
  - 51 babies have died
- Most common symptoms of disease are
  - Fever
  - Rash
  - Joint pan
  - Conjunctivitis
- Usually mild with symptoms lasting days to a week

Zika-affected Areas



- Pr
  Sc

Bolivia
Colombia
Curacao
Ecuador
French Guiana
Guatemala
Haiti
Jamaica
Mexico
Panama
Puerto Rico
Suriname
Venezuela
Cape Verde
Tonga

Integrated Mosqutio Management

IMM Definition

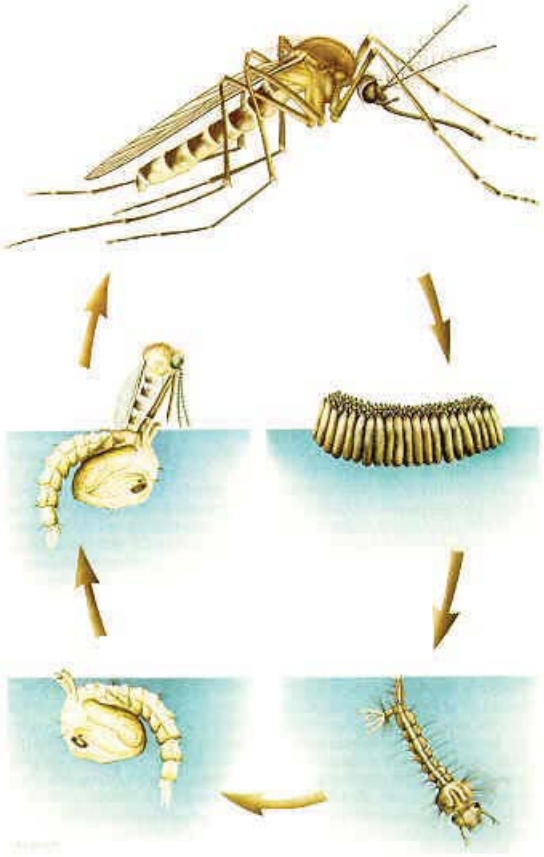
- Effective, environmentally sensitive approach to Mosquito Management
- Combines several control tactics for best possible results
- Must know your pest – biology, ecology, and habitat

1. Surveillance
2. Mapping
3. Set Action Thresholds
4. Physical Control or Source
5. Biological Control
6. Public Health Mosquitocides
7. Public Education
8. Record Keeping

IMM Reality

- IMM does not emphasize mosquito elimination or eradication

- Methods are specifically tailored to safely control each stage of the mosquito life cycle



Principles

- 3 Main Principles of IMM
  1. Start by identifying your pest
  2. Pests are managed to acceptable levels based on the use of thresholds
  3. The best way to manage pests is to use multiple control tactics

1. Identify Pest

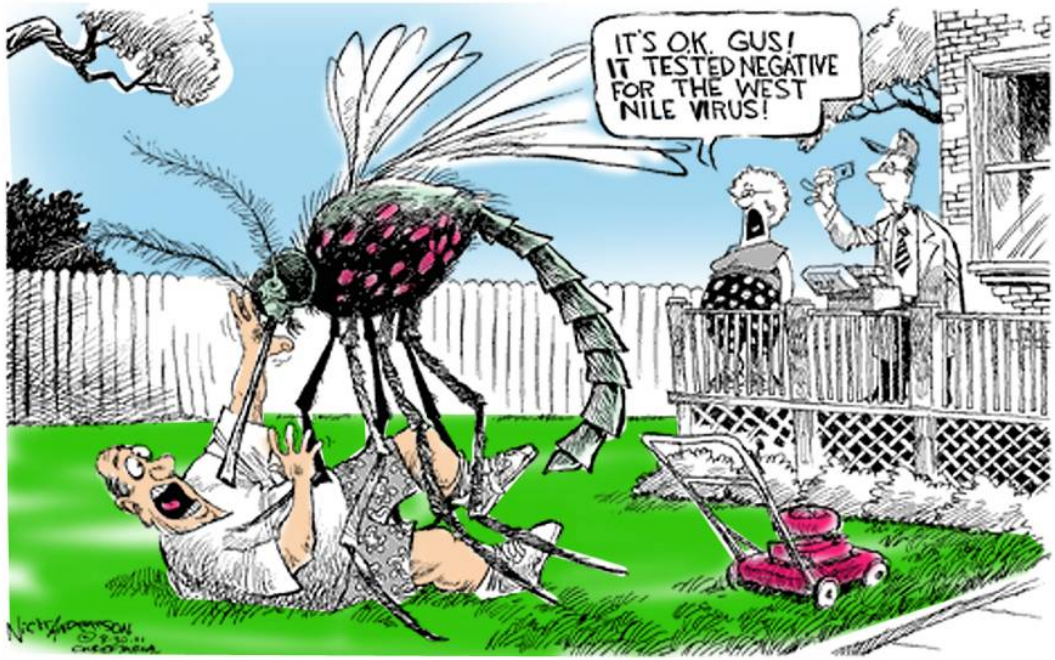
- Survey

- Identify genera / species

- Locate ecological habitat

2. Thresholds

- Points which pest populations are large enough to justify commencing control measures
- Are set for a specific pest and site
- Goal is to protect human health



3. Use Multiple Control Tactics

- Promote a rational use of pesticides.
- Utilize biological controls (native, noninvasive predators) to conserve and augment other control methods.
- Utilize source reduction (elimination, removal or reduction of larval mosquito habitats) where practical and prudent.
- Use target specific pesticides at the lowest effective rates to the extent possible.

Larvicides

Larvae and Pupae Management

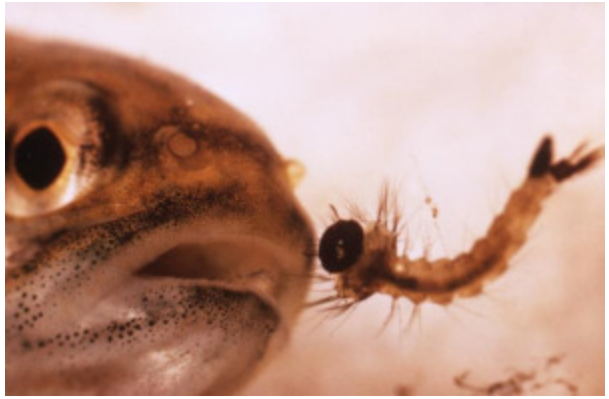
- Target immature mosquitoes in aquatic habitats
- Killing immatures prevents
  - adult emergence,
  - biting, and
  - disease spreading
- Oviposition sites are localized and concentrated
  - Makes them more efficient to control

Biological controls

- Control mosquito populations naturally in their oviposition habitats without harming the environment
  - Mosquito fish – *Gambusia affinis*
  - Predatory aquatic insect nymphs and larvae

Biological controls

- To use, must have basic knowledge of
  - Mosquito biology & ecology
  - The agents to be used

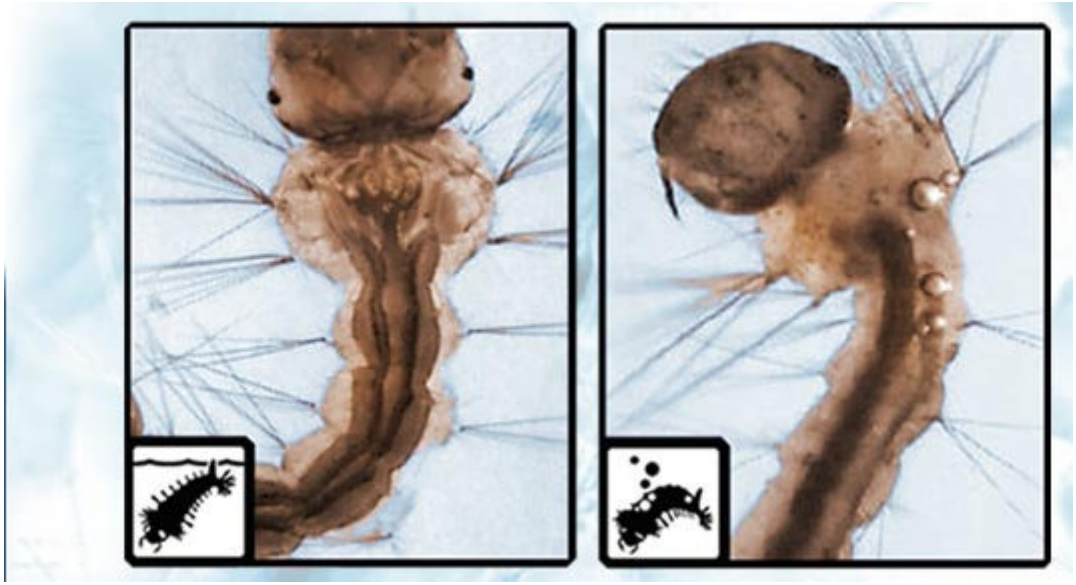


Mechanical Controls

- Larvasonic devices (acoustic larvicides)
  - Kill larvae by emitting sounds
  - The sonic frequency travels through the water
  - Disrupts the mosquito larvae's air bladder

Mechanical Controls

- Larvasonic devices
  - By the bladder absorbing the energy of the acoustics
  - Then the base of the larva's heads ruptures
  - Larvae die



Source Reduction

- Attack mosquitoes at the source
  - Eliminate potential larval habitats

- Tactics
  - Improve land drainage
  - Shred tires

Source Reduction

- Urban areas pose a problem
  - Eliminate open sewage / septic systems
  - Artificial containers – public knowledge
- But efforts must commence

EPA-registered larvicides

- Effective and safe methods
  - Insect growth regulators (IGR)
  - Biological insecticides
  - Oils & Films
  - Organophosphate
- Generally affect the environment less than adulticides

Bti

- Need higher rates of application
  - Older larvae
  - Polluted septic water
  - Heavy algae grow
- No effect on pupae
- Does not harm other insects, fish or animals

Bti

- Many formulations
  - Wettable powders
  - Liquids
  - Capsules
  - Granules
  - Briquettes
- Granules break down in 48 hrs
- Briquettes last up to 30 days

Bacillus sphaericus

- Effective against larvae
- Occurs worldwide naturally
- Causes damage and paralysis to the gut of larvae, they starve to death
- Not harmful to people, mammals or aquatic life if applied following label directions

Bs

- Comes in a granular form that must be mixed with water
  - Spray on ground or by air
- Residual - 1 to 4 weeks
- Is a bit more expensive than Bti
  - Contains living spores
  - Recycles in water pools
  - Persists more than 30 days
  - More effective in dirty water

Spinosad

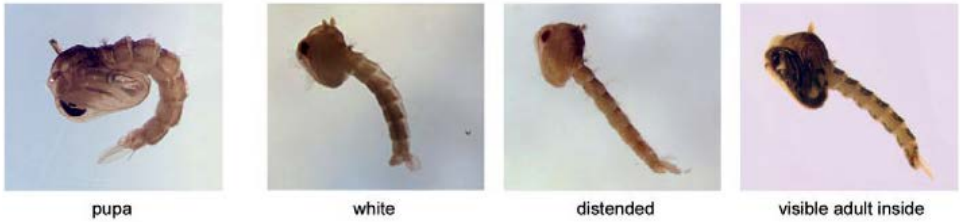
- Based on naturally occurring bacteria
- Highly effective by contact and ingestion
- Diminished effectiveness in polluted waters and full sunlight
- More expensive than Bti and Bs

- Can be used in
  - Catch basins
  - Woodland pools
  - Fresh floodwater areas
  - Polluted or impounded waters
  - Marshes

Insect Growth Regulators (IGR)

- Chemicals that kill insects by and development

- (s)-methoprene, acts like a hormone, prevents
  - normal molting
  - egg-laying
  - egg hatching
  - and life cycle development



(s)-methoprene

- Does not harm non-target species or fish

- Use in multiple locations
  - ditches
  - lakes
  - ponds
  - tires
  - catch basins
  - cattail marshes
  - flooded areas
  - irrigated cropland,
  - rice fields,
  - storm drains
  - swimming pools

- Several formulations:
  - Liquid – 7 – 10 day residual
  - Granular
  - Briquettes – 30 and 150 day

Adulticides

Adult Management

- Conducted by trained applicators when
  - Source elimination or larval control measures are not feasible
  - Or are clearly inadequate
  - Or when faced with imminent mosquito-borne disease

- Adulticide products are chosen based upon
  - Efficacy against species targeted for control
  - Resistance management concerns
  - Minimization of potential environmental impact

Adulticides

- Insecticides targeted at adult mosquitoes
- Needed to kill adult mosquitoes
- Can be deployed quickly and produce immediate results
- Conducted correctly, insecticides can reduce the risk of disease transmission
- Can be costly but necessary

Photo courtesy Dallas Morning News

Pyrethroids

- Synthetic chemicals
  - like pyrethrins
- Block movement from brain to muscles
- Last longer in the sunlight than pyrethrins
- Do not harm most people
- Can kill fish in high concentrations

Pyrethrins

- Break down within an hour of sunlight exposure when used on mosquitoes

- Formulated so not to harm most people

- Do not kill fish, when used correctly

Prentox®
Pyronyl™
Oil Concentrate #525

MGK®

Organophosphates

- Treatment for adults
  - cause paralysis
  - death
- Use as little as possible
  - rotate products regularly
  - adults become resistant
- Two available
  - Malathion
  - Naled

FYFANON® ULV
MOSQUITO INSECTICIDE

Public Education

- Involves a concerted effort by both control personnel and the community
  - Manage mosquito populations based upon informed decision-making
- Educate by encouraging resident support
  - Disposing of (or modifying) oviposition habitat
  - Proper screening methods
  - Proper application of personal protective measures
- Keep public informed of surveillance and control measures
- Personnel should maintain and upgrade their professional knowledge through continuing education training and/or attendance at professional conferences

Record keeping

- Applicators must maintain records of each pesticide application.
  - For 2 years
- Include information
  - Date of application
  - Time of application
  - Name of person applying
  - Location of application
  - Pesticide information
    - Product name
    - Product EPA reg #
    - Rate of product / unit
    - Total vol. of spray mix, dust, granules, other materials
    - Name of pest being treated
  - Treatment site
  - Total number of acres or volume of area treated
  - Wind direction & velocity
  - Air temp
  - Name and license # of applicator responsible

Follow the Four Ds

- Drain standing water
- Stay indoors during Dawn and Dusk
- Dress in long sleeves and pants
- Defend with repellents

What is a repellent?

Anything that repels, or disrupts the normal host seeking behavior of a pest.

Unregistered Products

- Some insect repellent products for sale in the US do not currently require EPA registration.
- In the 1990s,
  - EPA evaluated these active ingredients for safety
- Determined they posed minimal risk to human health Based on this minimal risk determination,
  - Note these products have not been evaluated for effectiveness

- Examples of ingredients
  - Citronella oil
  - Cedar oil
  - Geranium oil
  - Peppermint and peppermint oil
  - Soybean oil

Commercial Insect Repellents

- EPA Registered Repellents:
  - DEET
  - Picaridin
  - IR3535
  - Citronella
  - 2-undecanone
  - Oil of Lemon Eucalyptus
  - Catnip Oil

- CDC Approved Products:
  - DEET
  - Picaradin
  - IR3535
  - Oil of Lemon Eucalyptus

N,N-diethyl-m-toluamide (DEET)

- U.S. military discovered repellency of DEET in 1953
- Broad spectrum repellent effective against all mosquitoes, some flies and ticks
- Est. 78 million people in U.S. use DEET safely each year

US troops receiving repellents at the end of WWII. Malaria and other insect born diseases were a major source of casualties in the Pacific theater, leading to ground breaking research on repellents.

DEET

- Principal, most effective repellent available today
- The standard against which all other repellents are compared
- Most thoroughly studied and tested with protection documented up to 6-8 hours

Picaridin

- Registered by US EPA 2003
- High level of control comparable in many studies to DEET
- Low odor, not oily
- EPA lists as 3-8 hours repellency for different concentrations

Oil of Lemon Eucalyptus
Para-menthane-3,8-diol

- Derived from leaves of eucalyptus plant
- Similar smell and cooling to menthol
- EPA lists protection time at 6 hrs for most products containing 30-40% active ingredient

IR3535

- Used in Europe for 20 years prior to US registration in 1999
- Relatively short complete protection time, less than one-hour in some studies
- Among recommended products by CDC, for those needing shorter protection times than DEET

BioUD

2 - undecanone

- Registered 2007 by EPA
- Originally derived from wild tomatoes
- North Carolina State University 2008 lab studies
  - Arm cage studies compared favorably to DEET for Aedes
- Not yet on recommended list from CDC

Off! Clip-On Mosquito Repellent

- Releases vaporized form of metofluthrin (pyrethroid) and expels via small fan. To be clipped on a belt.
  - Spatial repellency
  - Mortality of mosquitoes
- Wind, personal movement may reduce effectiveness
- Limited studies
  - 77% to 80%, *Aedes albopictus*, *A. taeniorhynchus*, more recent (Kline, CMAVE)
  - 70% & 79% protection, *Aedes albopictus*, *A. taeniorhynchus* (Xue et al, 2012)

Repellents for clothing

- Certain products containing permethrin are recommended
  - on clothing
  - shoes
  - bed nets
  - camping gear
- Permethrin products should not be applied directly to skin
- Repellent treated clothing good for 30-40 washings

Repellents and Children

- American Academy of Pediatrics recommends
  - Using products containing no more than 30% DEET
  - On children over 2 months of age
- DEET products have no age restrictions
- Oil of lemon eucalyptus products should not be used on children under the age of three.
- The CDC does not recommend use of products that combine a sunscreen with an insect repellent

Maximizing Effectiveness

- Apply and re-apply a repellent according to the label instructions.
- The label is your guide to product safety and effectiveness.
- Don't overuse the products,
- If you don't follow the label directions, the product may not be as effective as you expect.