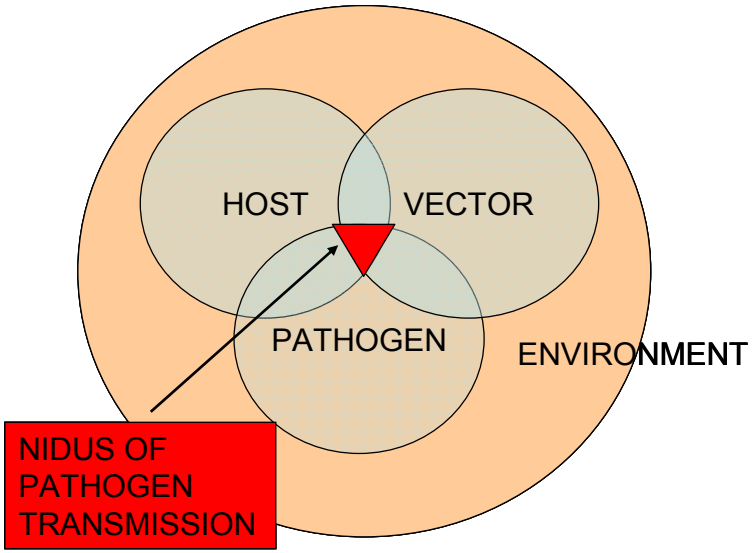
2013 APHL Annual Meeting &
Seventh Government
Environmental Laboratory
Conference, Raleigh, NC



Impact of environmental change on the transmission of arboviruses

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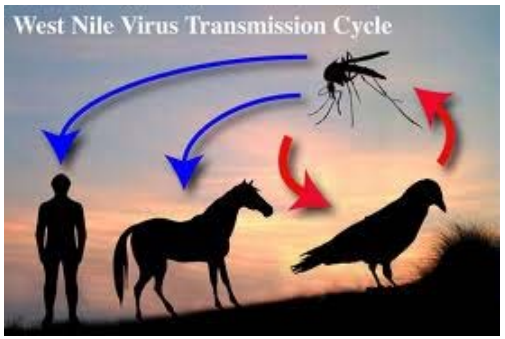


UCDAVIS VETERINARY MEDICINE

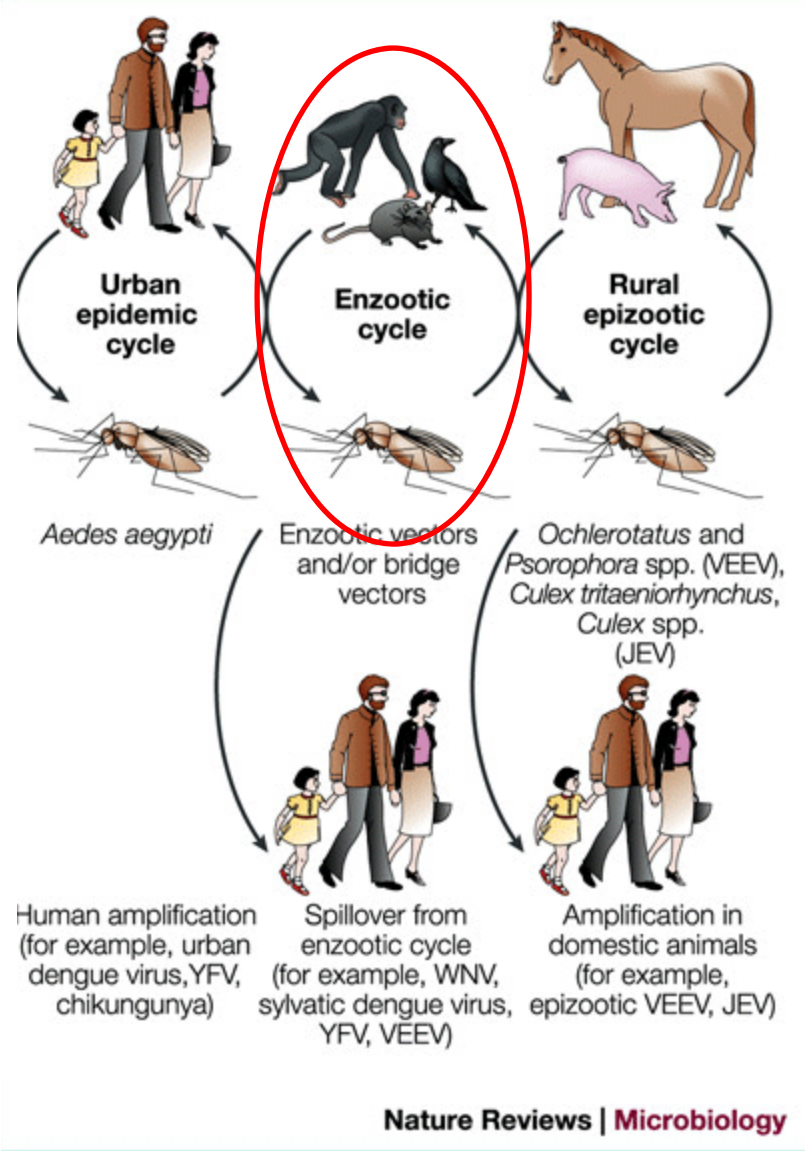
content

- Background – what are arboviruses
- Surveillance and PHL testing
- Intervention response to surveillance data
- Impact of environmental change
  - Population growth and urbanization
  - Effects of warming temperature
  - Thoughts on rainfall

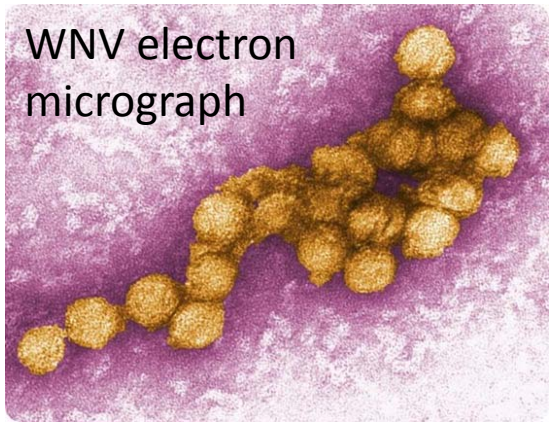
Background

- Arboviruses
  - Taxonomically diverse group of viruses transmitted by arthropods
  - Most originated as tropical zoonoses, some of which evolved to become anthroponoses [e.g., Yellow fever virus]

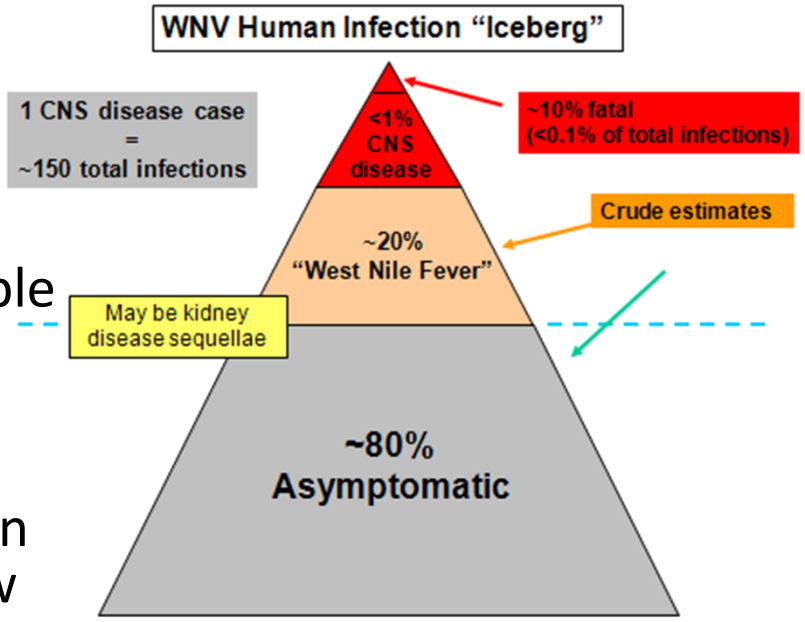
- Anthropogenic impacts:
  - Human population growth
  - Landscape change
  - Connectivity [transportation]
  - Climate change



Our NA problem: West Nile virus



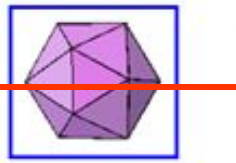
- Taxonomy: Flavivirus in the Japanese encephalitis serogroup. Related to SLEV, JEV
- Discovery: Isolated during a fever survey in the West Nile district of Uganda in 1937
- Disease: ranges from inapparent infection to flu-like illness to neuroinvasive disease to death. Possible chronic kidney infarction.
- Epidemics: Upper Egypt and South Africa in 1950s, Mediterranean and eastern Europe in 1990s, New World in 2000s – remarkable spread in the New World: east to west coast and from Canada to Argentina in 5 years
- No vaccine for humans



In USA: >30,000 confirmed cases
> 2M infections
2012 resurgence with 5,670 cases

What can be done?
Points of WNV intervention

Integrated vector management



Personal protection:
- avoidance
- repellents

Emergency adulticiding

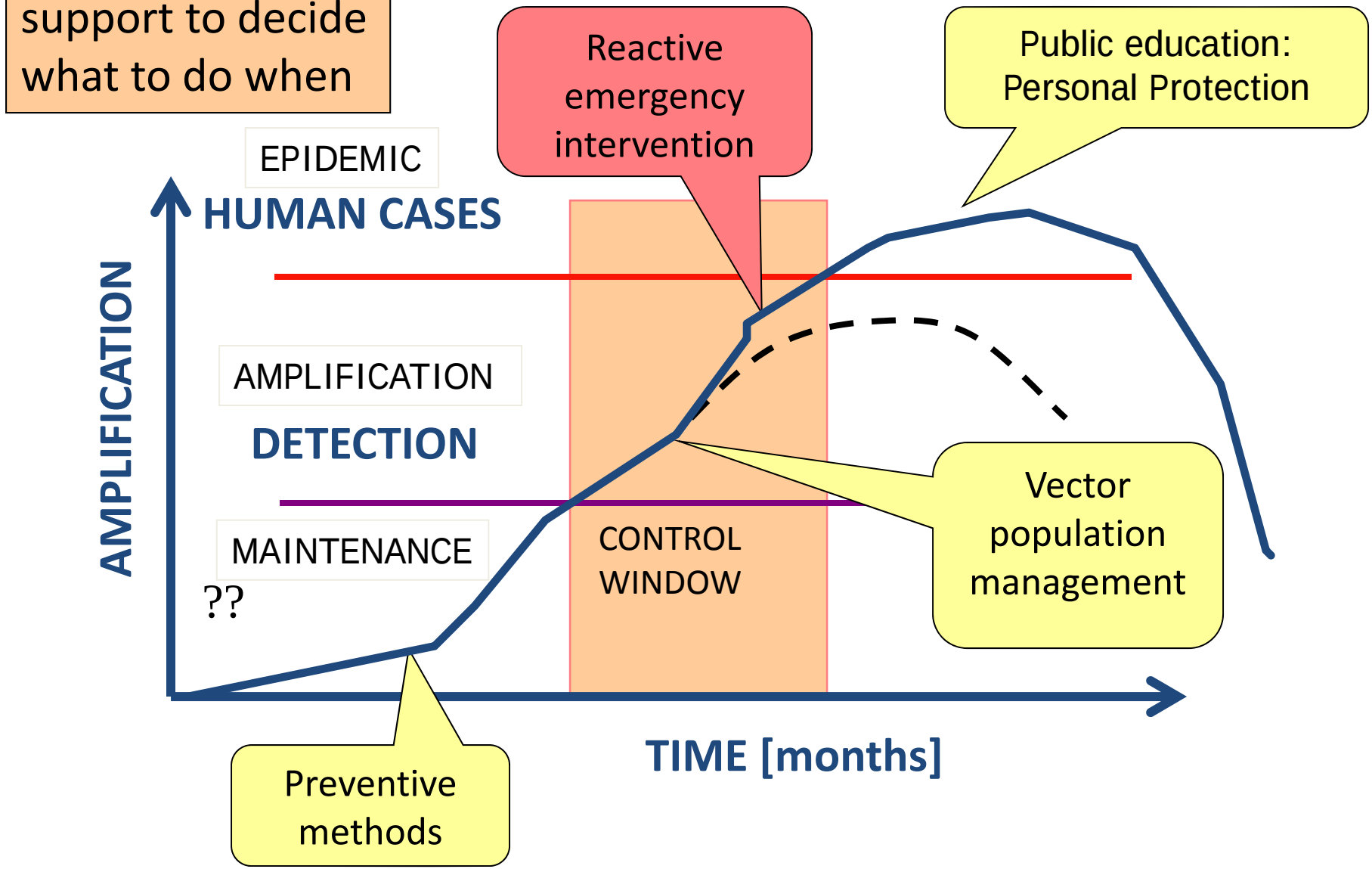
Reservoir removal or Vaccination??

Vaccination

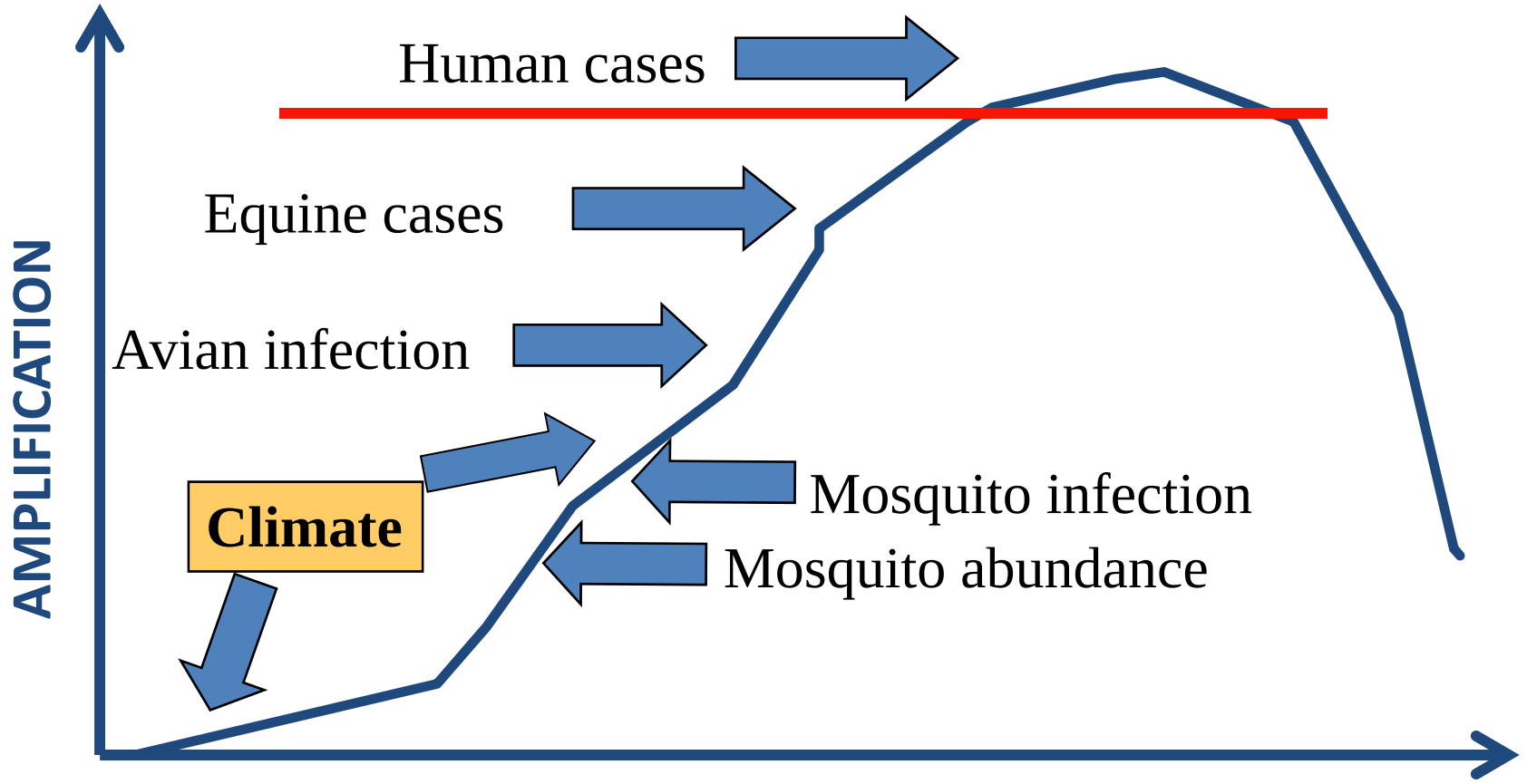
Modified from CDC website

INTEGRATED VECTOR MANAGEMENT: RESPONSE PARADIGM

Need decision support to decide what to do when



Tracking WNV



Climate variation:

1. Only early season predictor
2. Determines, in part, the shape of the amplification curve

Mosquito Sampling:

Abundance

NJ light trap

Dry ice-baited trap

Gravid female trap

Mosquitoes sorted to species and counted

Culex vectors carefully counted into pools of 50

Enzootic Transmission Measures

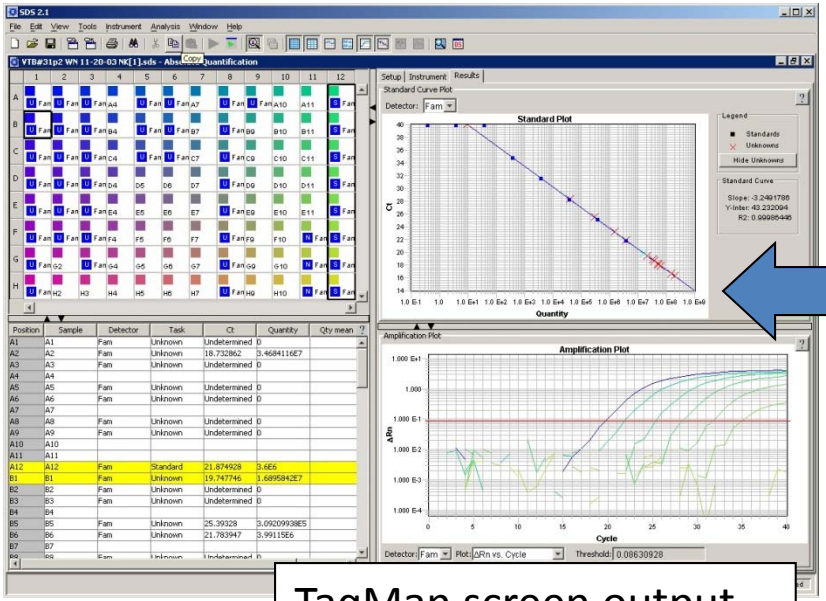
1. Free ranging bird serology [not universally done]

2. Sentinel chicken serology

3. Dead bird reports and testing

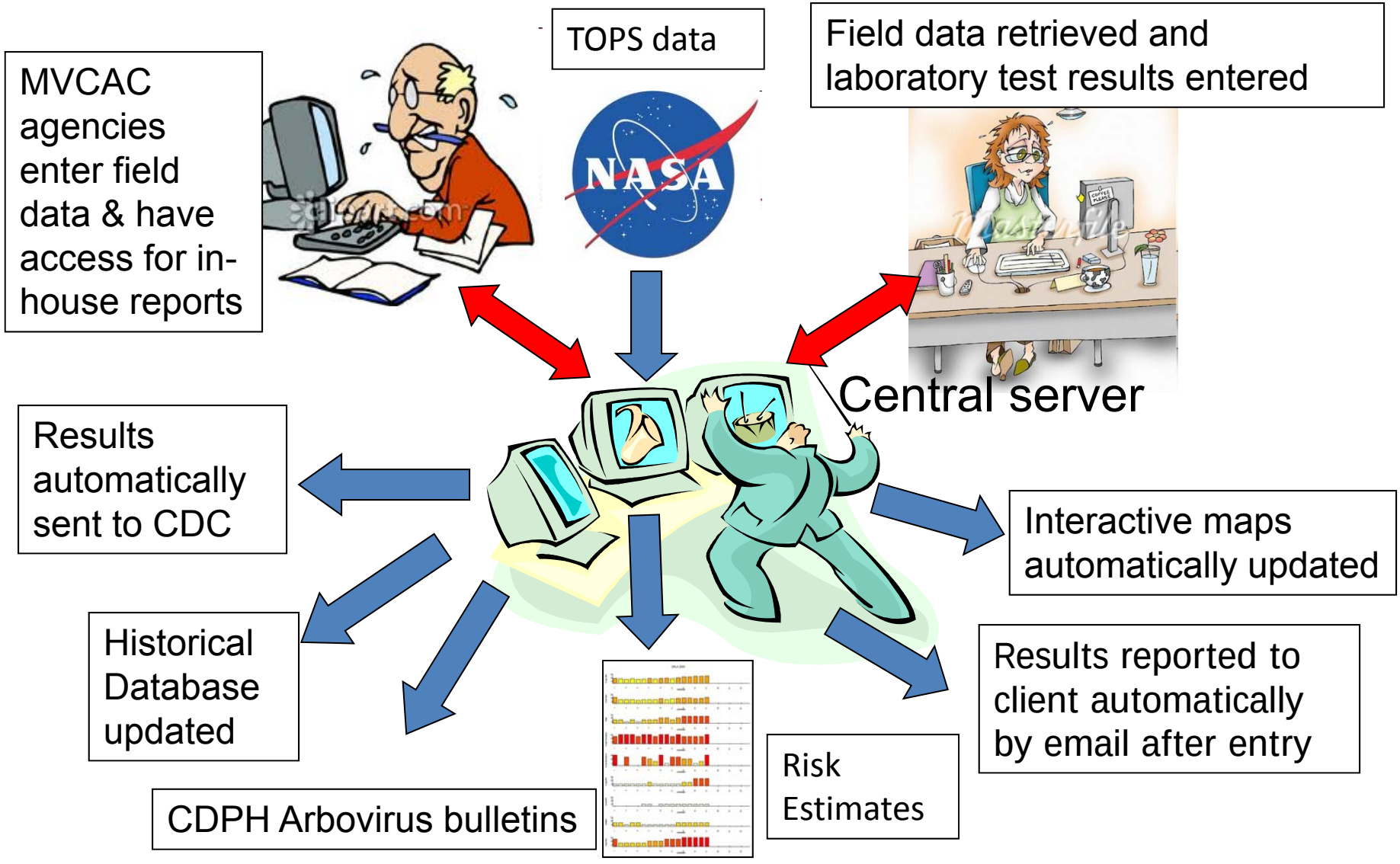
Paper strips rapidly tested by EIA and confirmed by IFA or western blot

Molecular diagnostics: real time RT-PCR



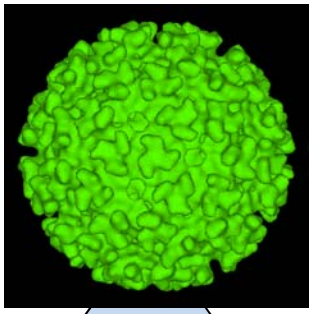
CalSurv Surveillance Gateway

Rapid Arbovirus Data Acquisition and Reporting system

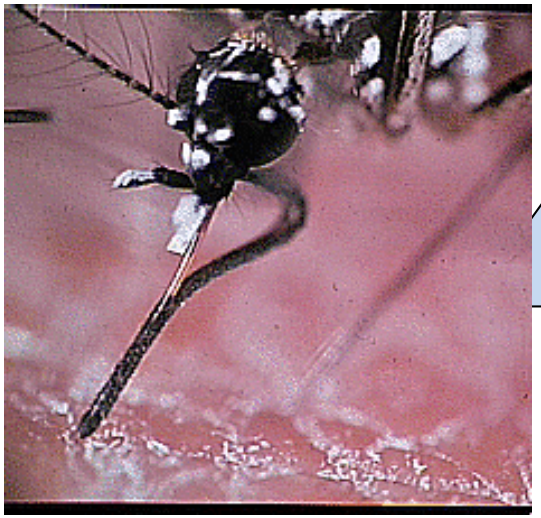


CLIMATE EFFECTS ALL COMPONENTS OF TRANSMISSION CYCLES

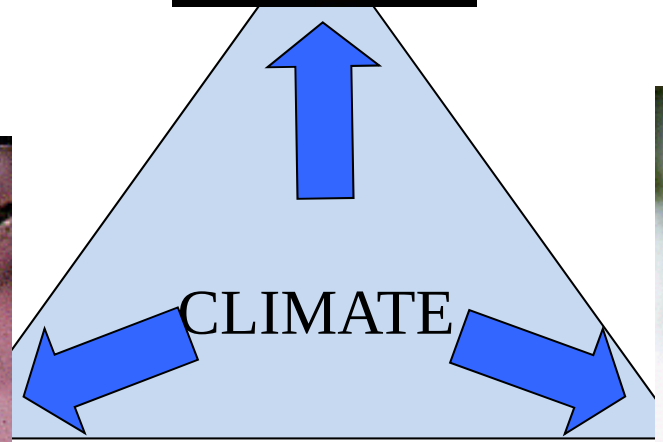
VIRUS



VECTOR



HOST



VECTORIAL CAPACITY
[factors affected by temperature]

$$C = ma^2 P^n V / -\log_e P$$

C = cases per case per day

ma = host biting rate

a = HI/GC, where HI = host selection index,

and GC = duration of the gonotrophic cycle

P = Probability of daily survival

n = Duration of the extrinsic incubation period

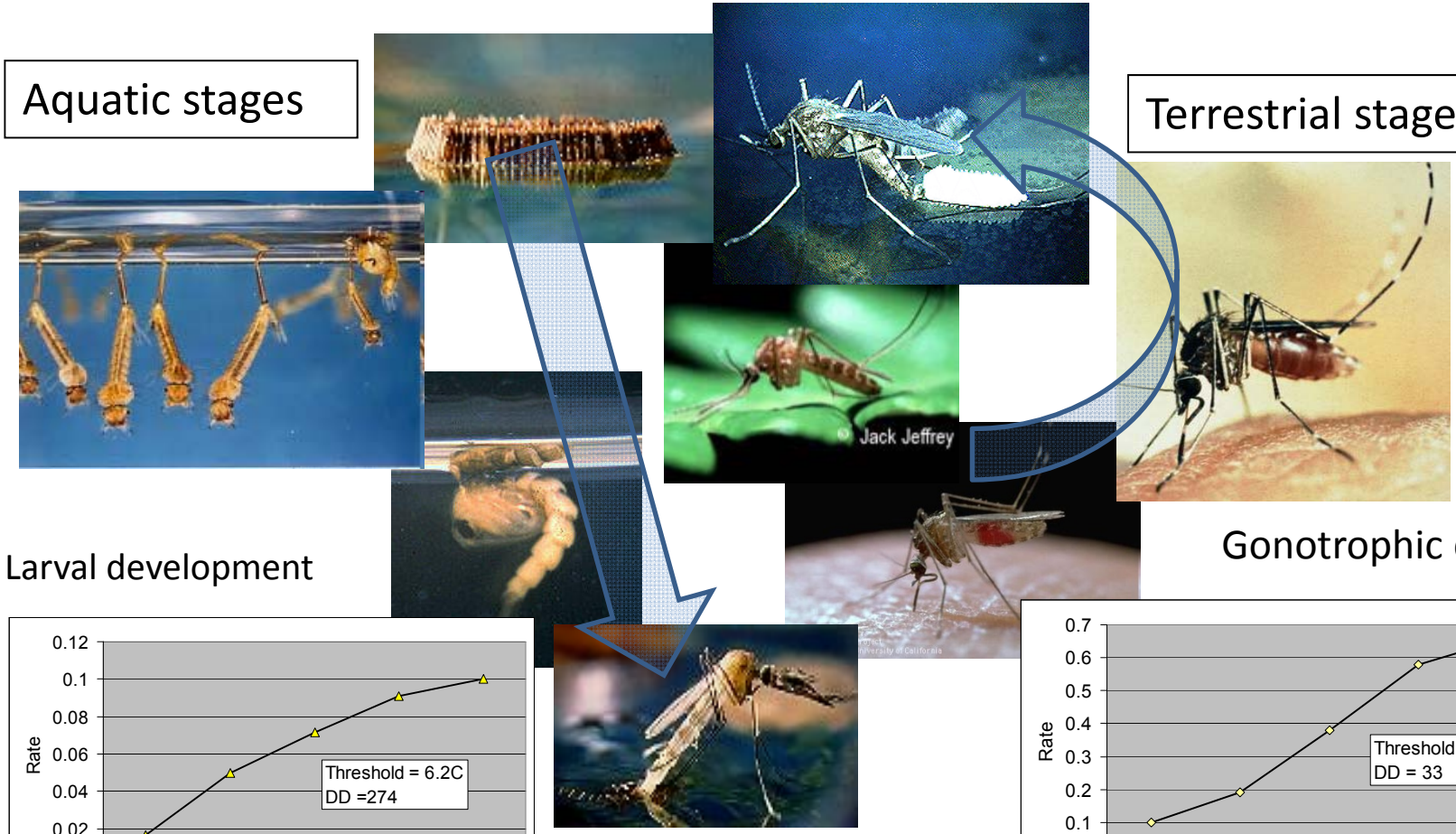
V = vector competence

Garrett-Jones (1964). Bull WHO 49: 569

Effects of temperature on mosquito life cycle

Aquatic stages

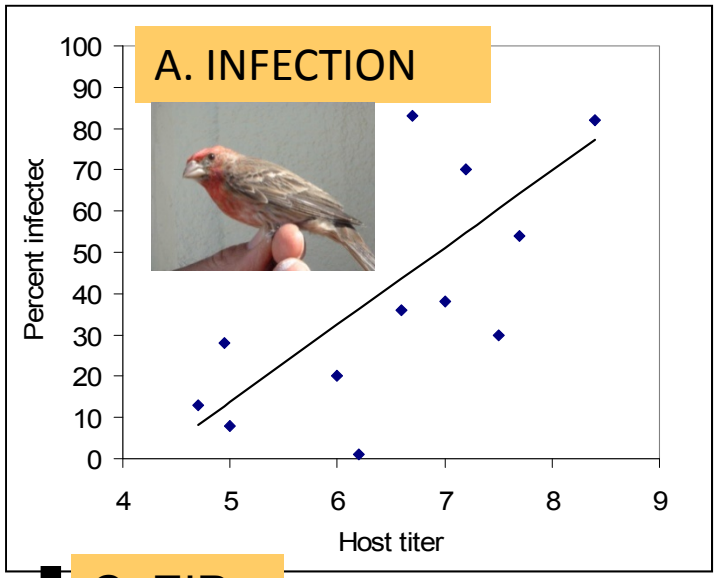
Terrestrial stages

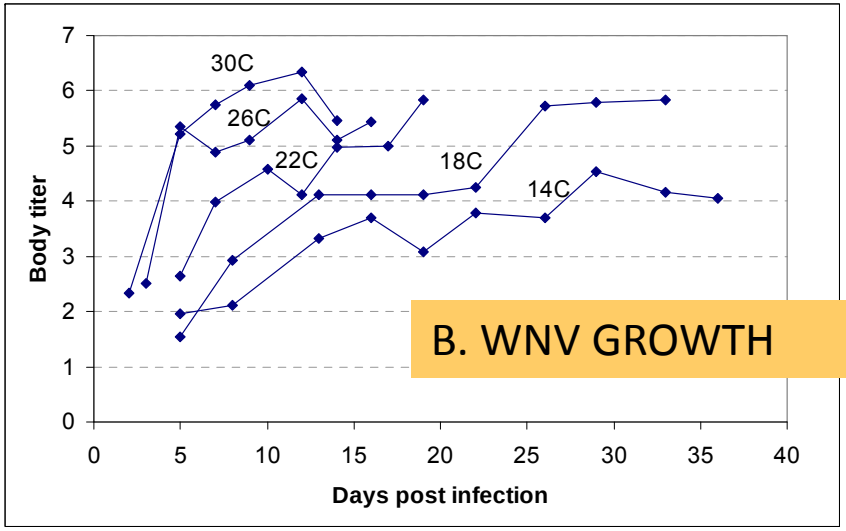


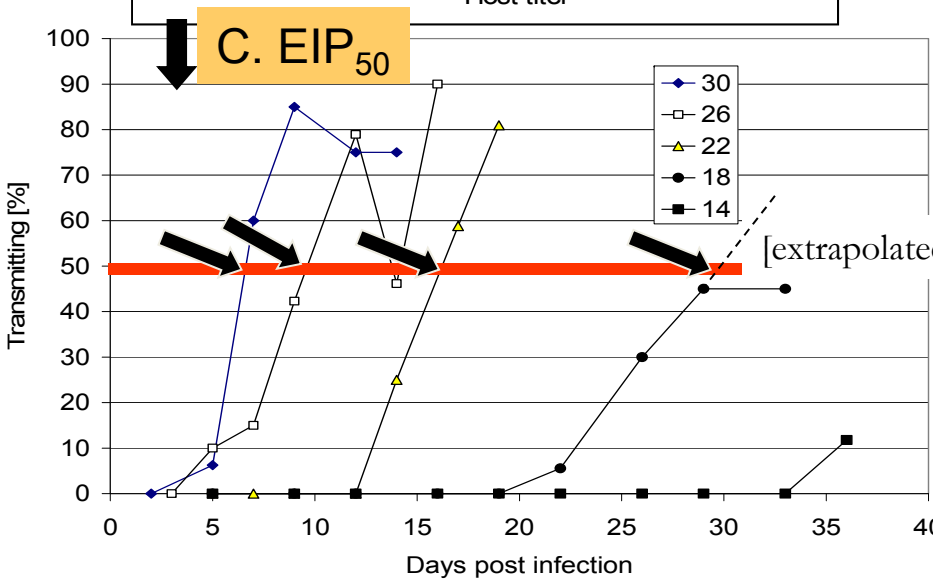
Larval development

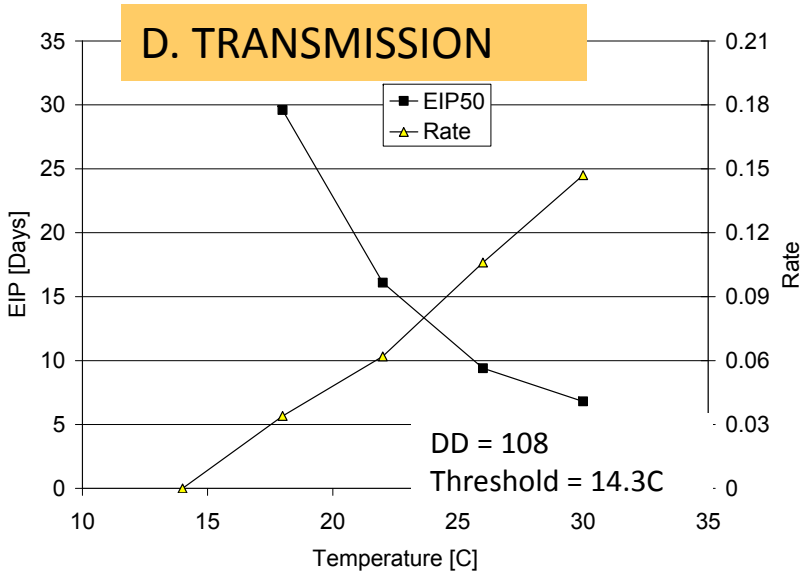
Gonotrophic cycle

Effects of host viremia and temperature on WNV infection and transmission





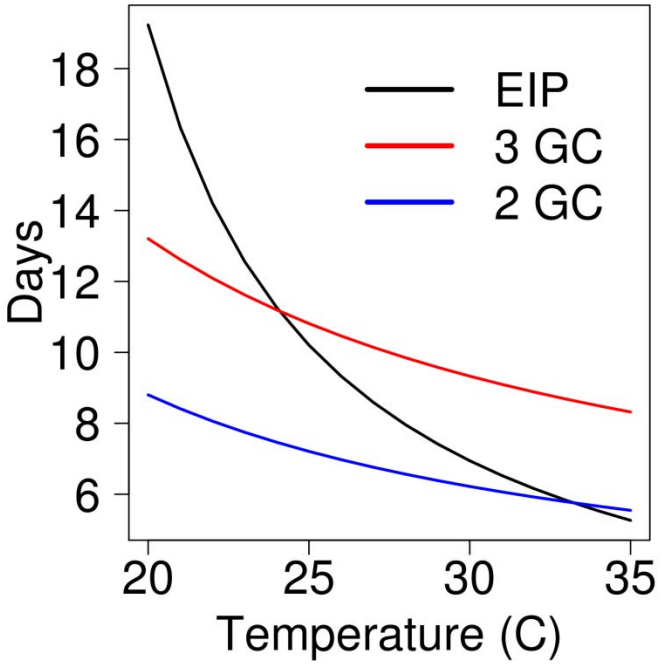




Reisen et al. 2006. JME 43:309

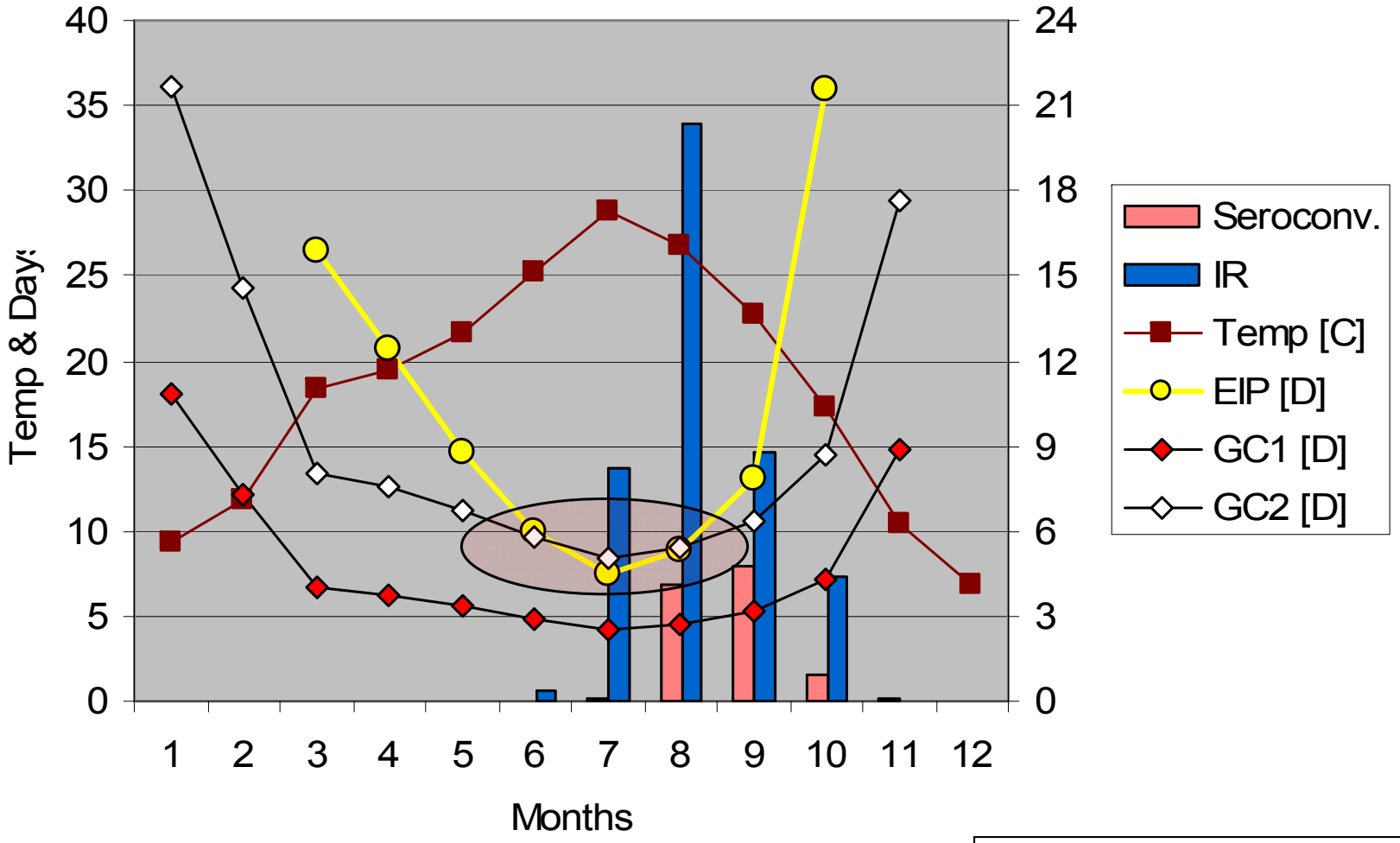
How is temperature related to WNV transmission?

- **Gonotrophic Cycle**
  - Length shortens with ↑ temperature
  - Affects rate of population growth & frequency of contact between mosquitoes and hosts
- **Extrinsic Incubation Period**
  - Time from mosquito infection → potential transmission
- For WNV, EIP declines at faster rate than GC with ↑ temperature, so interplay affects transmission
- BT [bites per transmission] = GC/EIP



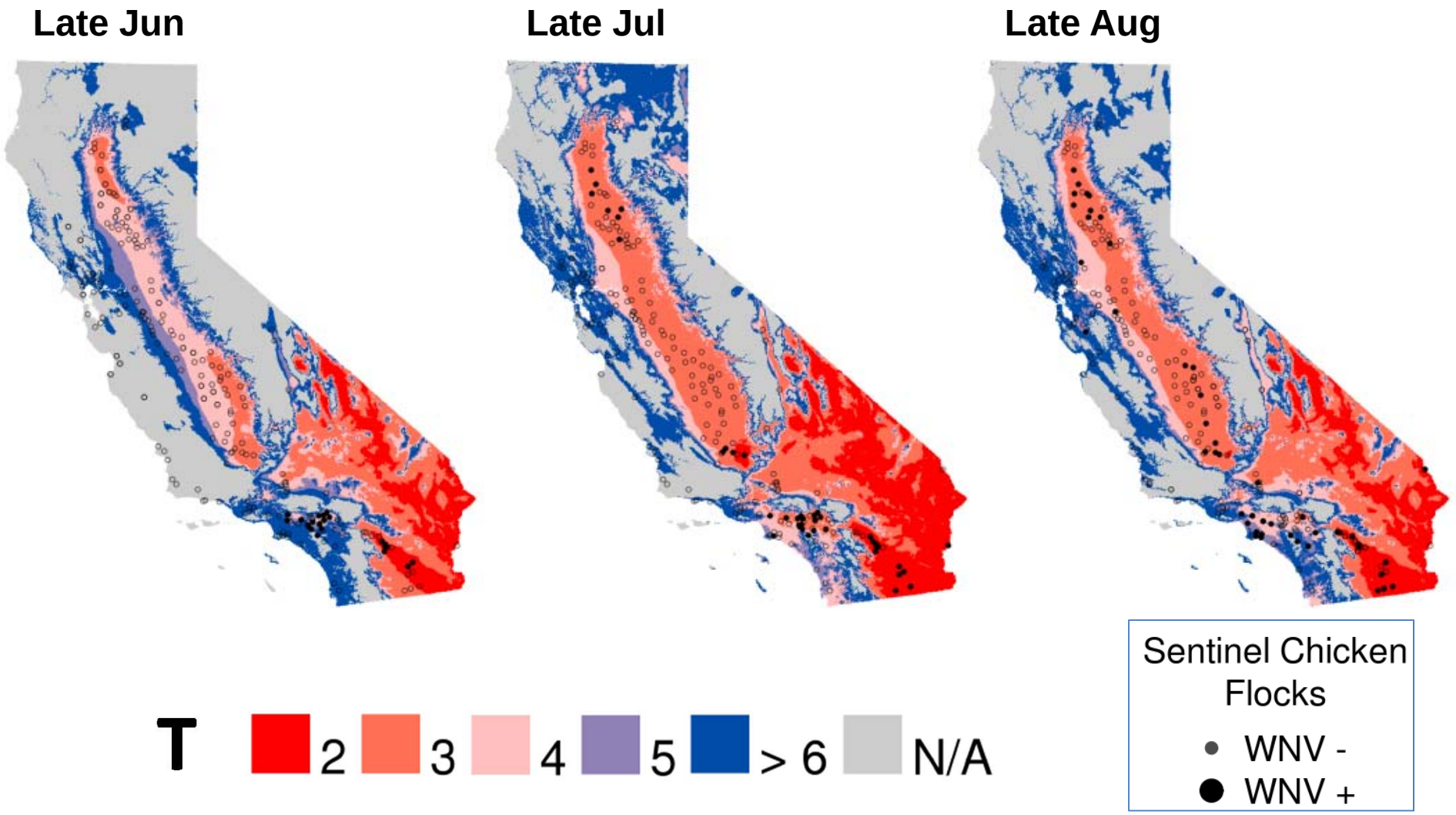
Reisen et al 1992 *JME*
Reisen et al 2006 *JME*

Dynamics of West Nile virus, Kern Co, 2004
Transmission: Temp >25C, EIP<10d, BT = 2

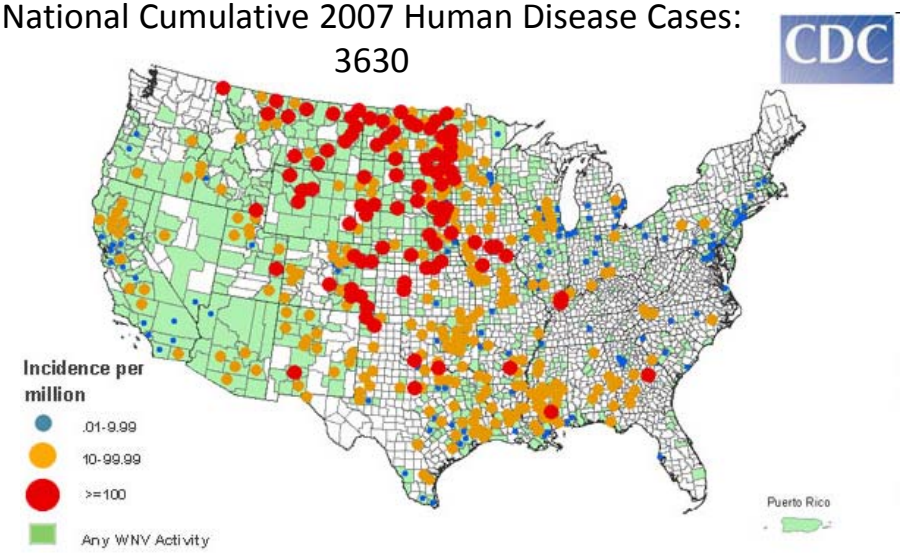


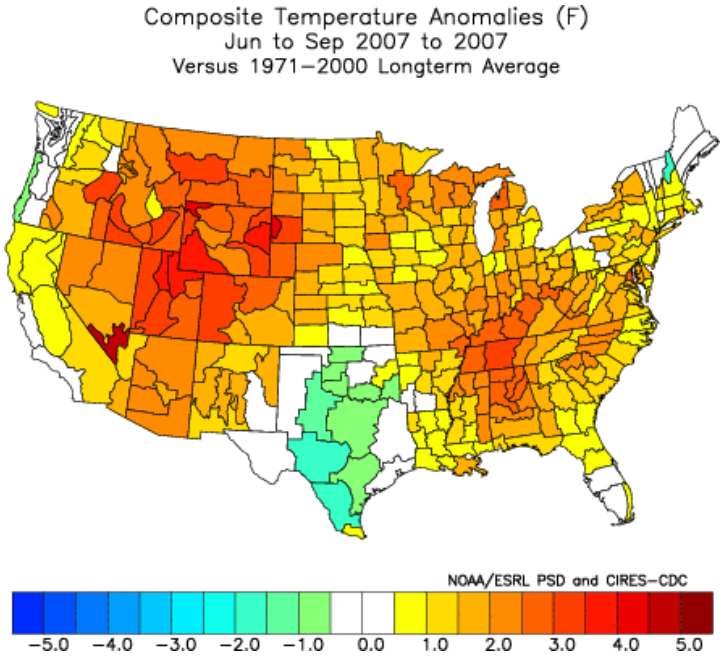
Reisen et al. 2006. JME 43:309

BT = EIP/GC or bites required for transmission during WNV introduction, 2004

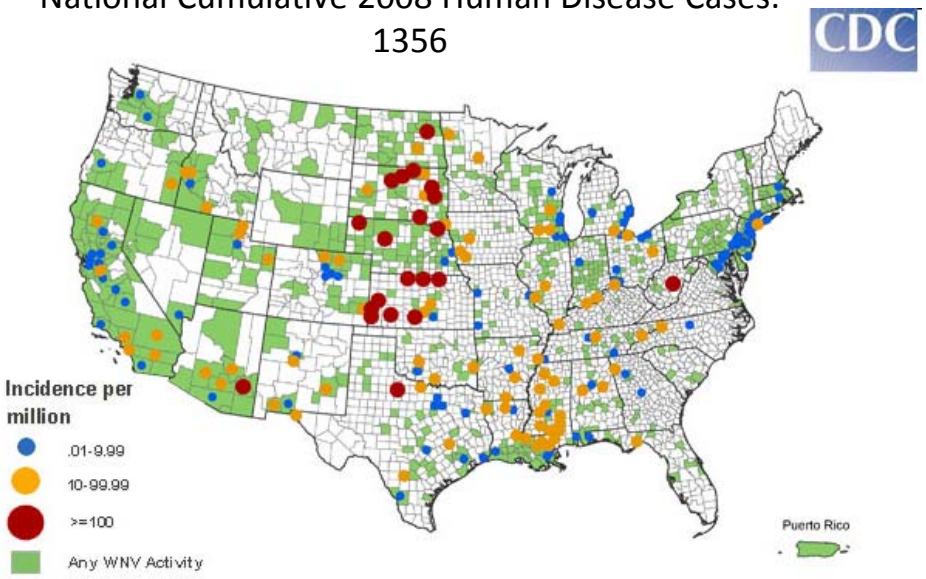


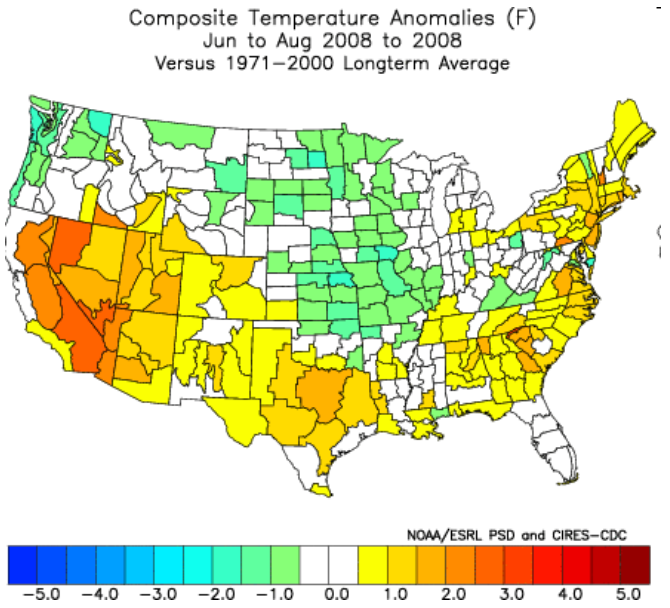
National Cumulative 2007 Human Disease Cases: 3630

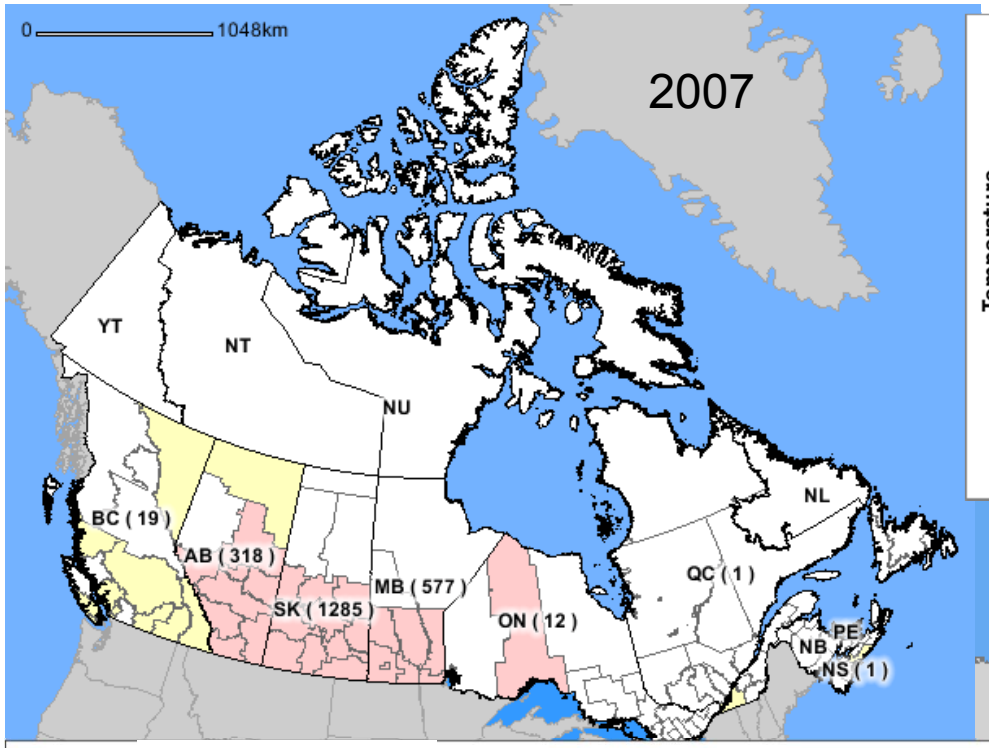


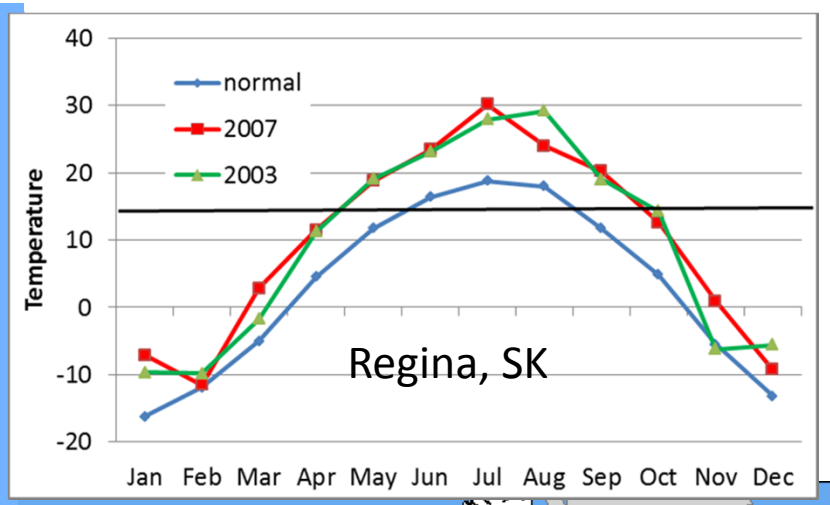


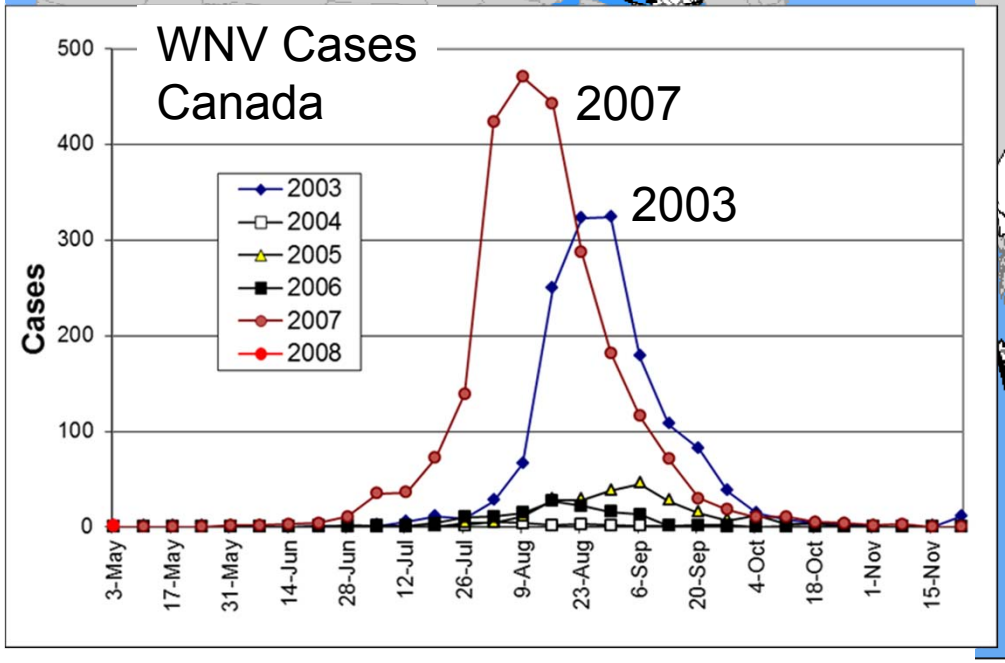
National Cumulative 2008 Human Disease Cases: 1356






0
1048km
2007
YT
NT
NU
BC (19)
AB (318)
SK (1285)
MB (577)
ON (12)
QC (1)
NL
PE
NB
NS (1)

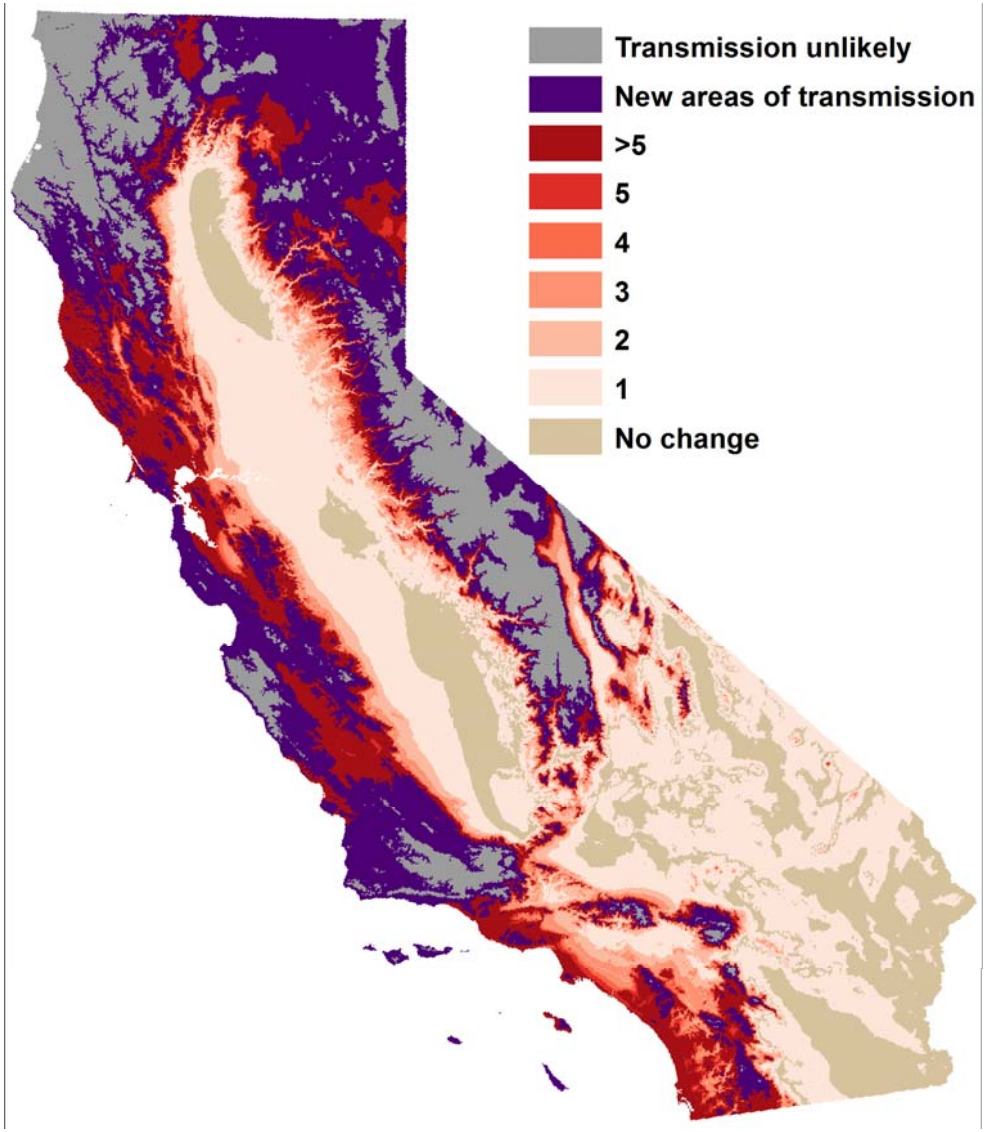

normal
2007
2003
Temperature
40
30
20
10
0
-10
-20
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Regina, SK


WNV Cases
Canada
2007
2003
2003
2004
2005
2006
2007
2008
Cases
500
400
300
200
100
0
3-May
17-May
31-May
14-Jun
28-Jun
12-Jul
26-Jul
9-Aug
23-Aug
6-Sep
20-Sep
4-Oct
18-Oct
1-Nov
15-Nov

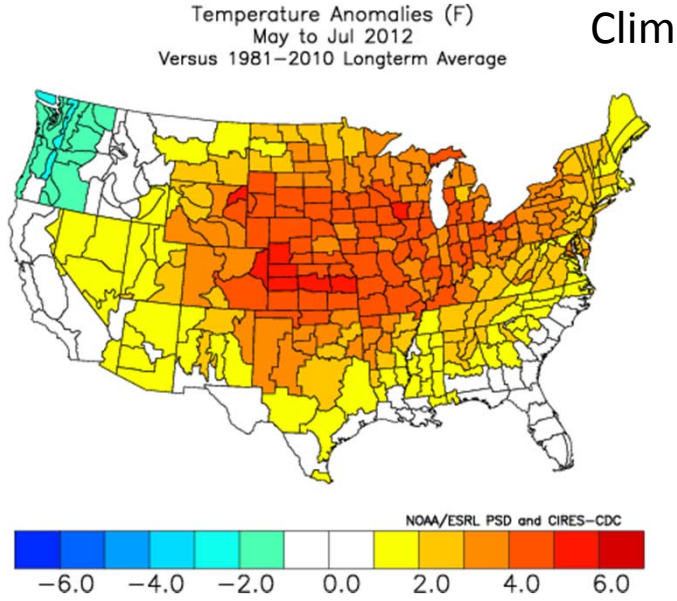

2008
YT
NT
NU
BC
AB
SK
MB
ON
QC
NL
PEI
NB
NS

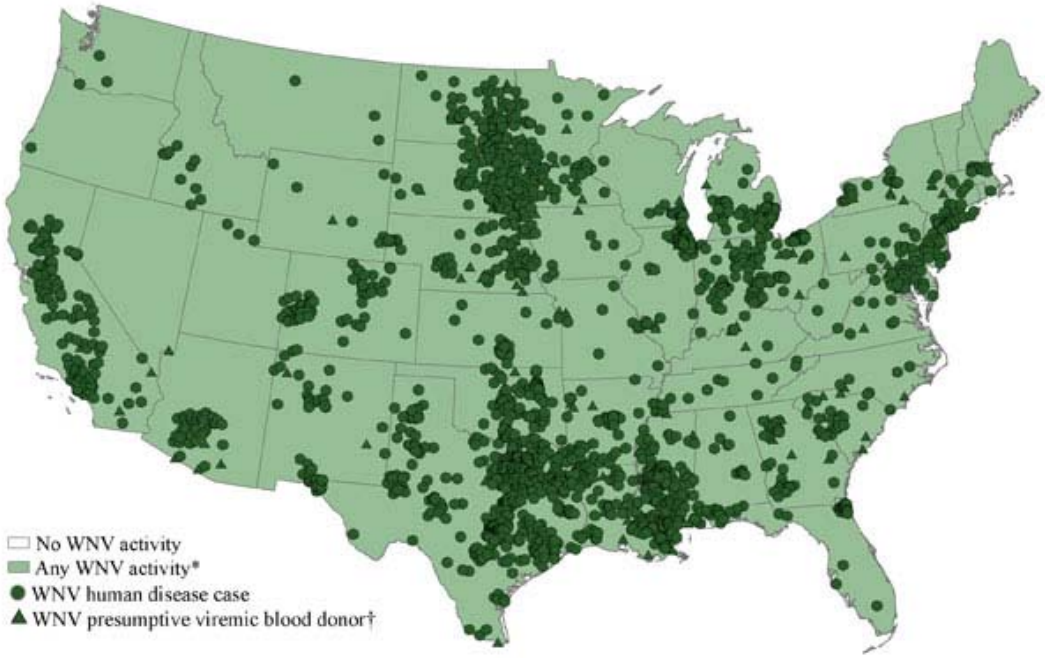
BT = EIP/GC (# bites for transmission) with 50 y climate change

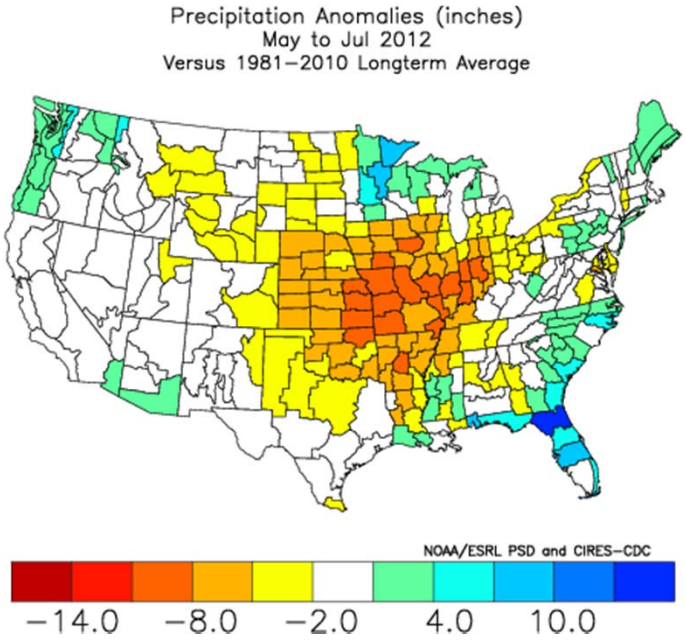
- Greatest 50 y impact is expected in SF Bay Area, coastal southern CA where human population densities are high
- Little change in the warmest areas of the state

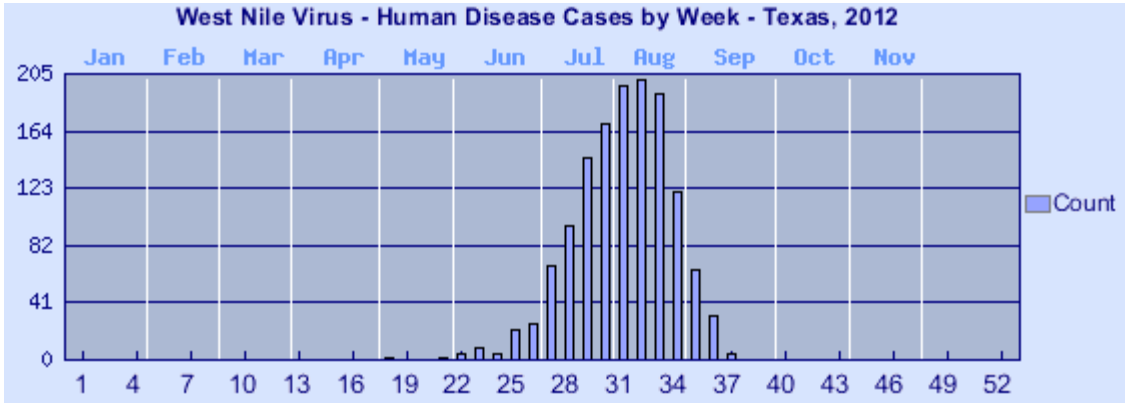


Climate anomalies and WNV cases for 2012







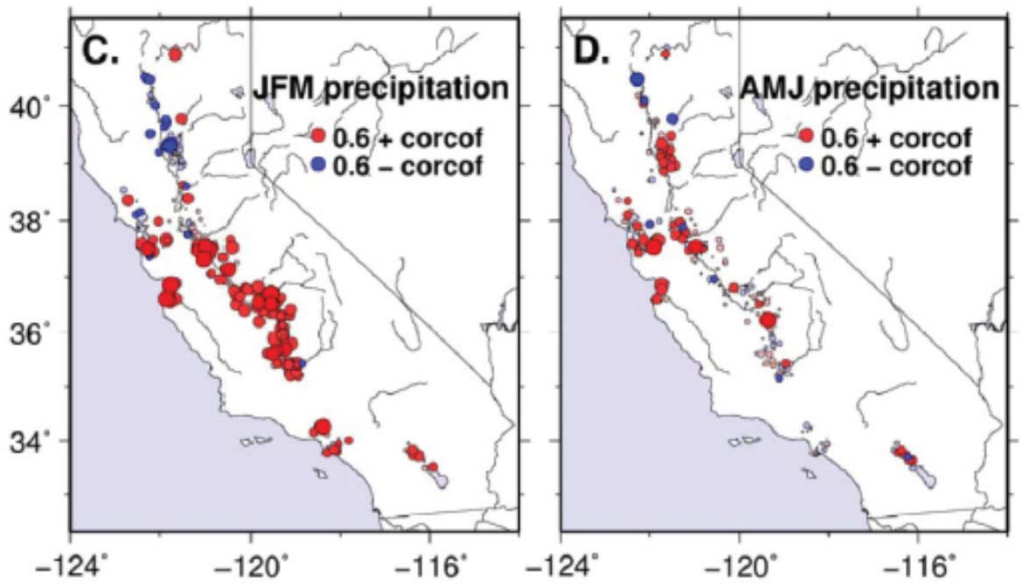


Cases as of 25 Sep 12: Texas epicenter = 1,355
National wide = 3,539 [Kansas = 30]

Variable effects of water
Too much vs Too little

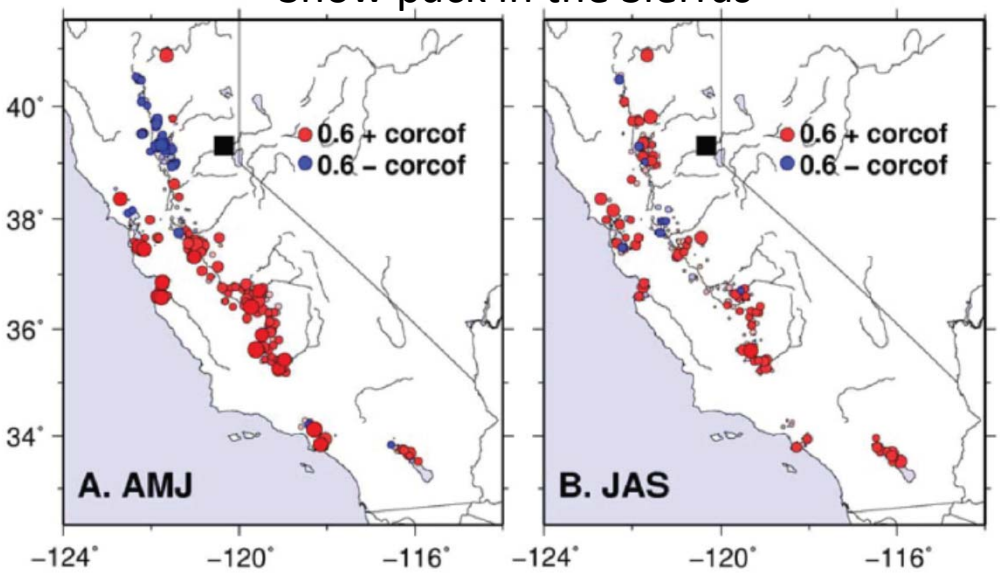
- Floods:
  - Reduces edge effect
  - Washout larvae
  - Scour waste water systems
- Drought:
  - Dries wetlands
  - Channels riparian systems
  - Increases irrigation: urban curb drizzle increases waste water system production.

Winter rainfall



Variable Effects of Rainfall*:*
Culex tarsalis abundance at 282 sites from 1950 to 2000.
C. Abundance during spring vs rain during winter.
D. Abundance during summer vs rain during spring.

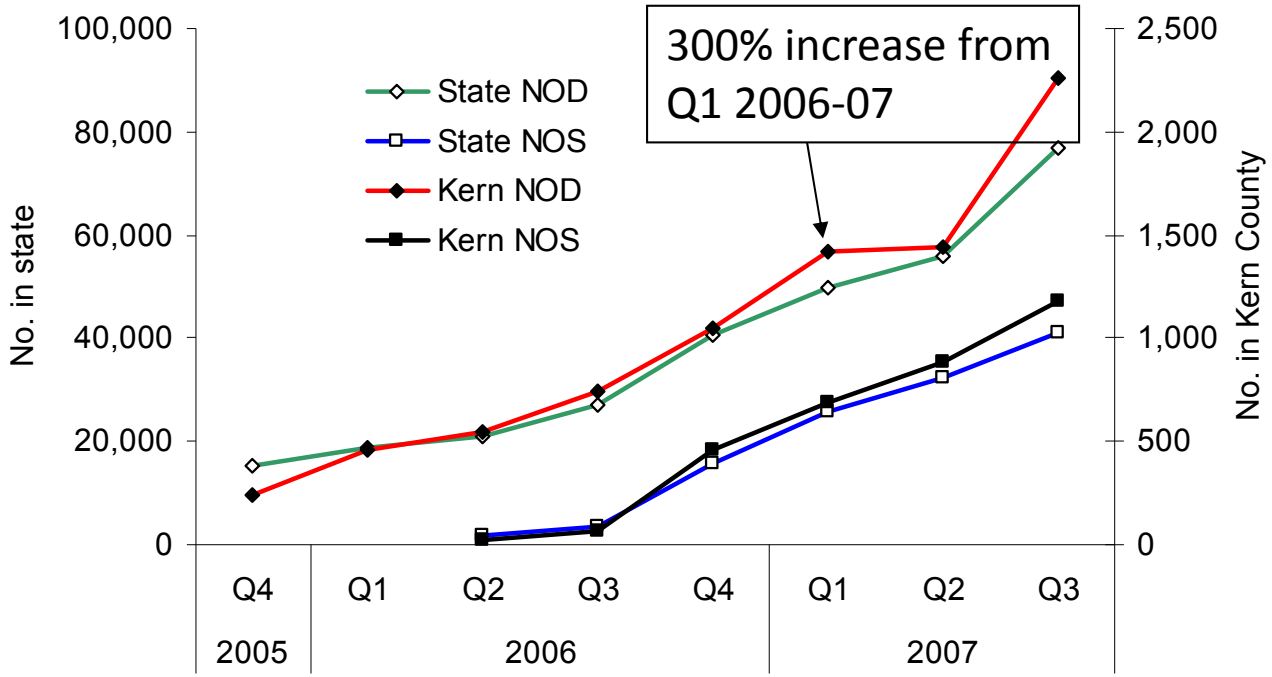
Snow pack in the Sierras



Culex tarsalis abundance from 1950 to 2000 during A) spring and B) summer vs. 1 Apr snow water equivalents at Donner summit.

ANTHROPOGENIC FACTORS: ADJUSTABLE RATE MORTGAGES AND HOUSING MARKET DECLINE

Notice of sale [NOS] and notice of delinquency rates in Kern County by quarter [Q] accompanied a 300% increase in human cases [57 in 2006 to 177 in 2007]



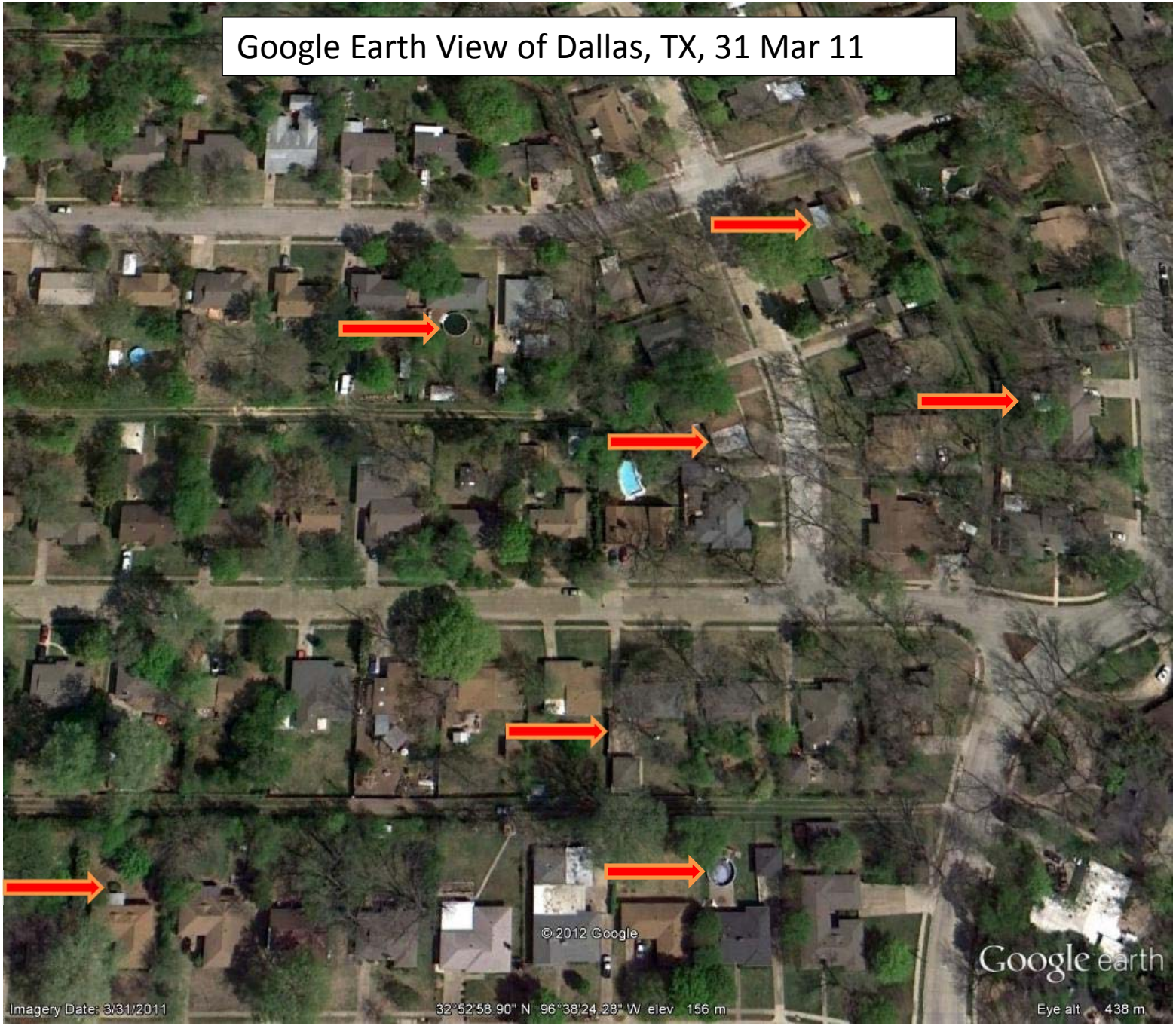
Reisen et al. 2008. EID 14: 1747

Adjustable rate mortgages ⟶ Abandoned houses
⟶ Neglected swimming pools

[http://www.zimbio.com/pictures/9Ot5CzQhAz9/Mosquitoes+Infest+Dormant+Pools+Foreclosed/45HmzCb6fTQ]

Bakersfield, 2007

Reisen et al. 2008. EID


Google Earth View of Dallas, TX, 31 Mar 11
© 2012 Google
Google earth
Imagery Date: 3/31/2011
32°52'58.90" N 96°38'24.28" W elev 156 m
Eye alt 438 m

Summary

- WNV is now endemic to NA
- 2012 showed WNV has the ability for widespread resurgence whenever conditions are conducive for amplification
- Effective mosquito control directed by surveillance science currently is the only public health intervention
- Warming will increase 1) the geographic distribution of the virus, 2) the length of the transmission season, and 3) the rate of virus amplification facilitating outbreaks
- Timely enzootic surveillance and human diagnostics will be necessary for risk recognition and timely intervention
- WNV will not be the last arbovirus to invade the USA; likely suspects include CHIKV, JEV and RRV from Asia, RVFV from Africa, SINDV from Europe, DENV and others from the Neotropics. Therefore, a vigilant diagnostic laboratory must not only provide rapid data for decision support, but also be able to detect new problems before they become established.