Current Status of Mosquito-Borne Viruses in North America

John D. Edman

Mosquito-Borne Virus Threats to Humans In North America

- Togaviridae (genus Alphavirus)
  - Eastern equine encephalitis virus **
  - Western equine encephalitis virus **
  - Venezuelan equine encphalitis virus **
- Bunyaviridae
  - California encephalitis viruses (La Crosse, etc.)
- Flaviviridae
  - West Nile virus **
  - St Louis encephalitis virus
  - Dengue viruses

**Virus that also effect horses

Some Generalizations

All mosquito-borne human arboviral diseases are zoonotic and occur naturally in non-human vertebrate hosts, often without visible symptoms. Humans and horses are generally dead-end hosts.

Human infections vary from inapparent to flu-like symptoms to severe neurological, paralytic or hemorrhagic symptoms (some residual) & death. Infection results in life-long immunity.

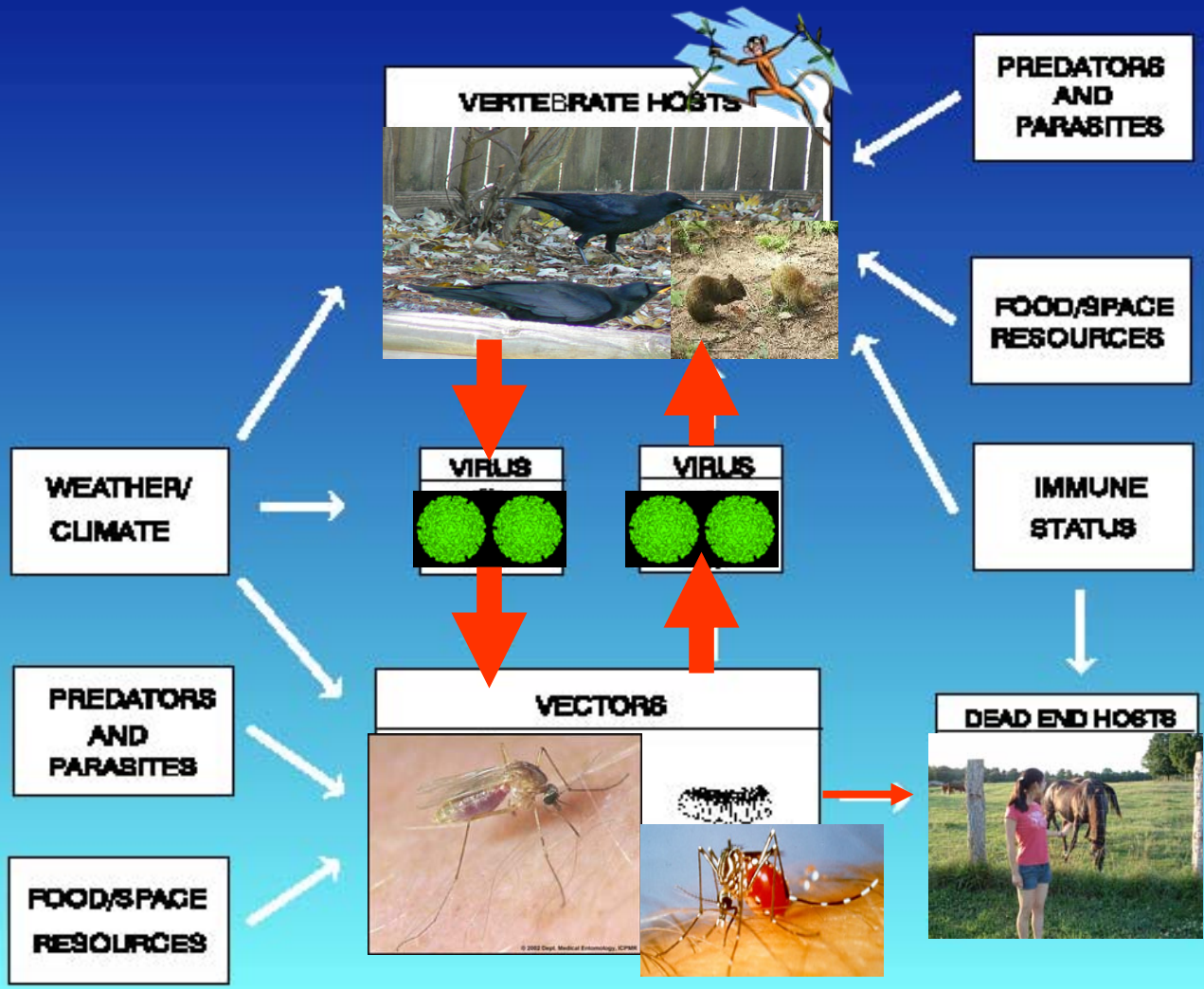
Symptoms in humans & horses occur ~3-10 days (usually 6-7 d) after the infected mosquito bite, etc. Old or young people are most affected. Horse mortality (>50%) is higher than in humans (<1-~25%)

None of the arboviruses can be cycled or maintained in humans except for the dengue viruses. VEE can briefly cycle in horses but is not maintained in horses.

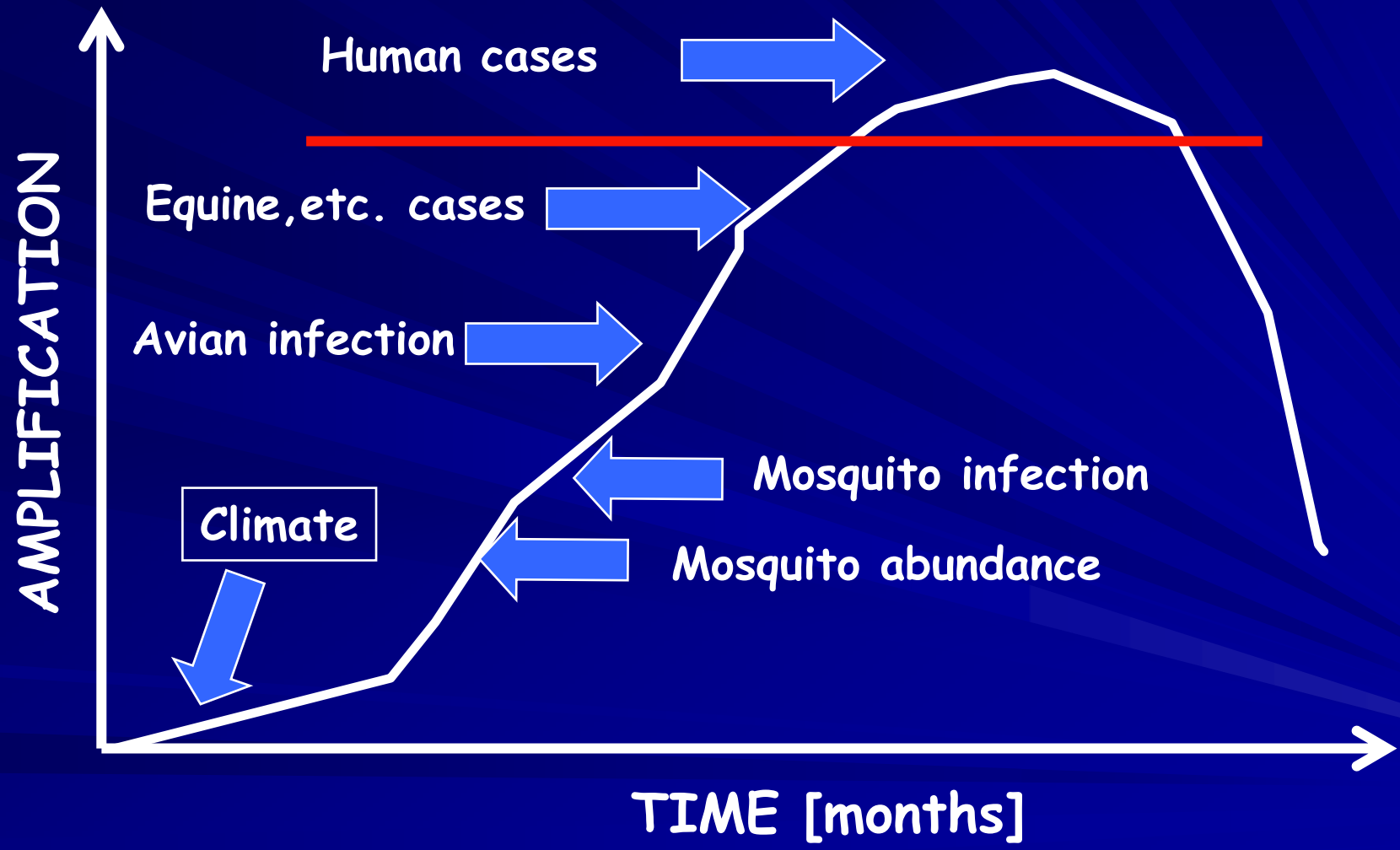
There are currently no licensed vaccines to protect humans against any of these viral disease. Horses vaccines exist for EEE, VEE, WEE, WN.

Good surveillance together with appropriate protective and vector control measures is currently the only public health strategy for avoiding severe outbreaks of arboviral diseases in humans.

Components in the Transmission and Maintenance of Arboviral Encephalitis



Surveillance Indicators Along Virus Amplification or Epidemic Curve



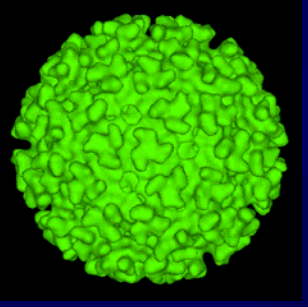
Mosquito Surveillance

Captive Bird Surveillance

Reservoir Hosts and Vectors

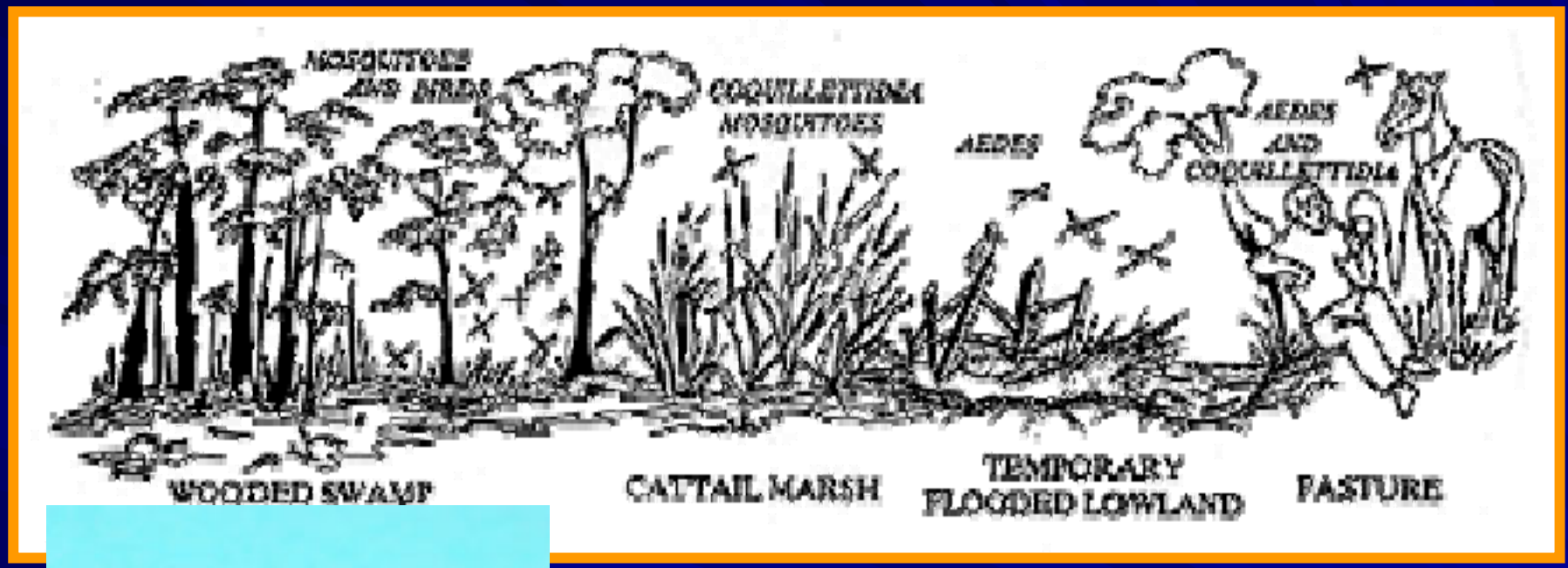
DISEASE	SYLVAN HOST	SYLVAN VECTOR	HORSE*/HUMAN VECTOR
EEE	Birds	*Cs. melanura*	*Aedes, Coquillettidia*
WEE	Birds	*Cx. tarsalis*	*Cx. tarsalis**
VEE	Rodents	*Cx. (Melan.)*	*Aedes, Psorophora*
CE/LAC	Chipmunk Tree squirrels	*Ae. triseriatus*	*Ae. triseriatus**
SLE	Birds	*Culex* spp.	*Culex* spp.*
WNV	Birds	*Culex* spp.	*Culex* spp.*
DEN	Wild Primates	Forest *Aedes*	*Ae. aegypti* *Ae. albopictus*

* No bridge vector required



Togaviridae

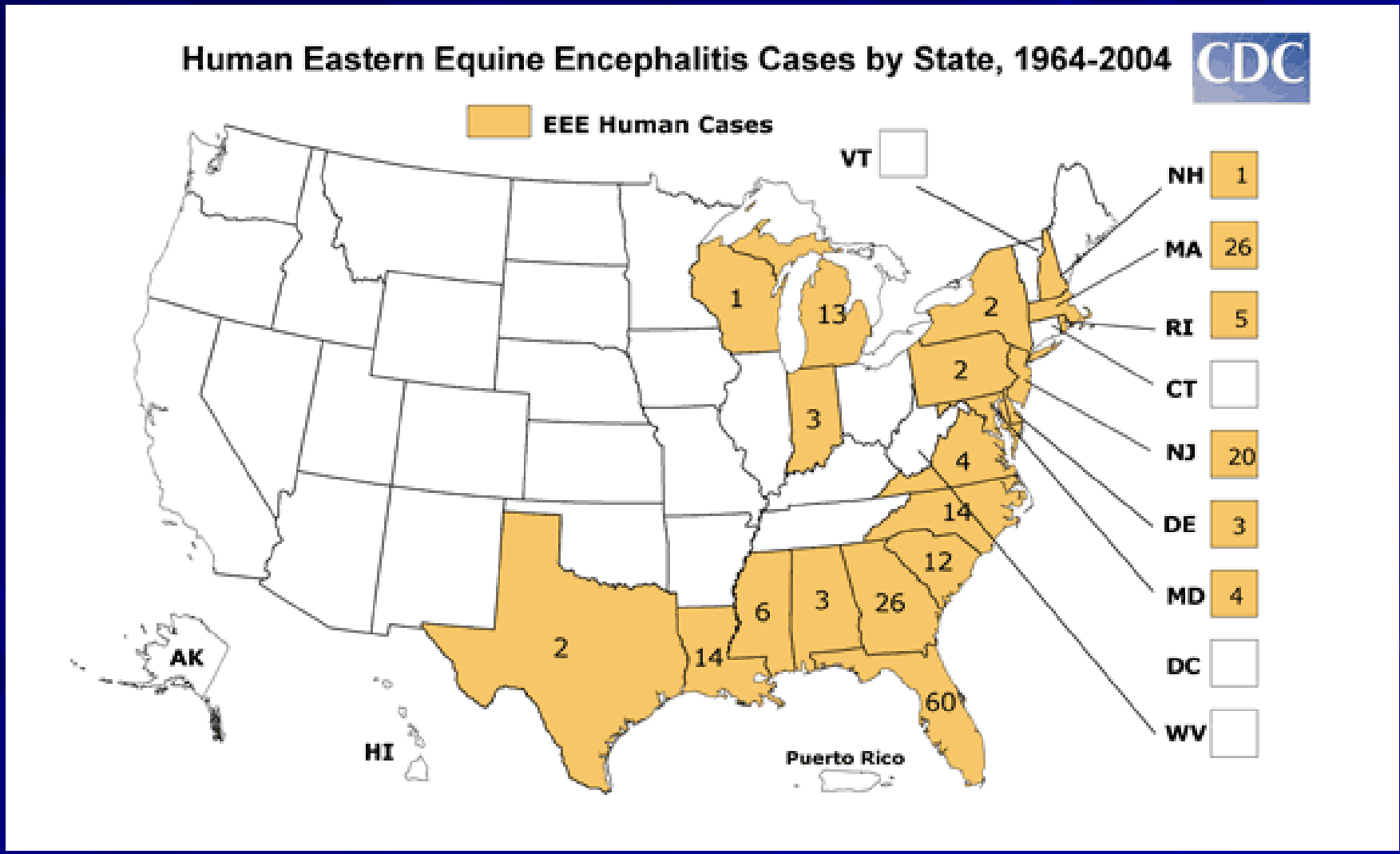
- Eastern equine encephalitis
- Western equine encephalitis
- Venezuelan equine encphalitis



Culiseta melanura

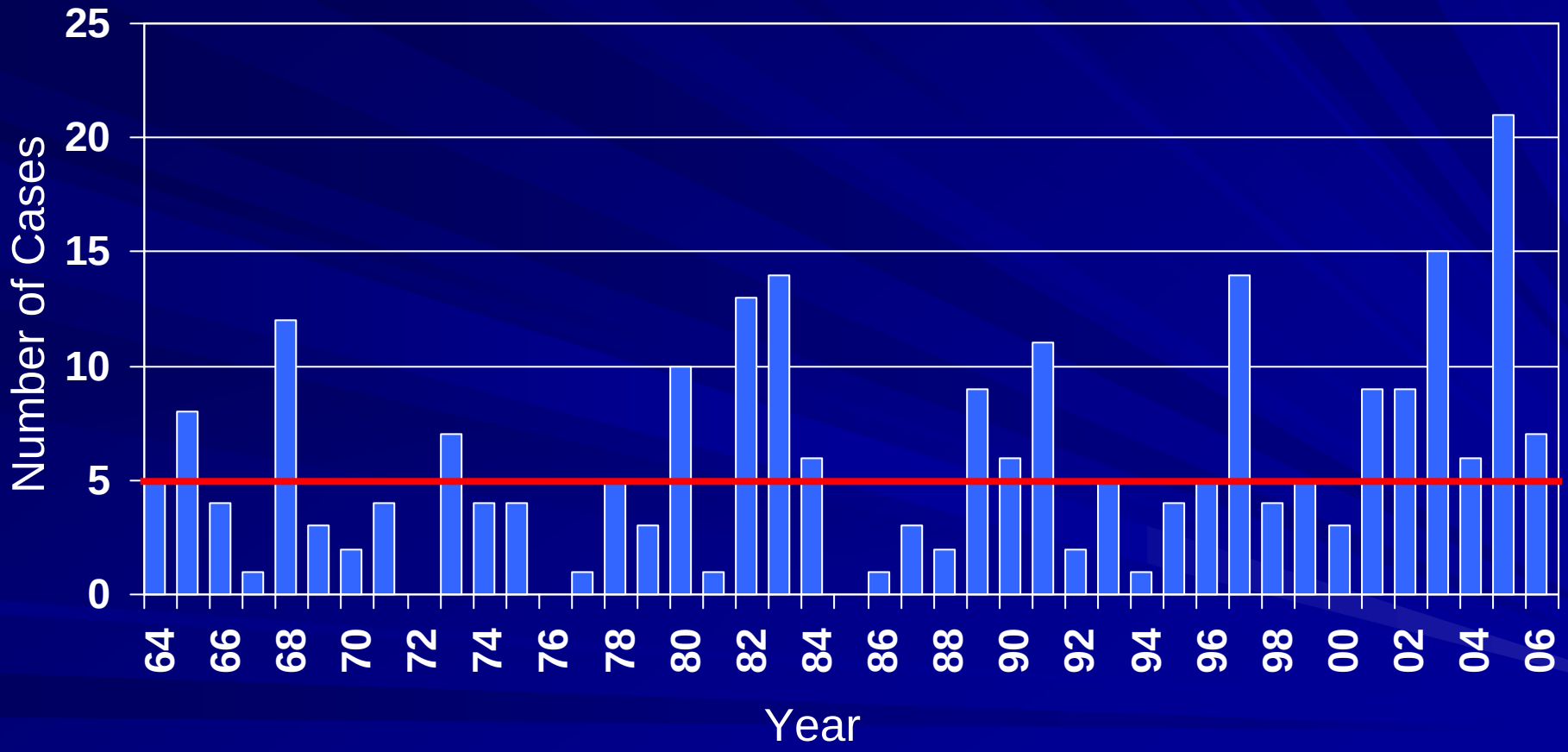
EEE Epidemiology

Distribution of Human Cases of EEE



Eastern Equine Encephalitis

Total Cases in U.S. 1964-2006



Reported Human Cases
Average = 5/year; Range = 0-21

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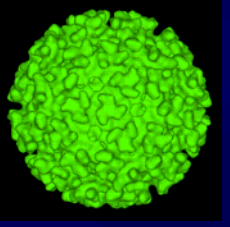
Confirmed & Probable Eastern Equine Encephalitis - All States

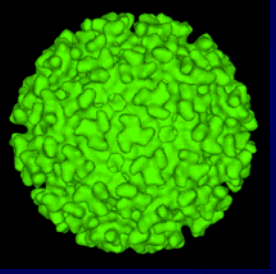
Human Cases - 1986-2005

1986-90	1991-95	1996-00	2001-05
21	23	31	60



EEE Summary

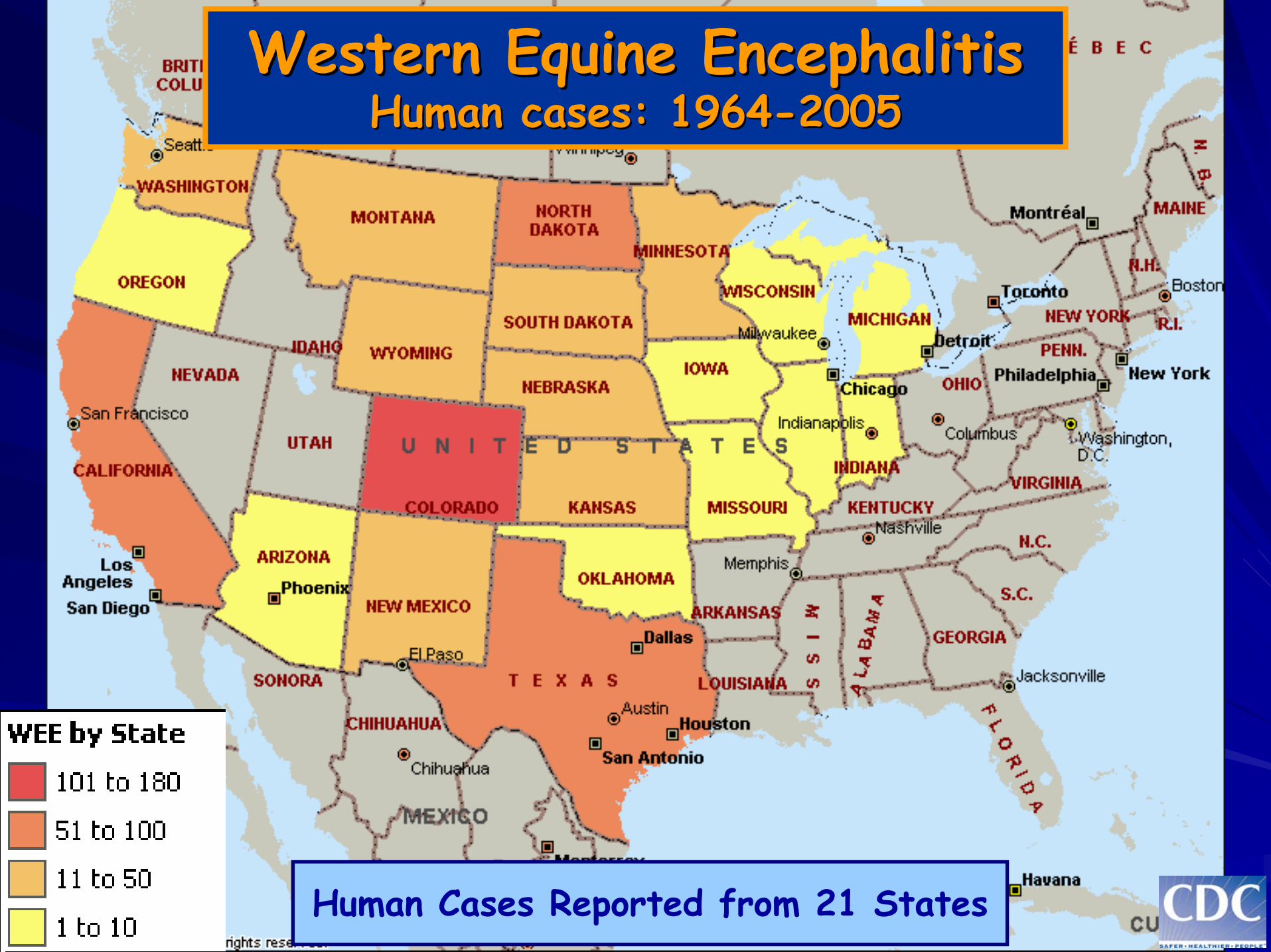
- Severe but rare neurological disease of humans (usually children), horses & non-native birds in Eastern U.S. & Great Lakes region.
- Incidence increasing due to human encroachment?
- Enzootic maintenance cycle in wetland forest birds.
- Overwintering of virus unresolved (birds, mosquitoes, other?).
- Different vectors in avian & human/horse transmission (*Cs melanura* verses *Aedes* spp, *Cq perterbans, Cx nigripalpus*).
- Difficult to do mosquito source reduction & chemical treatment in valued wetlands, so surveillance is critical.
- Zoning to avoid development near wetlands.



Togaviridae

- Eastern equine encephalitis
- **Western equine encephalitis**
- Venezuelan equine encphalitis

Western Equine Encephalitis
Human cases: 1964-2005



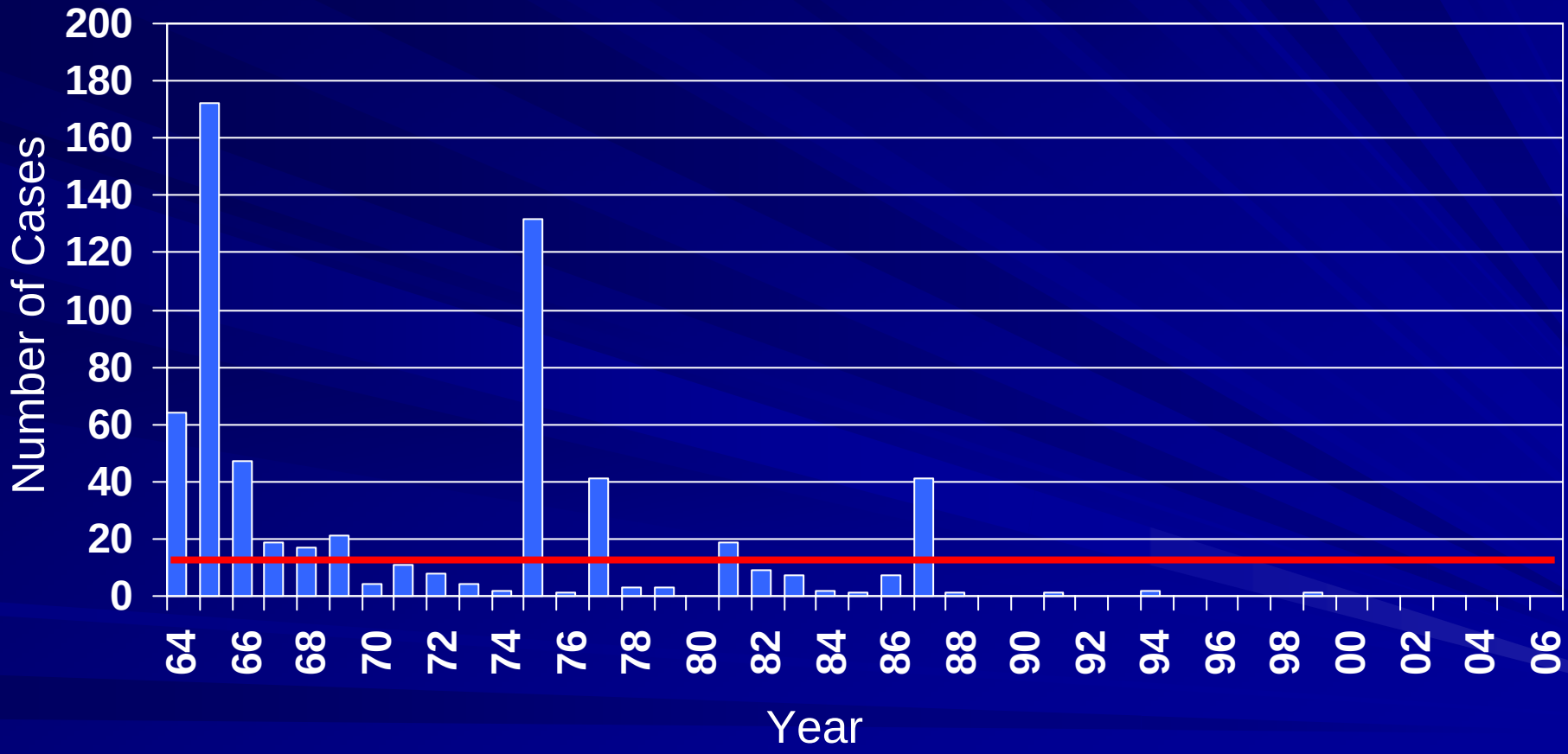
WEE by State

- 101 to 180
- 51 to 100
- 11 to 50
- 1 to 10

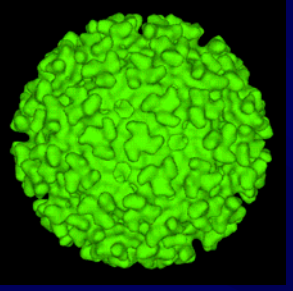
Human Cases Reported from 21 States

CDC

Western Equine Encephalitis
Total Cases in U.S. 1964-2006

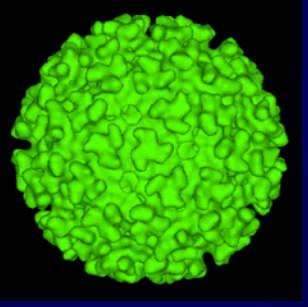


Reported Human Cases
Average = 15/year; Range = 0-172



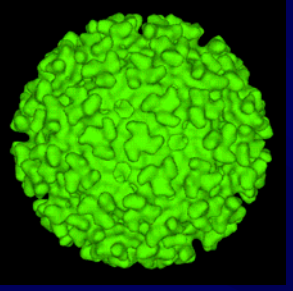
WEE Summary

- Serious but rare nerological disease of humans and horses in the central and northern Great Plains and irrigated valleys in the West, including Southern California.
- Less human mortality than EEE; no cases recently.
- Natural cycle in wild birds; commonly the more domesticated species.
- *Cx tarsalis* is the main vector to both avians and horses/humans but also *Aedes* spp in some areas.
- Overwintering mechanism unknown (TOT?).



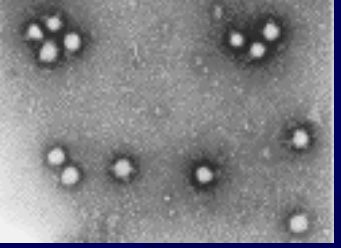
Togaviridae

- Eastern equine encephalitis
- Western equine encephalitis
- **Venezuelan equine encephalitis**



VEE Summary

- Serious equine & mild human neurological disease in South and Central America that occasionally invades Mexico and U.S. border areas (last time was 1971).
- Both enzootic and epizootic/epidemic strains exist but enzootic strains do not cause disease.
- Maintained by forest rodents and *Culex* (*Melanoconion*) mosquitoes.
- Epidemic transmission by flood-water *Aedes* and *Psorophora* spp. Sick horses have extremely high viremias and can infect mosquitoes.

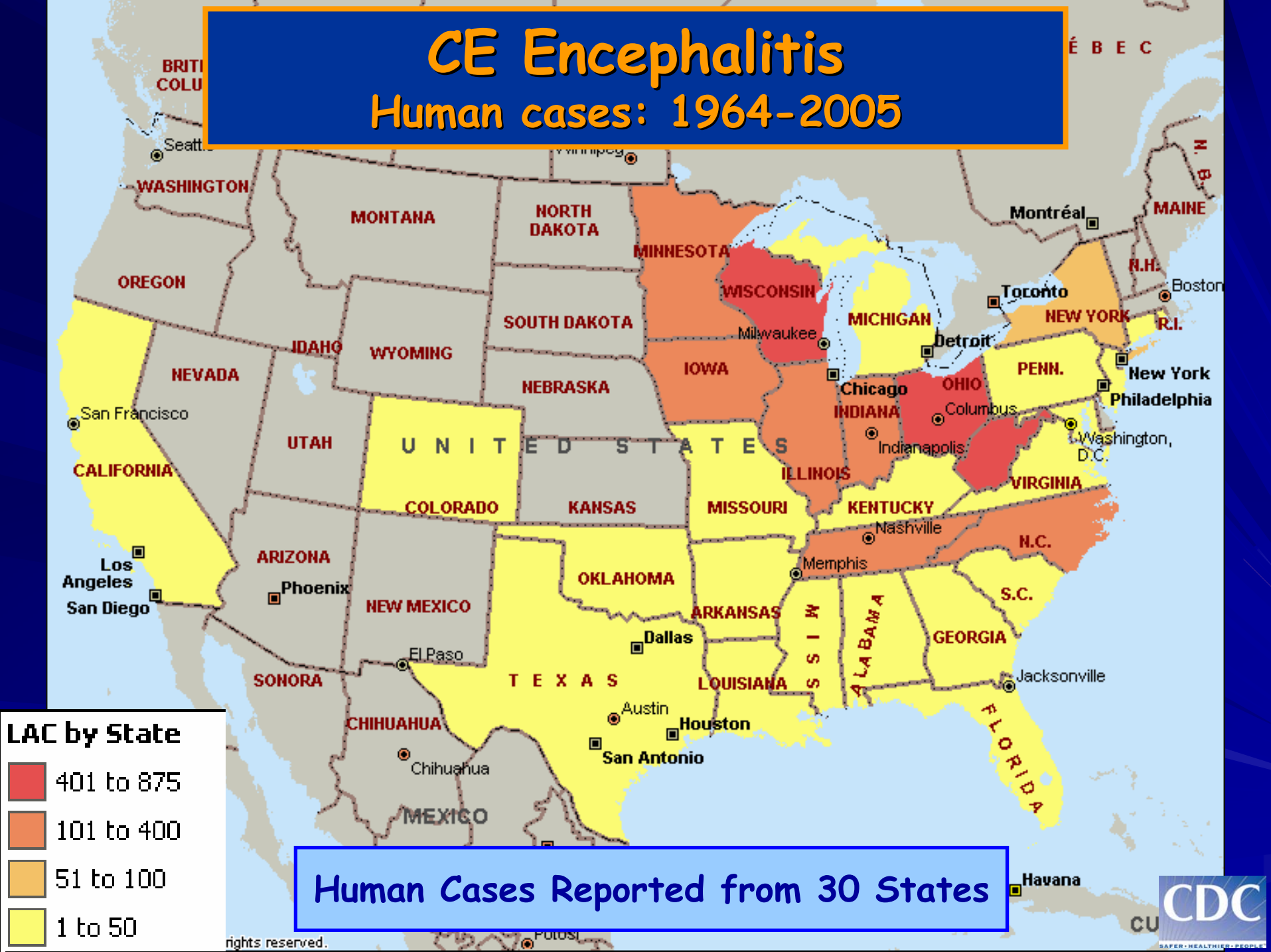


Bunyaviridae

- California Group viruses
  - LaCrosse encephalitis virus*
  - California encephalitis virus
  - Jamestown Canyon virus
  - Cache Valley virus, etc.

* Most important

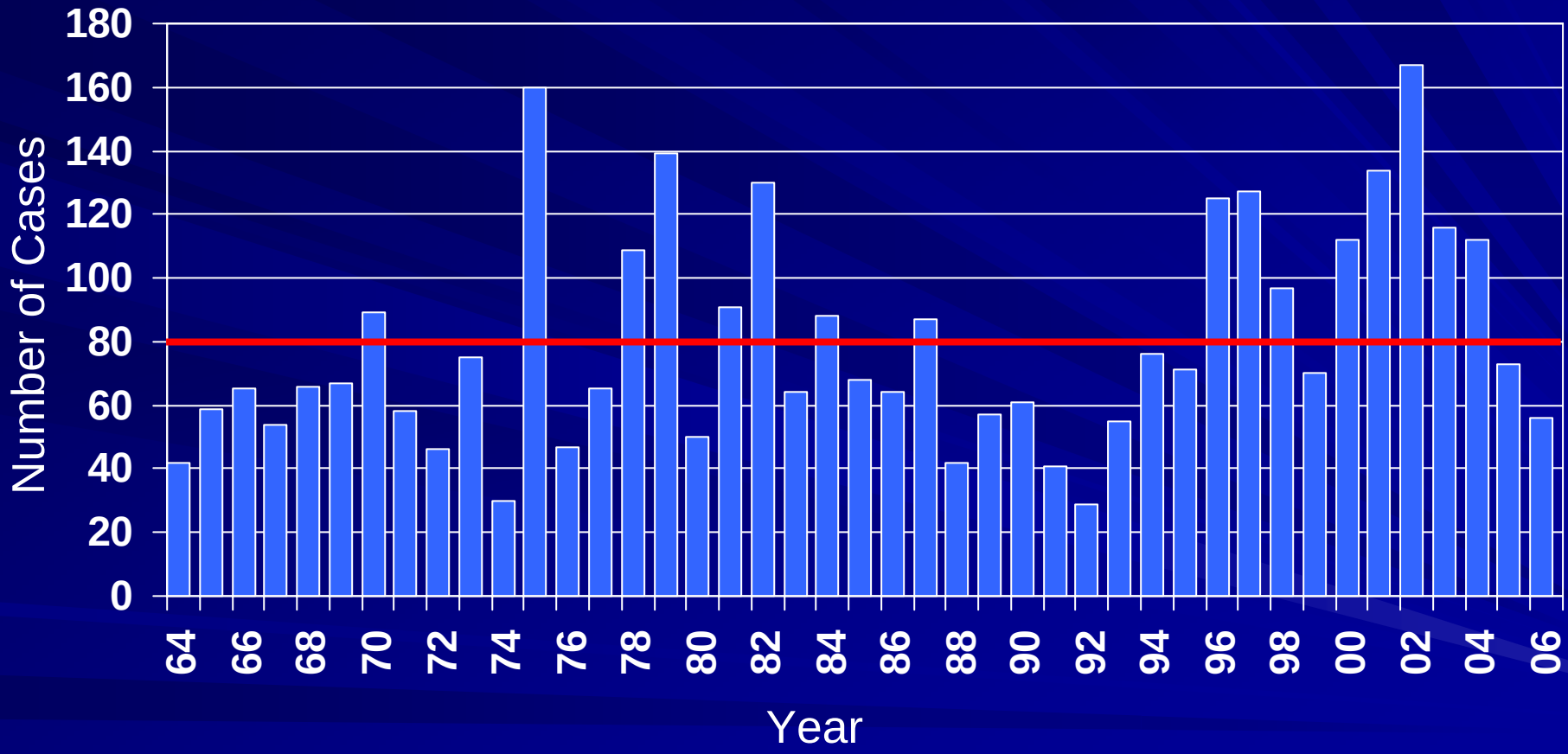
CE Encephalitis
Human cases: 1964-2005



La Crosse Encephalitis

California Encephalitis

Total Cases in U.S. 1964-2006



Reported Human Cases
Average = 80/year; Range = 29-167

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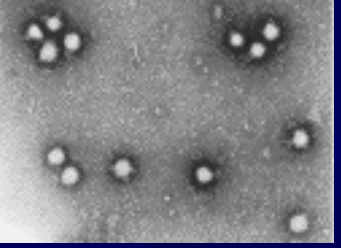
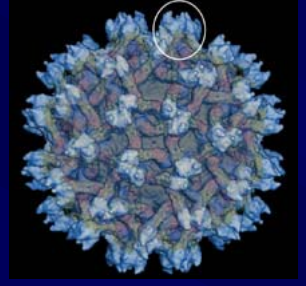


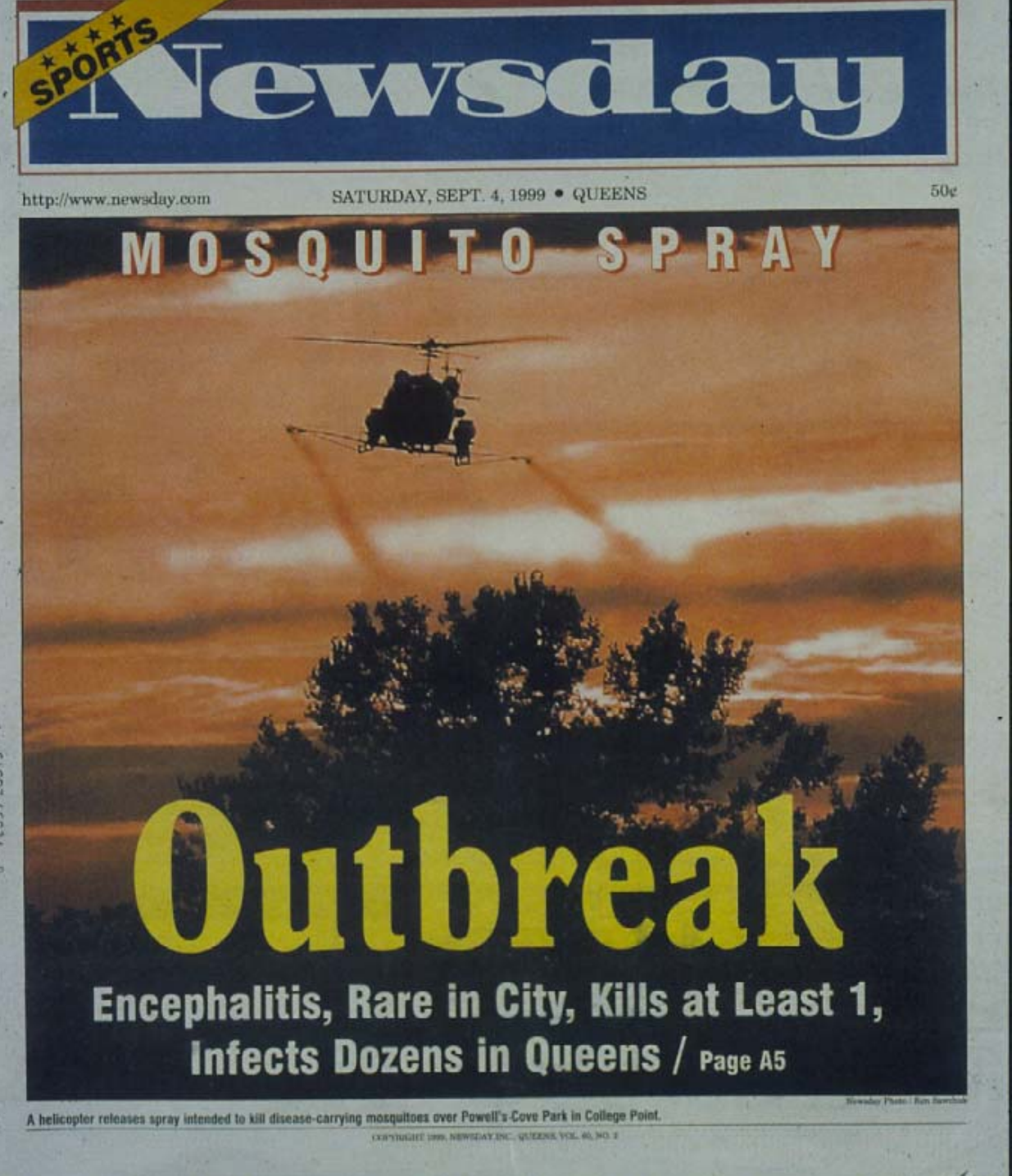
LAC SUMMARY

- Restricted to Eastern half of U.S.; major foci in Upper Midwest & Central Appalachian regions.
- Mainly affects children under 16 years old.
- Naturally cycle in chipmunks & tree squirrels in deciduous hardwood forests.
- Vectored by day-biting treehole mosquito, *Ae triseriatus.*
- Transovarial & venereal transmission in vector (virus over-winters in mosquito eggs).
- Human cases often associated with discarded tires, etc. in shaded areas near homes.
- Tire clean up and filling of tree holes.



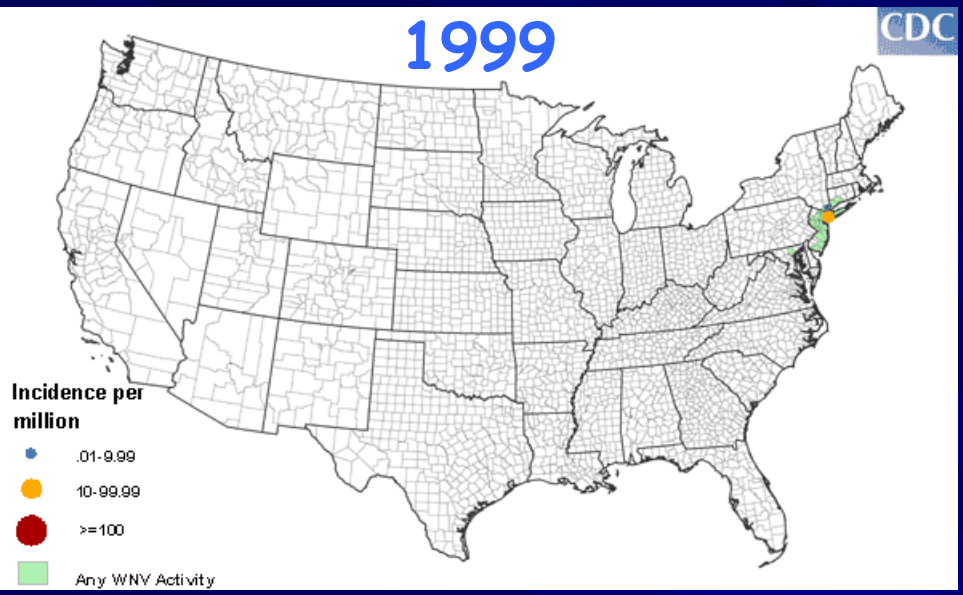
Flaviviridae

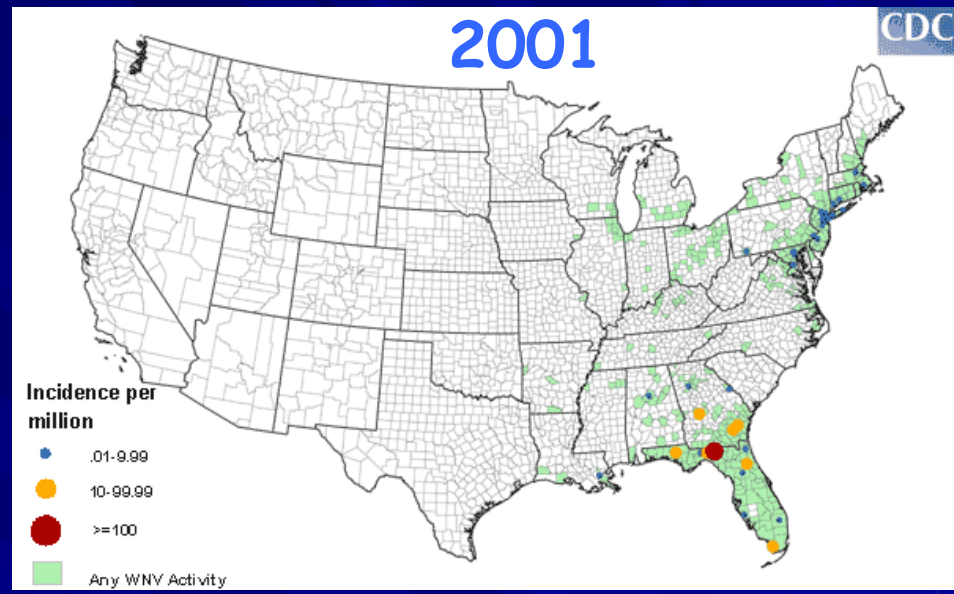
- West Nile fever virus
- St Louis encephalitis virus
- Dengue fever viruses (1, 2, 3, 4)

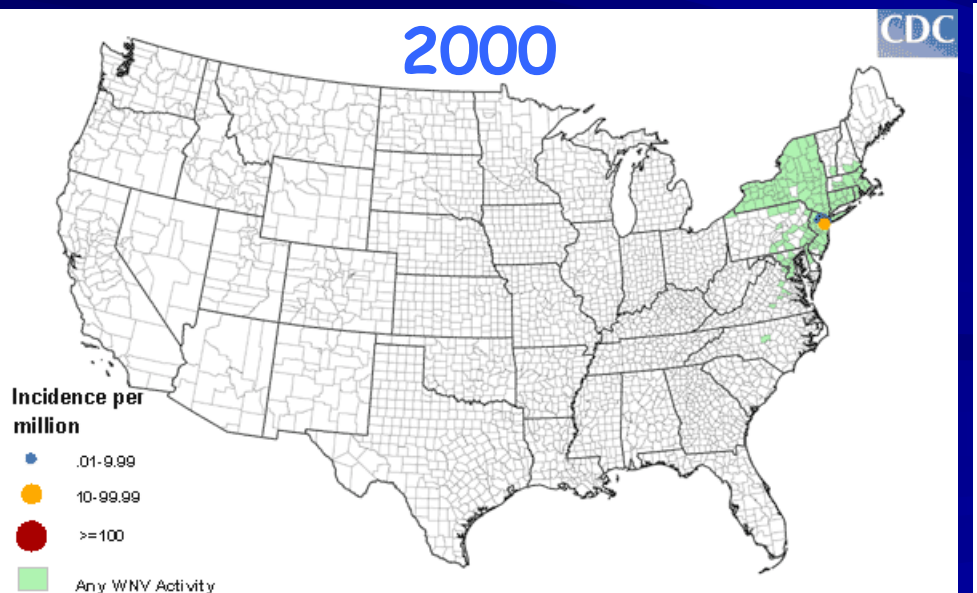


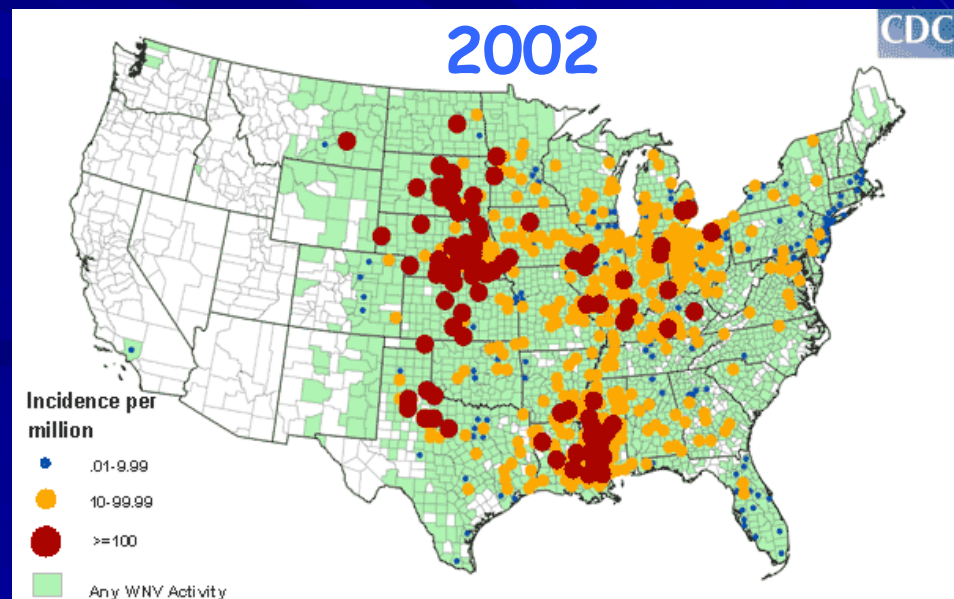
Summer of 1999

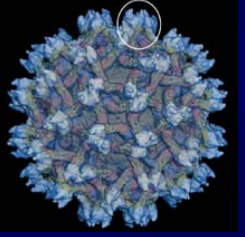
West Nile's Westward Spread



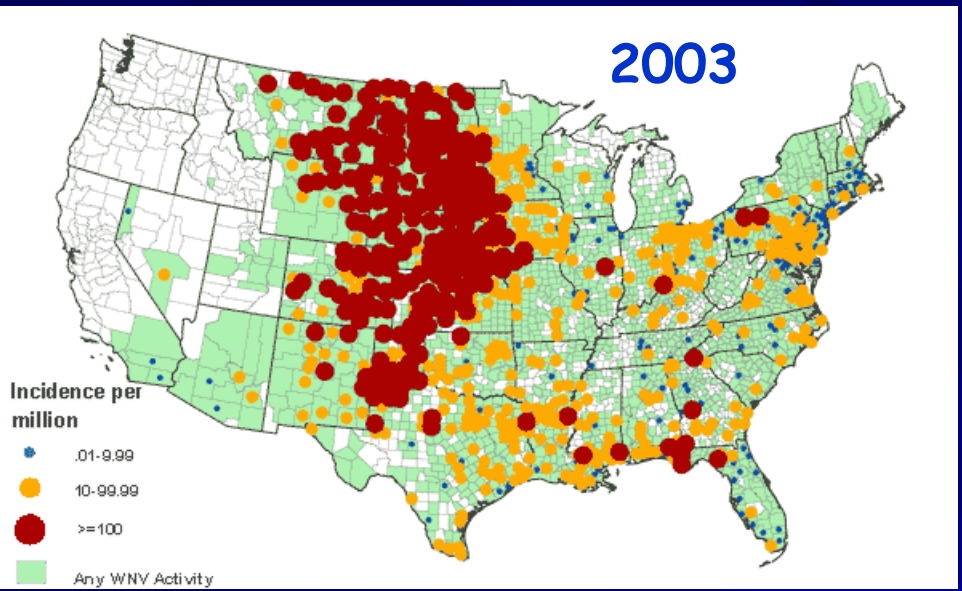


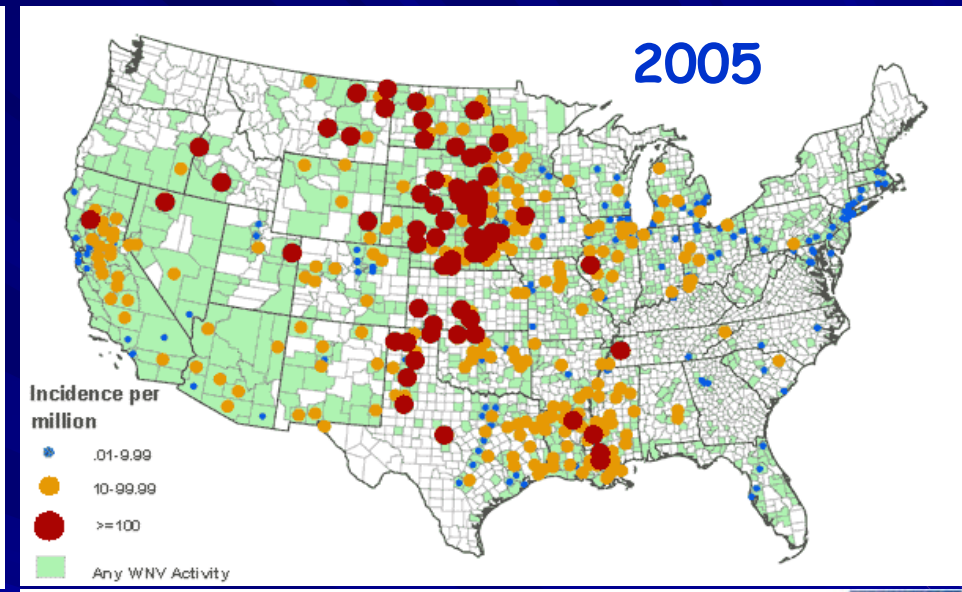


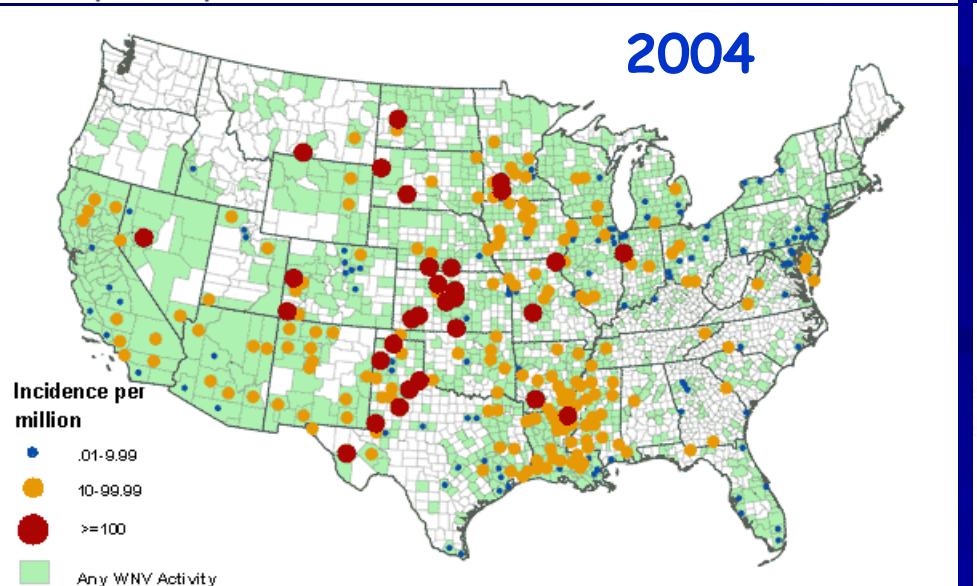


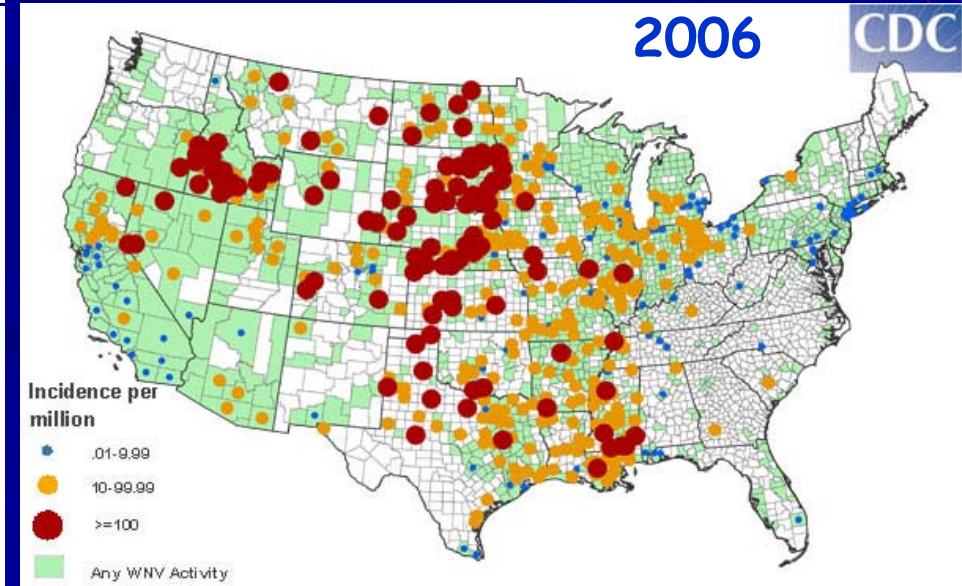


West Nile Spread



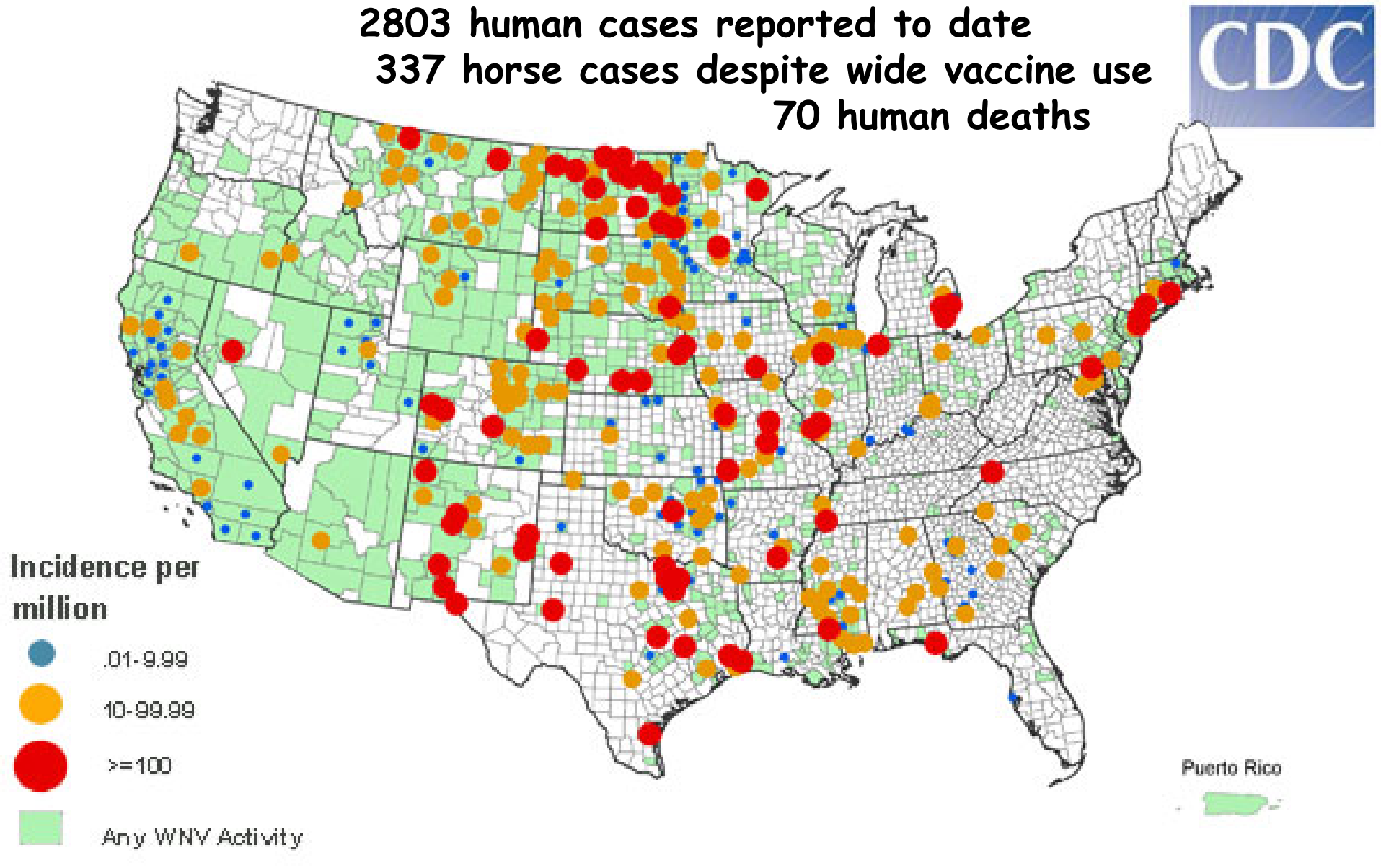






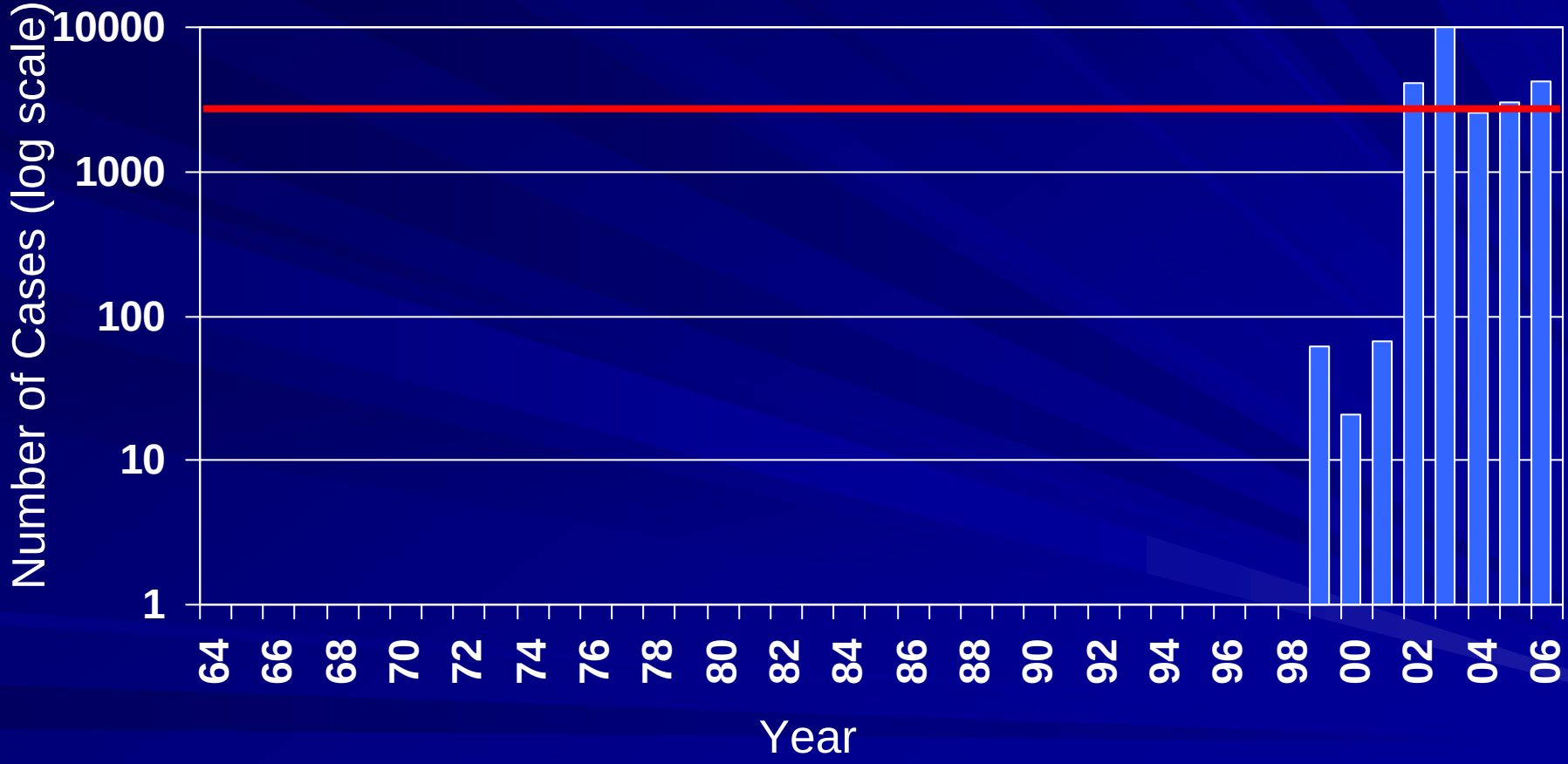
2007 Human Cases as of October 7

2803 human cases reported to date
337 horse cases despite wide vaccine use
70 human deaths



West Nile Virus

Total Cases in U.S. 1999-2006



Reported Human Cases Reported
Average = 2969/yr; range = 21-9862

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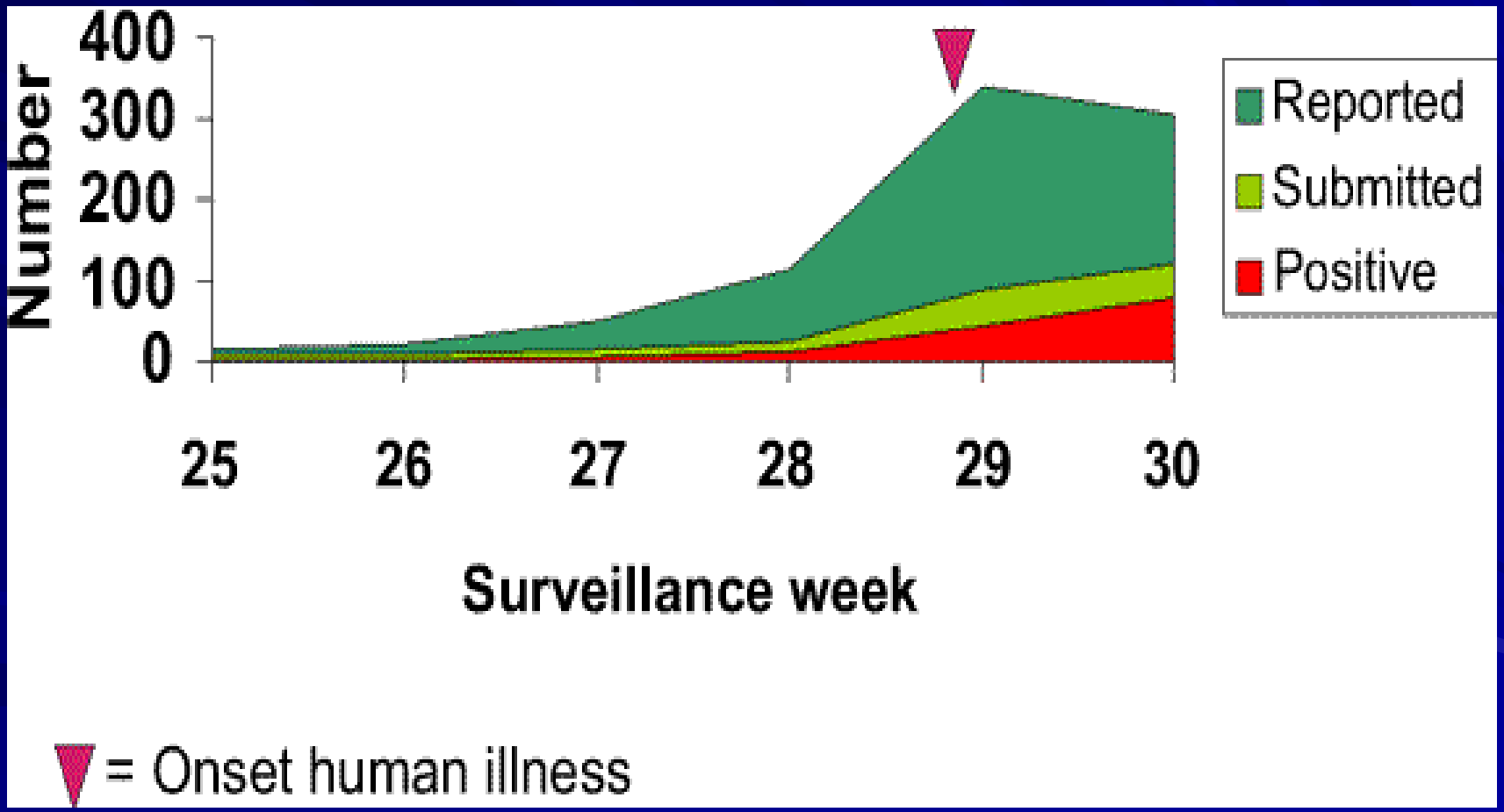
WN Virus Isolations - 2002

Genus	Positive Pools	% of Total
Culex	6,217	94.1
Aedes / Ochlerotatus	*252*	3.8
Anopheles	67	1.0
Psorophora	18	<1
Coquillettidia	12	<1
Culiseta	9	<1
Orthopodomyia	5	<1
Uranotaenia	4	<1
Unknown	17	<1

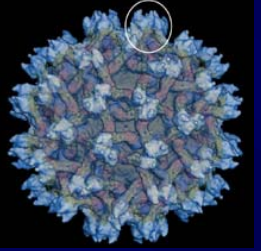
WN brought together some unusual partners….

No. of Reported, Submitted, and WNV-Infected Crows, 2000



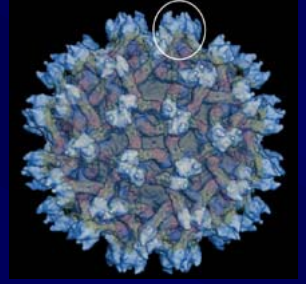
Birds as Dispersal Vehicles

Virus move south with fall migration
and north & west with spring migration?



WNV Summary

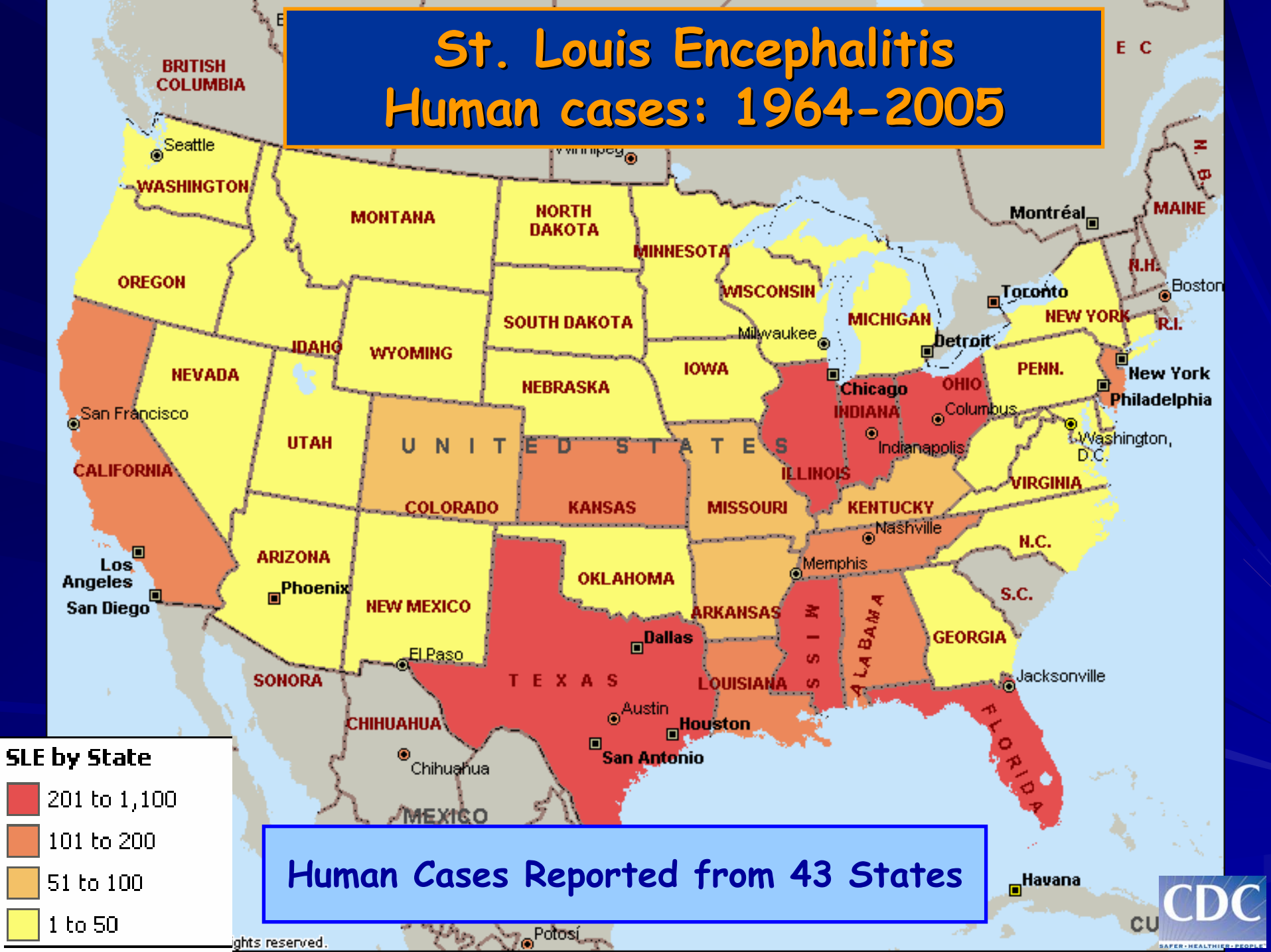
- Old World virus introduced into NYC in 1999, it is now the most important arbovirus in the U. S.
- In just 5 yrs, it spread to every State, Mex. & Can.
- WNV mainly affects the elderly, neuro & paralytic.
- Cycles in and kills many new world birds; especially crows & jays.
- WNV also isolated from many mammals and reptiles.
- Vectored by several species of *Culex* often associated with semi-permanent irrigated or polluted water.
- Also isolated from a large number of other species.
- Can overwinter in adult mosquitoes or migrating birds.



Flaviviridae

- West Nile fever virus
- St Louis encephalitis virus
- Dengue fever viruses (1, 2, 3, 4)

St. Louis Encephalitis Human cases: 1964-2005



SLE by State

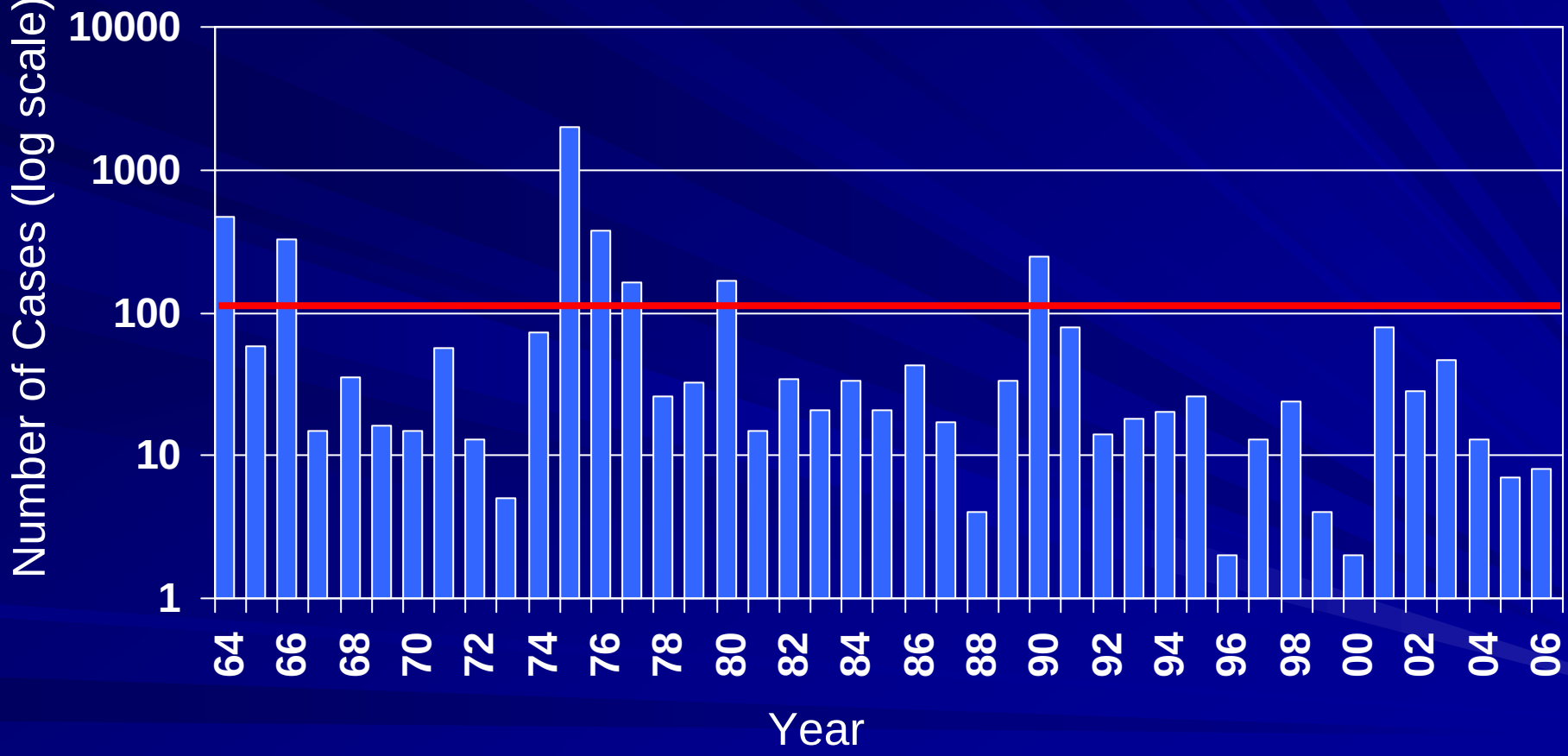
- 201 to 1,100
- 101 to 200
- 51 to 100
- 1 to 50

Human Cases Reported from 43 States

CDC

St. Louis Encephalitis

Total Cases in U.S. 1964-2006



Reported Human Cases
Average = 111/yr; Range = 2-1967

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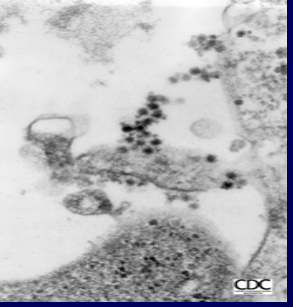
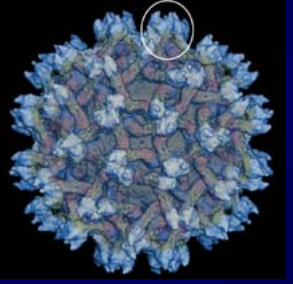


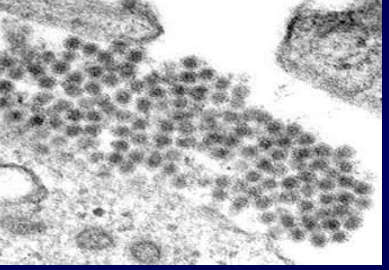
SLE Summary

- Close relative of WN virus but does not cause disease in equines.
- Elderly at highest risk of severe neurological disease.
- Most widespead and abundunt arbovirus in the U.S. prior to the arrival of WNV. Few cases recently (AZ)
- Naturally cycles in wild birds, especially peridomestic species.
- Similar *Culex* vectors to WNV (not as high titered or in as many other mosquito species).
- Over-wintering mechanism unknown.



Flaviviridae

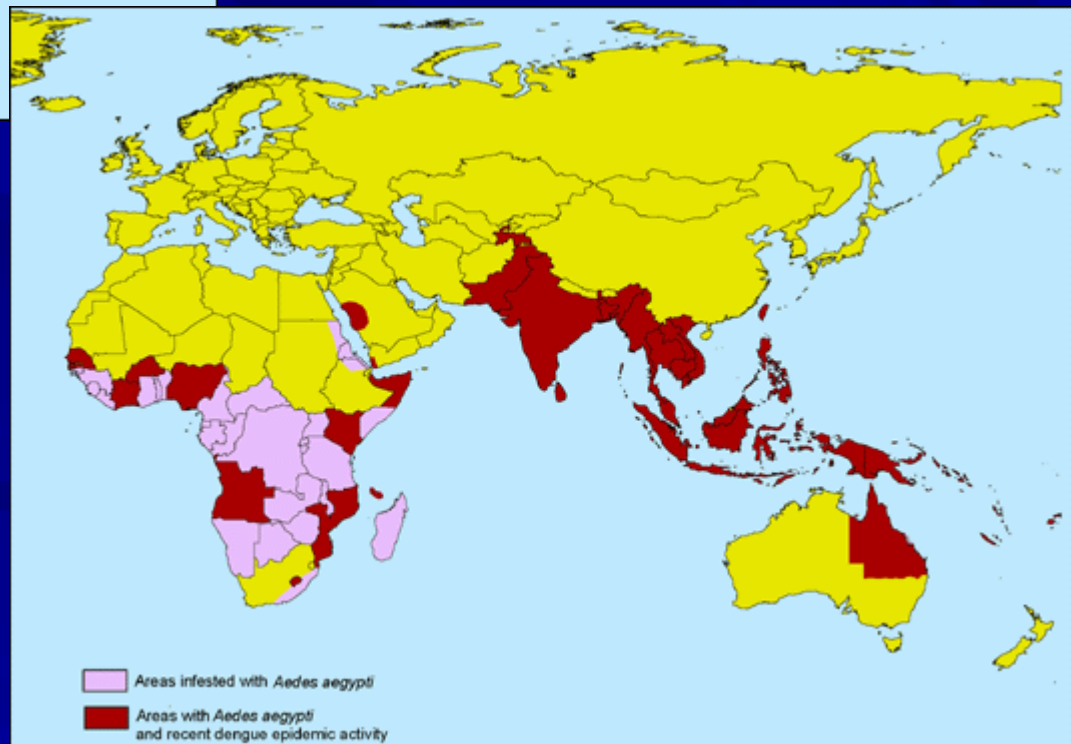
- West Nile fever virus
- St Louis encephalitis virus
- **Dengue fever viruses (1,2,3,4)**



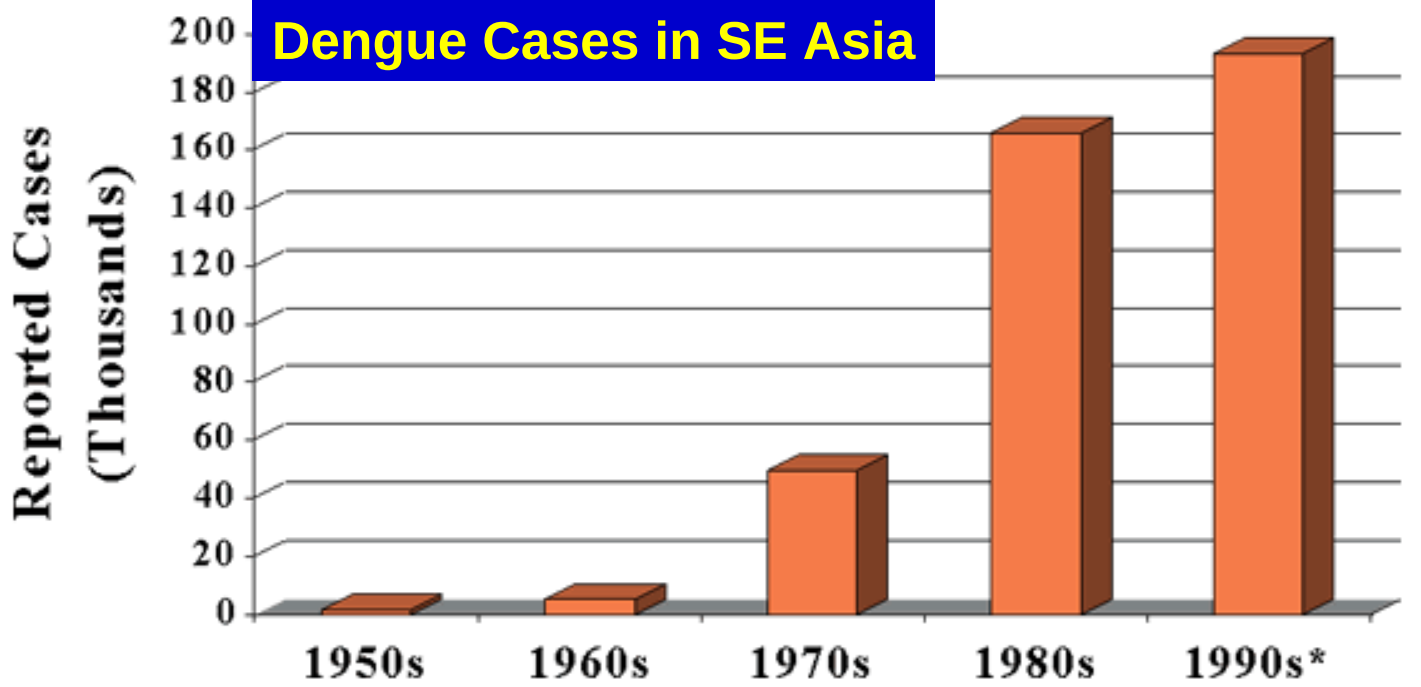
Dengue Fever & DHF

Worldwide Distribution

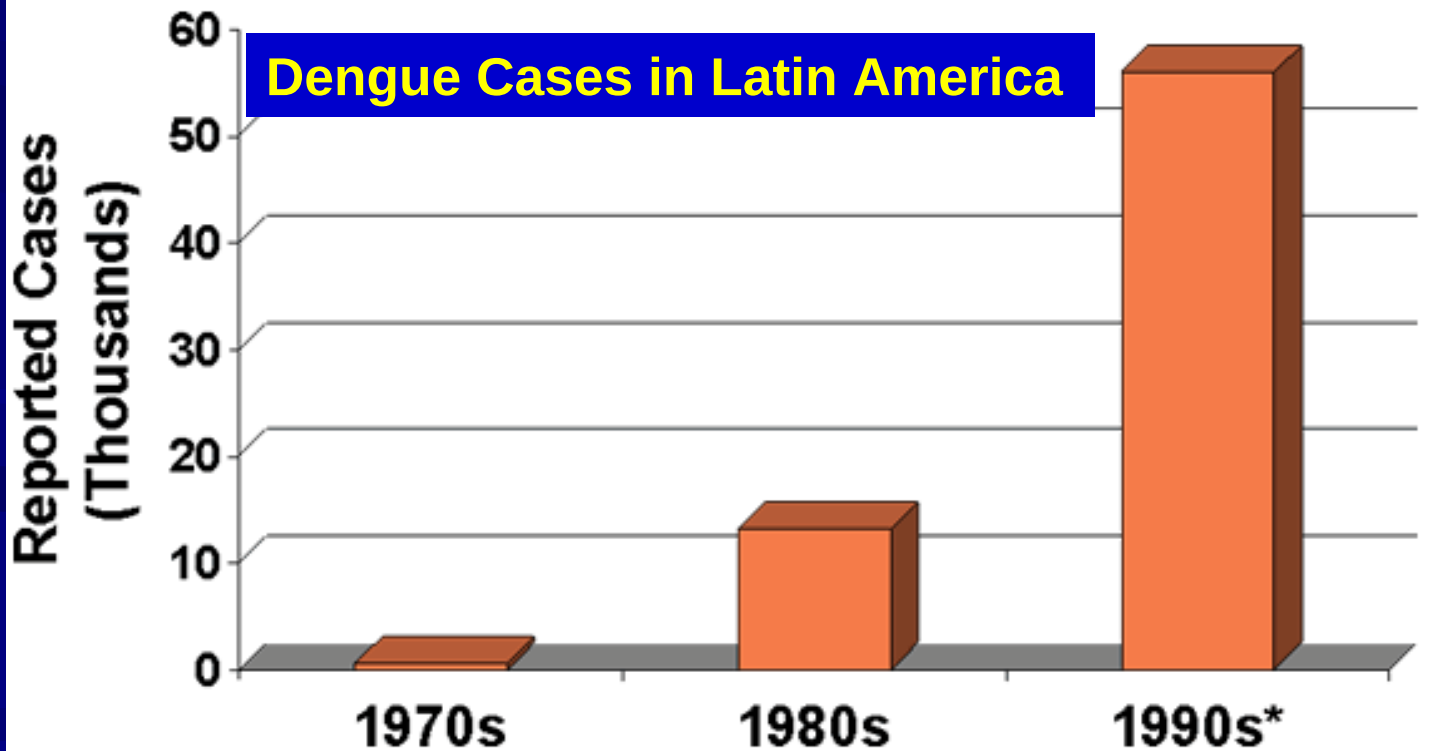
Dengue and Aedes aegypti

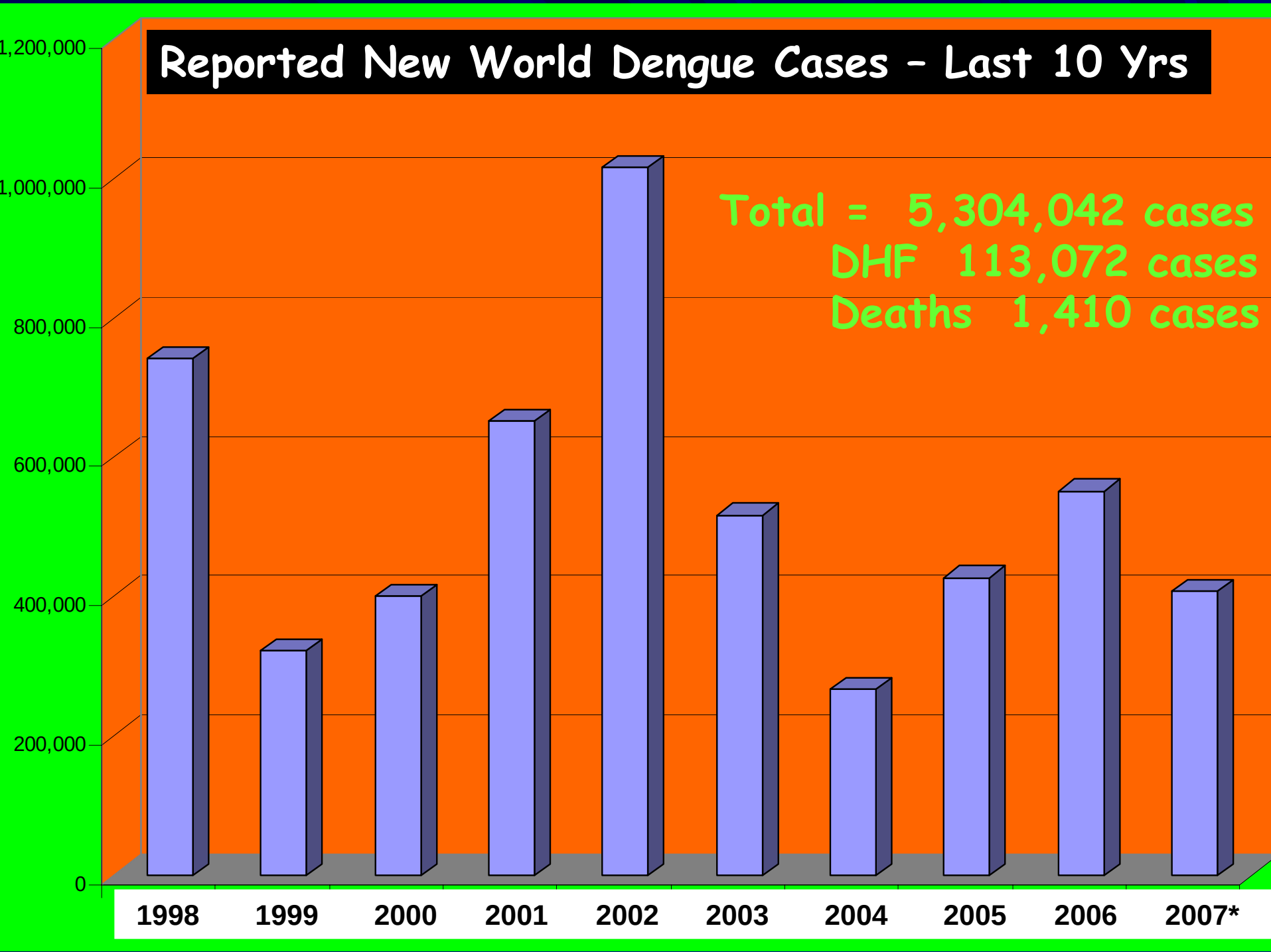


Dengue Cases in SE Asia

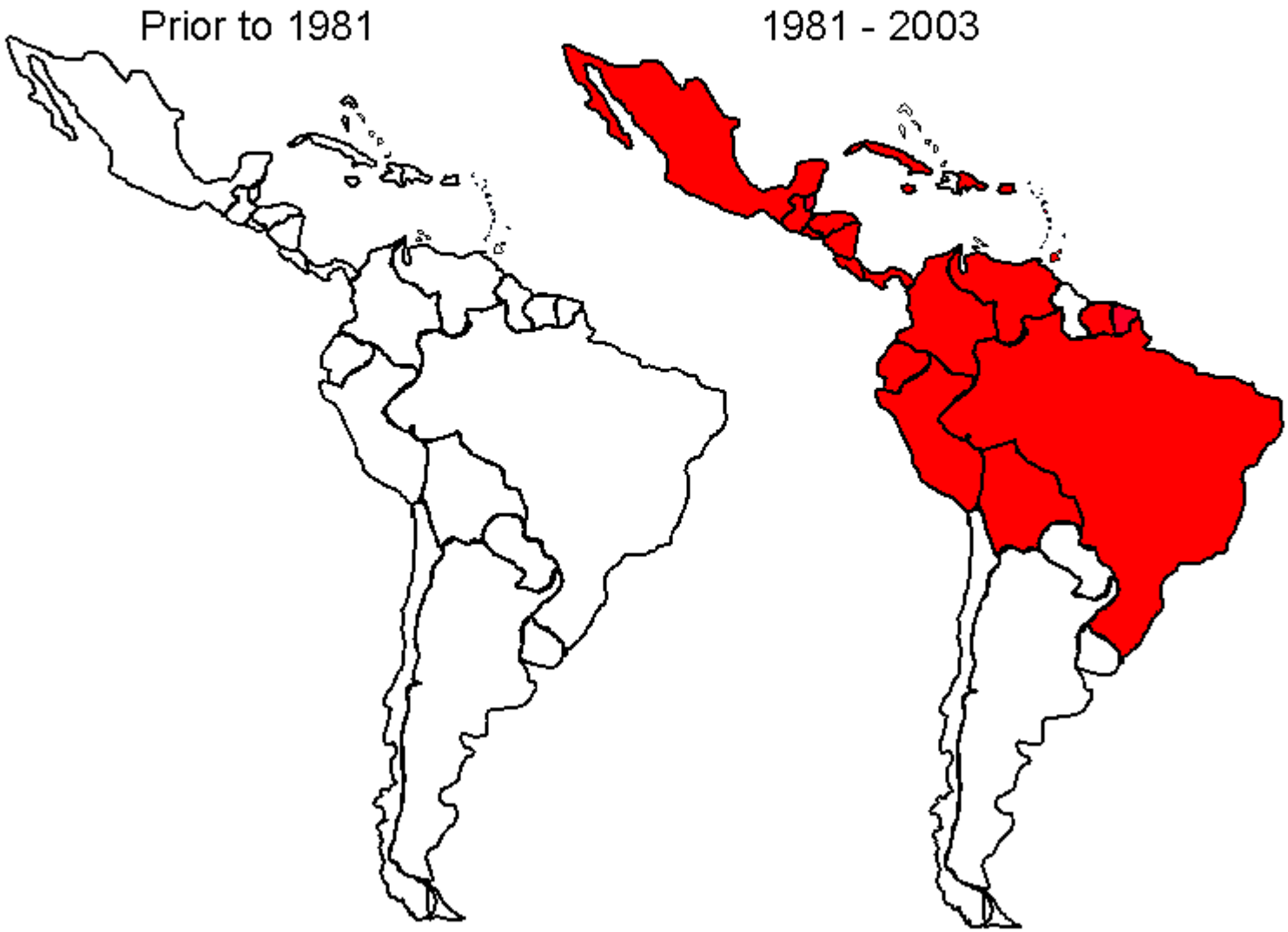


Dengue Cases in Latin America



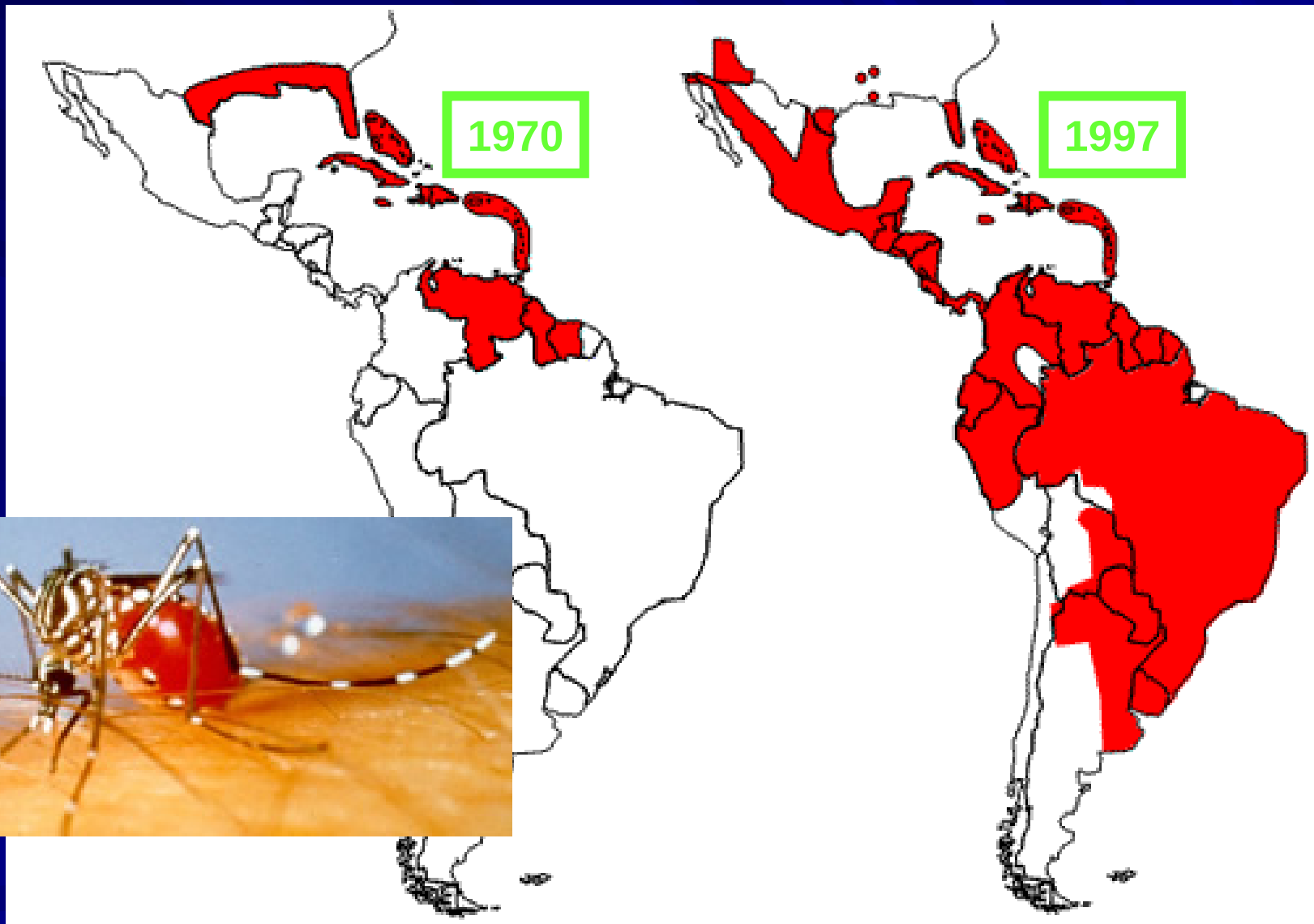

Reported New World Dengue Cases - Last 10 Yrs
Total = 5,304,042 cases
DHF 113,072 cases
Deaths 1,410 cases
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007*

American Countries with laboratory confirmed dengue hemorrhagic fever, prior to 1981 and from 1981 to 2003



Source: WHO/PAHO/CDC, Aug. 2004

Changing Distribution of *Ae aegypti*

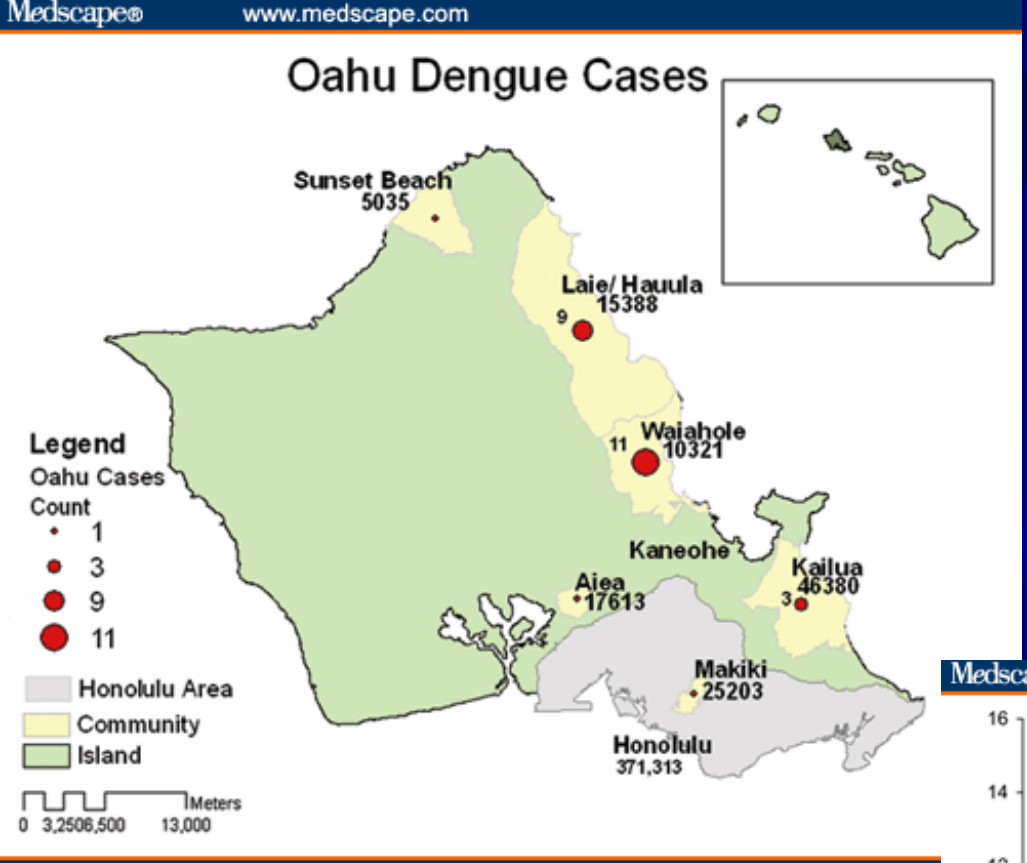


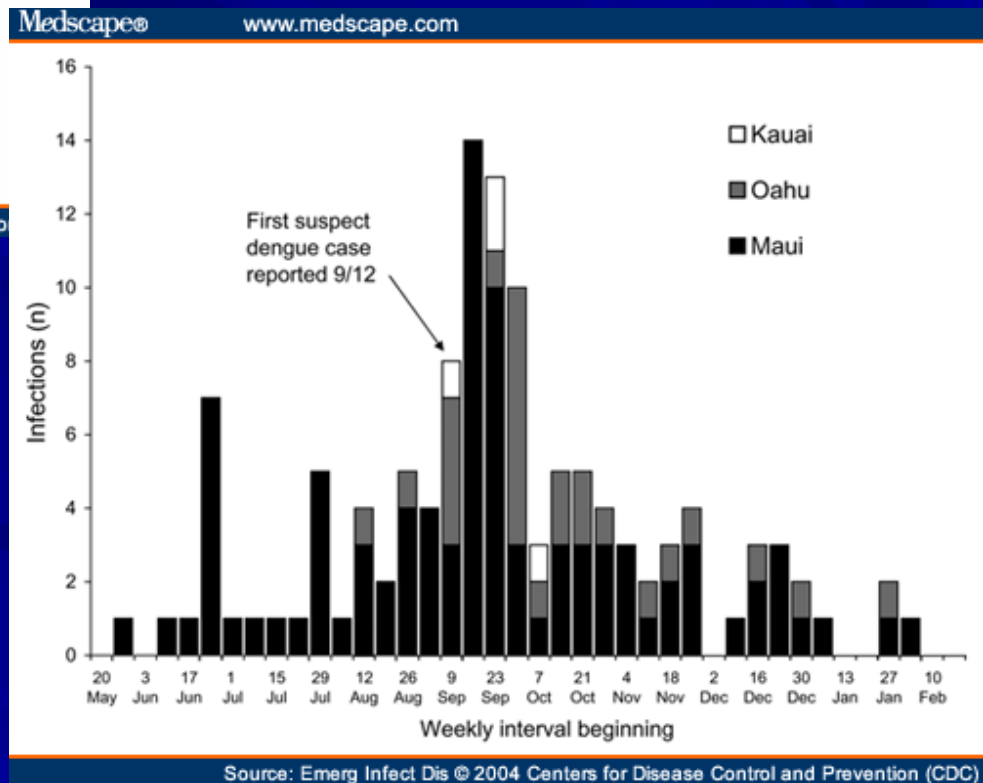
Current U.S.Distribution of Ae albopictus

Recent Dengue in the U.S. (Texas)

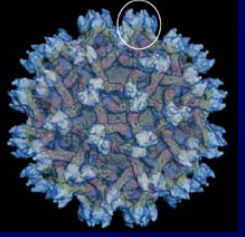
- Dengue epidemics occurred in the US in the 1800s and up until 1945.
- Recent indigenous transmission
  - 1980: 23 cases, first locally acquired since 1945
  - 1986: 9 cases
  - 1995: 7 cases
  - 1997: 3 cases
  - 1998: 1 case
  - 1999: 18 cases

Hawaiian Islands Outbreak 2001-2002





Transmitted by *Aedes albopictus* 122 Lab Positive Infections



DENV Summary

- Most important arbovirus worldwide with hundreds of thousands of cases and millions at risk annually in tropical regions. Case numbers are increasing.
- Four different dengue strains exist with only short term cross-strain immunity follow infection.
- DHF and DSS are often related to 2nd infections with a different strain. Mostly in children.
- Sylvan cycles in wild primates have been recently documented in Asia and Africa for 3 of 4 DEN strains. Sylvan vectors are canopy *Aedes* spp.
- *Ae aegypti* is the main vector in all urban and many rural areas. *Ae albopictus* is a vector in rural areas.
- Several vaccines have been under development for many years. Difficult strain-related problems.

THE

END