



Arboviruses of Public Health in the United States

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The findings and conclusions in this presentation are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention

Topics

- **Arboviruses in the United States**
 - **Arboviruses of public health importance**
 - **History and Current Status**
 - **Ecology and Epidemiology**
- **West Nile Virus**
 - **Establishment and Spread**
 - **Surveillance and Epidemiology**

Arboviruses in the United States

Selected representatives by Family

Eastern Equine Enceph.	Cache Valley	San Angelo	Buttonwillow	Reed Ranch
Venezuelan* Everglades	Lokern	Jamestown Canyon	Turlock	Muir Springs
Western Equine Enceph.	Northway	Jerry Slough	Potosi	Malpais Spring
Highlands J	Tensaw	South River	Rio Grande	Hart Park/Flanders
Fort Morgan	Main Drain	Keystone	Hughes	Sawgrass
St. Louis Enceph.	Virgin River	Trivittatus	Bluetongue	Kern Canyon
Powassan	Nepuyo	Mahogany Hammock	Epizootic Hemor Dis	
West Nile	Gumbo Limbo	Shark River	Mono Lake	
Dengue*	California Enceph.	Pahayokee	Colorado Tick Fever	
Yellow Fever*	La Crosse	Mermet	Vesicular Stomatitis	*not endemic

Arbovirus Family: Togaviridae Bunyaviridae Rhabdoviridae
 Flaviviridae Reoviridae

Urban Yellow Fever Epidemics in the United States 1793-1905



1. Philadelphia, 1793; 5,000 dead
2. New York City, 1795; 730 dead
3. Boston, New York City and Philadelphia, 1798; more than 5,000 dead
4. Baltimore, 1800; 1,200 dead
5. New Orleans, 1853; 8000 or more dead
6. Norfolk, 1855; 2,000 dead
7. Mississippi Valley, 1878; 20,000 dead
8. Cuba, 1898; hundreds dead.
9. New Orleans, 1905; more than 900 dead

Urban Yellow Fever Epidemics in the United States 1793-1905



Currently:

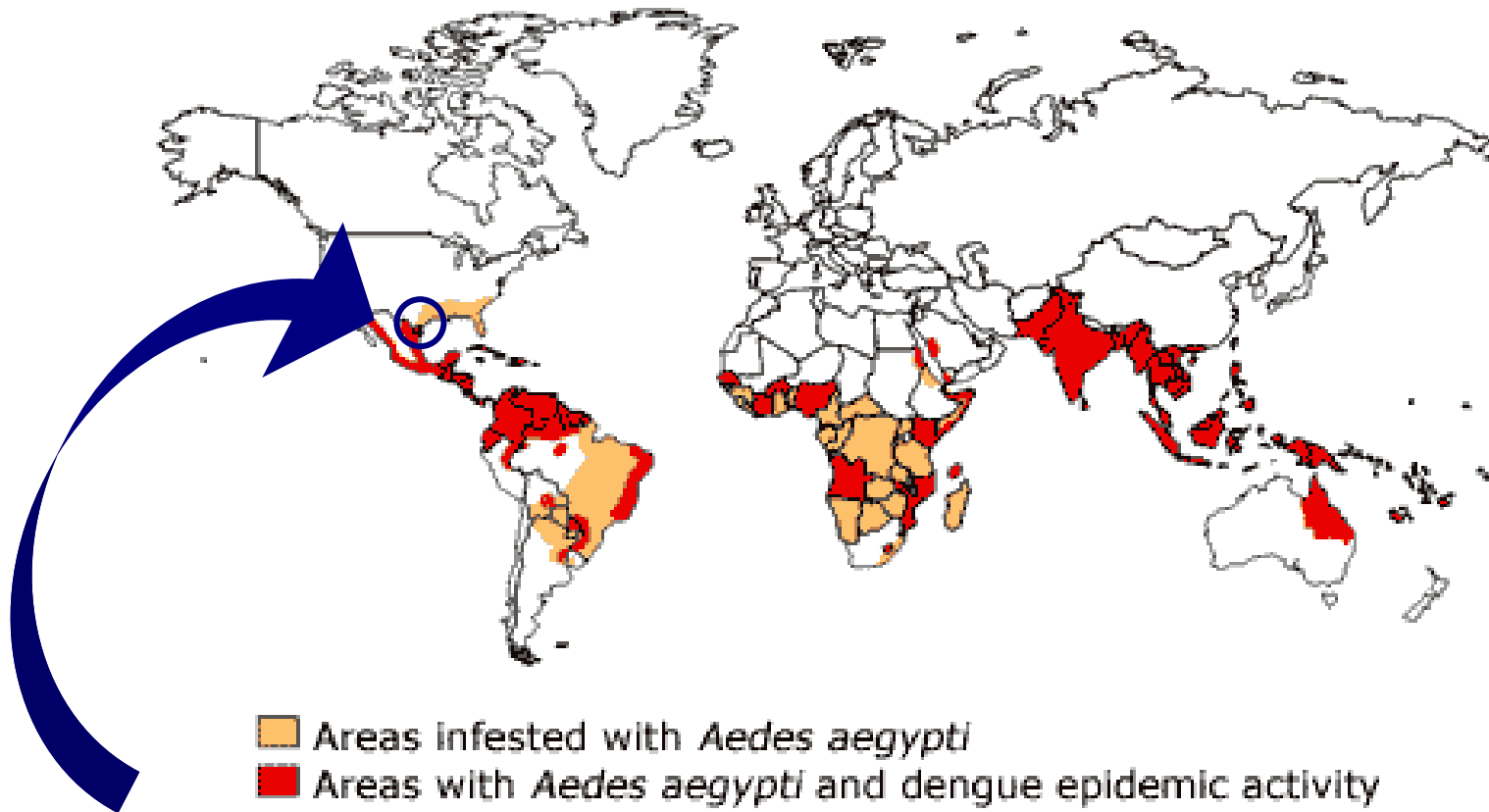
- Rare imported cases with travel history
- No local transmission

1. Philadelphia, 1793; 5,000 dead
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8. Cuba, 1898; hundreds dead.
9. New Orleans, 1905; more than 900 dead

Dengue in the United States

- **Intermittent endemic transmission and epidemics from 1790's through early 1900's.**
- **Overlap Yellow Fever epidemics.**

World Distribution of Dengue - 2003

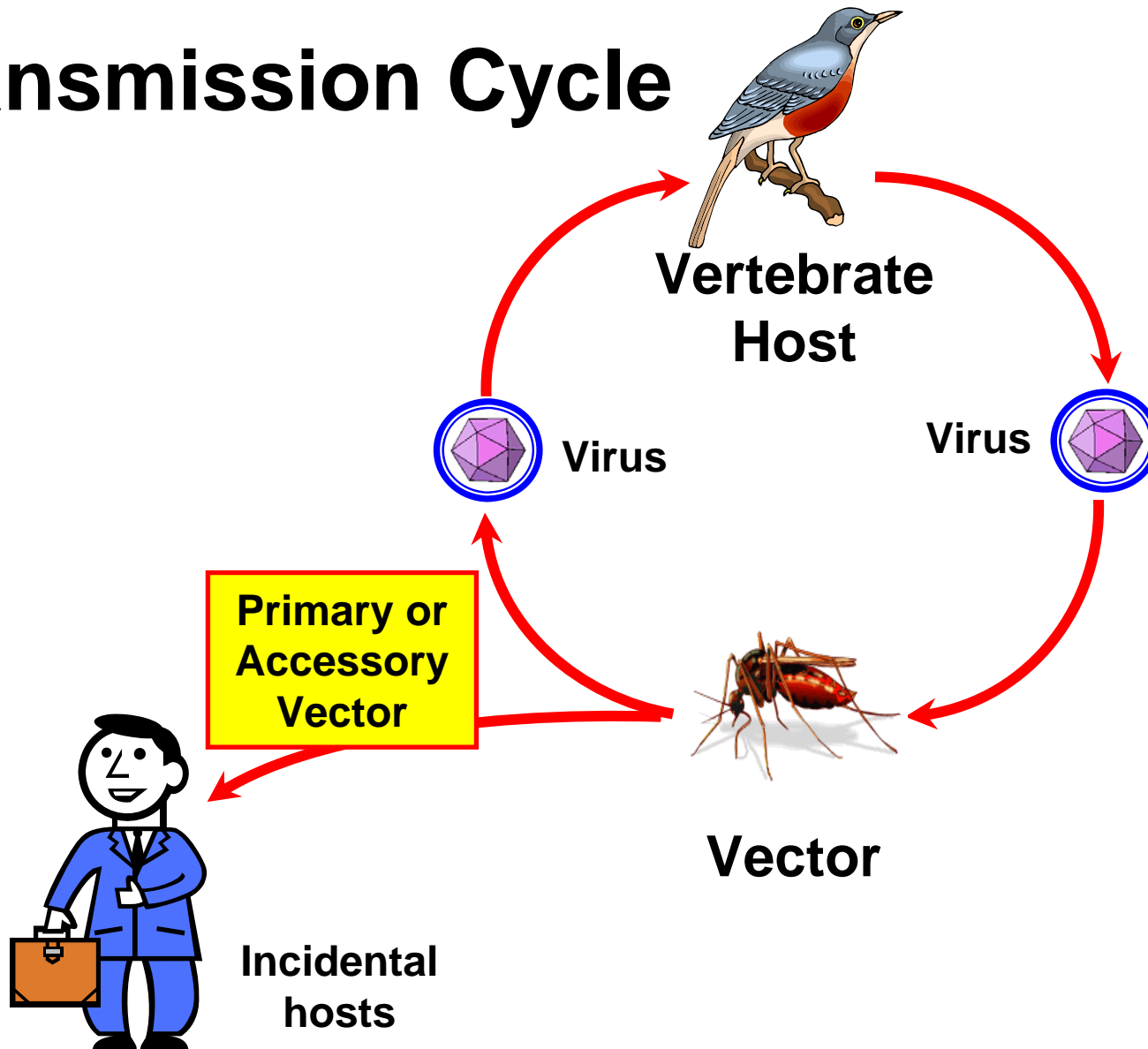


Currently, imported cases, sporadic endemic transmission along U.S.A – Mexico border areas.

PRIMARY ARBOVIRUSES AFFECTING HUMANS IN THE U.S.

- **Eastern Equine Encephalitis**
- **Western Equine Encephalitis**
- **La Crosse**
- **Saint Louis Encephalitis**
- **West Nile**

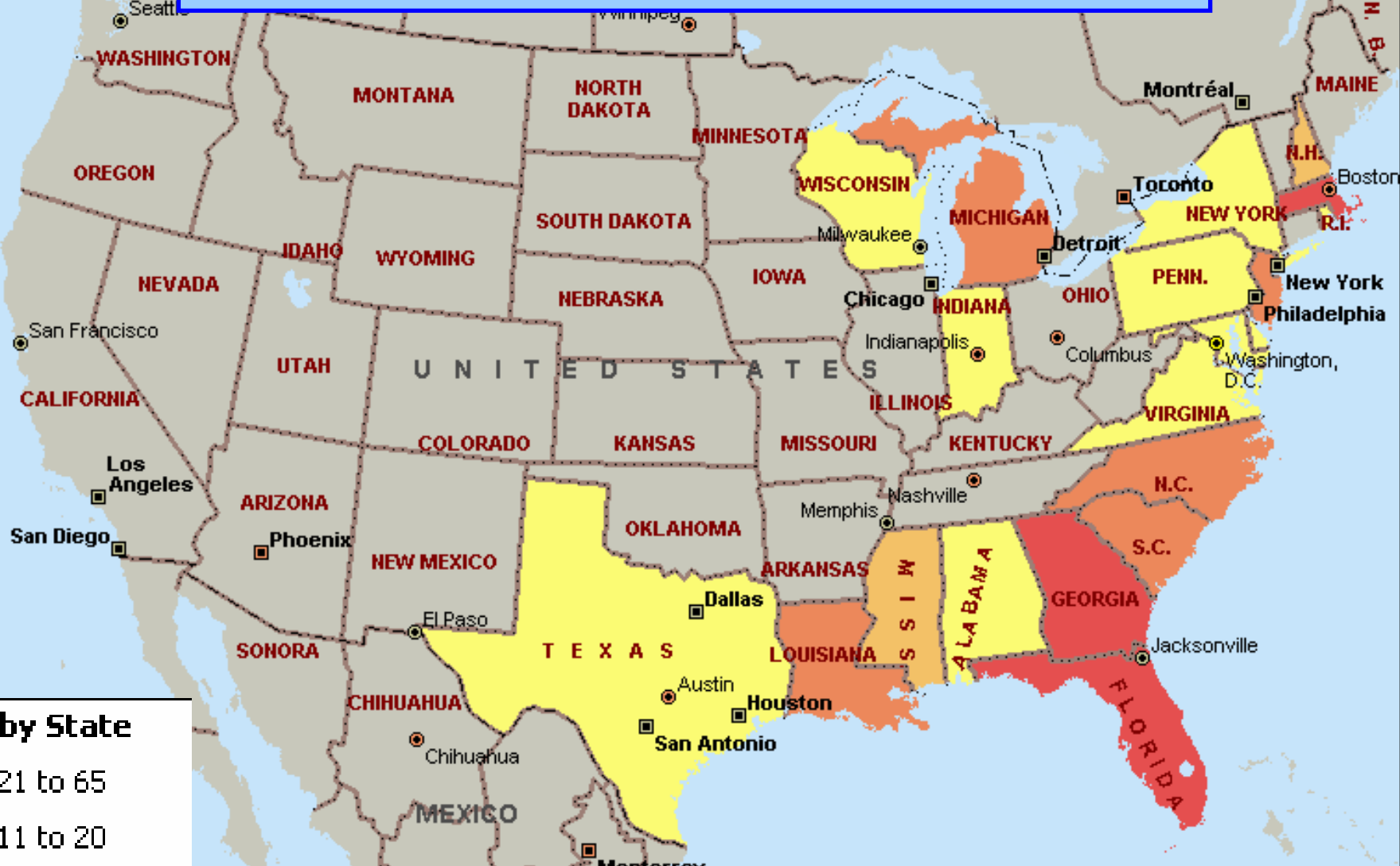
Arboviral Zoonosis Transmission Cycle



PRIMARY ARBOVIRUSES AFFECTING HUMANS IN THE U.S.

- **Geographic Distribution**
- **Ecology**
 - vertebrates and vectors
- **Epidemiology**
 - Long term trends

Eastern Equine Encephalitis Human cases: 1964-2005



Human Cases Reported from 20 States

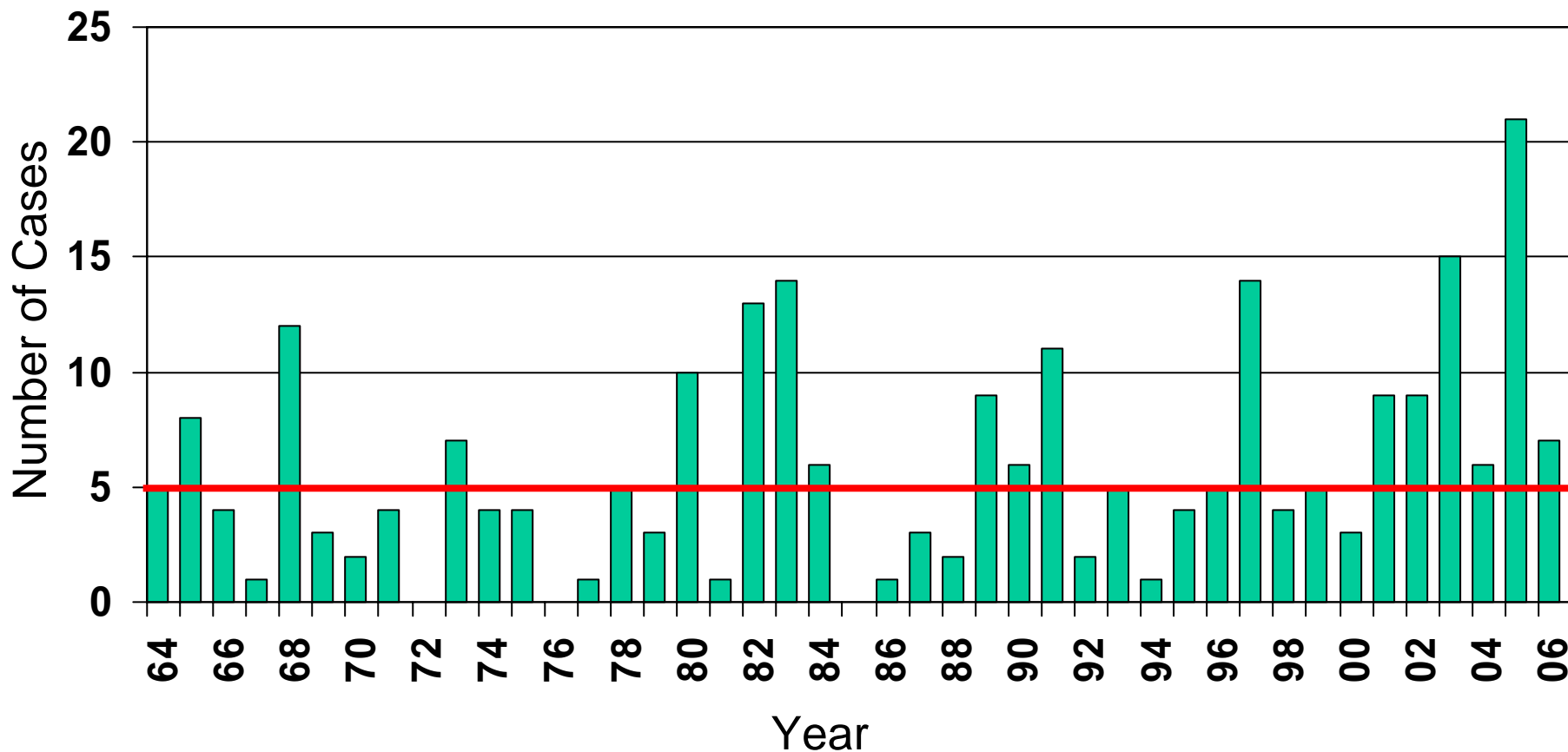
EASTERN EQUINE ENCEPHALITIS

Alphavirus

- **Habitat Associations: Freshwater, hardwood swamps**
- **Vertebrate host - Birds**
- **Epizootic vector**
 - *Cs. melanura*
- **Vectors to mammals**
 - *Cq. perturbans*
 - *Ae. vexans*
 - *Oc. sollicitans*
 - *Cx. nigripalpus*

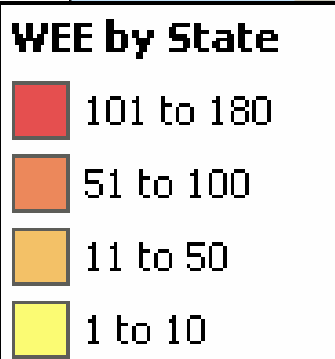
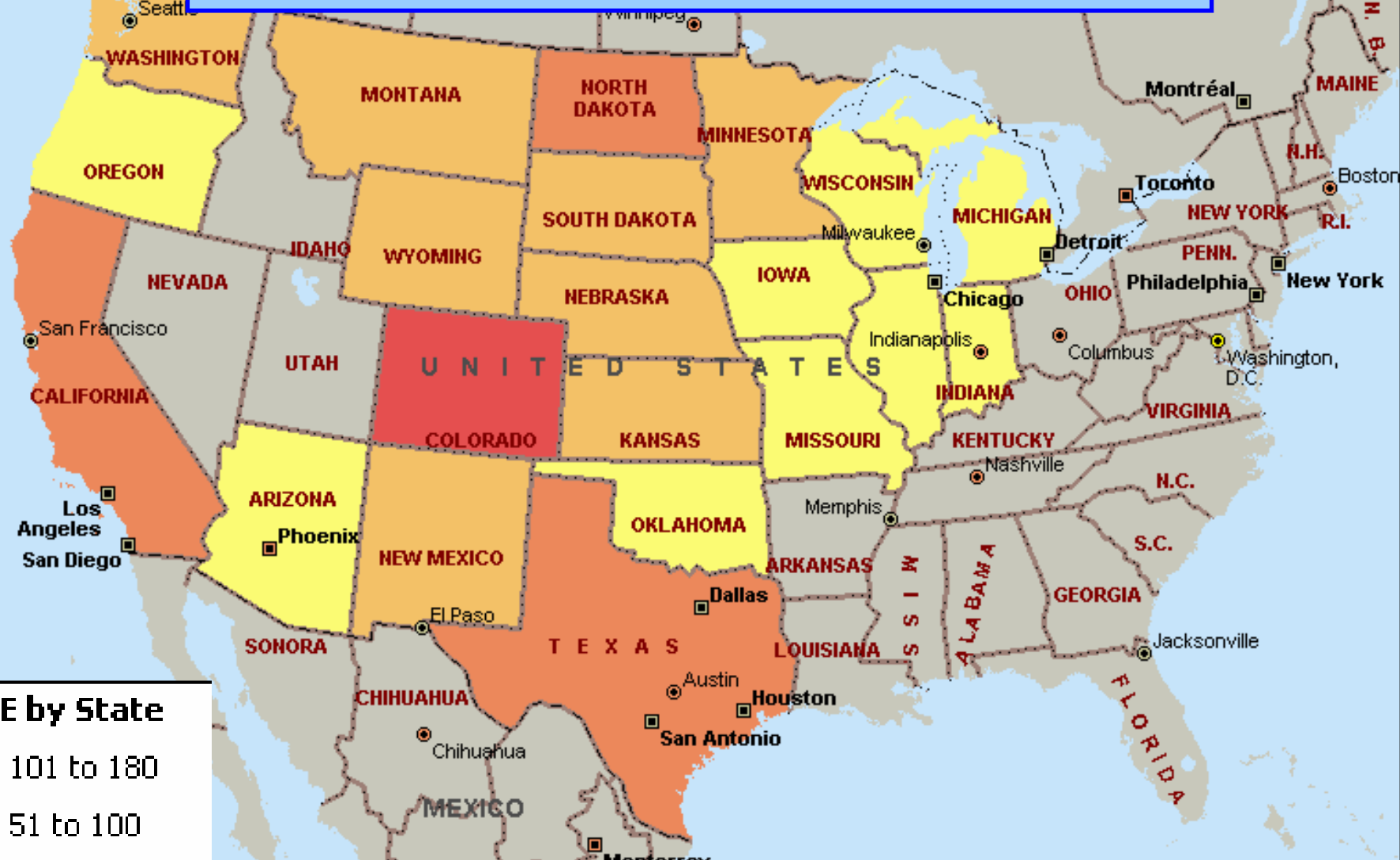
Eastern Equine Encephalitis

Total Cases in U.S. 1964-2006



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

Western Equine Encephalitis Human cases: 1964-2005



Human Cases Reported from 21 States

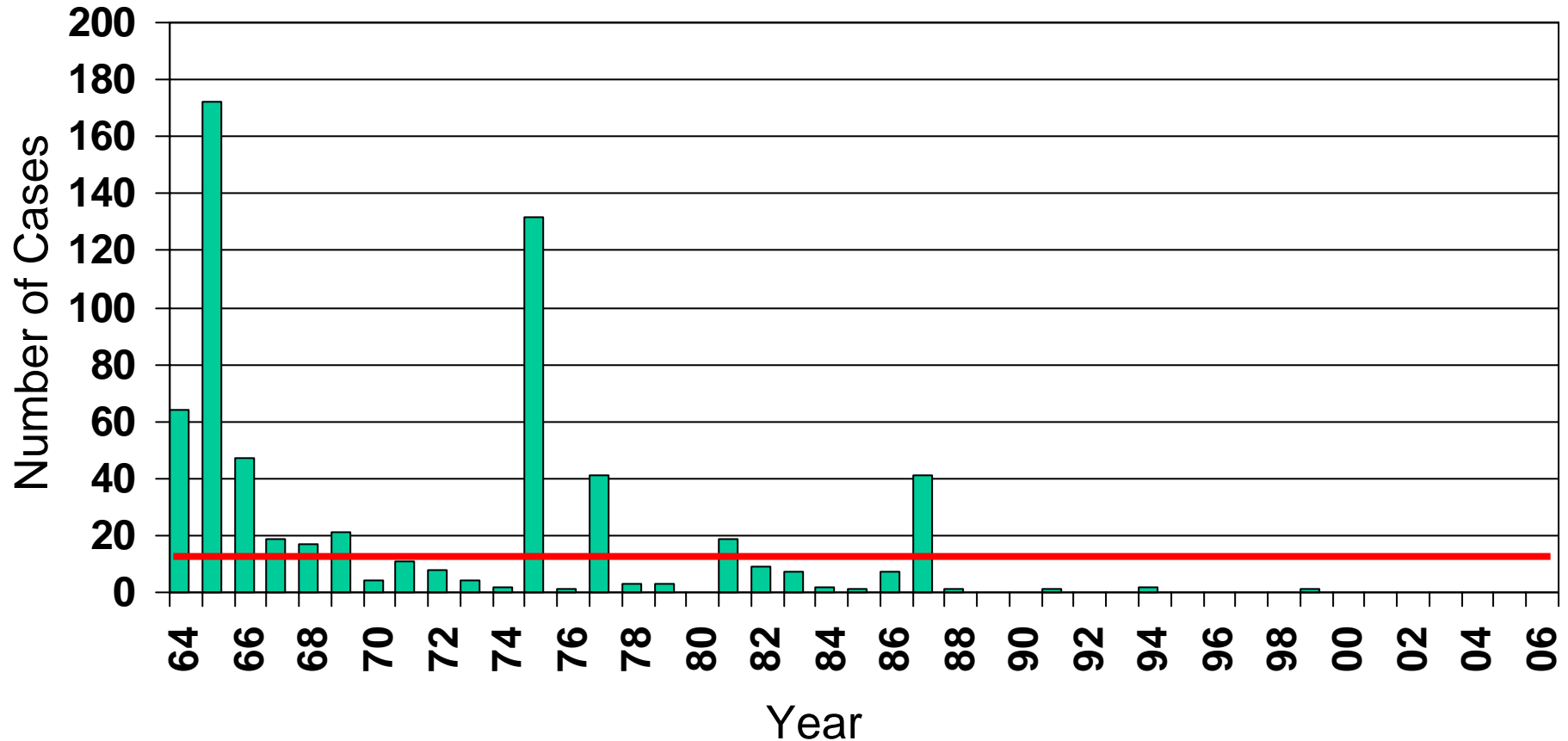
WESTERN EQUINE ENCEPHALITIS

Alphavirus

- **Habitat Associations: Irrigated areas and river flood plains**
- **Vertebrate host - birds**
- **Vectors**
 - *Cx. tarsalis*
 - Other mosquitoes?

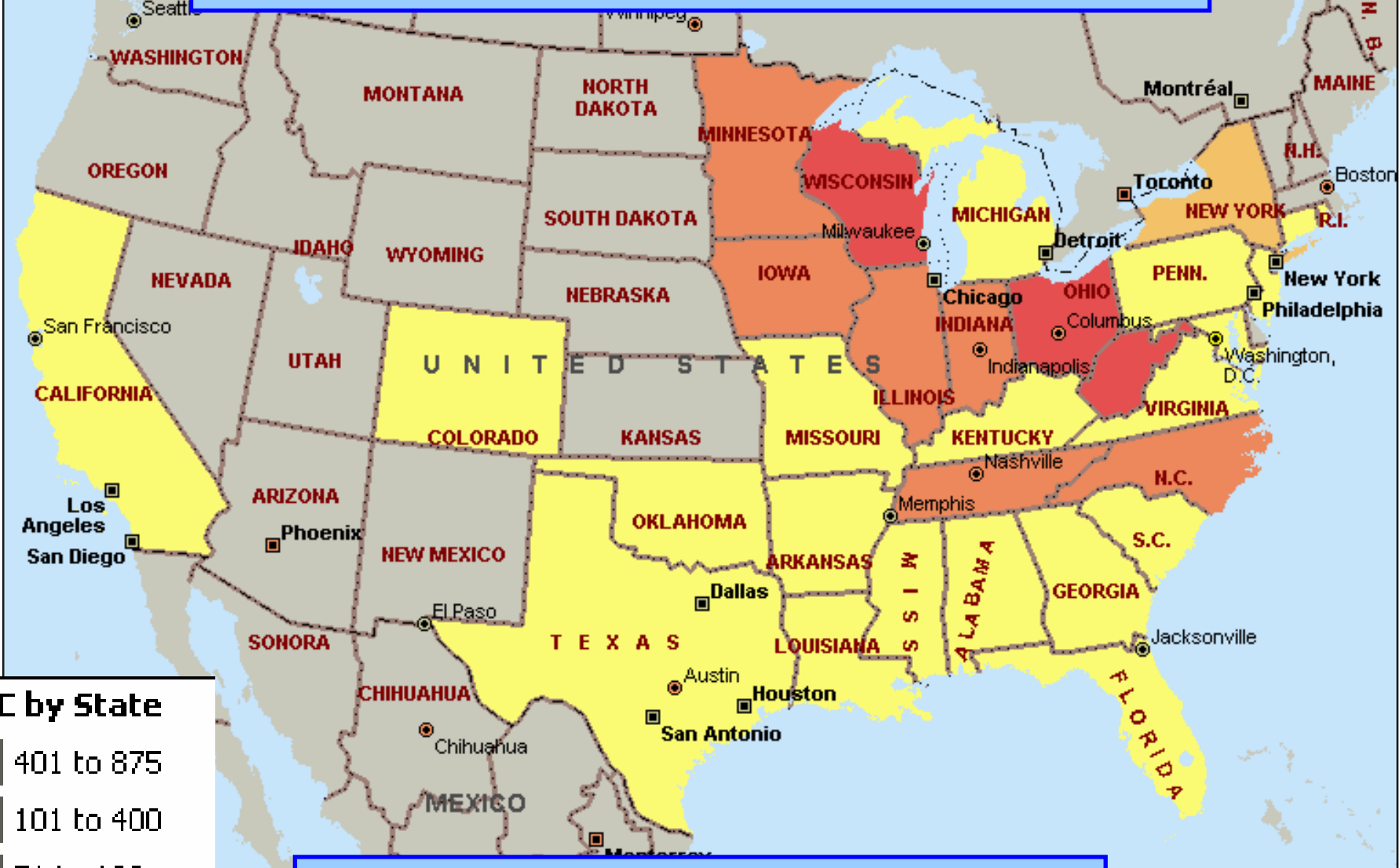
Western Equine Encephalitis

Total Cases in U.S. 1964-2006



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

La Crosse Encephalitis Human cases: 1964-2005



LAC by State

	401 to 875
	101 to 400
	51 to 100
	1 to 50

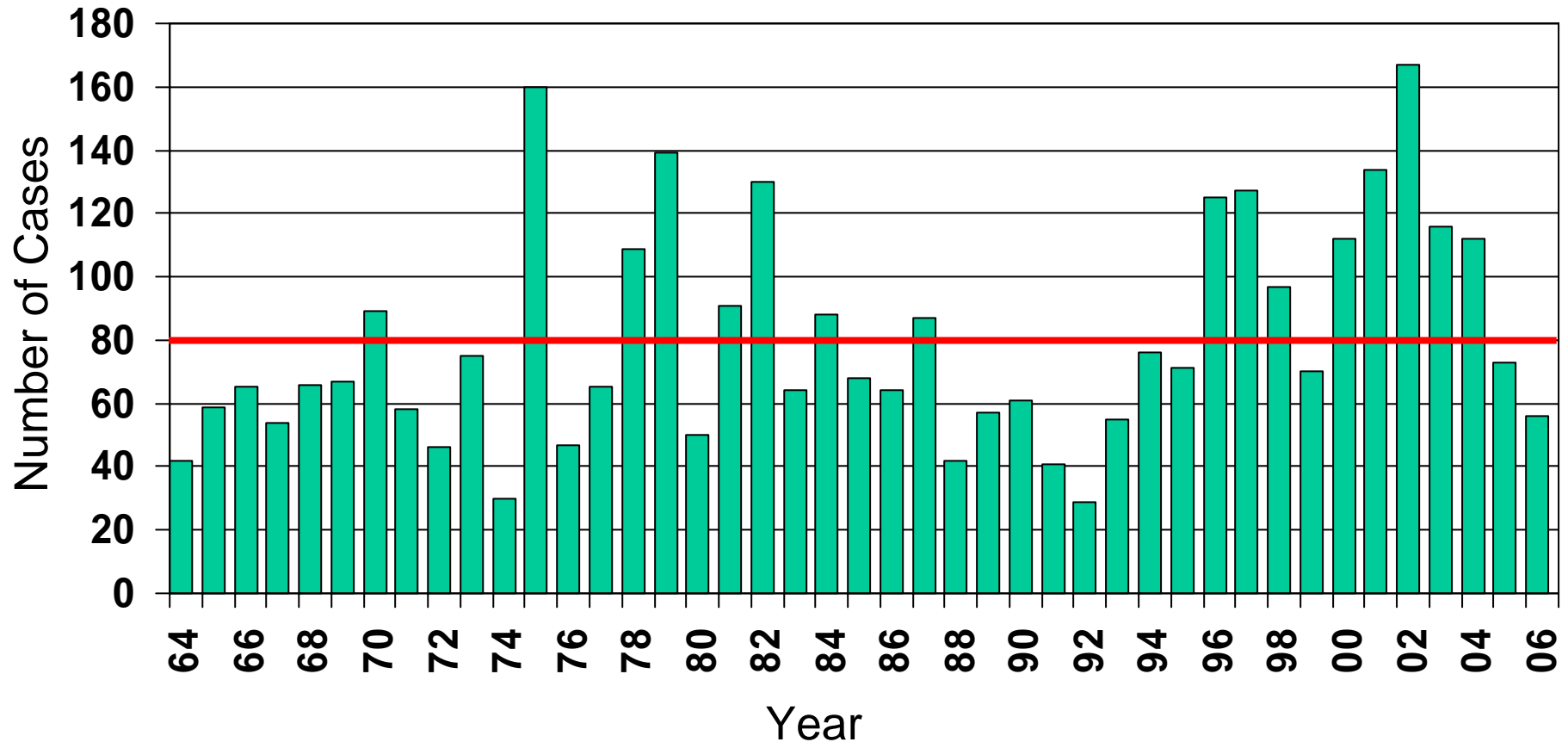
Human Cases Reported from 30 States

LA CROSSE Bunyavirus California Serogroup

- **Habitat Associations: Hardwood Forests**
- **Vertebrate hosts:- Chipmunks, Squirrels**
- **Vectors**
 - *Oc. triseriatus* primary vector
 - *Oc. canadensis*
 - *Ae. albopictus* (*suspected*)

La Crosse Encephalitis

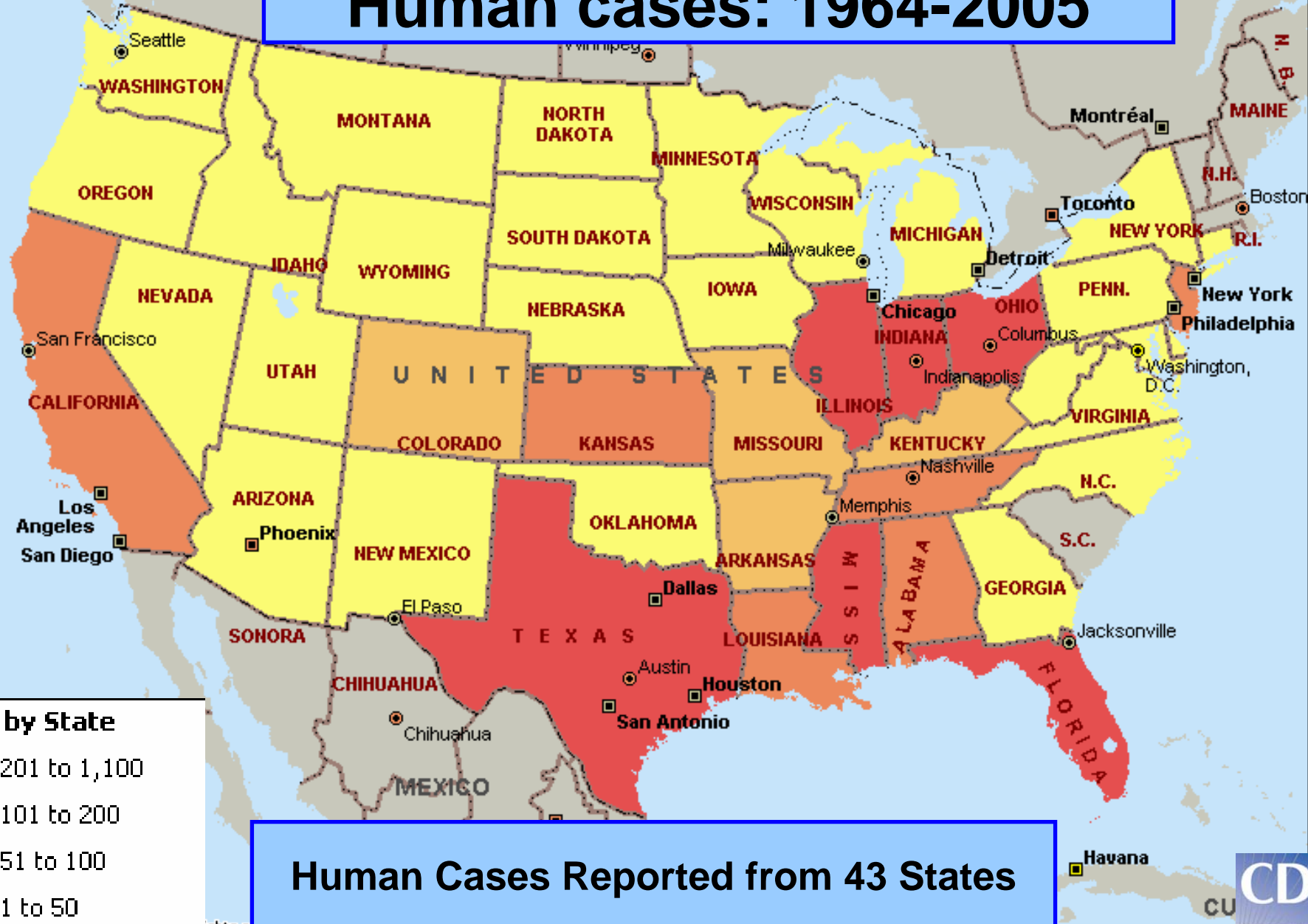
Total Cases in U.S. 1964-2006



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

St. Louis Encephalitis

Human cases: 1964-2005

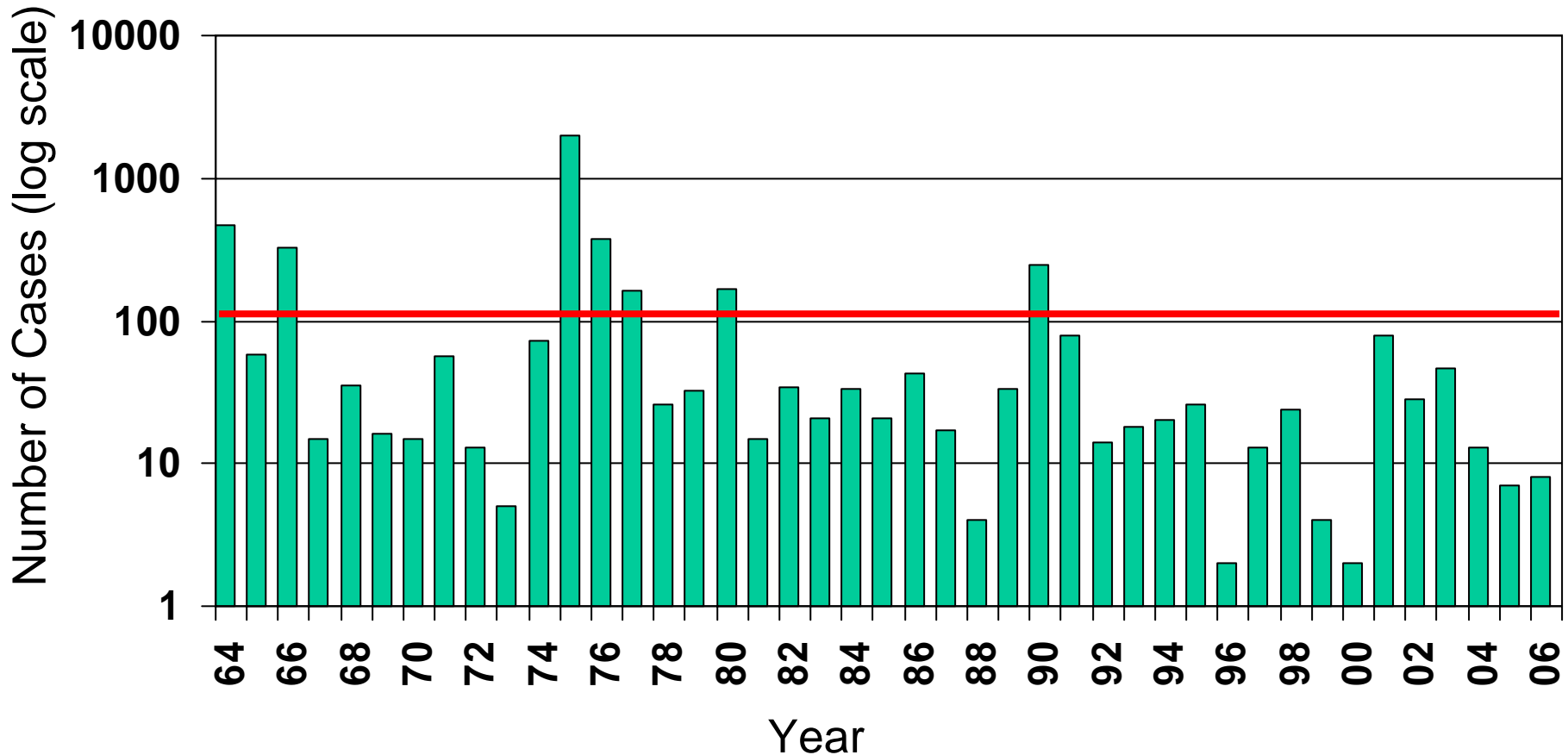


ST. LOUIS ENCEPHALITIS Flavivirus

- **Habitat Associations: Various, urban suburban, rural**
- **Vertebrate host - birds**
- **Vectors:**
 - **East: *Cx. pipiens*, *Cx. quinquefasciatus***
 - **West: *Cx. tarsalis***
 - **Florida: *Cx. nigripalpus***

St. Louis Encephalitis

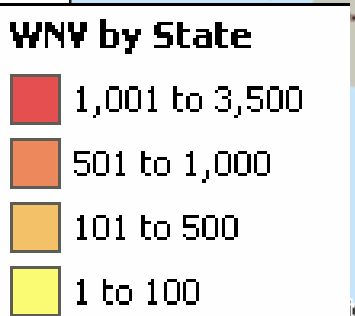
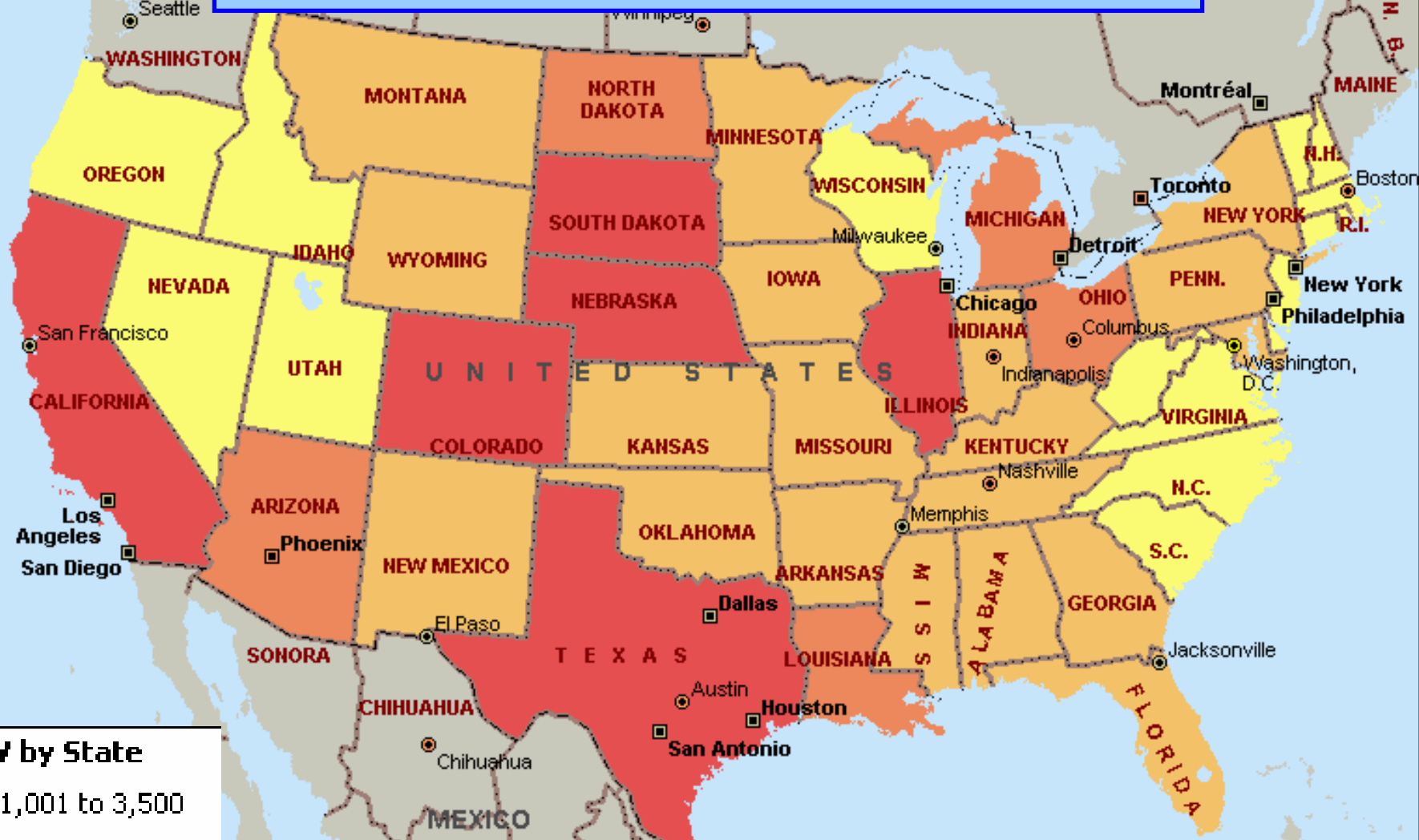
Total Cases in U.S. 1964-2006



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

West Nile

Human cases: 1999- 2005



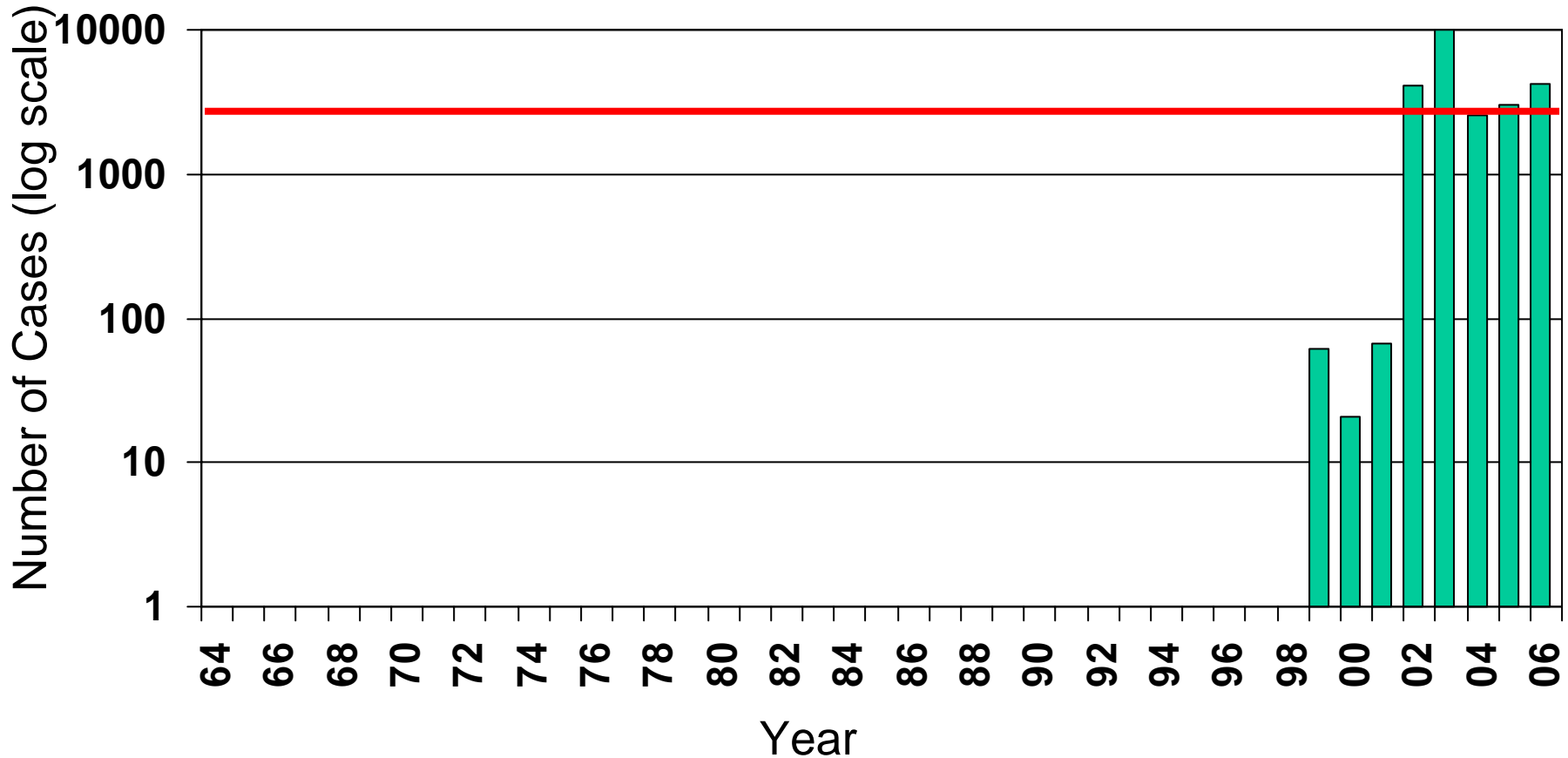
Human Cases Reported from 46 States

WEST NILE Flavivirus

- **Habitat Associations: Various – urban, suburban, rural**
- **Vertebrate host: Birds**
- **Vectors:**
 - **East: *Cx. pipiens*, *Cx. quinquefasciatus***
 - **West: *Cx. tarsalis***
 - **Florida: *Cx. nigripalpus***
 - **Numerous other species may be locally important during epidemic transmission**

West Nile Virus

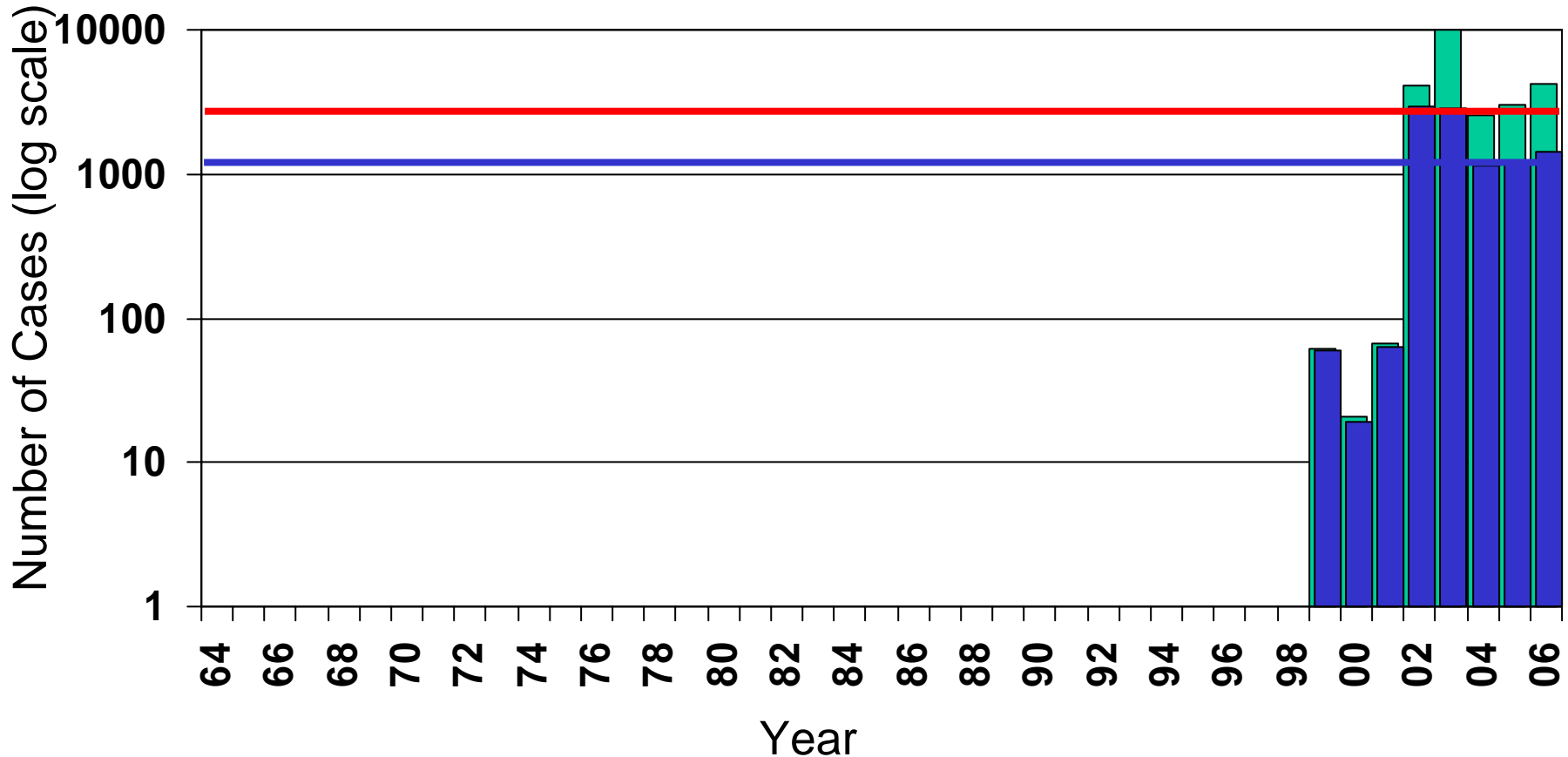
Total Cases in U.S. 1999-2006



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

West Nile Virus

Neuroinvasive Cases in U.S. 1999-2006



Reported Human Cases Reported
Average = 1210/yr; range = 19-2866

Arbovirus Cases

Cases in U.S. 1996-2006

Year	EEE	WEE	LAC	SLE	WN	WNND
06	7	0	56	8	4219	1433
05	21	0	73	7	3000	1188
04	6	0	112	12	2539	1142
03	12	0	116	37	9862	2866
02	9	0	167	28	4156	2946
01	9	0	134	79	66	64
00	3	0	112	3	21	19
99	5	1	70	4	62	59
98	4	0	97	24		
97	14	0	127	13		
Average	9	<1	106	21	2990	1214

Non-WNV Arbovirus Reports 2006 (tentative 12-12-06)

State	DEN	EEE	Flavivirus Non Specified	LAC	Non-LAC Calif Serogroup	Other Arbovirus	POW	SLE	Grand Total
AL	1								1
AZ	1							2	3
FL				1					1
GA		1							1
IA	1			1					2
IN				1					1
KY								1	1
LA		1		2				2	5
MA		5							3
MI				1					1
MN				1		1			2
MO	1								1
MS			1		1				2
NC				8					8
NH	2							1	3
OH	5			10				1	16
PA						1			1
SC	1			1					2
TN				6					6
TX	4		3					1	8
WA	2								2
WI	4			1			1		6
WV				7					7
Grand Total	22	7	4	40	1	2	1	8	83

West Nile Virus

- **West Nile virus.**
 - **Distribution in the U.S.**
 - **Public Health Impact**

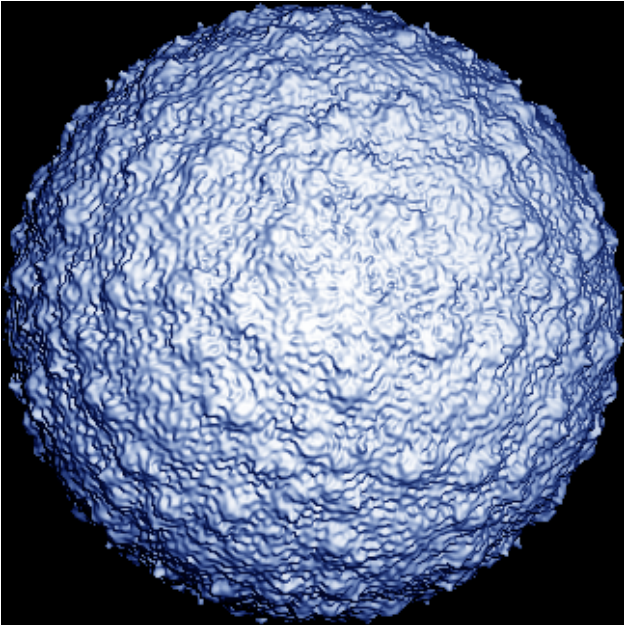
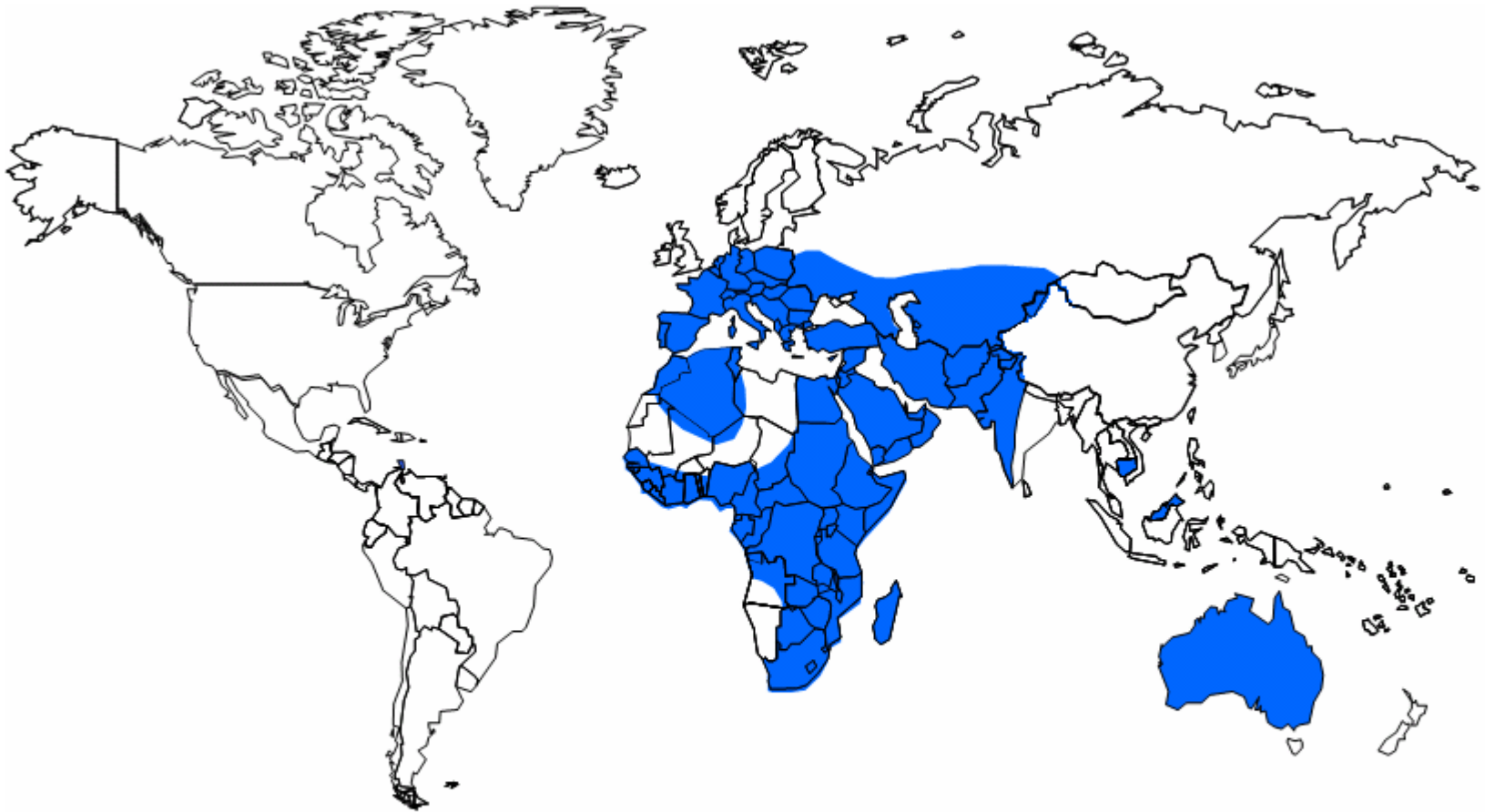
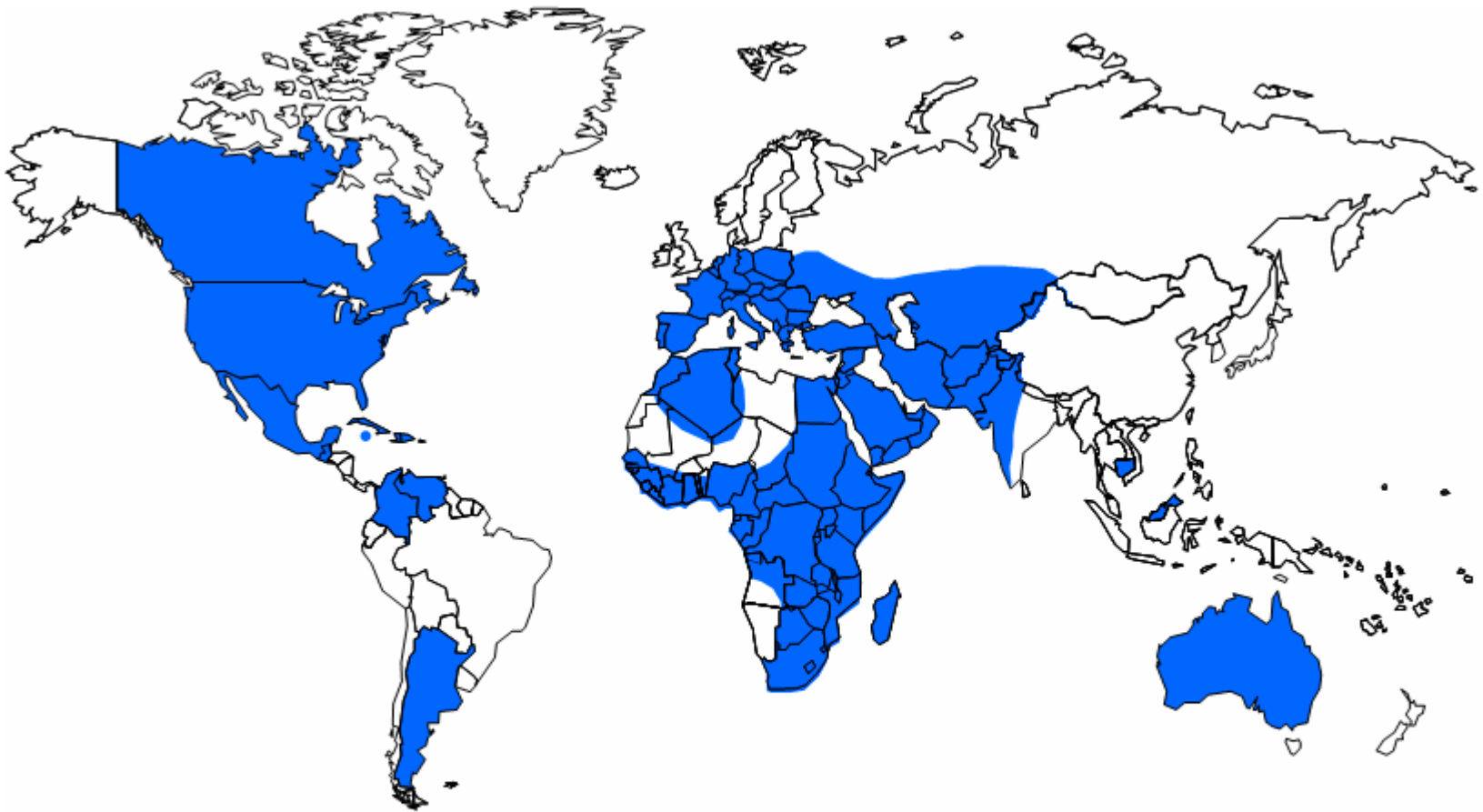


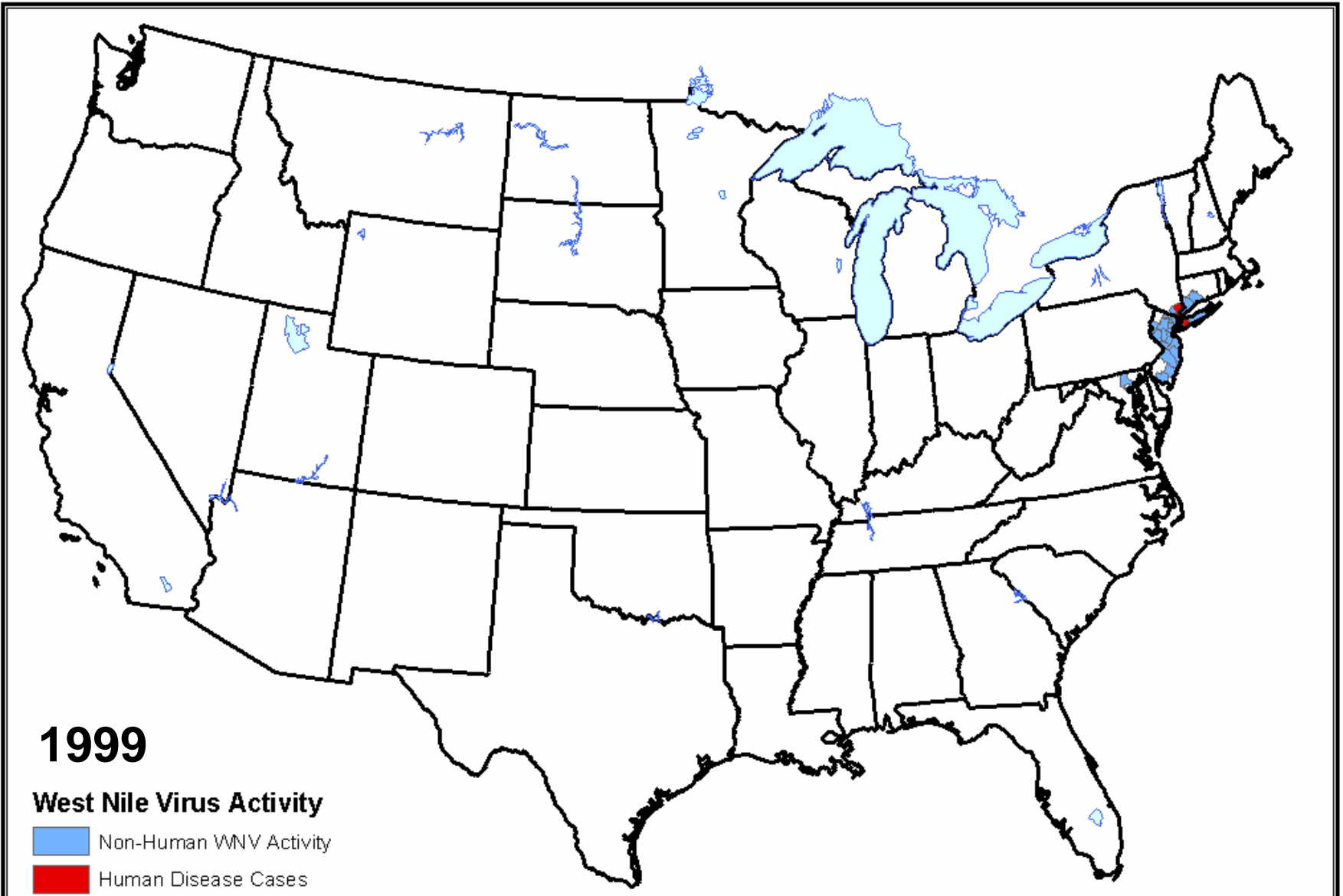
Image: Richard J. Kuhn
Purdue University

West Nile Virus Distribution Pre-1999





West Nile Virus Distribution Current (November 2006)





1999

West Nile Virus Activity

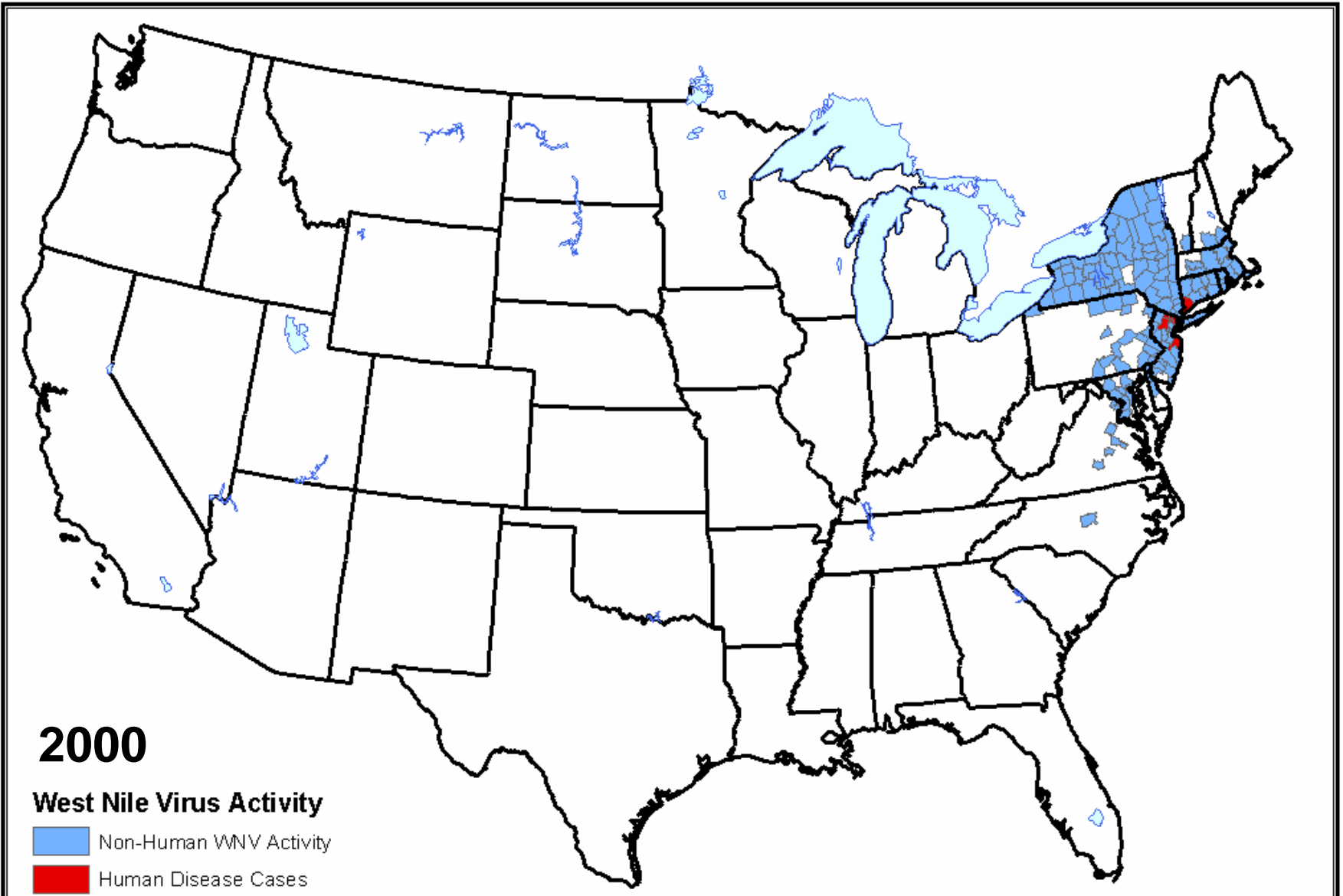
-  Non-Human WNV Activity
-  Human Disease Cases

4 States

62 Cases



National Center for Infectious Diseases
West Nile Virus Activity
Cumulative results for 1999 calendar year





2000

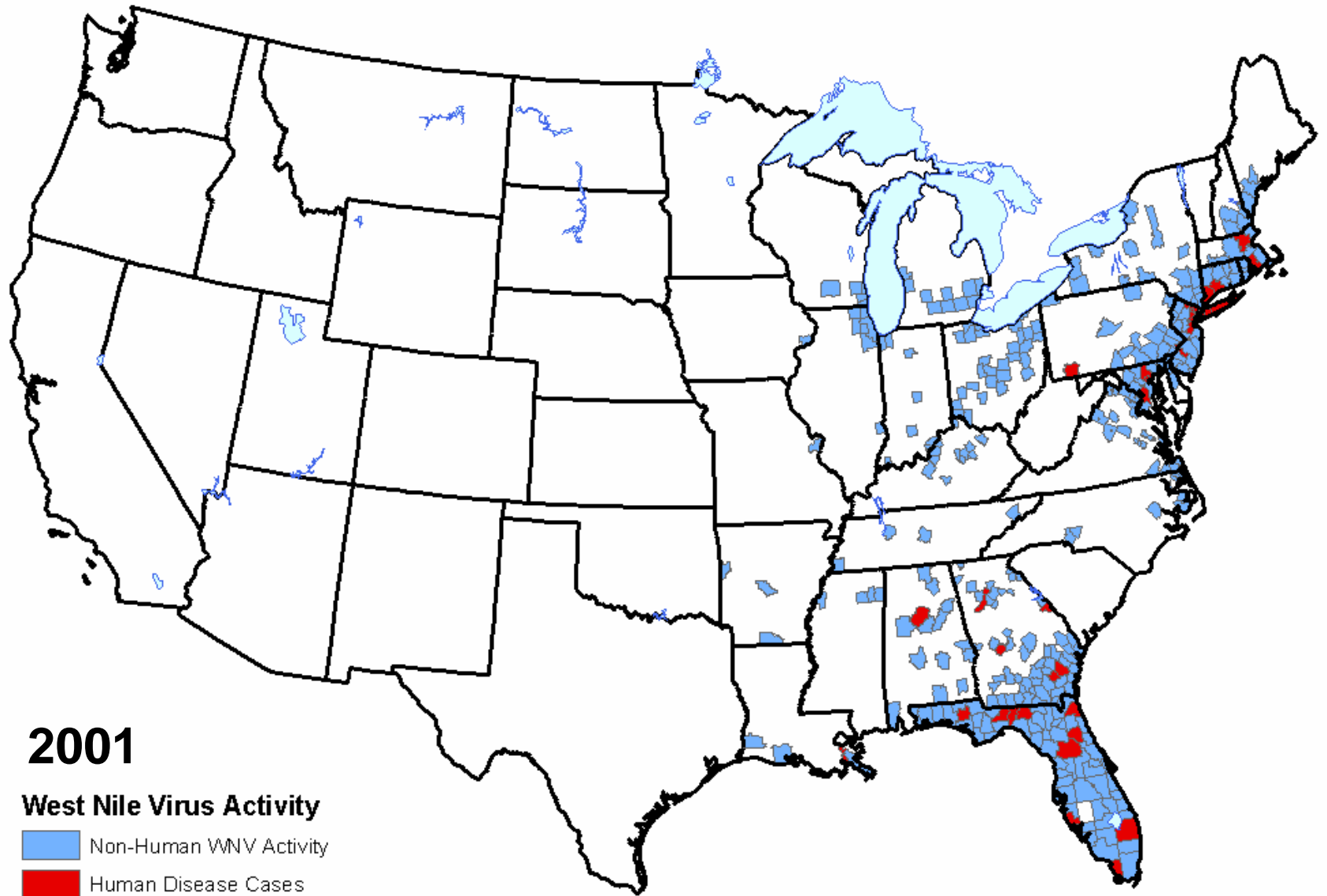
West Nile Virus Activity

-  Non-Human WNV Activity
-  Human Disease Cases

12 States
21 Cases



National Center for Infectious Diseases
West Nile Virus Activity
Cumulative results for 2000 calendar year





2001

West Nile Virus Activity

-  Non-Human WNV Activity
-  Human Disease Cases

27 States

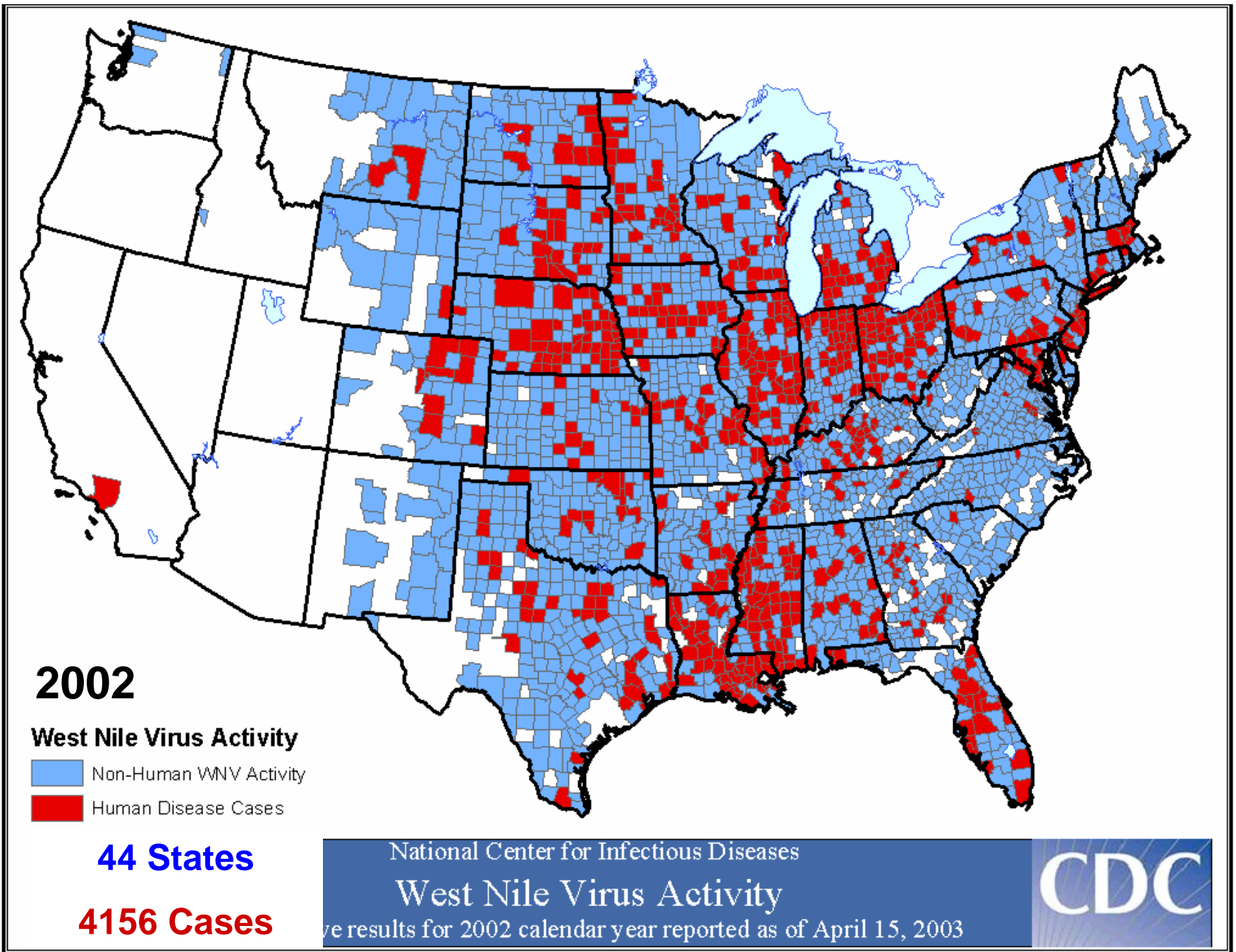
66 Cases

National Center for Infectious Diseases

West Nile Virus Activity



Cumulative results for 2001 calendar year

CDC



2002

West Nile Virus Activity

-  Non-Human WNV Activity
-  Human Disease Cases

44 States

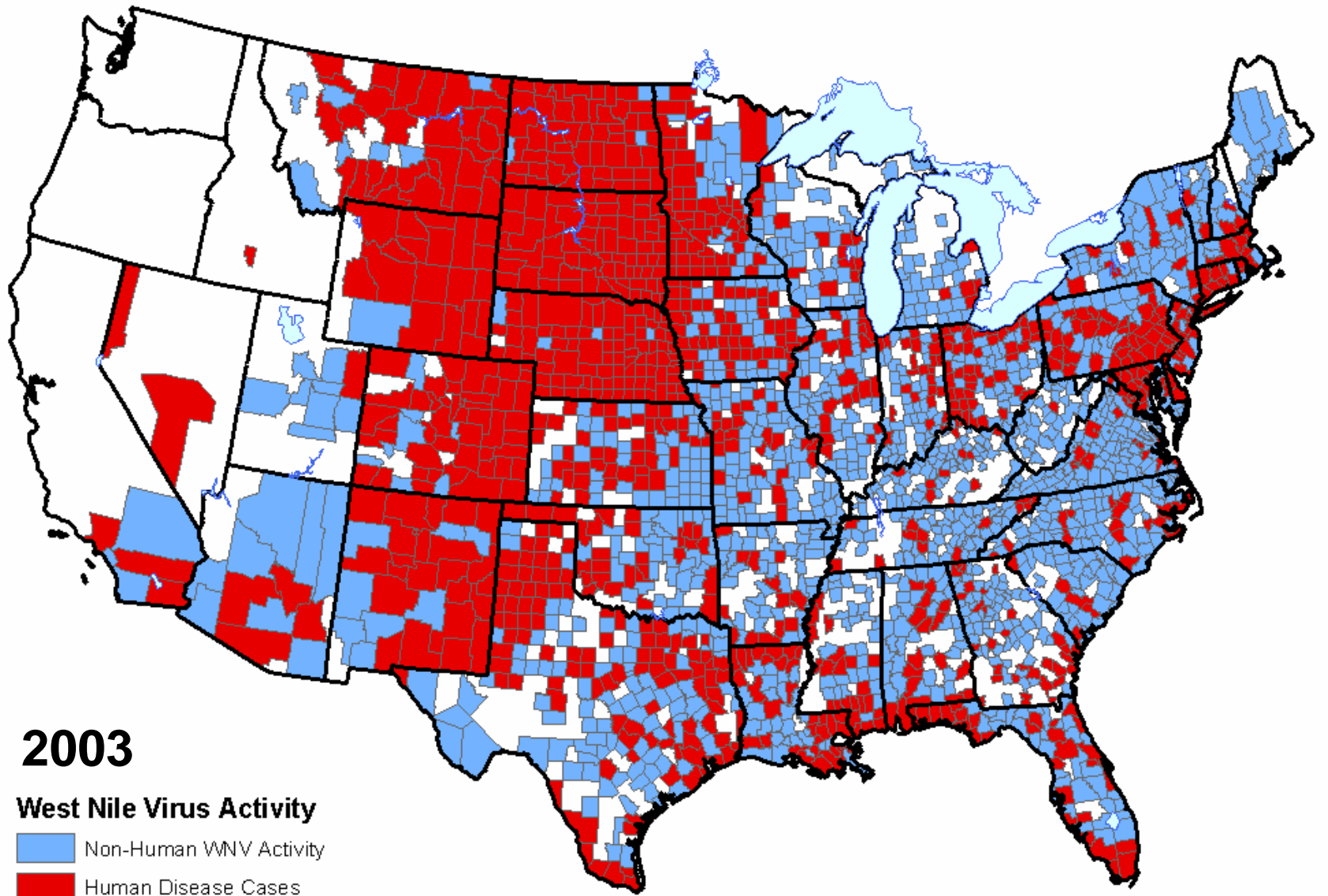
4156 Cases

National Center for Infectious Diseases

West Nile Virus Activity



Final results for 2002 calendar year reported as of April 15, 2003

CDC



2003

West Nile Virus Activity

-  Non-Human WNV Activity
-  Human Disease Cases

46 States

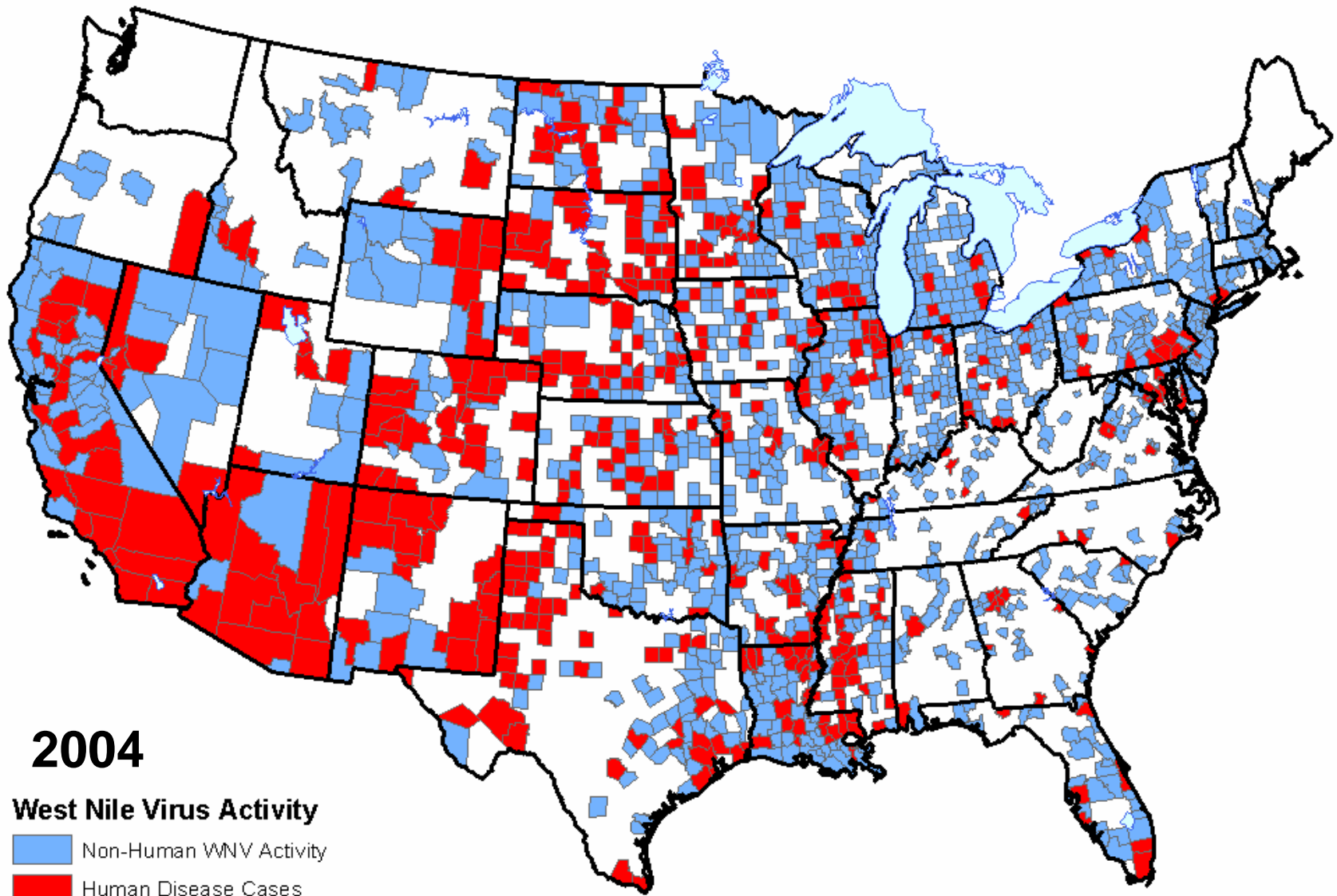
9862 Cases

National Center for Infectious Diseases

West Nile Virus Activity



Final results for 2003 calendar year reported as of May 20, 2004

CDC



2004

West Nile Virus Activity

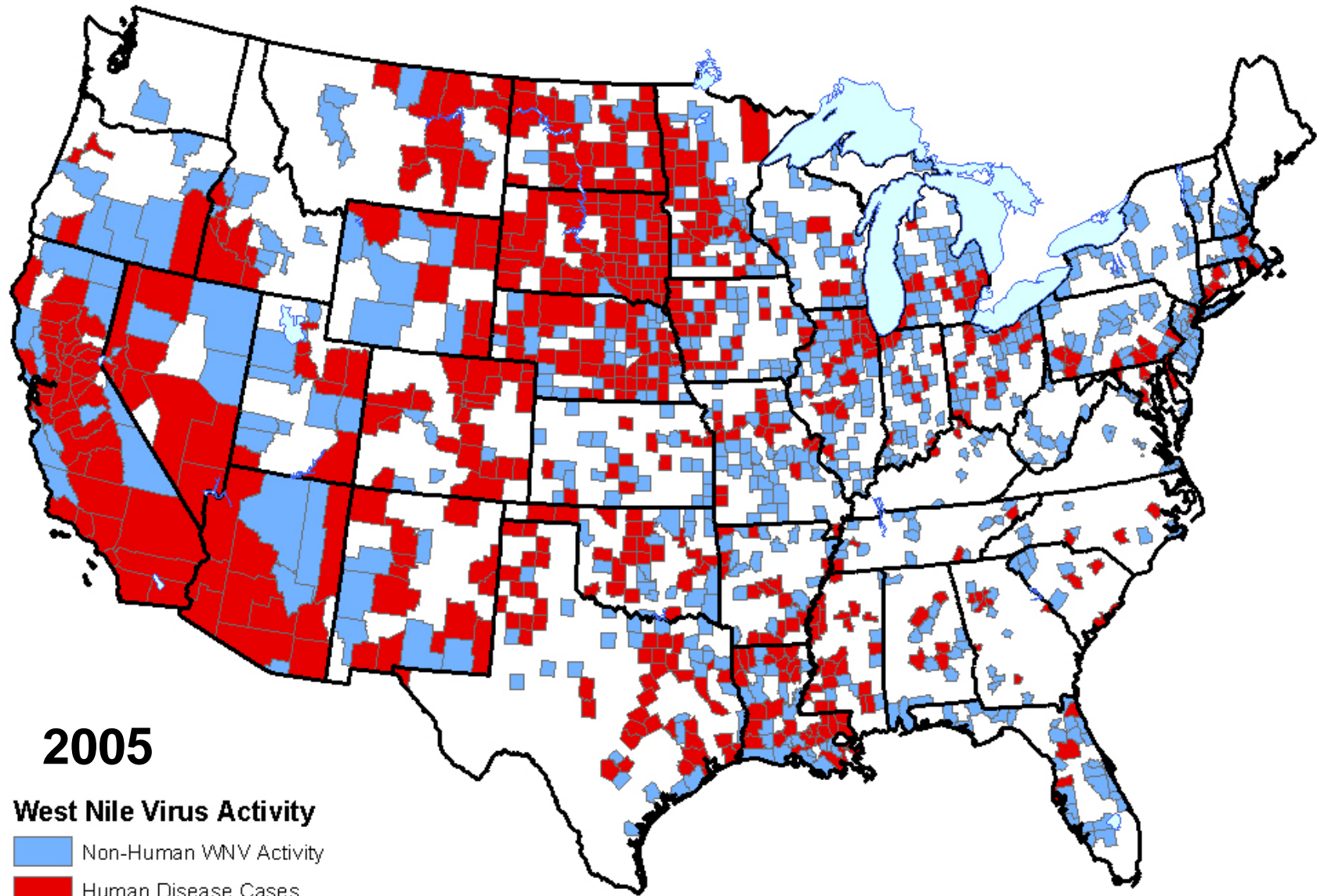
-  Non-Human WNV Activity
-  Human Disease Cases

47 States

2535 Cases



National Center for Infectious Diseases
West Nile Virus Activity
Positive results for 2004 calendar year reported as of January 11, 2005





2005

West Nile Virus Activity

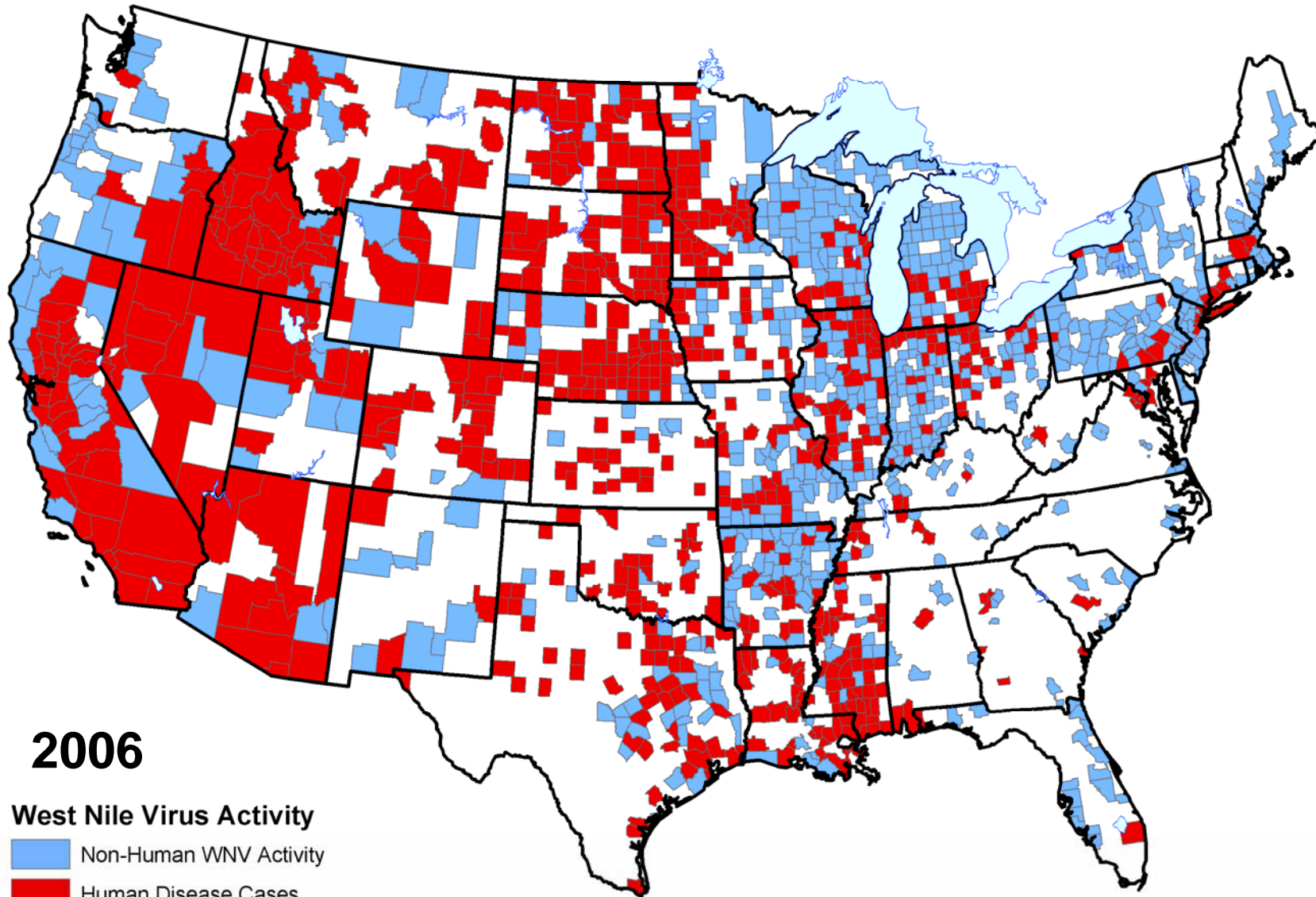
-  Non-Human WNV Activity
-  Human Disease Cases

48 States

2819 Cases



National Center for Infectious Diseases
West Nile Virus Activity
Active results for 2005 calendar year reported as of January 3, 2006





2006


West Nile Virus Activity

-  Non-Human WNV Activity
-  Human Disease Cases

48 States

4219 Cases

National Center for Infectious Diseases
West Nile Virus Activity
Relative results for 2006 calendar year reported as of Dec 15, 2006



61 Mosquito Species Reported WNV Positive in U.S. 1999-2006

<i>Ae aegypti</i>	<i>Cx erraticus</i>	<i>De cancer</i>	<i>Oc provocans</i>
<i>Ae albopictus</i>	<i>Cx erythrothorax</i>	<i>Ma tittilans</i>	<i>Oc sollicitans</i>
<i>Ae cinereus</i>	<i>Cx nigripalpus</i>	<i>Oc atlanticus/tormentor</i>	<i>Oc squamiger</i>
<i>Ae vexans</i>	<i>Cx pipiens</i>	<i>Oc atropalpus</i>	<i>Oc sticticus</i>
<i>An atropos</i>	<i>Cx quinquefasciatus</i>	<i>Oc canadensis</i>	<i>Oc stimulans</i>
<i>An barberi</i>	<i>Cx restuans</i>	<i>Oc cantator</i>	<i>Oc taeniorhynchus</i>
<i>An crucians/bradleyi</i>	<i>Cx salinarius</i>	<i>Oc condolenscens</i>	<i>Oc triseriatus</i>
<i>An franciscanus</i>	<i>Cx stigmatosoma</i>	<i>Oc dorsalis</i>	<i>Oc trivittatus</i>
<i>An freeborni</i>	<i>Cx tarsalis</i>	<i>Oc dupreei</i>	<i>Or signifera</i>
<i>An hermsi</i>	<i>Cx territans</i>	<i>Oc fitchii</i>	<i>Ps ciliata</i>
<i>An punctipennis</i>	<i>Cx thriambus</i>	<i>Oc fulvus pallens</i>	<i>Ps columbiae</i>
<i>An quadrimaculatus</i>	<i>Cs impatiens</i>	<i>Oc grossbecki</i>	<i>Ps ferox</i>
<i>An walkeri</i>	<i>Cs incidens</i>	<i>Oc infirmatus</i>	<i>Ps howardii</i>
<i>Cq perturbans</i>	<i>Cs inornata</i>	<i>Oc japonicus</i>	<i>Ur sapphirina</i>
<i>Cx coronator</i>	<i>Cs melanura</i>	<i>Oc melanimon</i>	
	<i>Cs morsitans</i>	<i>Oc nigromaculis</i>	

Bird mortality in North Am. – >300 species

American Crow	Carolina Wren	Gray Catbird	Northern Goshawk	Scissor-tailed Flycatcher
American Goldfinch	Cedar Waxwing	Gray-cheeked Thrush	Northern Harrier	Sharp-shinned Hawk
American Kestrel	Chilean Flamingo	Great Black-backed Gull	Northern Mockingbird	Short-eared Owl
American Robin	Chimney Swift	Great Blue Heron	Northern Parula	Snowy Owl
American White Pelican	Cockatiel	Great Egret	Northern Saw-whet Owl	Song Sparrow
Bald Eagle	Cockatoo	Great Horned Owl	Northern Waterthrush	Steller's Jay
Baltimore Oriole	Common Grackle	Great-tailed Grackle	Osprey	Swainson's Hawk
Barn Owl	Common Ground-Dove	Green Heron	Ovenbird	Swainson's Thrush
Barn Swallow	Common Loon	Guanay Cormorant	Pied-billed Grebe	Swallow-tailed Kite
Barred Owl	Common Nighthawk	Harris' Hawk	Prairie Falcon	Trail's Flycatcher
Belted Kingfisher	Common Raven	Hermit Thrush	Purple Finch	Tufted Titmouse
Black Skimmer	Common Yellowthroat	Herring Gull	Purple Martin	Tundra Swan
Black Vulture	Cooper's Hawk	Hooded Warbler	Red-crowned Parrot	Turkey Vulture
Black-billed Magpie	Dickcissel	House Finch	Red-eyed Vireo	Varied Tit
Black-capped Chickadee	Domestic Chicken	House Sparrow	Red-headed Woodpecker	Veery
Black-crowned Night Heron	Double-crested Cormorant	Impeyan Pheasant	Red-shouldered Hawk	Virginia Rail
Blackpoll Warbler	Downy Woodpecker	Kentucky Warbler	Red-tailed Hawk	Warbling Vireo
Black-throated Blue Warbler	Eastern Bluebird	Killdeer	Red-winged Blackbird	Western Scrub-Jay
Black-whiskered Vireo	Eastern Kingbird	Laughing Gull	Ring-billed Gull	White-breasted Nuthatch
Blue Jay	Eastern Phoebe	Least Bittern	Ring-necked Pheasant	White-crowned Pigeon
Blythe's Tragopan	Eastern Screech-Owl	Loggerhead Shrike	Rock Dove	White-winged Dove
Boat-tailed Grackle	Eastern Towhee	Lorikeet species	Rose-breasted Grosbeak	Wild Turkey
Brewer's Blackbird	Emu	Macaw	Rough-legged Hawk	Winter Wren
Broad-winged Hawk	Eurasian Collared-Dove	Mallard	Ruby-throated Hummingbird	Wood Duck
Bronze-winged Duck	Eurasian Wigeon	Merlin	Ruddy Duck	Wood Thrush
Brown Thrasher	European Goldfinch	Mississippi Kite	Ruddy Turnstone	Yellow Warbler
Brown-headed Cowbird	European Starling	Mourning Dove	Ruffed Grouse	Yellow-bellied Sapsucker
Budgerigar	Evening Grosbeak	Mute Swan	Rusty Blackbird	Yellow-billed Cuckoo
Canada Goose	Field Sparrow	Nashville Warbler	Sandhill Crane	Yellow-crowned Night-Heron
Canada Warbler	Fish Crow	Northern Bobwhite	Savannah Sparrow	Yellow-rumped Warbler
Canvasback	Fox Sparrow	Northern Cardinal	Scarlet Ibis	Zebra Finch
Carolina Chickadee	Golden Eagle			

WN Virus Disease Burden in the United States

Reported WNV Disease in Humans, United States 1999-2006

WN Fever	13,921
WN Neuroinvasive	9,786
Total	23,707
Deaths	928

Estimated WNV burden 1999-2006

**9,786 WNND cases
x 20 WN fever cases/WNND**

195,720 WNV Fever Cases

**9,786 WNND cases
+ 195,720 WNV Fever Cases**


205,506 Symptomatic WNV Cases

**9,786 WNND cases
x 150 infections/WNND case**

1.46 Million WNV Infections

Novel Modes of West Nile Virus Transmission

- **Transfused blood**
- **Transplanted organs**
- **Breast milk**
- **Transplacental transmission**
- **Percutaneous, occupational exposure**
- **Conjunctival exposure**
- **Dialysis?**



**WNV Risk Reduction through
Predictive Surveillance
Integrated Mosquito Management
and
Personal Protection**



SAFER • HEALTHIER • PEOPLE™

National Center for Zoonotic, Vector-Borne and Enteric Diseases

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