Role of Corvids in the epidemiology of West Nile virus in California*

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Those that did the work….

- Center for Vectorborne Diseases:
  - C Barker, B Eldridge, B Park: spatial analysis, data management
  - H Lothrop, S Wheeler, M Kennsington, M Palmer, P Miller: field ecology Coachella Valley
  - J Wilson: field ecology Los Angeles
  - V Martinez, B Carroll, S Hallam, D Jurich, K Newlen: field ecology and vector competence, Kern County
  - V Armijos, C Nielsen: field ecology Sacramento & Yolo Counties
  - Y Fang, M Shafii, S Garcia, N Kahl, S Astari, B Cahoon-Young, A Brault: laboratory diagnostics
- California Animal Health and Food Safety:
  - L Woods: dead bird necropsies
- Coachella Valley MVCD: B Lothrop, D Gomsi, A Gutierrez
- Greater Los Angeles VCD: M Madon, J Hazelrigg, S Kluh, P OConnor, J Spoehl, S Tabatabaeepour
- Kern MVCD: R Takahashi, R Quiring
- Sacramento-Yolo MVCD: S Wright, D Brown, G Yoshimura, D Eldin Elnaiem, K Kelly
- California Department of Health Services
  - C Glaser, C Jean: human surveillance
  - B Sun: veterinary surveillance
  - C Cossen, L Baylis: sentinel chicken serology
  - V Kramer, S Husted, A Hom, R Carney, L Marcus: dead bird surveillance, data reporting
- Scripps Institute of Oceanography, University of California, San Diego
  - D Cayan, M Dettinger, M Tyree: Climate analysis

Those that paid for the work….

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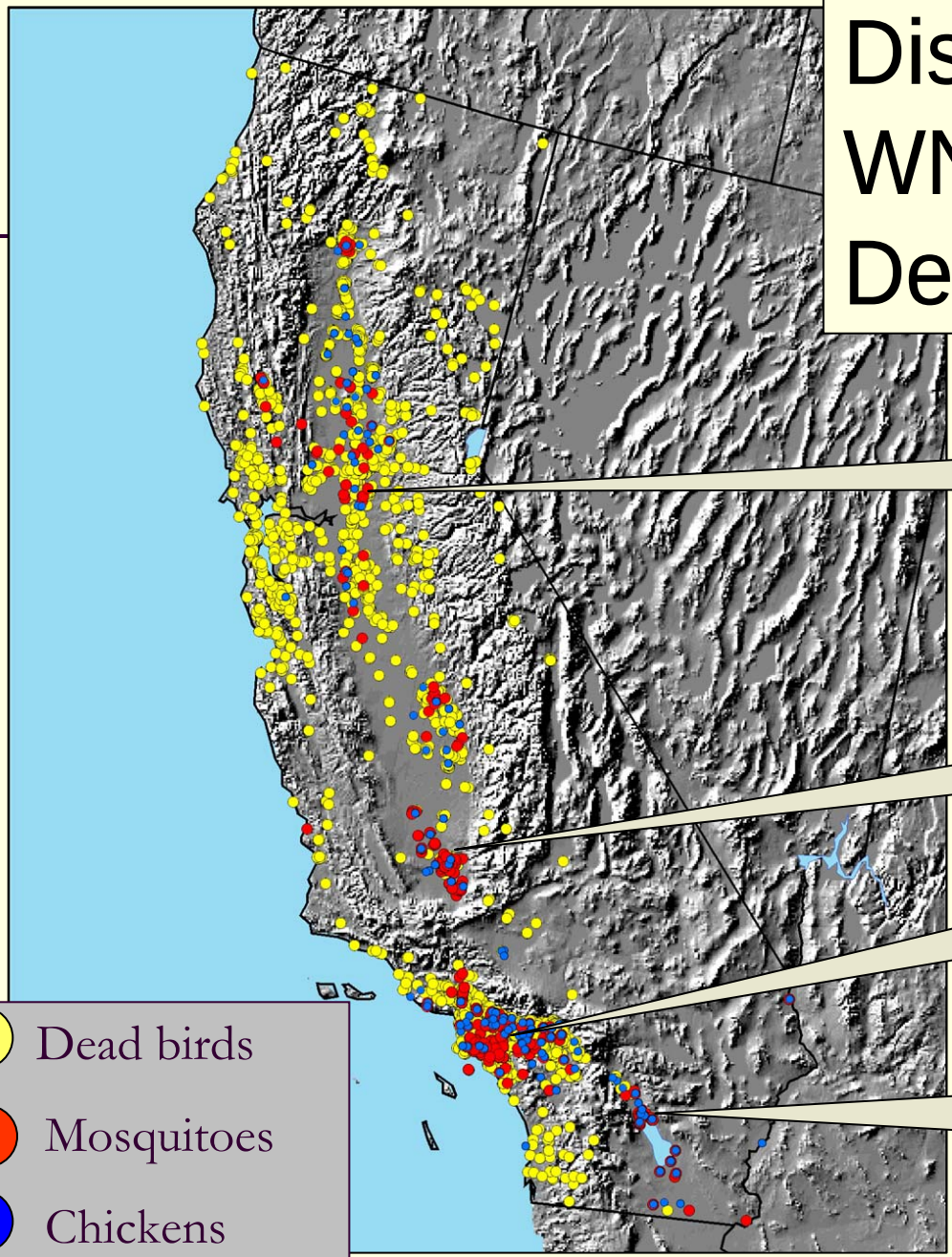
- Centers for Disease Control and Prevention
- Office of Global Programs NOAA
- Coachella Valley, Greater LA, Kern and Sac-Yolo MVCDs
- University-Wide Mosquito Research Program

Content – California focused

- Background:
  - Distribution of WNV in California, 2004
- Natural experiment based on corvid distributions: 2004 epidemic in southern California
  - Distribution of Corvids
  - Host competence
  - Mosquito infection rates
  - Case count and incidence of infection
- Spatial analysis of dead birds
  - American crows
  - Western scrub jays
  - Dead crows delineate foraging radius in LA
    - *Culex* infection rates
    - Human case distributions
- Importance of ‘herd immunity’ in peridomestic passerines
- Emerging concepts of WNV epidemiology

Distribution of WNV in California, December 2004



Invasion of Sacramento

Invasion and amplification in Kern County

Epidemic transmission in Los Angeles

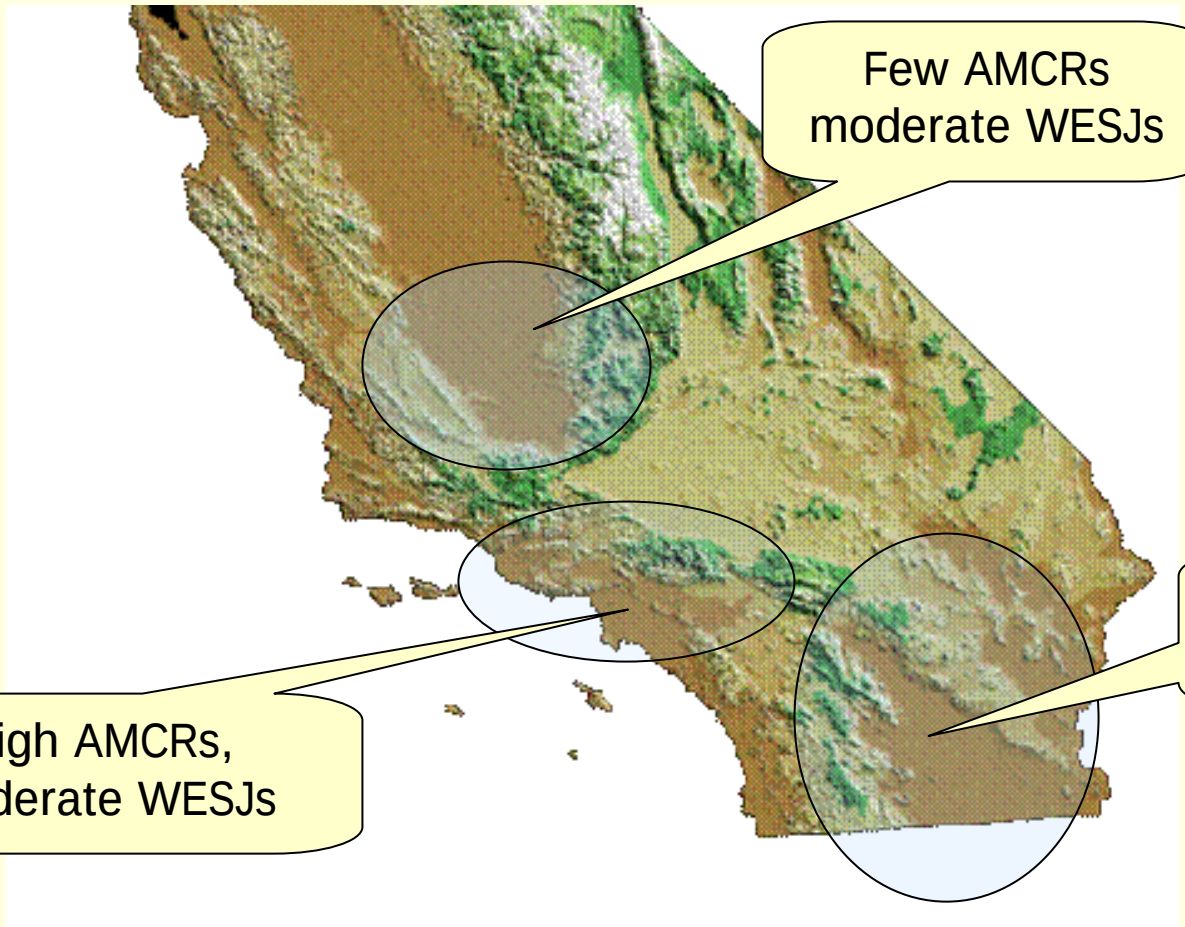
Widespread enzootic activity in SE California

Dead birds

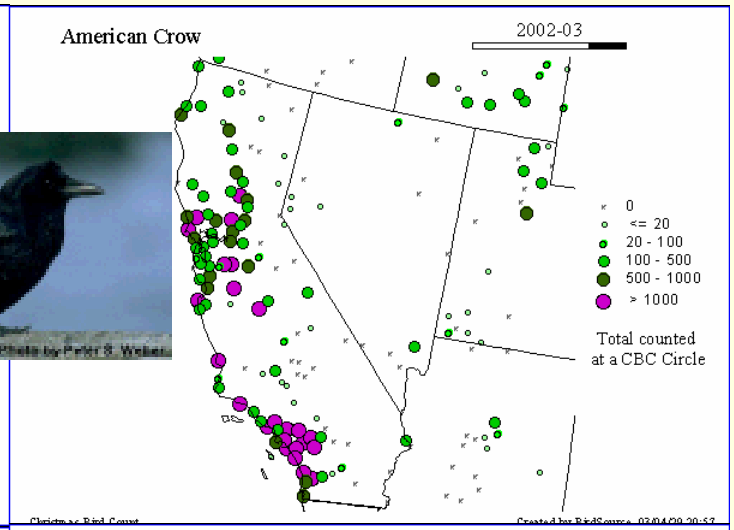
Mosquitoes

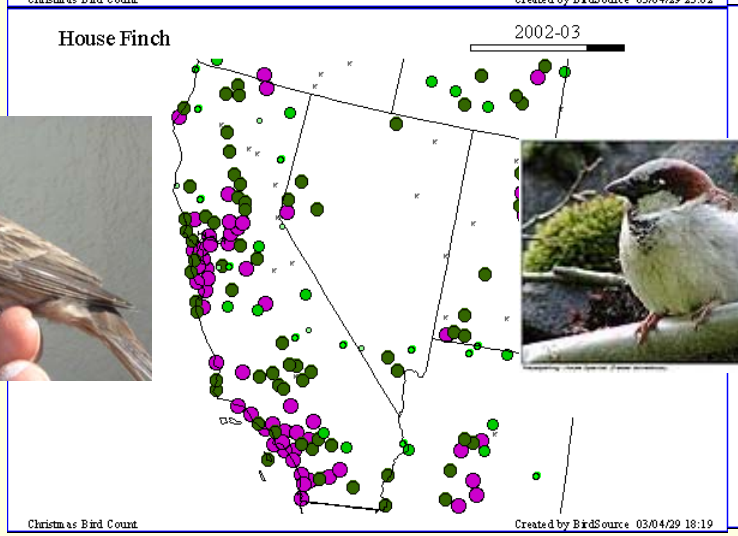
Chickens

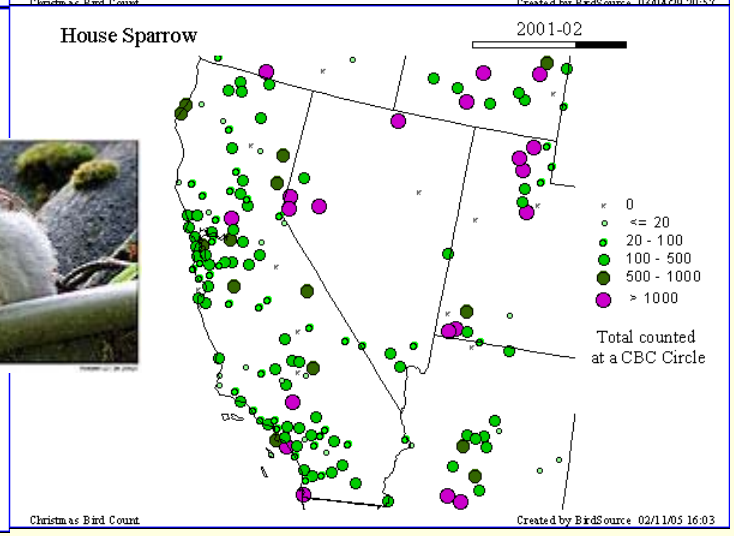
Natural experiment: three areas in southern California with different densities of corvids



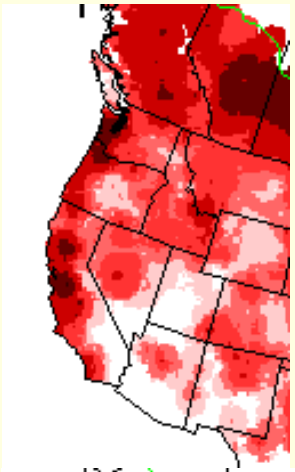
Distribution of effective hosts in California based on CBC data, 2003



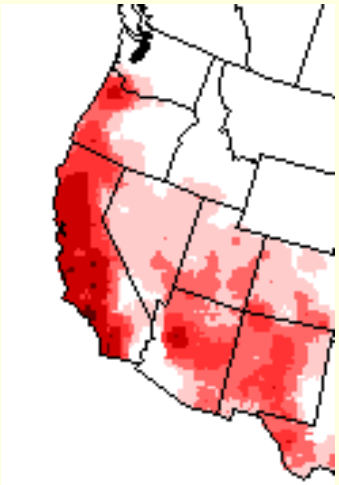




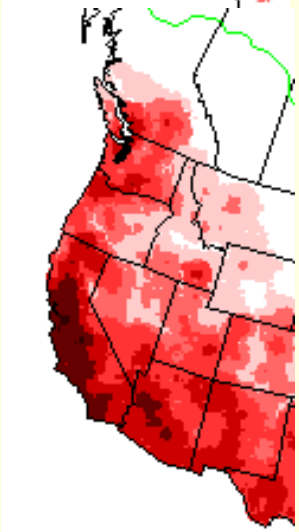
Distribution of effective WNV hosts in California based on BBC data [http://www.mbr-pwrc.usgs.gov/]



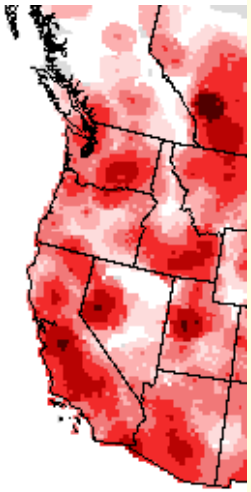
American crow



Western scrub jay

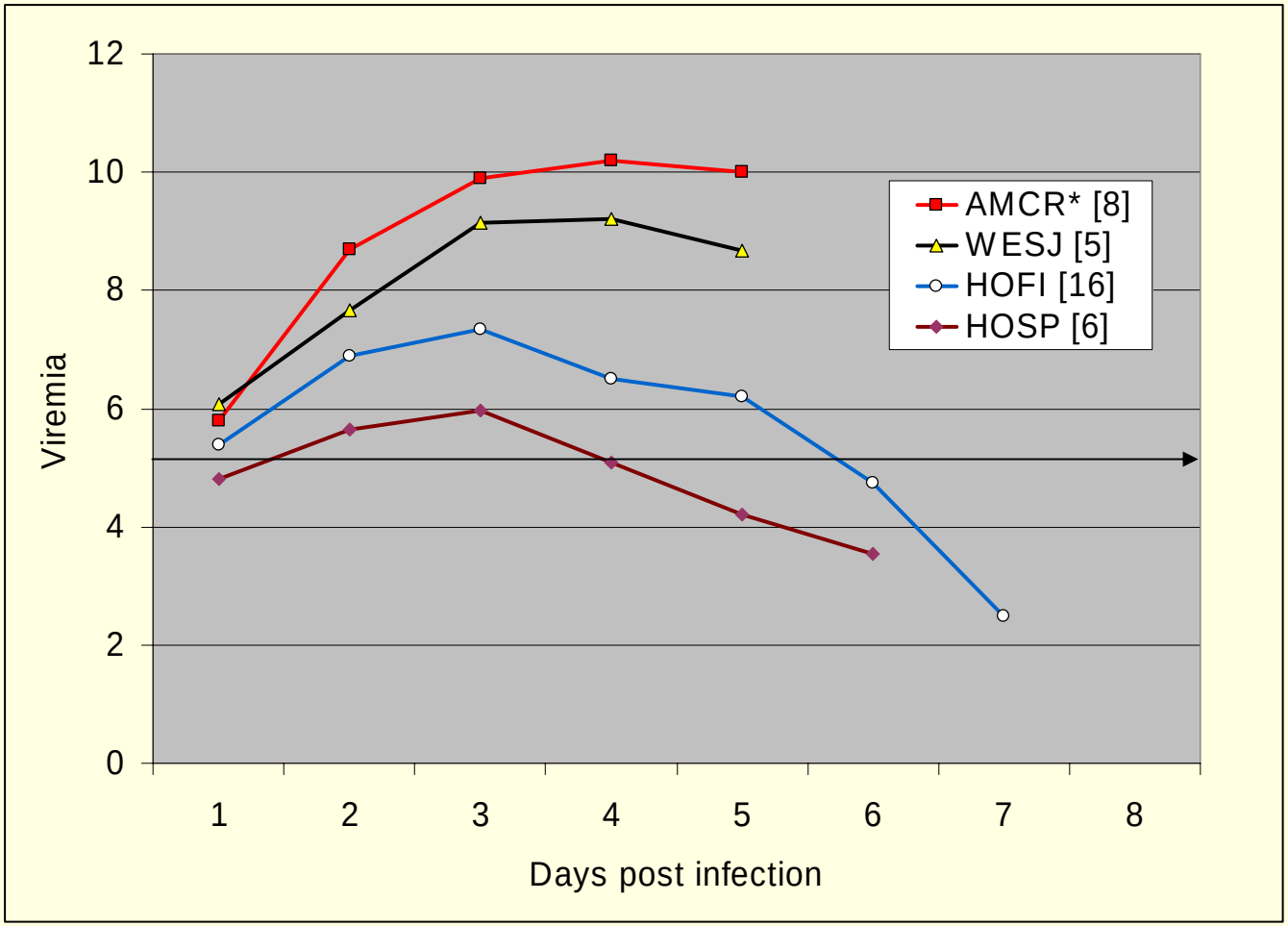


House finch



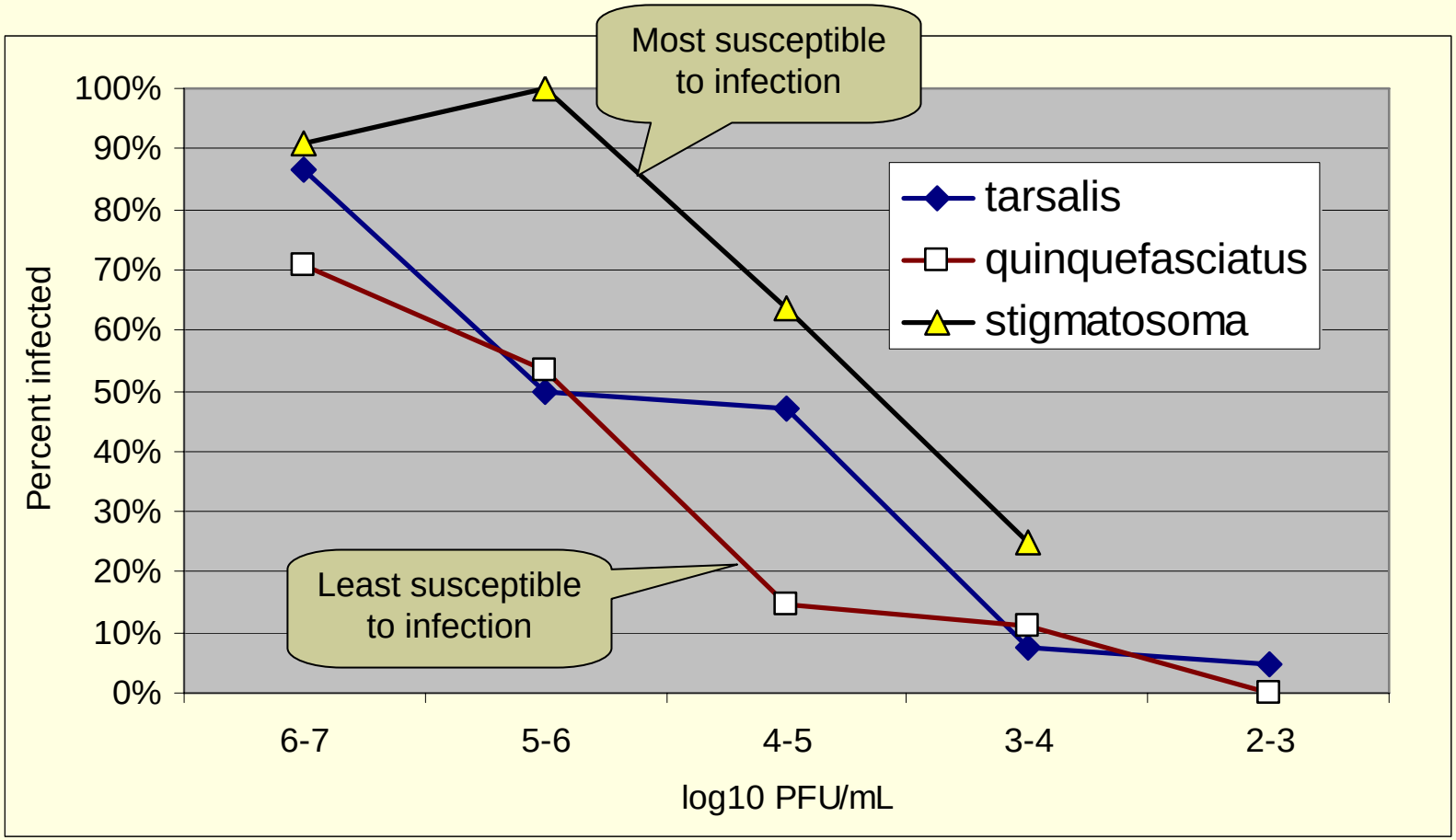
House sparrow

Viremia profiles [$\log_{10}$ PFU/mL] for two Corvid and two peridomestic passerine species to West Nile virus infection



* Data from Komar et al. 2003 EID 9: 311

Vector competence of *Culex* vectors in southern California, 2005



Data summarizes 2 experiments in each of 3 study areas, n = 20 – 30 females/exp

Infection rates for *Culex* species tested from southern California, May – Sep 2004

Culex species	Pools tested	Total mosquitoes tested	WNV positives	Infection Rate per 1,000	Lower Limit	Upper Limit
		Coachella Valley				
quinquefasciatus	132	3,132	4	1.29	0.42	3.08
tarsalis	424	15,137	63	4.56	3.54	5.79
erythrothorax	15	715	0			
		Kern County				
quinquefasciatus	406	15,325	86	6.42	5.17	7.89
tarsalis	410	16,893	85	5.72	4.60	7.04
		Los Angeles				
erythrothorax	263	12575	3	0.24	0.06	0.65
quinquefasciatus	1029	38,420	270	8.09	7.18	9.09
tarsalis	135	4,411	18	4.34	2.68	6.70
stigmatosoma	37	613	6	10.22	4.32	20.89

MLE Calculated from Biggerstaff: http://www.cdc.gov/ncidod/dvbid/westnile/software.htm

Incidence of WNV cases [CNS + fever] among human populations, California 2004

Area	Population size (in 1000s)[a]	WNV cases[b]	Incidence per 100,000
California	33,871	819	2.42
Coachella Valley	336	7	2.08
Los Angeles County	9,519	327	3.44
Kern County	662	60	9.06

[a] Based on 2,000 census figures

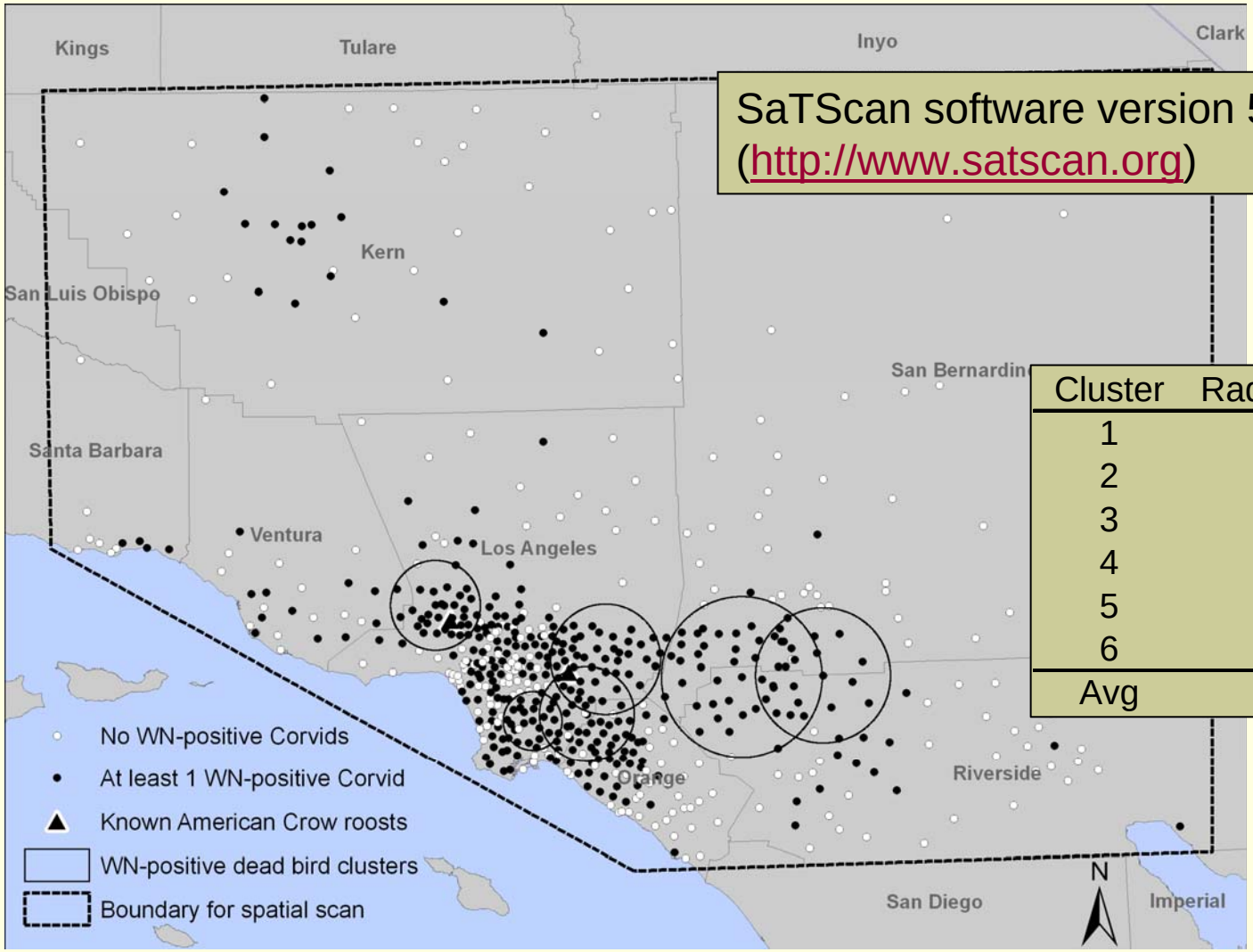
[b] through 15 Dec 04, West Nile fever and Neurological Disease as well as infections detected by blood banks included.

Data from: http://westnile.ca.gov/2004_maps.htm

Spatial distribution:
Dispersion of corvids determines the patterns of risk

Crows at large staging area, Whittier Narrows Wildlife Area, Sep, 2004

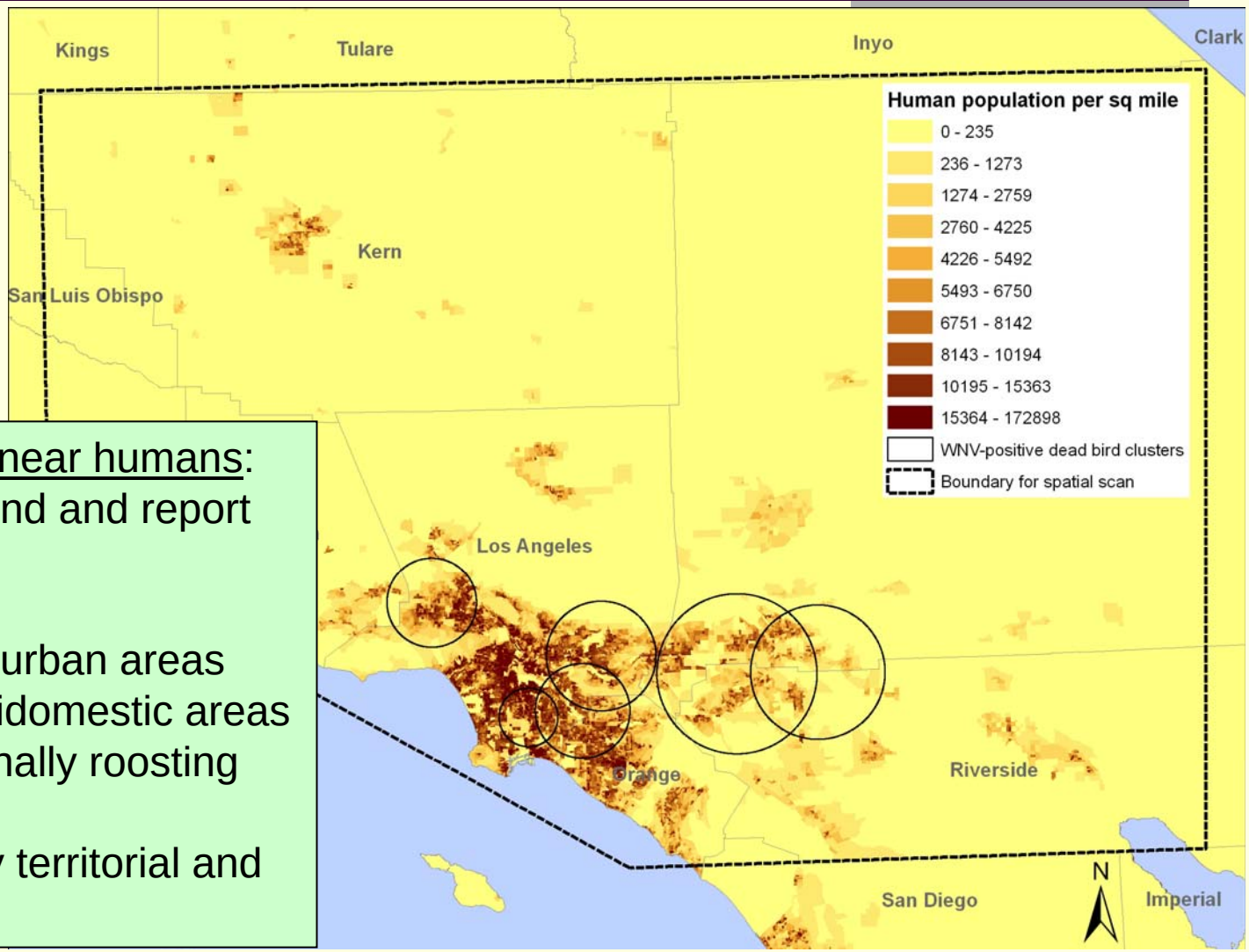
Distribution of dead corvids [AMCR & WESJ] reported by the public that tested positive for WNV, 2004



SaTScan software version 5.1 (http://www.satscan.org)

Cluster	Radius [km]
1	18.4
2	26.8
3	15
4	15.8
5	22.6
6	9.8
Avg	18.1

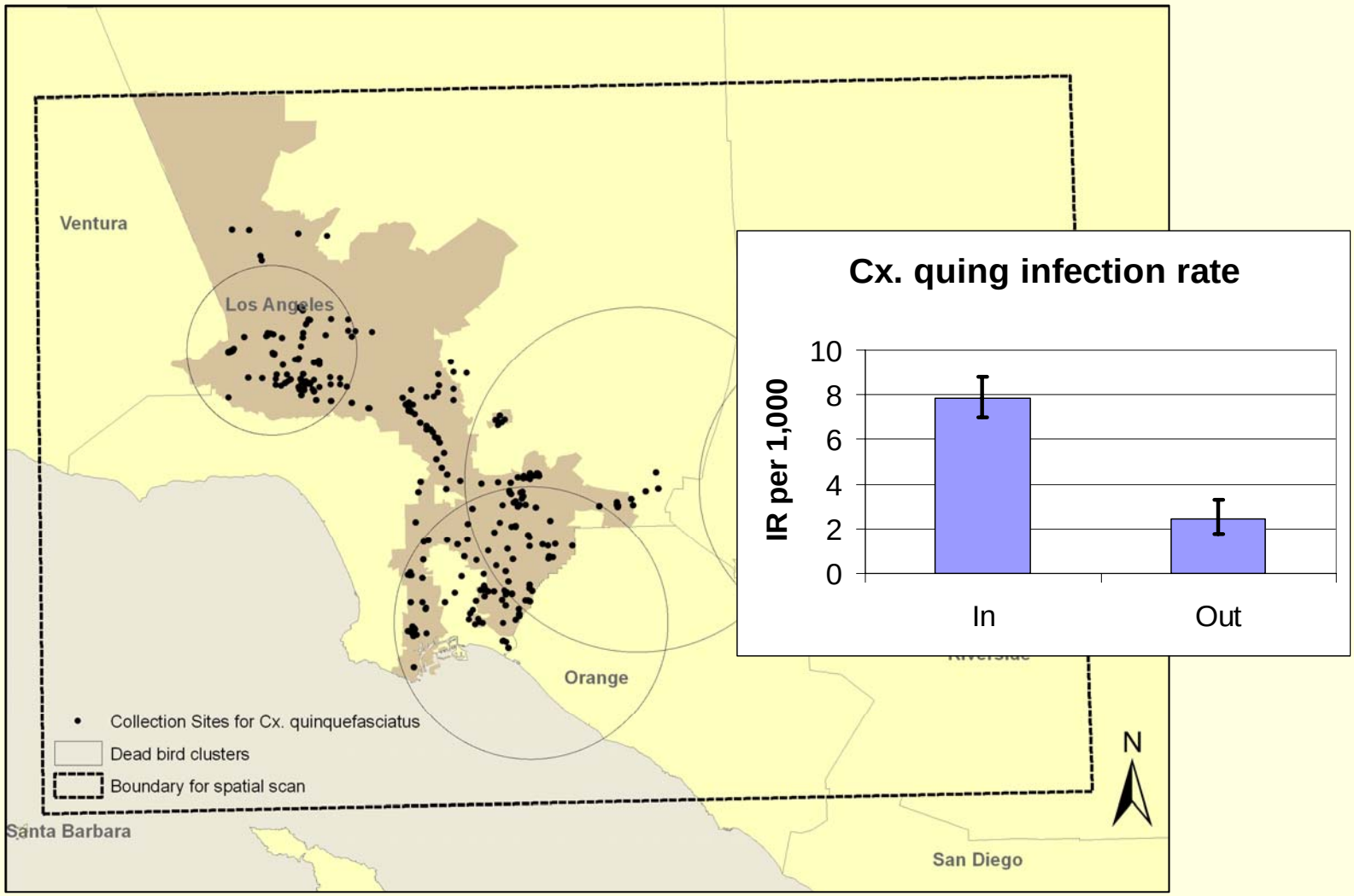
Human density per sq mi in relation to dead bird clusters in southern California, 2004



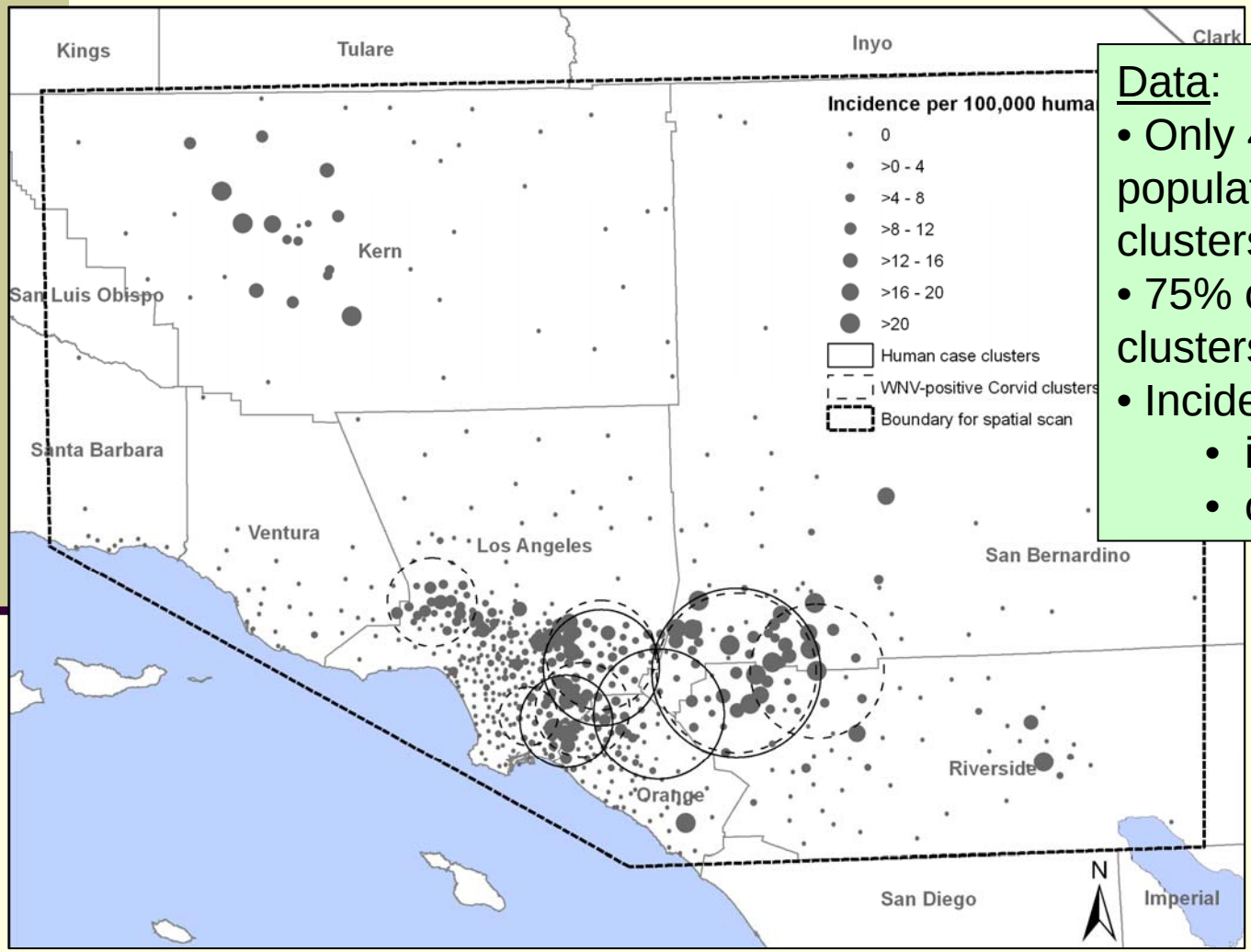
Dead bird clusters near humans:

- Humans have to find and report dead birds
- Corvids:
  - Live near periurban areas
  - Forage in peridomestic areas
- Clusters - communally roosting AMCRs
- WESJs are highly territorial and evenly distributed

Mosquito trap locations, Greater LA VCD, and dead bird clusters, 2004



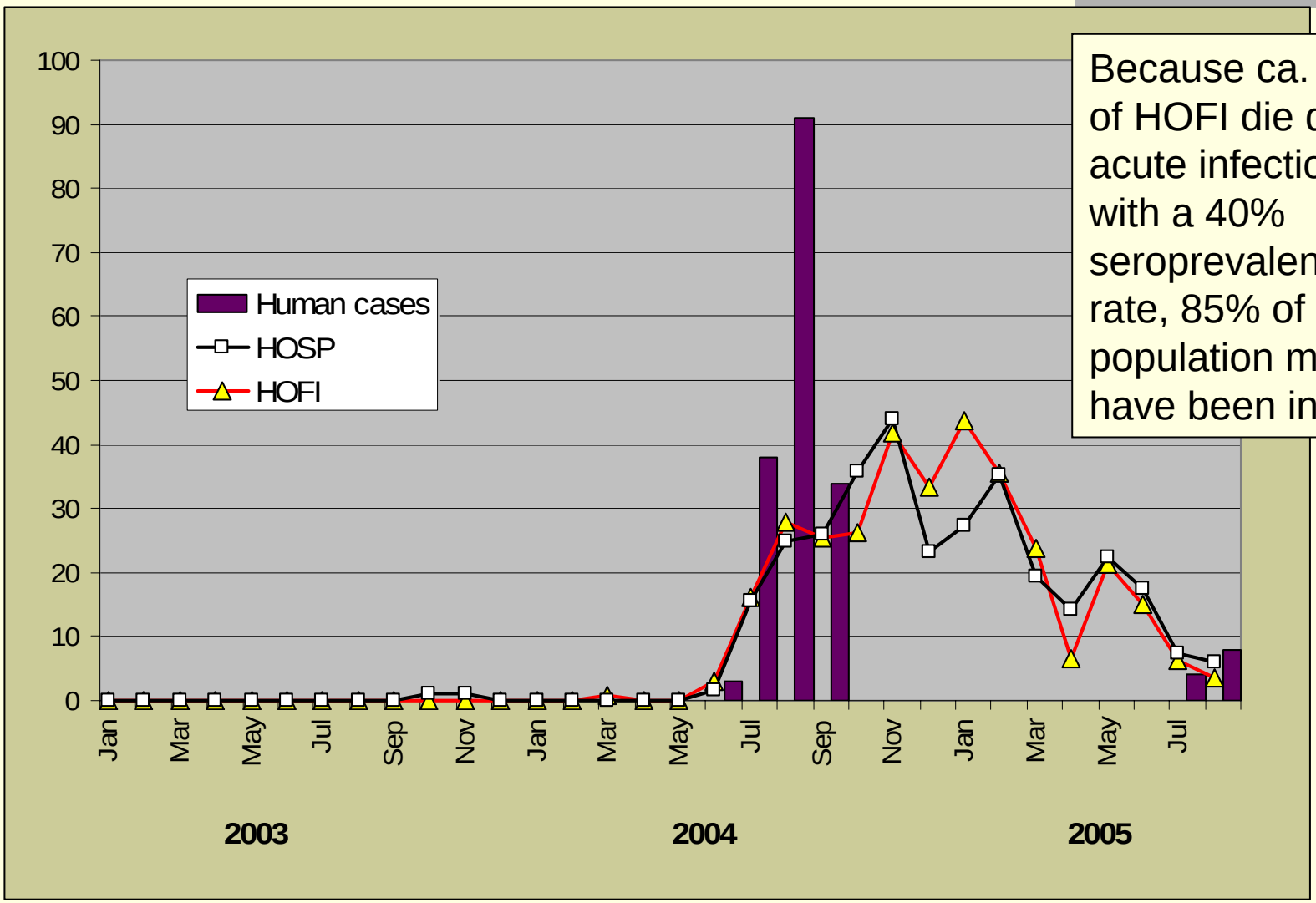
Congruent clusters of human cases per zip code in relation to dead corvid clusters



Data:

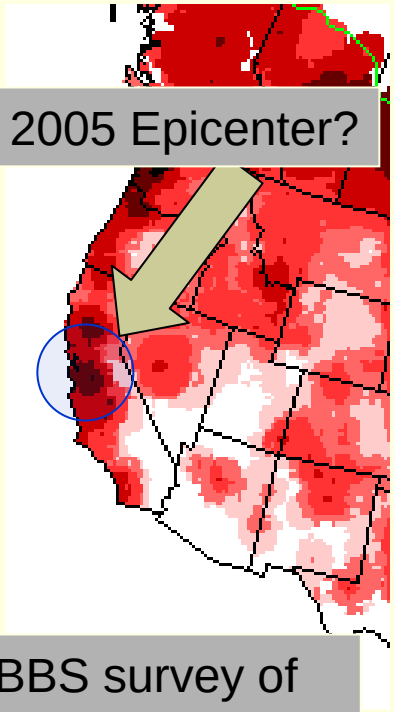
- Only 41% of human population lived within clusters
- 75% cases lived within clusters
- Incidence per 100,000
  - in clusters = 5.9
  - outside clusters = 1.3

WNV seroprevalence in House finches and House sparrows and the occurrence of human cases, Los Angeles County

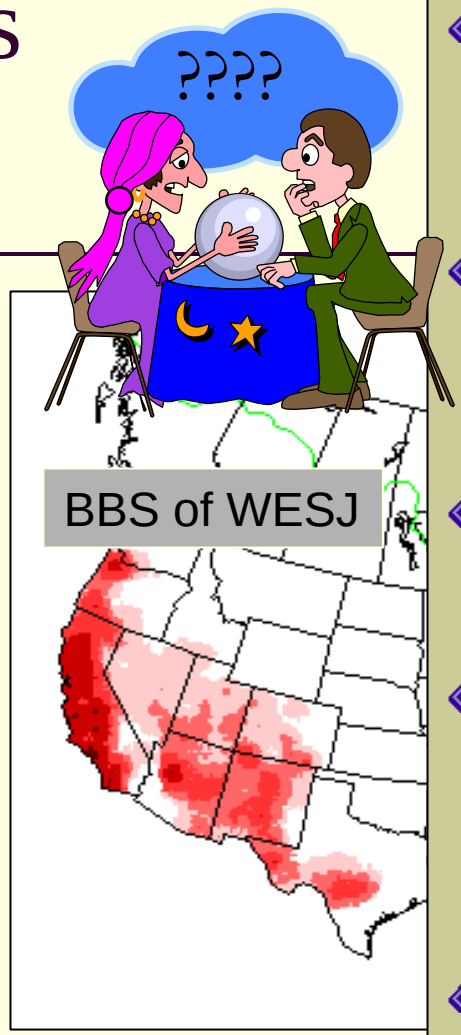


Because ca. 75% of HOFI die during acute infection, with a 40% seroprevalence rate, 85% of the population may have been infected

Predictions for 2005



BBS survey of American crow distribution California



- Epidemic will subside south of Tehachapi Mts because most crows have died or are now immune
- Enzootic transmission will intensify in Central Valley, driven by American crows and Western scrub jays
- Peak transmission will occur later in summer in Central Valley than in SOCAL
- Human involvement will be focal, periurban and associated with communal crow roosts that ‘drive’ virus into *Cx. pipiens* popualtions
- Epidemic could worsen

Sacramento-Yolo Counties: The 2005 WNV Epicenter

188 human cases:

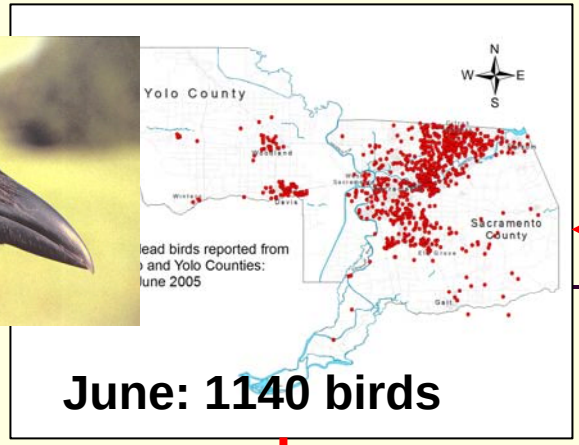
- **1 death**
- **51 cases of neuroinvasive disease**
- **121 cases of WNV fever**
- **15 asymptomatic cases**

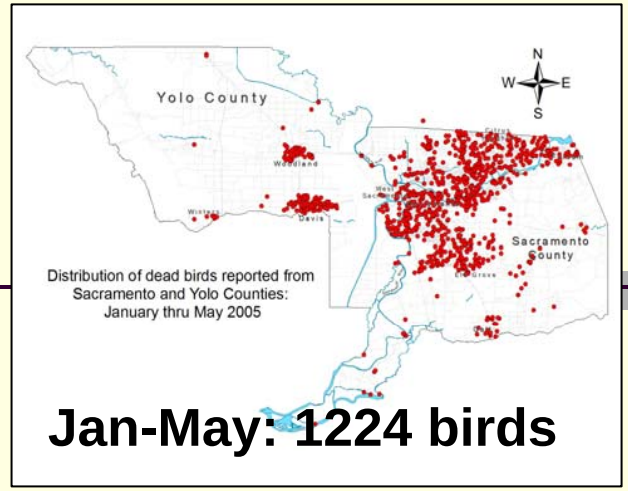
47 infections in horses

53.6 % infection rate in 110 sentinel chickens

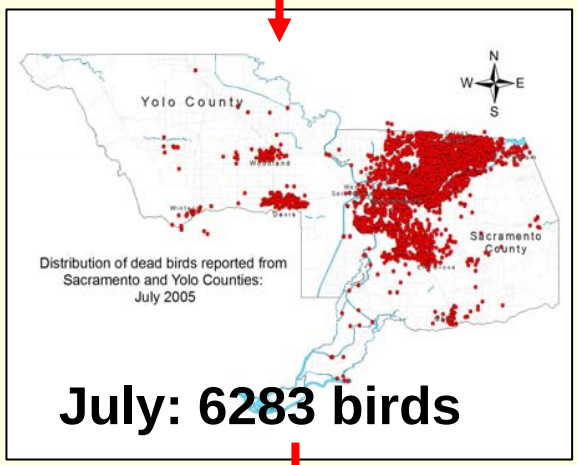
19,429 dead bird reports

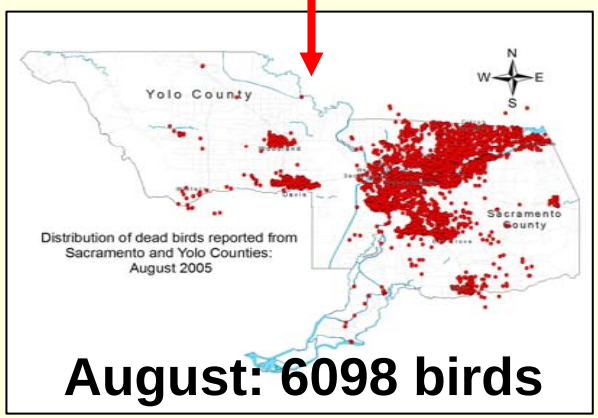
Slide from Dia-Eldin A. Elnaiem, Sac-Yolo MVCD

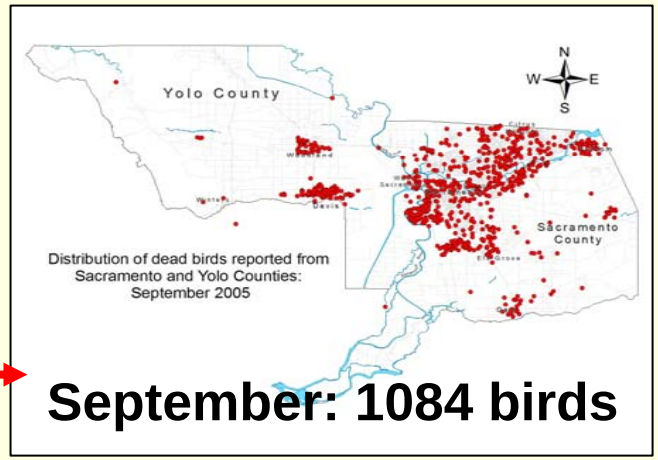




Sac-Yolo Counties Monthly dead birds reports, 2005





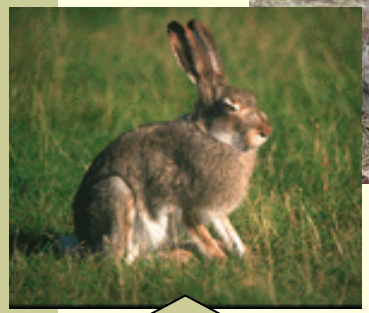


Slide from Dia-Eldin A. Elnaiem, Sac-Yolo MVCD

West Nile virus transmission cycles in California

Rural cycles

Urban cycle



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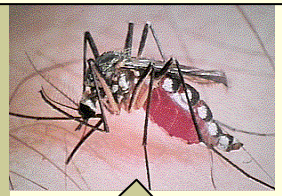
Ochlerotatus



Culex tarsalis

Bird/Mosquito Movement?

Culex pipiens stigmat. ?erythro.

Other species

Dead end hosts

Summary

- Competence and distribution of mosquito vectors in relation to avian hosts determines the efficiency of local transmission
- Virulence of WNV for corvids and the resulting elevated viremia seem critical to efficiently infect moderately susceptible urban mosquitoes in the *Culex pipiens* complex
- Distribution patterns of Corvids seems to determine the distribution of human cases in urban landscapes