Rabies Surveillance in California

Annual Report 2014

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Introduction

Rabies is a severe encephalitis caused by a Rhabdovirus in the genus *Lyssavirus*. Following a variable incubation period that can range from one week to several years, early clinical signs and symptoms of rabies--including headache, fever, chills, cough or sore throat, anorexia, nausea, vomiting, and malaise--are non-specific and easily mistaken for more common conditions. Disease progresses rapidly (within 1-2 weeks) to central and peripheral neurologic manifestations including altered mental status (e.g., hyperactivity and agitation), irritation at the site where the virus was introduced, hydrophobia, excessive salivation, and difficulty swallowing due to laryngeal spasms. Ultimately, autonomic instability, coma, and death occur, due mainly to cardiac or respiratory failure. No treatment protocol has proven consistently effective for clinical rabies and reports of patients surviving are exceedingly rare. If a person is exposed to the virus, prompt post-exposure prophylaxis (PEP) by administration of rabies immune globulin and vaccine can prevent progression to clinical rabies.

Variants of rabies virus are maintained in certain mammalian species, but all rabies viruses are capable of infecting any mammal, including humans. In California, bat variant rabies viruses exist throughout the state, while the California skunk variant is found mostly north of the Tehachapi mountain range. Domestic animals (dogs, cats, and livestock) can be infected with these rabies variants through contact with rabid wildlife but do not typically sustain transmission. Each year since 1957, the Director of the California Department of Public Health (CDPH) has identified counties in California where rabies constitutes a public health hazard. The Director has declared all 58 counties in California as rabies areas each year since 1987.

Since the early 20th century, CDPH has overseen a statewide rabies surveillance and control program. Local departments of public health and environmental health, animal control agencies and shelters, and medical and veterinary practitioners collaborate with CDPH to prevent rabies in California by:

- Providing reliable laboratory services for the diagnosis of rabies in humans and animals,
- Regulating and enforcing rabies vaccination of dogs to provide a protective "firewall" that reduces the potential for human exposure,
- Investigating reports of animals that bite humans,
- Assessing risk of rabies exposure by subjecting biting animals to isolation and observation, or euthanasia and testing,
- Offering recommendations for PEP for exposed humans,
- Developing and disseminating preventive education on rabies, and
- Collecting, collating, and reporting surveillance data on rabies in humans and animals.

Reporting and Analysis

The California Code of Regulations (17 CCR §2500) lists rabies in either humans or animals as a reportable disease. Health care providers, including physicians and

veterinarians, in knowledge of a confirmed or suspected case of rabies are required to report immediately to the local health officer. Infection with rabies is confirmed in animals by detection of rabies virus antigen, typically in central nervous system tissue, by direct fluorescent antibody assay (DFA) performed by a certified public health microbiologist. Diagnostic testing of suspected rabies in human patients is particularly challenging and no single test can accurately diagnose rabies ante-mortem, therefore several tests on multiple tissue samples are typically pursued. Diagnosis can be made by DFA (e.g., biopsy of nuchal skin or brain), polymerase chain reaction (e.g., nuchal skin biopsy or saliva), or demonstration of rabies-specific antibodies in blood or cerebrospinal fluid by immunofluorescent antibody assay or Rapid Fluorescent Focus Inhibition Test (RFFIT). In 2014, 34 local public health laboratories in California had qualified microbiologists and resources to perform rabies testing in animals. The CDPH Viral and Rickettsial Diseases Laboratory (VRDL) provides primary and confirmatory testing for rabies in animals, diagnostic testing of suspect human rabies patients, and characterization of rabies viruses to variant type. Local public health departments report confirmed cases of rabies in humans and animals to CDPH. This surveillance report summarizes information on human and animal rabies cases reported to CDPH in 2014.

Rabies in Animals

In 2014, specimens from 5,899 animals were tested for rabies in California – approximately 10 percent fewer than the annual average of 6,562 specimens tested during the previous ten years, 2004-2013. Of the 56 counties that tested at least one animal for rabies, the number of animals tested per county ranged from 1 to 644.

Rabies was confirmed in 200 animals, consistent with the 198 cases confirmed in 2013 and the annual average of 203 cases in the previous ten years, 2004-2013. One or more rabid animals were identified in 33 counties (Table 1), which reported between 1 and 39 rabid animals. Rabies was reported in 197 (98.5%) wild animals and 3 (1.5%) domestic animals in 2014.

Wild Animals

Of the 197 cases of rabies reported in wild animals in 2014, 168 (85%) were bats, 28 (14%) were skunks, and 1 (1%) was a fox.

Bats

A total of 1532 bats from 54 counties were tested for rabies in 2014 (Figures A, B). The 168 rabid bats reported in 2014 were comparable to the annual average of 168 reported in the previous ten years, 2004-2013 (Figure C). The greatest number of rabid bats (39) was reported in Los Angeles County; Los Angeles County has reported the most rabid bats for eight of the ten years from 2005 through 2014. The seven southernmost counties – Ventura, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Imperial – collectively accounted for 44 percent of all rabid bats detected in California in 2014 (Figure B). Rabid bats were most frequently reported during late-summer and autumn; over half of all rabid bats (88, 52%) were reported in the months of July,

August, September, and October (Figure D). Information on species was reported for 22 rabid bats: 9 Mexican Free-tailed Bats (*Tadarida brasilensis*), 9 Little Brown Bats (*Myotis lucifugus*), 2 Hoary Bats (*Lasiurus cinereus*), 1 Western Long-eared Bat (*M. evotis*), and 1 *Myotis* sp.

Skunks

A total of 432 skunks from 37 counties were tested for rabies in 2014, of which 28 from eight counties were confirmed (Figure E). Four times as many skunks tested positive for rabies in 2014 as in 2013 (7), though the number of skunks tested remained the same (435, compared to 432 in 2013). More than half of the rabid skunks in California in 2014 were reported from El Dorado County (16). Rabid skunks were most frequently reported during the winter and spring; nearly half (13, 46%) of all rabid skunks in 2014 were reported in January through March.

Foxes

A total of 56 foxes from 24 counties were tested for rabies in 2014. Rabies was confirmed in one fox from Trinity County. This case was reported in mid October, consistent with observations from 2012 and 2013 during which most rabid foxes were reported in late autumn.

Domestic Animals

In 2014, 3392 domestic animals (dogs, cats, horses, cattle, goats, and sheep) were tested for rabies. Rabies was confirmed in one dog and two cats, slightly above the mean of 1.1 domestic animal rabies cases per year in the previous ten years, 2004-2013.

In July, an unvaccinated 13-week-old cat from San Joaquin County was presented dead to a veterinarian. One of nine kittens from two litters, the kitten had begun to act in an unusual and aggressive manner the previous day, biting and scratching both owners and the other kittens. The kitten's brain was submitted to the San Joaquin County Public Health Laboratory, where rabies virus was detected by DFA. Subsequent strain typing performed by VRDL identified the rabies virus recovered from the kitten as consistent with the Mexican Free-tailed Bat (*T. brasiliensis*) variant. Both owners received rabies PEP. The eight other kittens were euthanized. The two adult female cats had died—one by automobile, one of unknown causes—an unspecified period prior to the kitten's onset of illness.

In September, a three-year-old female spayed domestic shorthair cat was collected by Amador County Animal Control following unprovoked attacks on two caretakers earlier that day. The cat was placed in 10-day bite quarantine and died shortly thereafter. Testing of the cat's brain by El Dorado County Public Health Laboratory identified rabies virus. The positive result was confirmed by VRDL, and the virus was characterized as consistent with the Mexican Free-tailed Bat (*T. brasiliensis*) variant. The caretakers acquired the cat from a local animal shelter two years previously, at which time it had received one rabies vaccination. The cat lived outdoors in a rural area, where it had

opportunity for, but no known, contact with wildlife. The two caretakers who sustained bite and scratch wounds received rabies PEP. Another cat that likely had contact with the rabid cat was euthanized; tests for rabies virus were negative.

In October, a five-year-old unvaccinated German Shepherd dog was euthanized by Sacramento County Animal Care following approximately one week of hyper-salivation, bleeding from the nose and mouth, howling, and aggressive behavior. The Sacramento County Public Health Laboratory reported observing rabies virus in the dog's brain. Confirmation of the positive result by VRDL identified the virus as consistent with the California skunk variant. Four household members and a volunteer at an animal rescue organization received rabies PEP. An unvaccinated cat in the household was placed into a 180-day home quarantine, but was lost to follow up approximately one month before the end of quarantine when the family moved without notifying Animal Care.

Rabies in Humans

Rabies was not diagnosed in any California residents in 2014. Four cases of rabies were diagnosed in California residents in the last ten years (2005-2014), the most recent in a Contra Costa County resident in 2012.

Rabies in the United States

A total of 6,033 cases of animal rabies and one case of human rabies were reported in the U.S. in 2014 [Monroe et al 2016]. Wild animals accounted for 92.6 percent of all cases; raccoons represented the largest proportion of cases (30.2%), followed by bats (29.1%) and skunks (26.3%). Domestic animals accounted for 7.4 percent of all rabid animals and included 59 dogs and 272 cats. California rabid animals accounted for 3.3 percent of all animal cases in 2014.

Discussion

Every year since 2000, more cases of rabies have been detected in bats than in any other animal in California, averaging 168 reports per year. The number of rabid bats reached a 90-year peak of 227 in 2012, but the 168 confirmed rabid bats in 2014 continues the renormalization observed in 2013 (188 rabid bats; Figure F). Although the number of bats tested for rabies (1532) declined in 2014 from the 13-year high of 1815 in 2013, the 10.9 percent of bats that tested positive for rabies is consistent with the 10-year average of 10.7 percent. These data suggest that while minor fluctuations in rabies dynamics occur in bat populations, likely attributable to both intrinsic (virus, host) and extrinsic (environment, climate) factors, the prevalence of bat rabies in California, to the extent that it is measurable by the passive surveillance system, remains relatively constant from year to year.

Skunks were the second most commonly identified rabid animal in California in 2014. A unique skunk variant of rabies virus circulates in populations of skunks in certain regions of California. In 2014, rabid skunks were identified in parts of the state historically recognized as enzootic for skunk rabies, with the western Sierra Nevada foothills

(Amador, El Dorado, Mariposa, and Placer counties) accounting for over 80 percent of all reports. In addition to maintenance of their own adapted variant, skunks remain susceptible to spillover of rabies from other species, particularly bats. In 2014, a single rabid skunk was identified in Los Angeles County, an area uncommon for skunk rabies. Characterization by VRDL verified that this skunk was infected with a rabies virus variant typically found in Mexican Free-tailed Bats (*T. brasiliensis*). Most such spillover events represent isolated incidents; sustained transmission of rabies virus variants among non-adapted host species is believed to be uncommon. However, evolution and adaptation of virus variants across mammalian orders (Chiroptera to Carnivora) has been reported (Leslie et al 2006). Routine characterization of all rabies virus isolates is critical for early recognition of emerging variants with the potential for efficient and sustained transmission across multiple species.

Rabies incidence in wild animals in temperate regions often follows certain seasonal patterns. In most of the United States, including California, rabies detections in bats commonly peak in the late summer and early autumn when juvenile bats are beginning to venture out from the colonies, and when migratory bats are preparing to abandon their roosts for winter. Among terrestrial rabies variants, detections of skunks infected with the south central skunk variant have been reported to peak in winter and early spring: e.g., January and February in southcentral Arizona (Clark et al 2015); January through May in southeastern Arizona (Hass and Dragoo 2006); March through May in Arkansas (Heidt et al 1982) and Texas (Pool and Hacker 1982). Winter seasonality was observed with the California skunk variant in 2014; nearly half of all skunk rabies cases were identified between January and March. Winter is the primary mating season for skunks in northern California. Territoriality and competition for mates during this time may contribute to increased frequency and severity of contact between skunks, resulting in greater opportunities for transmission of pathogens, including rabies virus.

In 2014, the Intergovernmental Panel on Climate Change released its fifth report which projected, among other events, warmer temperatures and reduced precipitation for many areas, including North America (IPCC 2014). These environmental shifts have been hypothesized to lead to changes in the epidemiology of some communicable diseases, including zoonoses such as rabies (Greer et al 2008). Following the driest 12 months on record for California, in January 2015, Governor Edmund G. Brown, Jr., proclaimed a State of Emergency in California due to drought conditions, declaring 75 percent of California under an Extreme or Exceptional drought. Altered precipitation patterns and decreased abundance of natural water sources likely have competing effects on rabies in wildlife reservoirs. Increased competition for sparse water sources may lead to range expansion—or contraction--and differential mortality among rabies reservoir species, as well as their predators and prey (Kim et al 2014). By expanding their territory into residential and other human habitats where artificial water sources are maintained, rabid animals are more likely to be observed—and collected, tested, and confirmed—than if they succumbed to the disease elsewhere. The appreciable increase in cases of rabies in skunks in the western Sierra Nevada in 2014 may be due in part to an influx of

skunks into developed areas in search of water; 35 skunks from El Dorado County were submitted for rabies testing in 2014, compared to only 5 skunks in 2013. The long-term effects of California's enduring drought on rabies epizootiology among other species elsewhere in the state remain to be determined.

A single rabid fox reported in 2014 continues the low incidence observed in wild canids since the mid 1990s. Ten or fewer rabid foxes were reported each of the last 20 years, with the exception of 2009 when an epizootic centered in Humboldt County contributed 38 rabid foxes to the total of 41 reported that year (Figure F). The single rabid fox in 2014 in Trinity County, likely represented an isolated spillover of California *Myotis* bat rabies, rather than a continuation of the previous epizootic event in neighboring Humboldt County.

Two cats were diagnosed with rabies in 2014 in Amador and San Joaquin counties. Both cats were infected with bat virus variants, as were feline cases in 2013 and 2012. A single rabid bat was noted in Amador County, and no rabid bats were reported in San Joaquin County, though most surrounding counties reported at least one rabid bat in 2014. The cats' owners did not specifically recall any encounters with wildlife, but the Amador cat, and both of the queens associated with the kitten in San Joaquin County, had access to the outside. Since both queens were found dead weeks prior to the kitten showing symptoms, their rabies status was not known and the mechanism of the kitten's exposure could not be determined. Cats are the domestic animals most frequently diagnosed with rabies in California and the rest of the United States; in 2013, 247 rabid cats were reported nationwide, compared to 89 dogs [Dyer 2014]. The natural predatory demeanor and curiosity of cats disposes them to engage in close, repeated contact with wildlife, such as a downed bat, allowing for potential transmission of rabies virus. Although some cities and counties in California require cats to be licensed and/or vaccinated against rabies, the absence of a statewide requirement leaves the majority of pet cats unprotected against rabies. The American Association of Feline Practitioners Vaccination Advisory Panel recommends vaccination against rabies for all cats that live in rabies-endemic areas [Scherk et al 2013], which includes all of California. The rabid cat in Amador County had received one rabies vaccine but was 12 months or more overdue for a booster dose. Veterinarians and cat owners should be mindful of the limited and unpredictable protection afforded by a single dose of rabies vaccine. Reliable long-term immunity is conferred only following vaccine boosters administered at intervals specified in the vaccine label.

One domestic dog from Sacramento County was confirmed infected with the California skunk variant of rabies virus in 2014. In the weeks preceding its illness, the dog had resided in El Dorado County, which experienced a large increase in the number of cases of skunk rabies in 2014. Dogs are the species tested most frequently for rabies in California, owing to their involvement in bite incidents, with 1931 dogs tested in 2014. Over 43,000 dog bites were reported in California in 2014, of which more than 60 percent were from dogs without documentation of current rabies vaccinations.

No human cases of rabies were detected in California in 2014. However, recognized bites or other concerning contact with a confirmed rabid animal were reported for 29 of the 200 animal rabies cases, resulting in at least 49 persons undergoing rabies PEP. A thorough investigation of every confirmed rabid animal by knowledgeable public health officials is critical to ensure that all persons who had contact with the animal are identified, assessed, and counseled regarding their need for rabies PEP.

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Table 1. Reported cases of rabies in animals, California, 2014.

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
TOTAL	168	28	2	1	0	1	0	0	0	0	200
Alameda	2	0	0	0	0	0	0	0	0	0	2
-Berkeley City	0	0	0	0	0	0	0	0	0	0	0
Alpine	0	0	0	0	0	0	0	0	0	0	0
Amador	1	2	1	0	0	0	0	0	0	0	4
Butte	6	0	0	0	0	0	0	0	0	0	6
Calaveras	0	0	0	0	0	0	0	0	0	0	0
Colusa	2	0	0	0	0	0	0	0	0	0	2
Contra Costa	5	0	0	0	0	0	0	0	0	0	5
Del Norte	0	0	0	0	0	0	0	0	0	0	0
El Dorado	0	16	0	0	0	0	0	0	0	0	16
Fresno	2	0	0	0	0	0	0	0	0	0	2
Glenn	2	0	0	0	0	0	0	0	0	0	2
Humboldt	0	0	0	0	0	0	0	0	0	0	0
Imperial	0	0	0	0	0	0	0	0	0	0	0
Inyo	0	0	0	0	0	0	0	0	0	0	0
Kern	3	0	0	0	0	0	0	0	0	0	3
Kings	0	0	0	0	0	0	0	0	0	0	0
Lake	0	0	0	0	0	0	0	0	0	0	0
Lassen	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	39	0	0	0	0	0	0	0	0	0	39
-Long Beach City	1	1	0	0	0	0	0	0	0	0	2
-Pasadena City	1	0	0	0	0	0	0	0	0	0	1
Madera	0	0	0	0	0	0	0	0	0	0	0
Marin	13	0	0	0	0	0	0	0	0	0	13
Mariposa	2	3	0	0	0	0	0	0	0	0	5
Mendocino	0	0	0	0	0	0	0	0	0	0	0
Merced	0	0	0	0	0	0	0	0	0	0	0
Modoc	0	0	0	0	0	0	0	0	0	0	0
Mono	0	0	0	0	0	0	0	0	0	0	0
Monterey	0	2	0	0	0	0	0	0	0	0	2
Napa	0	0	0	0	0	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0	0	0	0	0
Orange	7	0	0	0	0	0	0	0	0	0	7
Placer	2	1	0	0	0	0	0	0	0	0	3
Plumas	0	0	0	0	0	0	0	0	0	0	0
Riverside	6	0	0	0	0	0	0	0	0	0	6
Sacramento	2	1	0	1	0	0	0	0	0	0	4
San Benito	0	2	0	0	0	0	0	0	0	0	2
San Bernardino	11	0	0	0	0	0	0	0	0	0	11
San Diego	7	0	0	0	0	0	0	0	0	0	7
San Francisco	6	0	0	0	0	0	0	0	0	0	6
San Joaquin	0	0	1	0	0	0	0	0	0	0	1
San Luis Obispo	0	0	0	0	0	0	0	0	0	0	0
San Mateo	2	0	0	0	0	0	0	0	0	0	2
Santa Barbara	0	0	0	0	0	0	0	0	0	0	0
Santa Clara	8	0	0	0	0	0	0	0	0	0	8
Santa Cruz	1	0	0	0	0	0	0	0	0	0	1
Shasta	0	0	0	0	0	0	0	0	0	0	0
Sierra	0	0	0	0	0	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0	0	0	0	0	0
Solano	2	0	0	0	0	0	0	0	0	0	2
Sonoma	8	0	0	0	0	0	0	0	0	0	8
Stanislaus	1	0	0	0	0	0	0	0	0	0	1
Sutter	1	0	0	0	0	0	0	0	0	0	1
Tehama	0	0	0	0	0	0	0	0	0	0	0
Trinity	0	0	0	0	0	1	0	0	0	0	1
Tulare	0	0	0	0	0	0	0	0	0	0	0
Tuolumne	0	0	0	0	0	0	0	0	0	0	0
Ventura	4	0	0	0	0	0	0	0	0	0	4
Yolo	14	0	0	0	0	0	0	0	0	0	14
Yuba	7	0	0	0	0	0	0	0	0	0	7

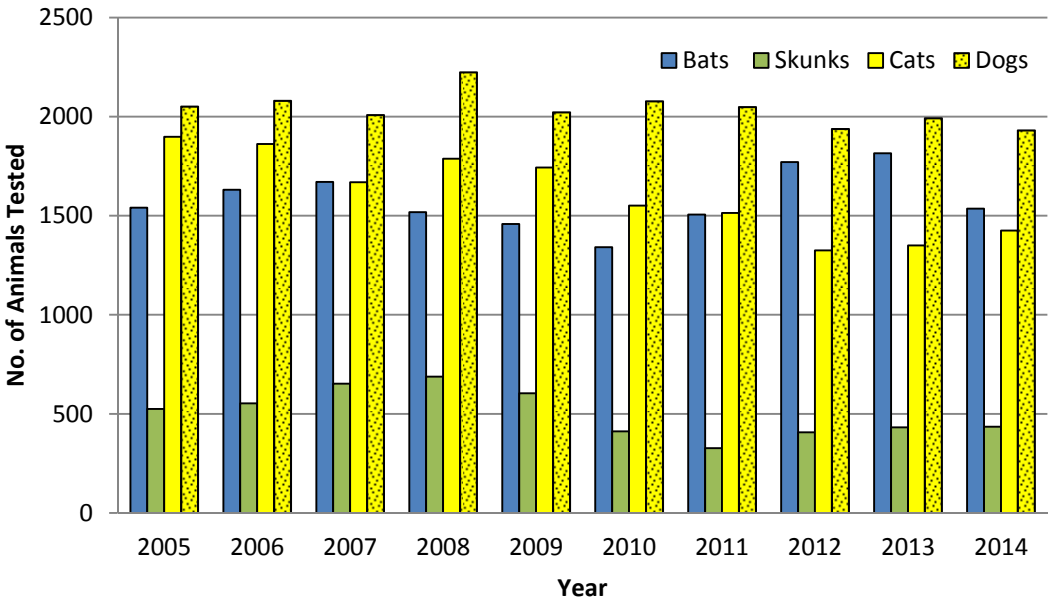

Figure A. Selected wild and domestic animals tested for rabies in California, 2005-2014.

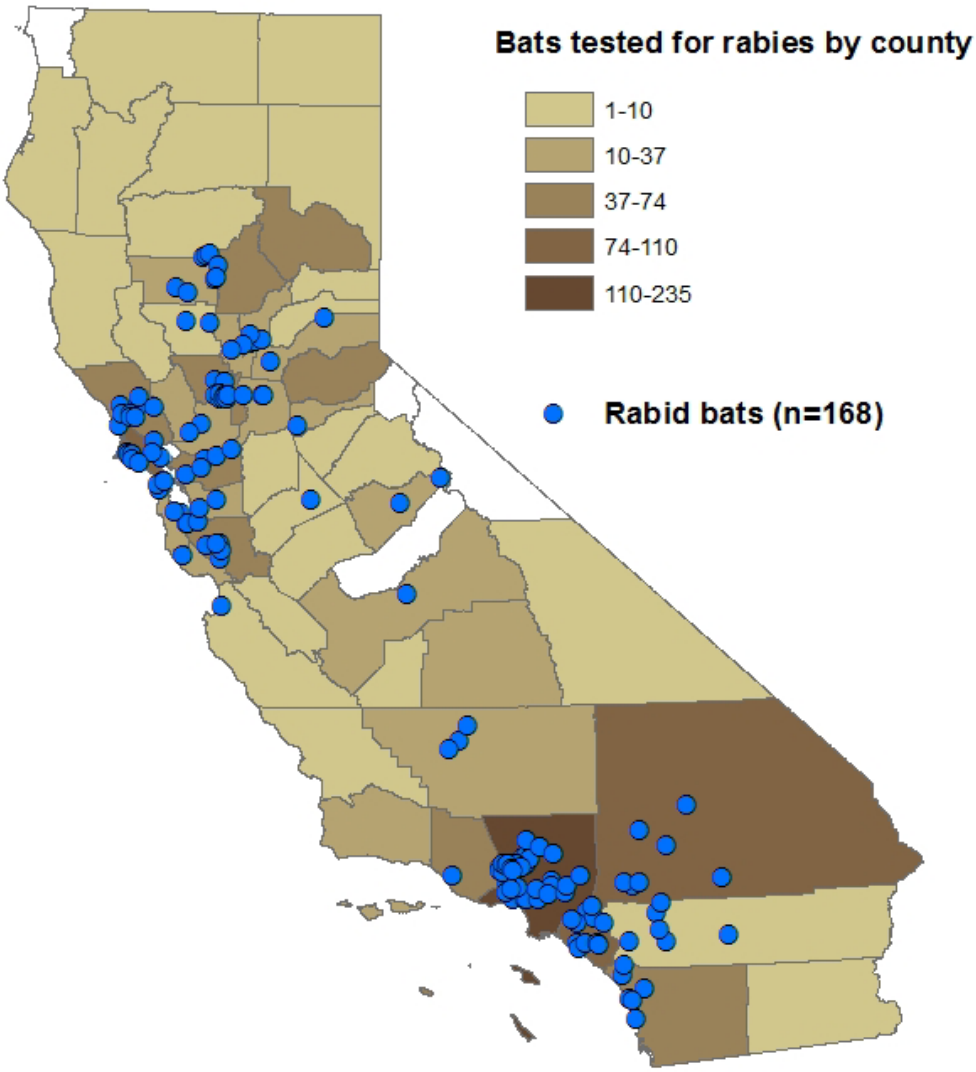

Figure B. Bats tested for rabies by county with positive cases by zip code of collection site, California, 2014.

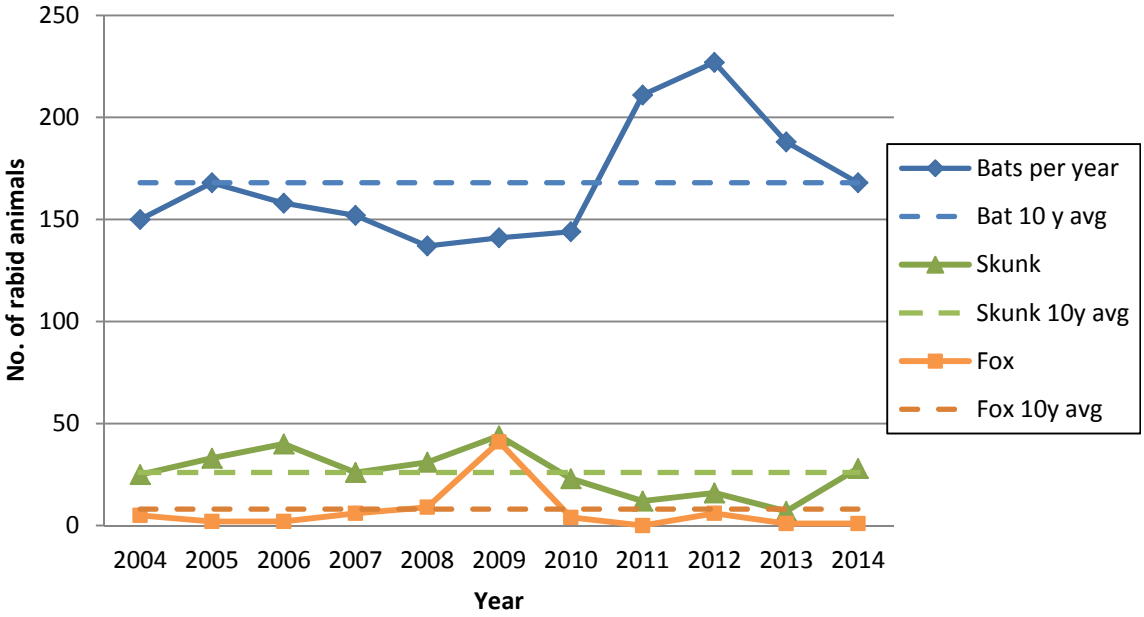

Figure C. Cases of rabies among wildlife in California, 2005-2014.

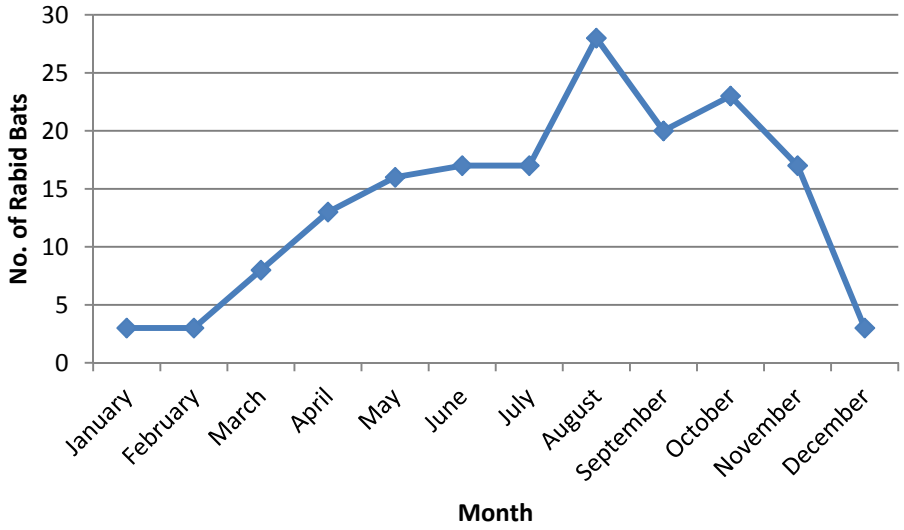

Figure D. Cases of rabies in bats by month of testing, California, 2014.

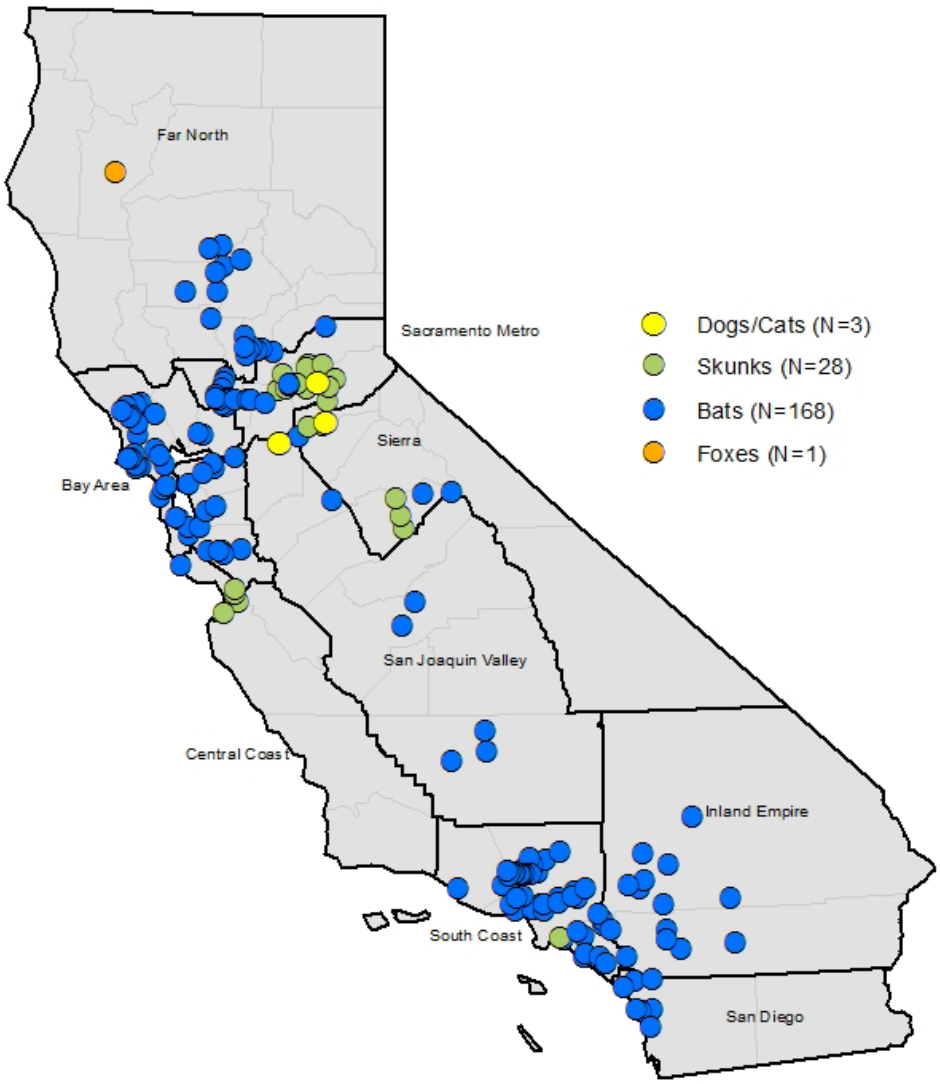

Figure E. Cases of rabies in domestic and wild animals by zip code of collection site, California, 2014.

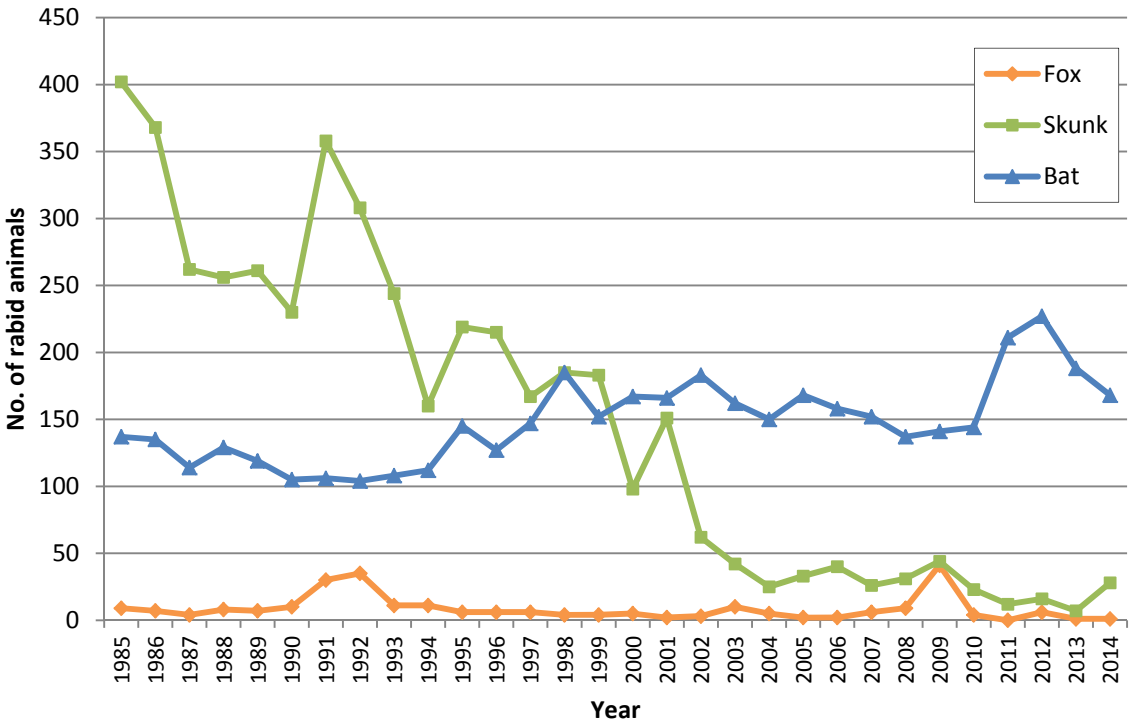

Figure F. Cases of rabies among wildlife in California, 1985-2014.