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Rabies surveillance in the United States during 2005

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Summary—During 2005, 49 states and Puerto Rico reported 6,417 cases of rabies in nonhuman animals and 1 case in a human being to the CDC, representing a 6.2% decrease from the 6,836 cases in nonhuman animals and 8 cases in human beings reported in 2004. Approximately 92% of the cases were in wildlife, and 8% were in domestic animals. Relative contributions by the major animal groups were as follows: 2,534 raccoons (39.5%), 1,478 skunks (23%), 1,408 bats (21.9%), 376 foxes (5.9%), 269 cats (4.2%), 93 cattle (1.5%), and 76 dogs (1.2%). Compared with numbers of reported cases in 2004, cases in 2005 decreased among all groups, except bats, horses, and other wild animals. Decreases in numbers of rabid raccoons during 2005 were reported by 10 of the 20 eastern states in which raccoon rabies was enzootic and decreased overall by 1.2%, compared with 2004.

On a national level, the number of rabies cases in skunks during 2005 decreased 20.4% from the number reported in 2004. Once again, Texas reported the greatest number (n = 392) of rabid skunks and the greatest overall state total of rabies cases (741). Texas reported no cases of rabies associated with the dog/coyote rabies virus variant and only 8 cases associated with the Texas gray fox rabies virus variant (compared with 22 cases in 2004). The total number of cases of rabies reported nationally in foxes decreased 3.3%, compared with those reported in 2004. The 1,408 cases of rabies reported in bats represented a 3.5% increase over numbers reported in 2005. Cases of rabies in cats, dogs, cattle, and sheep and goats decreased 4.3%, 19.2%, 19.1%, and 10%, respectively, whereas cases reported in horses and mules increased 9.3%. In Puerto Rico, reported cases of rabies in mongooses increased 29.8%, and rabies in domestic animals decreased 37.5%.

One case of human rabies was reported from Mississippi during 2005. This case was submitted by the state to the CDC's unexplained deaths project and diagnosed as rabies retrospectively.

Throughout developed countries, rabies remains a disease primarily affecting and maintained by wildlife populations (**Figure 1**). During 2005, wild animals accounted for more than 92% of all rabies cases reported to the CDC. The most frequently reported rabid wildlife remain raccoons, skunks, bats, and foxes; however, their relative proportions have continued to fluctuate because of epizootics of rabies among animals infected with several distinct rabies virus variants (**Figure 2**).[1]

Rabies control programs, including extensive vaccination campaigns implemented during the 1940s and 1950s, caused a substantial decline of rabies in domestic animals in the United States and eliminated the circulation of the major canine variants of the rabies virus in dogs (*Canis lupus*) by the 1960s. During the late 1970s and early 1980s, a canine rabies virus variant reemerged in southern Texas. This virus had been maintained historically in coyotes (*Canis latrans*) and transmitted to unvaccinated dogs. Oral rabies virus vaccination programs were initiated to interrupt transmission of this rabies virus variant. With cooperation by Mexico via the Border Infectious Disease Surveillance project, this variant has probably been eliminated in the United States.[2–5] Rabies cases associated with a second canine rabies virus variant found mainly in gray foxes (*Urocyon cinereoargenteus*) in west and central Texas have similarly been reduced. Regulations in place in Texas and other states prohibit-

Abbreviations

ORV	Oral rabies virus vaccination
V-RG	Vaccinia-rabies glycoprotein
DFA	Direct immunofluorescent antibody
USDA WS	USDA Wildlife Services
GAT	Georgia, Alabama, and Tennessee

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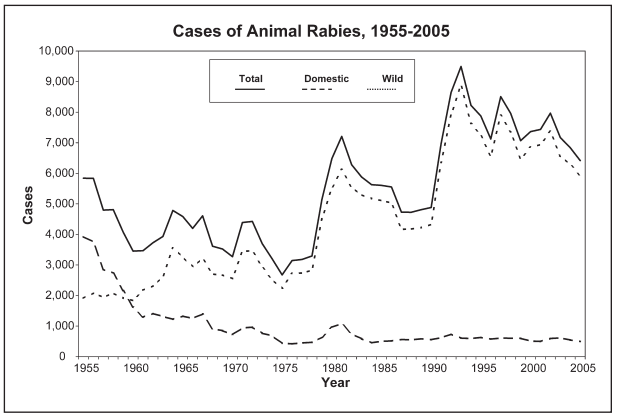

Figure 1—Cases of animal rabies in the United States, by year, 1955 to 2005.

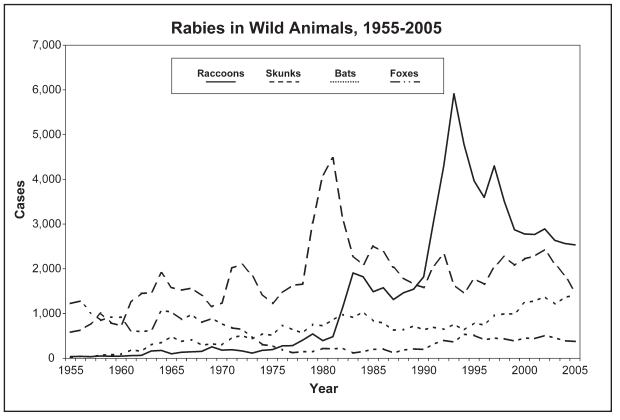

Figure 2—Cases of rabies in wild animals in the United States, by year and species, 1955 to 2005.

ing the translocation of certain wild animal species for hunting and restocking purposes may have reduced the likelihood of accidental introduction of rabies virus variants into unaffected areas.[1,6,7]

Various public health activities, including vaccination of companion animals, vaccination programs targeting wildlife, and ongoing education programs, have contributed to the reduction in transmission of rabies virus from terrestrial animals to human beings.[8] However, emerging rabies cases in human beings have resulted from infection with rabies virus variants that are associated with bats.[9,10] Rabies control in bats is difficult by conventional methods. Prevention of rabies in human beings resulting from infection with bat-associated rabies virus variants is further challenged by the frequent absence of documented exposure histories involving a bat bite. Since 2000, 15 of 17 cases of indigenously acquired rabies in human beings were associated with rabies virus variants maintained by bats, as determined by genetic analysis or epidemiologic investigation. Only 3 of these cases involved a report of a definite bat bite (4 received organ transplants from a rabies virus–infected donor).[6,10] Two cases of bat-associated rabies were reported to have no known exposure to a bat. The remaining 6 cases indicated some prior contact with a bat (eg, awakening to find a bat on the body or picking up a grounded bat). The most likely route of infection with rabies virus (excluding inoculation via infected transplant material) remains transmission by a bite that either was ignored or went unnoticed during an interaction with a bat.

Rabies virus infections of terrestrial animals in most areas of the United States occur in geographically definable regions where virus transmission is pri-

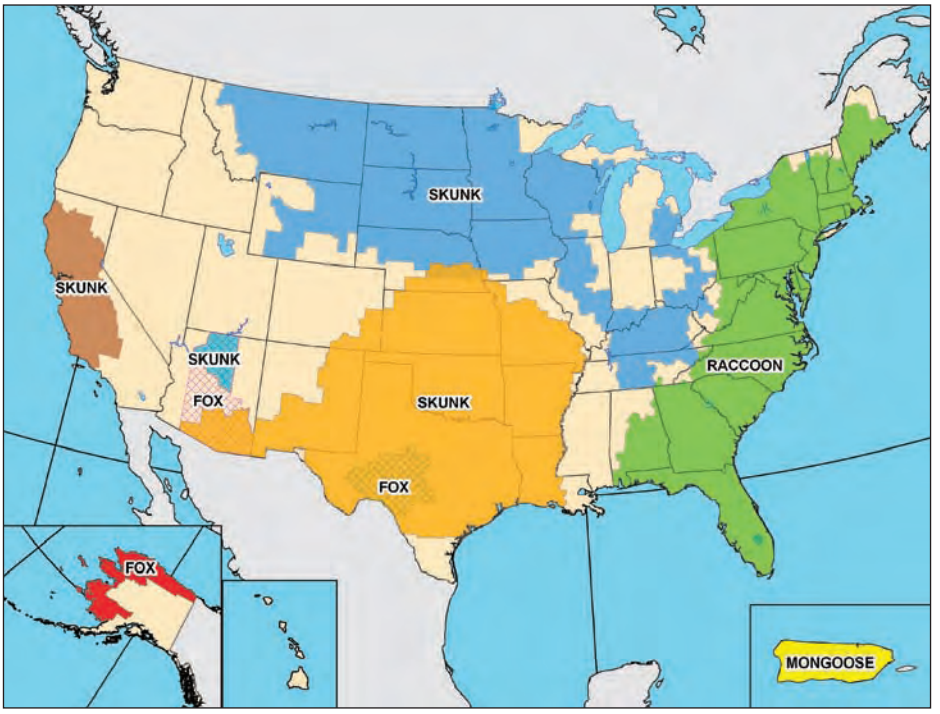

Figure 3—Distribution of major rabies virus variants among wild terrestrial reservoirs in the United States and Puerto Rico.

marily between members of the same species. Spillover infection from these species to other animals occurs but rarely initiates sustained intraspecific transmission. Once established, enzootic virus transmission within a species can persist regionally for decades or longer.

Rabies virus variants can be identified by reaction with panels of monoclonal antibodies[11] or by comparing patterns of nucleotide substitution determined by genetic analysis.[1,12] Spatial boundaries of enzootic rabies in reservoir species are temporally dynamic (**Figure 3**). Affected areas may expand and contract through virus transmission and population interactions.[13,14] Population increases and emigration result in the expansion of rabies-infected areas, whereas natural barriers, such as mountain ranges and bodies of water, may restrict animal movements or sustain lower population densities that slow the spread of rabies. Unusual animal dispersal patterns and human-mediated translocation of infected animals have resulted in more rapid and unexpected introductions of rabies into new areas.[1,6,7,12–14]

Raccoons (*Procyon lotor*) have been recognized as a major reservoir for rabies in the southeastern United States since the 1950s. An outbreak that began during the late 1970s in the mid-Atlantic states was attributed to the translocation by human beings of infected raccoons from the Southeast.[15] Although identifiable as separate foci prior to 1994, the mid-Atlantic and southeastern fronts merged in North Carolina in 1995. Rabies is now enzootic in raccoons in all of the eastern coastal states as well as in Alabama, Ohio, Pennsylvania, Tennessee, Vermont, and West Virginia.

Three rabies virus variants are responsible for disease in skunks (primarily *Mephitis mephitis*) in California and the north central and south central United States. In Alaska, a long-standing reservoir for rabies virus exists in red and arctic foxes (*Vulpes vulpes* and *Alopex lagopus*, respectively). Rabies spread during the 1950s among red foxes across Canada and, intermittently, to foxes in adjoining areas of the New England states. Although rabies persists in foxes in Alaska, reports of rabid foxes have declined in Canada, in part because of ORV programs.[16] Two rabies virus variants are in geographically limited populations of gray foxes in Arizona and Texas. Enzootic rabies among canids in southern Texas had been the result of long-standing interactions between unvaccinated domestic dogs and coyotes at the Texas-Mexico border.[2–5] However, only 2 dogs (believed to have been translocated from outside the United States) have been reported infected with the dog/coyote rabies virus variant in Texas since 2001. On the island of Puerto Rico, another wildlife rabies reservoir exists in mongooses.[17,18] Rabies virus maintained and circulated by mongooses is periodically transmitted to unvaccinated dogs and cats.[6]

Despite the threat of rabies transmission from wild terrestrial carnivores, the use of population-reduction programs to control rabies among such animals is not desirable. Programs in Europe and southeastern Canada have used modified-live or recombinant virus vaccines for the oral inoculation of free-ranging wildlife reservoir species (predominantly foxes) to control the disease. During the past 2 decades, more than 100 million doses of vaccine-laden bait have been distributed over 6 million square kilometers in Europe,[19] with promising results for controlling rabies in red foxes. The use of ORV in Switzerland during the past 30 years resulted in a declaration of rabies-free status for that country in 1998, and similar strategies in France led to rabies-free status being declared in 2000.[20] Substantial decreases in the number of reported cases of rabies in fox populations in southern Ontario strongly support the hypothesis that rabies virus associated with red foxes can be eliminated by vaccination.[16] Distribution of a V-RG recombinant vaccine targeting raccoons in the eastern United States[21–23] and gray foxes and coyotes in Texas[5] has shown promise as a complement to traditional rabies control methods (eg, parenteral vaccination of domestic animals). Products used in oral vaccination programs are self-replicating, and the unintentional exposure of nontarget species, including human beings, must be minimized and monitored.[24,25]

Overlaying the patterns of rabies virus maintenance among terrestrial mammals are multiple, independent reservoirs for rabies virus in several species of insectivorous bats. Rabies virus transmission among bats appears to be primarily intraspecific, and distinct virus variants can be identified for different bat species. In contrast to maintenance cycles in terrestrial animals, however, the greater mobility of bats precludes definitive range mapping of different variants, other than the geographic ranges of the implicated host bat species. Because bat species known to be reservoirs for rabies virus are found in all areas of the continental United States, every state except Hawaii is considered enzootic for rabies. Although transmission of rabies virus from bats to terrestrial mammals occurs, such transmission rarely results in sustained, independent, intraspecific cycles among terrestrial animals. Such occurrences represent significant shifts in host adaptation and the emergence of rabies virus variants in a new host species. In 2001, this rare phenomenon was demonstrated by the adaptation of a rabies virus variant associated with big brown bats (*Eptesicus fuscus*) in Flagstaff, Ari, to skunks (*M mephitis*) in an area previously naive for terrestrial rabies.[26] Prior genetic analysis indicated a net difference of 15% to 20% between rabies virus RNA sequences in bats, compared with those in terrestrial mammals. Thus, instances of spillover transmission of rabies virus from bats are readily detectable, as would be sustained transmission of a bat-associated rabies virus variant in a terrestrial mammal population.

This report is prepared annually to inform veterinarians and public health officials of the current status of rabies in the United States. Information is provided on the geographic distribution of rabies and long- and short-term temporal patterns for reported cases of rabies in various species. Long-term trends for reported cases of rabies in animals in the United States are generated by examining reports beginning in 1955. For this report, short-term trends were determined by comparing reported cases from 2005 with those from 2004 and by examining seasonal patterns for selected species.

Table 1—Cases of rabies in the United States, by state and category, during 2005.

Rabies in the United States, 2005

				Domestic animals						Wild animals								
State (city)	All animals	Domestic	Wild	Cats	Cattle	Dogs	Horses/ mules	Sheep/ goats	Other domestic	Raccoons	Skunks	Bats	Foxes	Other wild*	Rodents and lagomorphs	Human beings	2004	Change %
AK	4	2	2	0	0	2	0	0	0	0	0	0	2	0	0	0	11	–63.64
AL	78	5	73	1	0	2	2	0	0	41	0	21	11	0	0	0	66	18.18
AR	36	6	30	2	2	2	0	0	0	0	15	15	0	0	0	0	55	–34.55
AZ	168	2	166	2	0	0	0	0	0	1	66	84	12	3[a]	0	0	120	40.00
CA	204	2	202	2	0	0	0	0	0	0	32	167	2	0	1[p]	0	184	10.87
CO	44	1	43	0	1	0	0	0	0	0	0	42	1	0	0	0	47	–6.38
CT	210	5	205	4	0	0	1	0	0	128	36	35	4	2[b]	0	0	223	–5.83
DC	33	1	32	0	0	1	0	0	0	23	0	9	0	0	0	0	32	3.13
DE	38	3	35	1	0	0	2	0	0	28	2	2	2	0	1[q]	0	59	–35.59
FL	202	33	169	28	0	5	0	0	0	108	2	27	29	3[c]	0	0	204	–0.98
GA	256	15	241	9	0	4	2	0	0	156	40	23	16	6[d]	0	0	344	–25.58
HI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
IA	108	15	93	5	7	2	1	0	0	0	33	60	0	0	0	0	100	8.00
ID	12	0	12	0	0	0	0	0	0	0	0	12	0	0	0	0	8	50.00
IL	51	1	50	0	1	0	0	0	0	0	6	43	1	0	0	0	51	0.00
IN	12	0	12	0	0	0	0	0	0	0	0	12	0	0	0	0	12	0.00
KS	80	18	62	6	5	4	3	0	0	0	56	4	2	0	0	0	99	–19.19
KY	17	0	17	0	0	0	0	0	0	0	6	11	0	0	0	0	23	–26.09
LA	7	0	7	0	0	0	0	0	0	0	3	4	0	0	0	0	4	75.00
MA	329	4	325	4	0	0	0	0	0	207	69	33	11	3[e]	2[r]	0	325	1.23
MD	386	30	356	28	1	1	0	0	0	245	28	41	39	0	3[s]	0	336	14.88
ME	61	0	61	0	0	0	0	0	0	37	21	3	0	0	0	0	69	–11.59
MI	39	5	34	4	0	0	0	1	0	0	5	28	1	0	0	0	42	–7.14
MN	71	24	47	9	10	5	0	0	0	0	33	13	0	0	1[t]	0	94	–24.47
MO	73	2	71	0	0	1	1	0	0	0	17	54	0	0	0	0	59	23.73
MS	6	0	5	0	0	0	0	0	0	0	0	5	0	0	0	1	11	–45.45
MT	15	0	15	0	0	0	0	0	0	0	2	13	0	0	0	0	26	–42.31
NC	458	26	432	16	3	4	3	0	0	276	60	22	68	4[f]	2[u]	0	659	–30.50
ND	36	13	23	6	2	5	0	0	0	0	22	1	0	0	0	0	75	–52.00
NE	60	20	40	5	9	1	5	0	0	0	33	5	2	0	0	0	104	–42.31
NH	12	0	12	0	0	0	0	0	0	6	4	1	1	0	0	0	32	–62.50
NJ	241	18	223	17	1	0	0	0	0	146	31	32	6	1[g]	7[v]	0	210	14.76
NM	10	0	10	0	0	0	0	0	0	0	3	7	0	0	0	0	6	66.67
NV	17	0	17	0	0	0	0	0	0	0	0	17	0	0	0	0	8	112.50
NY	563	34	529	21	9	1	3	0	0	334	85	79	24	3[h]	4[w]	0	533	5.63
NYC	28	0	28	0	0	0	0	0	0	23	4	1	0	0	0	0	14	100.00
OH	70	1	69	0	0	0	1	0	0	34	2	31	0	1[i]	1[x]	0	77	–9.09
OK	79	25	54	7	8	5	4	1	0	0	52	2	0	0	0	0	114	–30.70
OR	8	0	8	0	0	0	0	0	0	0	0	8	0	0	0	0	7	14.29
PA	413	38	375	29	2	3	2	2	0	254	55	39	19	4[j]	4[y]	0	415	–0.48
PR	71	10	61	4	1	4	1	0	0	0	0	0	0	61[k]	0	0	63	12.70
RI	29	2	27	2	0	0	0	0	0	9	10	6	2	0	0	0	45	–35.56
SC	220	15	205	8	0	7	0	0	0	129	21	21	31	3[l]	0	0	181	21.55
SD	68	24	44	2	14	2	6	0	0	0	42	2	0	0	0	0	94	–27.66
TN	48	2	46	0	0	1	1	0	0	4	23	16	3	0	0	0	52	–7.69
TX	741	41	700	12	11	8	7	3	0	27	392	257	23	1[m]	0	0	913	–18.84
UT	15	0	15	0	0	0	0	0	0	0	0	15	0	0	0	0	7	114.29
VA	496	42	454	29	6	4	2	1	0	247	122	24	57	1[n]	3[z]	0	474	4.64
VT	59	0	59	0	0	0	0	0	0	37	10	11	1	0	0	0	45	31.11
WA	15	0	15	0	0	0	0	0	0	0	0	15	0	0	0	0	20	–25.00
WI	28	0	28	0	0	0	0	0	0	0	2	26	0	0	0	0	10	180.00
WV	75	9	66	6	0	2	0	1	0	34	18	6	6	2[o]	0	0	74	1.35
WY	18	0	18	0	0	0	0	0	0	0	15	3	0	0	0	0	8	125.00
Total	**6,418**	**494**	**5,923**	**269**	**93**	**76**	**47**	**9**	**0**	**2,534**	**1,478**	**1,408**	**376**	**98**	**29**	**1**	**6,844**	**–6.22**
% 2005†	100.00	7.70	92.29	4.19	1.45	1.18	0.73	0.14	0.00	39.48	23.03	21.94	5.86	1.53	0.45	0.02		
Total 2004‡	6,844	544	6,292	281	115	94	43	10	1	2,564	1,856	1,361	389	90	32	8		
% Change§	–6.22	–9.19	–5.86	–4.27	–19.13	–19.15	9.30	–10.00	–100.00	–1.17	–20.37	3.45	–3.34	8.89	–9.38	–87.50		

*Other wild includes: [a]2 bobcats, 1 coyote; [b]1 bobcat, 1 deer; [c]2 bobcats; [d]4 bobcats, 2 coyotes; [e]2 coyotes, 1 otter; [f]2 bobcats, 1 coyote, 1 opossum; [g]1 otter; [h]1 coyote, 2 deer; [i]1 coyote; [j]1 bobcat, 3 deer; [k]61 mongooses; [l]3 bobcats; [m]1 bobcat; [n]1 bobcat; [o]1 bobcat, 1 deer. Rodents and lagomorphs include: [p]1 rabbit; [q]1 groundhog; [r]2 groundhogs; [s]2 groundhogs, 1 beaver; [t]1 groundhog; [u]1 groundhog, 1 beaver; [v]7 groundhogs; [w]3 groundhogs, 1 beaver; [x]1 groundhog; [y]4 groundhogs; [z]3 groundhogs. †Percentage of all rabid animals in 2005. ‡2004 total by species. §Percentage change from 2004.

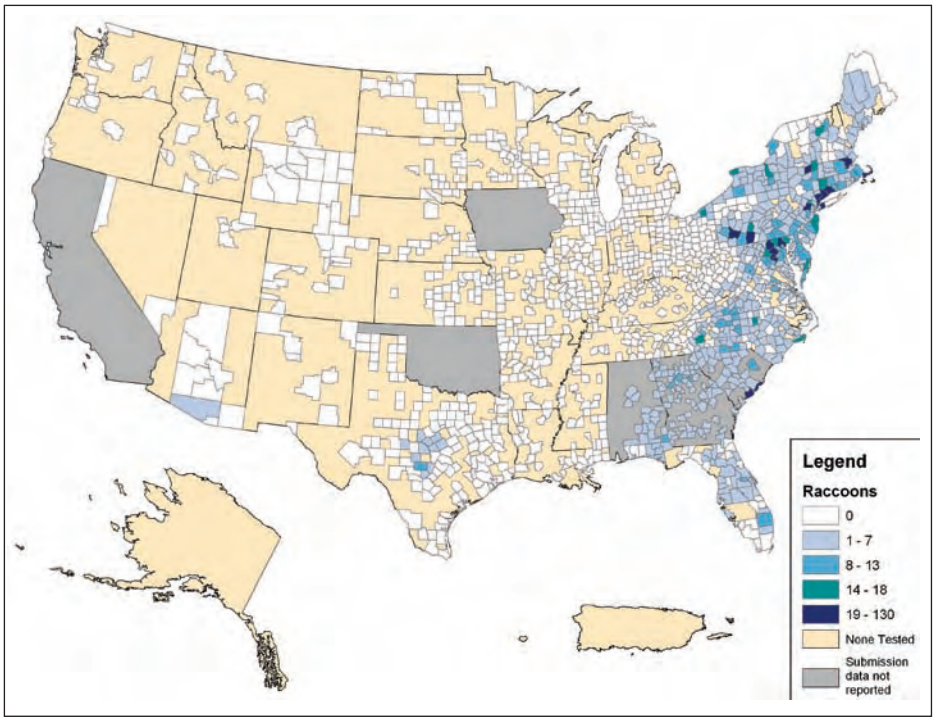

Figure 4—Reported cases of rabies in raccoons, by county, 2005.

Summaries of 2005 surveillance data are provided for Canada and Mexico because of common borders and frequent travel between the United States and these countries. A brief update on cases of rabies and other related activities reported to the CDC during 2006 is also included.

Collection of Data

Data collection procedures were similar to those described previously.[27] Between January 1 and December 31, 2005, all 50 states, New York City, the District of Columbia, and Puerto Rico reported, on a monthly basis, the number of cases of rabies in animals to the CDC by county of origin and type of animal. Typically, epidemiologic data are provided for all animals tested. States reporting only positive cases for 2005 included Alabama, California, Georgia, Iowa, Oklahoma, and South Carolina.

States report rabies cases among most terrestrial mammals using the common name of these animals (usually identifiable to the taxonomic level of genus and often to the level of species). However, bats are frequently reported only to the taxonomic level of order (eg, *Chiroptera* = bats). Several states reported data by use of the Public Health Laboratory Information System or the Laboratory Information Tracking System.[28,29] All year-end totals were confirmed by e-mail or telephone verification with state or territorial health department officials. Data from Canada were obtained from the Animal Health and Production Division, Canadian Food Inspection Agency, and data from Mexico were obtained from the Ministries of Agriculture and Livestock (SAGARPA) and Wildlife and Natural Resources (SEMARNAT).

Diagnosis in animals suspected of having rabies was made by DFA staining of rabies viral antigen in brain material submitted to the state health laboratories as described in the standard DFA protocol for rabies.[30] Virus isolation in neuroblastoma cell cultures or mice, nucleic acid detection via reverse transcriptase–PCR assays, and sequencing were used to confirm some cases.

Geographic areas for different rabies virus reservoirs in the United States were produced by aggregating data from 2001 to 2005. Counties where cases were reported in the reservoir species over this period were selected and dissolved in a software program[a] to produce a polygon representing the distribution of that reservoir. Reservoir maps are presented as only an estimate of the relative distribution of each major terrestrial rabies virus variant maintained by a particular reservoir species. Because of the paucity of samples tested at some localities and a lack of antigenic typing or genetic sequencing where reservoirs meet, defining precise viral fronts is difficult. Geographic location was provided only to the county level, and maps represent cases at this jurisdictional level.

Rabies in Wild Animals

Wild animals accounted for 5,923 of the 6,418 (92.3%) reported cases of rabies in 2005 (Figure 1). This number represents a nearly 6% decrease from the 6,292 cases reported in 2004 (**Table 1**). Raccoons continued to be the most frequently reported rabid wildlife species (39.5% of all animal cases during 2005), followed by skunks (23.0%), bats (21.9%), foxes (5.9%), and other wild animals, including rodents and lagomorphs (1.5%). Numbers of reported cases in skunks, foxes, and raccoons decreased 20.4%, 3.3%, and 1.2%, respectively, from 2004 totals, whereas cases in bats increased by 3.5%.

Raccoons—The 2,534 cases of rabies in raccoons reported in 2005 were the lowest in 15 years. Decreases in numbers of rabid raccoons during 2005 were reported by 10 of the 20 eastern states in which raccoon rabies is enzootic, including Tennessee (63.6% decrease; 11 cases in 2004 to 4 cases in 2005), Georgia (31.3%; 227 to 156), North Carolina (28.5%; 386 to 276), New Hampshire (25.0%; 8 to 6), Ohio (24.4%; 45 to 34), West Virginia (24.4%; 45 to 34), Delaware (24.3%; 37 to 28), Florida (23.9%; 142 to 108), Virginia (7.5%; 267 to 247), and Connecticut (4.5%; 134 to 128; **Figures 4 and 5**; Table 1).[27] Nine states with well-documented enzootic raccoon rabies report-

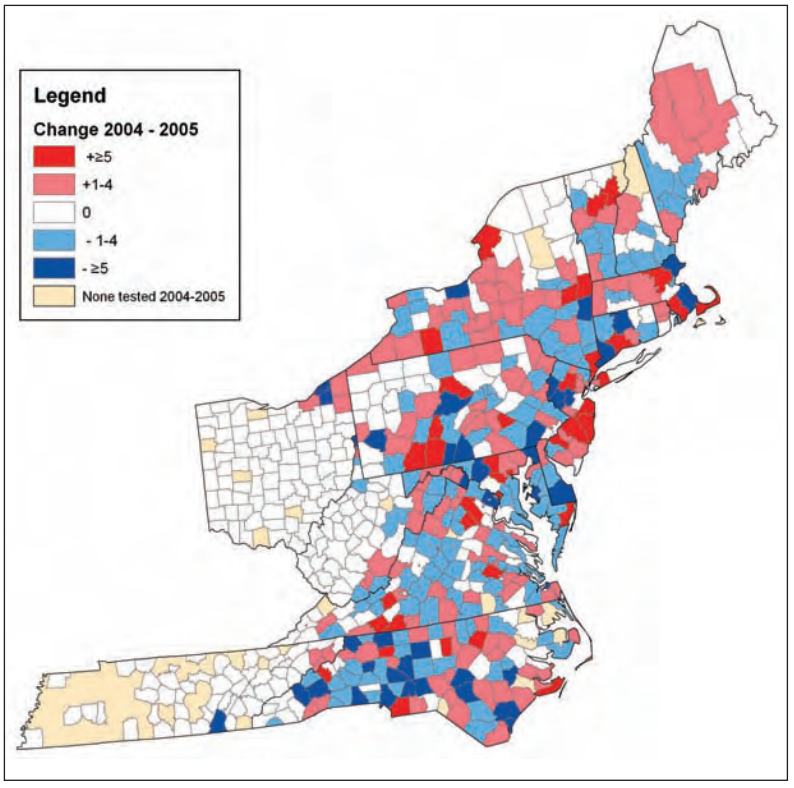

Figure 5—Changes in reported cases of rabies in raccoons in the mid-Atlantic and northeastern states, 2004 to 2005.

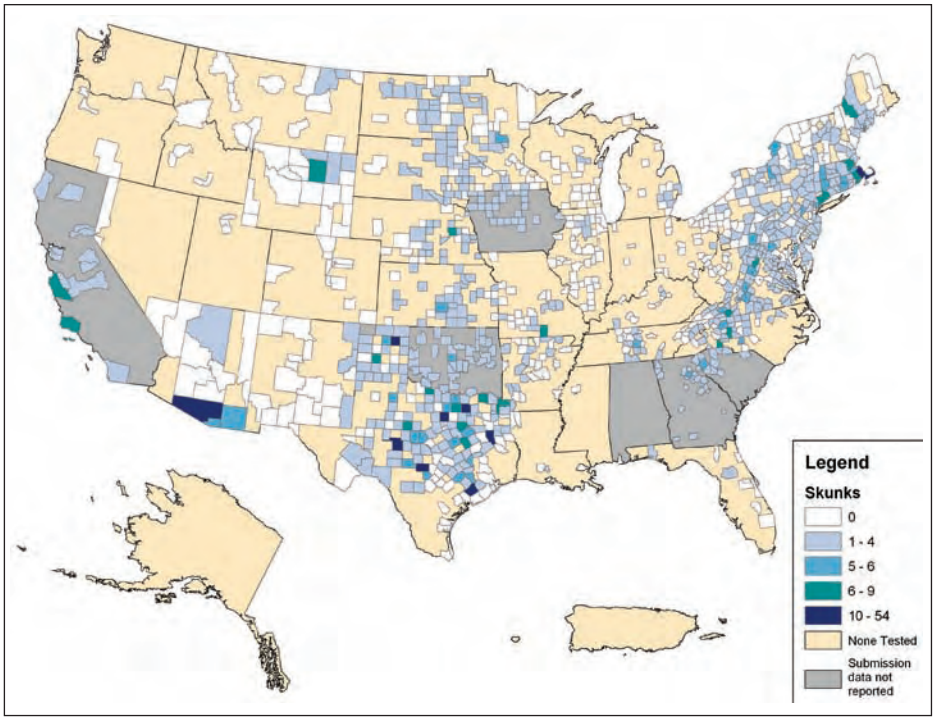

Figure 6—Reported cases of rabies in skunks, by county, 2005.

ed increases in the numbers of rabid raccoons, including Vermont (146.7% increase; 15 cases in 2004 to 37 cases in 2005), Alabama (13.9%; 36 to 41), Maine (42.3%; 26 to 37), New York (32.0%; 253 to 334), Massachusetts (22.5%; 169 to 207), South Carolina (16.2%; 111 to 129), New Jersey (15.0%; 127 to 146), Pennsylvania (7.2%; 237 to 254), and Maryland (0.4%; 244 to 245). New York City and the District of Columbia reported increases of 130.0% (10 to 23) and 91.7% (12 to 23), respectively, during 2005. Rhode Island reported no change from last year. The states of the northeastern/mid-Atlantic focus of the raccoon rabies epizootic, consisting of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia as well as the District of Columbia and New York City, accounted for 70.1% (1,792 cases; 9.4% increase) of the 2,534 total rabies cases in raccoons in 2005. The southeastern states of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee reported 28.2% (714 cases; 21.8% decrease) of the total cases in raccoons.

Ohio reported 38 cases of rabies in animals infected with the raccoon rabies virus variant (34 raccoons, 2 skunks, 1 coyote, and 1 groundhog). These cases were primarily from the same 2 counties identified in 2004 (Geauga and Lake),[27] but additional cases were identified in 4 other counties (Ashtabula, Belmont, Cuyahoga, and Trumbull). Contingency actions, including enhanced surveillance and extension of the ORV barrier, were initiated after the first rabid raccoon was identified in 2004. Raccoon rabies cases continue to decrease. Cases of rabies in raccoons have continued unabated across Barnstable County in Massachusetts since the Cape Cod ORV barrier was breached in February 2004. Rabies cases among raccoons have increased 26.2%, compared with the previous year (130 cases in 2005, compared with 103 cases in 2004). Rabid raccoons reported by Texas (27 cases) and Arizona (1) were the result of spillover infection from the south central skunk rabies virus variant.

Skunks—The 1,478 reported cases of rabies in skunks (mainly *M mephitis*) in 2005 represented a 20.4% decrease from the number reported in 2004

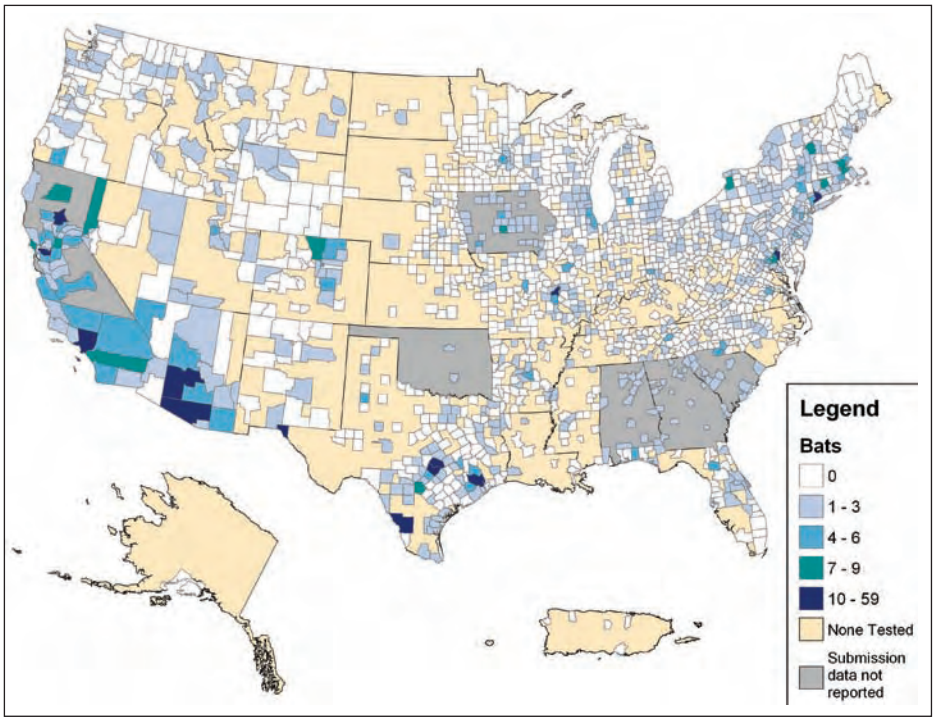

Figure 7—Reported cases of rabies in bats, by county, 2005.

(**Figure 6**; Table 1). Twenty-five of 42 states reported decreased numbers, and decreases of ≥ 50% from 2004 were reported by Idaho (100% decrease; 1 case in 2004 0 cases in 2005), Indiana (100%; 1 to 0), New Hampshire (76.5%; 17 to 4), Montana (75.0%; 8 to 2), Rhode Island (64.3%; 28 to 10), Delaware (60.0%; 5 to 2), Kentucky (57.1%; 14 to 6), North Dakota (55.1%; 49 to 22), Arkansas (53.1%; 32 to 15), Vermont (52.4%; 21 to 10), and North Carolina (50.0%; 120 to 60). Texas reported the greatest number of rabies cases in skunks (392; a 26.6% decrease from the 534 cases reported in 2004) and the greatest overall state total of rabies cases (741) during 2005. Sixteen states and New York City reported increases in numbers of rabid skunks in 2005. States that reported increases of > 100%, compared with cases reported in 2004, were Wyoming (650% increase; 2 cases in 2004 to 15 cases in 2005), New Mexico (200%; 1 to 3), New York City (300%; 1 to 4), and Arizona (175.0%; 24 to 66). Louisiana and Illinois reported no cases of rabies in skunks in 2004, but reported 3 and 6 cases, respectively, in 2005. States in which the raccoon rabies virus variant is enzootic reported 43.5% (643/1,478) of the cases of rabies in skunks, the majority of which were presumably the result of spillover transmission of the virus from raccoons. Rhode Island reported more rabid skunks (10) than rabid raccoons (9) for a ninth consecutive year.

Bats—Rabies in bats accounted for 21.9% of all cases of rabies in animals reported in 2005 (Table 1). The 1,408 cases reported in 2005 represented an increase of 3.45% over those reported in 2004. Rabies in bats is widely distributed throughout the United States, with cases reported from all 48 contiguous states (**Figure 7**). During 2005, Texas reported the largest number of cases in bats (257; 18.2%), followed by California (167; 11.9%) and Arizona (84; 6%). Seven states (Idaho, Indiana, Mississippi, Nevada, Oregon, Utah, and Washington) reported rabies in bats, but not in terrestrial mammals. Alaska, Hawaii, and Puerto Rico did not report any cases of bat rabies. Of the bats infected with rabies virus, 38.4% (540/1,408) were identified beyond the taxonomic level of order (17 to genus, 523 to species). Among bats identified to the species level, 62.0% (335/540) were *E fuscus*, the big brown bat; 12.8% (69/540) were *Tadarida brasiliensis*, the Brazilian (Mexican) free-tailed bat; 6.1% (33/540) were *Myotis lucifugus*, the little brown bat; 4.6% (25/540) were *Lasiurus cinereus*, the hoary bat; 3.1% (17/540) were *Pipistrellus hesperus*, the western pipistrelle; 2.2% (12/540) were *Lasiurus borealis*, the red bat; 1.9% (10/540) were *Lasionycteris noctivagans*, the silver-haired bat; 0.9% (5/540) were *Lasiurus xanthinus*, the western yellow bat; 0.9% (5/540) were *Myotis evotis*, the long-eared Myotis; 0.7% (4/540) were *Antrozous pallidus*, the pallid bat; 0.7% (4/540) were *Myotis californicus*, the California bat; 0.4% (2/540) were *Pipistrellus subflavus*, the eastern pipistrelle; 0.2% (1/540) were *Myotis keenii*, the Keen's Myotis; and 0.2% (1/540) were *Nycticeius humeralis*, the evening bat. Unspeciated bats of the genus *Myotis* (17/540) accounted for the remaining rabid bats and contributed 3.1% to the total of bats identified beyond the taxonomic level of order. Not all states were able to speciate bats, nor did all states report total numbers of bats tested for rabies.

Foxes—Foxes (mainly *V vulpes*) accounted for 5.9% of all cases of rabies in animals reported in 2005 (Table 1). The 376 cases of rabies in foxes represented a 3.3% decrease from 2004, and most (330; 87.8%) were reported by states affected by the raccoon rabies virus variant (**Figure 8**). Sixteen states reported decreases in the number of rabid foxes, compared with cases reported in 2004: Vermont (85.7% decrease; 7 cases in 2004 to 1 case in 2005), Alaska (77.8%; 9 to 2), Delaware (60.0%; 5 to 2), California (60.0%; 5 to 2), Georgia (54.3%; 35 to 16), Nebraska (50.0%; 4 to 2), New Hampshire (50.0%; 2 to 1), Arizona (29.4%; 17 to 12), New York (20.0%; 30 to 24), Pennsylvania (13.6%; 22 to 19), and North Carolina (8.1%; 74 to 68). Georgia was the only state to report a decrease of > 10 cases from 2004 to 2005. Arkansas, the District of

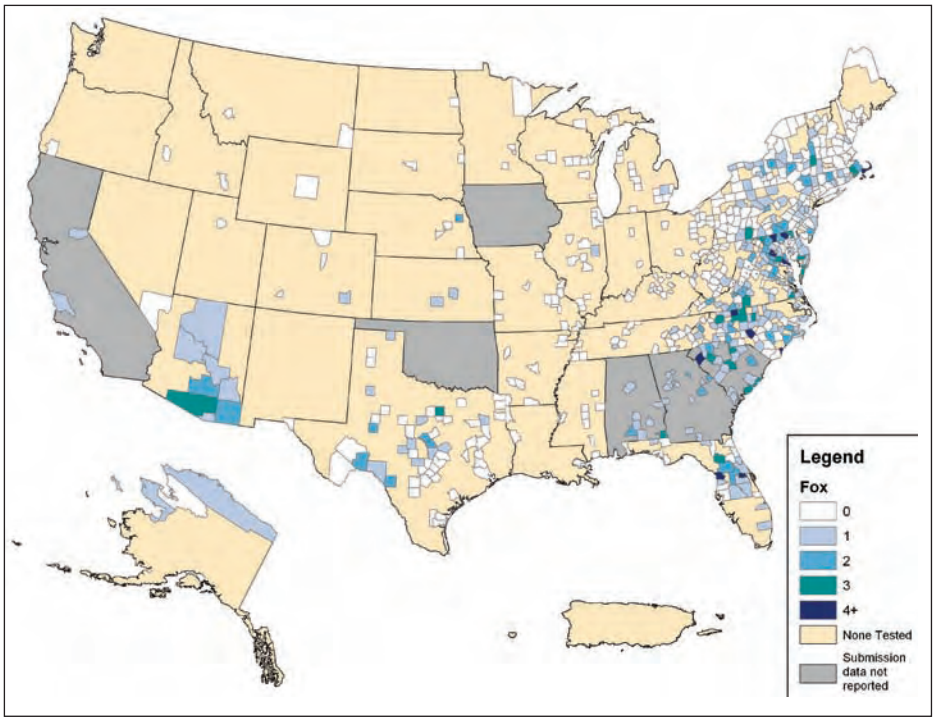

Figure 8—Reported cases of rabies in foxes, by county, 2005.

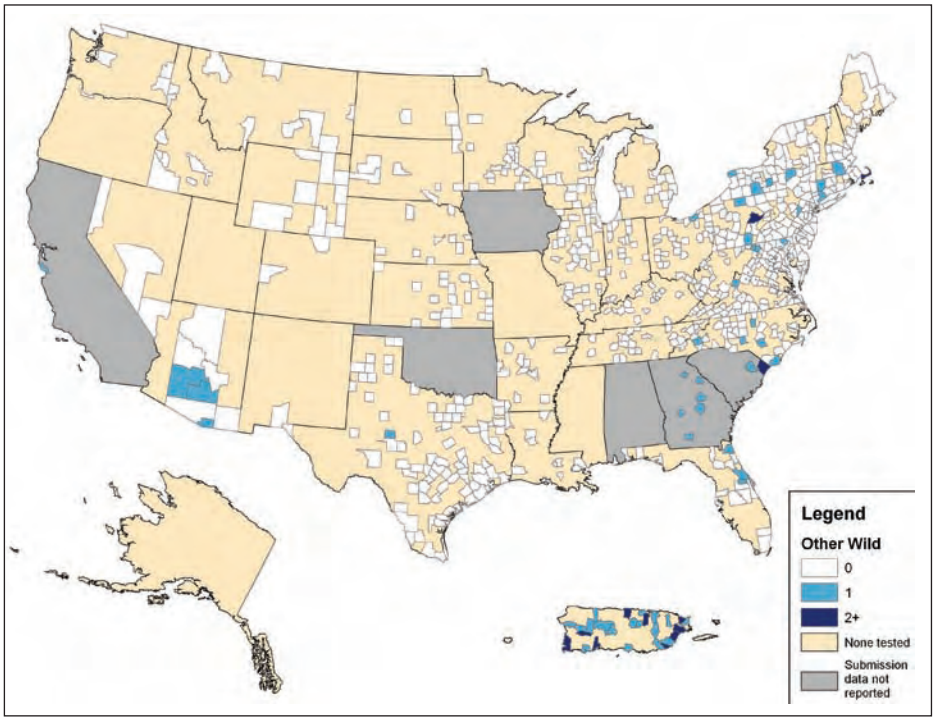

Figure 9—Reported cases of rabies in "Other wild" and "Rodent and lagomorph" category of Table 1, by county and municipio (Puerto Rico), 2005.

Columbia, Iowa, and Oklahoma all reported a single case of rabies in a fox in 2004, but no cases in 2005. Twelve states reported increases in the number of rabid foxes. Maryland (62.5% increase; 24 cases in 2004 to 39 cases in 2005), South Carolina (47.6%; 21 to 31), and Alabama (1,000%; 1 to 11) reported the greatest increases of 15, 10, and 10 cases, respectively, over 2004. Colorado, Illinois, and Rhode Island reported no cases of rabies in foxes in 2004, but 1, 1, and 2 cases in 2005, respectively. Most cases of rabies in foxes reported by eastern states were likely due to the raccoon rabies virus variant. Typically, rabies in gray foxes in Arizona and Texas is the result of infection with gray fox rabies virus variants, unique to independent gray fox reservoirs in each of those states.

Other wild animals— Puerto Rico reported 61 rabid mongooses (*Herpestes javanicus*) during 2005, a 29.8% increase from the 47 cases reported in 2004 (**Figure 9**). Other wildlife in which rabies was reported included 25 groundhogs (*Marmota monax*), 18 bobcats (*Lynx rufus*), 8 coyotes (*C latrans*), 7 white-tail deer (*Odocoileus virginianus*), 3 beavers (*Castor canadensis*), and 1 opossum (*Didelphis virginiana*). With the exception of 1 groundhog in Minnesota and 1 rabbit in California, all cases of rabies in rodents and lagomorphs were reported by states in which rabies is enzootic in raccoons. No cases of rabies associated with the dog/coyote variant of the rabies virus, previously circulating in regions of southern Texas, were reported in 2005 (Table 1).

Rabies in Domestic Animals

Domestic species accounted for 7.7% of all rabid animals reported in the United States in 2005 (Table 1). The number of domestic animals reported rabid in 2005 (494) represented a 9.2% decrease from the total reported in 2004 (**Figure 10**). Cases of rabies reported in cats and dogs decreased 4.3% and 19.2%, respectively. Virginia reported the largest number of rabid domestic animals (42 cases),

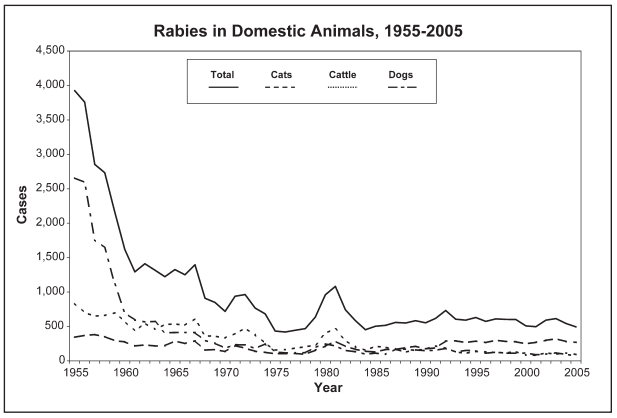

Figure 10—Cases of rabies in domestic animals in the United States, by year, 1955 to 2005.

followed by Texas (41), Pennsylvania (38), New York (34), and Florida (33).

Cats—Most (203) of the 269 cases of rabies in cats were reported from states in which the raccoon rabies virus variant is present (**Figure 11**). Remaining cases were reported principally by Central Plains states, where most cases were presumably the result of spillover from rabid skunks. Eight states reported > 10 cases of rabies in cats (Pennsylvania, 29 cases; Virginia, 29; Florida, 28; Maryland, 28; New York, 21; New Jersey, 17; North Carolina, 16; and Texas, 12). Twenty-three states, the District of Columbia, and New York City did not report any rabid cats. Puerto Rico reported 4 cases of rabies in cats, presumably spillover from the mongoose rabies virus variant.

Dogs—Texas (8 cases) and South Carolina (7) reported the largest numbers of cases of rabies in dogs by individual states. No other states reported > 5 cases of rabies in dogs in 2005. All dogs reported from Texas were spillover infections from rabid skunks. No cases were reported involving the dog/coyote rabies virus variant. Twenty-eight states and New York City did not report any rabid dogs. Puerto Rico reported 4 cases of rabies in dogs (**Figure 12**).

Other domestic animals—The number of cases of rabies in cattle decreased 19.1% from 115 in 2004 to 93 in 2005 (**Figure 13**; Table 1). Distribution of rabid cattle was similar to that of rabid skunks in the central and Midwestern states (Figures 6 and 13) and to rabid raccoons in the mid-Atlantic/northeastern region (Figures 5 and 13). South Dakota (14 cases), Texas (11), Minnesota (10), Nebraska (9), and New York (9) reported the largest numbers of rabid cattle. No other state reported > 8 cases of rabies in cattle in 2005. The 47 cases of rabies reported in horses and mules (including donkeys) in 2005 represented a 9.3% increase from the 43 cases reported in 2004. Other reported cases of rabies in domestic animals included 6 goats and 3 sheep.

Seasonal Trends

The frequency of reported cases of rabies in raccoons was highest during March and April, with a gradual decline in cases to July. A slight increase occurred in August before declining rapidly to reach a low in the number of cases reported in December (**Figure 14**). Reporting for rabid skunks followed a similar seasonal trend, but with a secondary peak in September rather than August. Reports of rabid bats increased from January through the spring before a dramatic surge to reach a peak in August, followed by a steep decline from September through December.

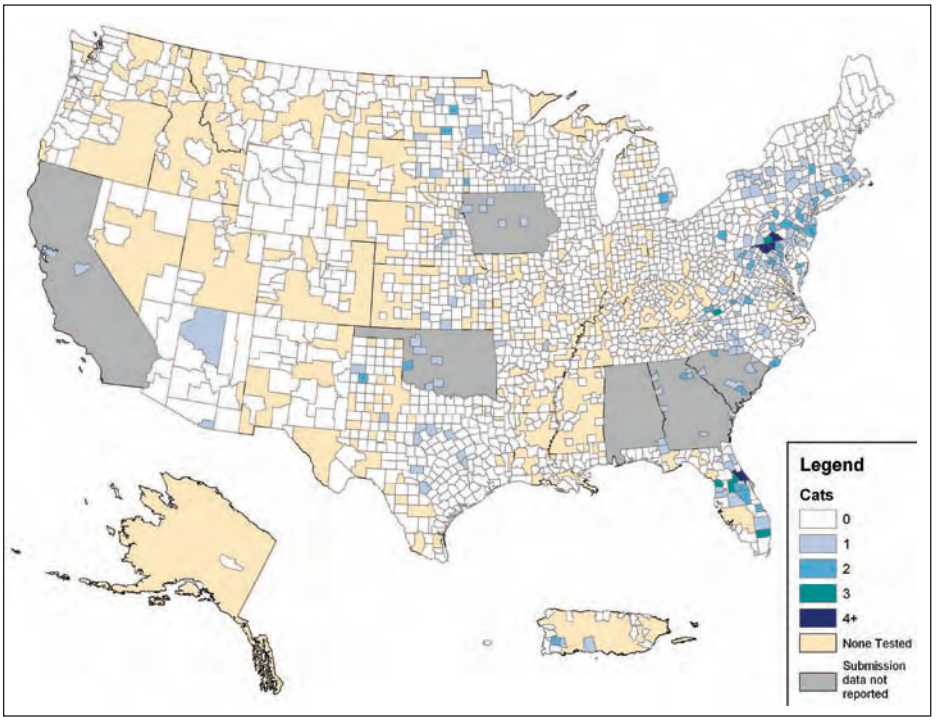

Figure 11—Reported cases of rabies in cats, by county and municipio (Puerto Rico), 2005.

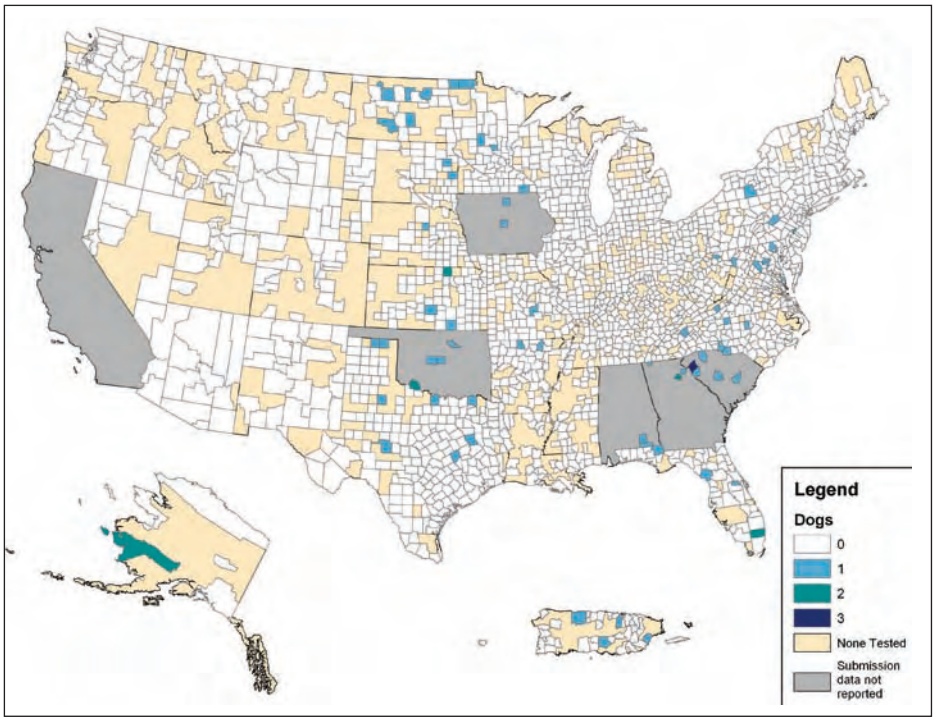

Figure 12—Reported cases of rabies in dogs, by county and municipio (Puerto Rico), 2005.

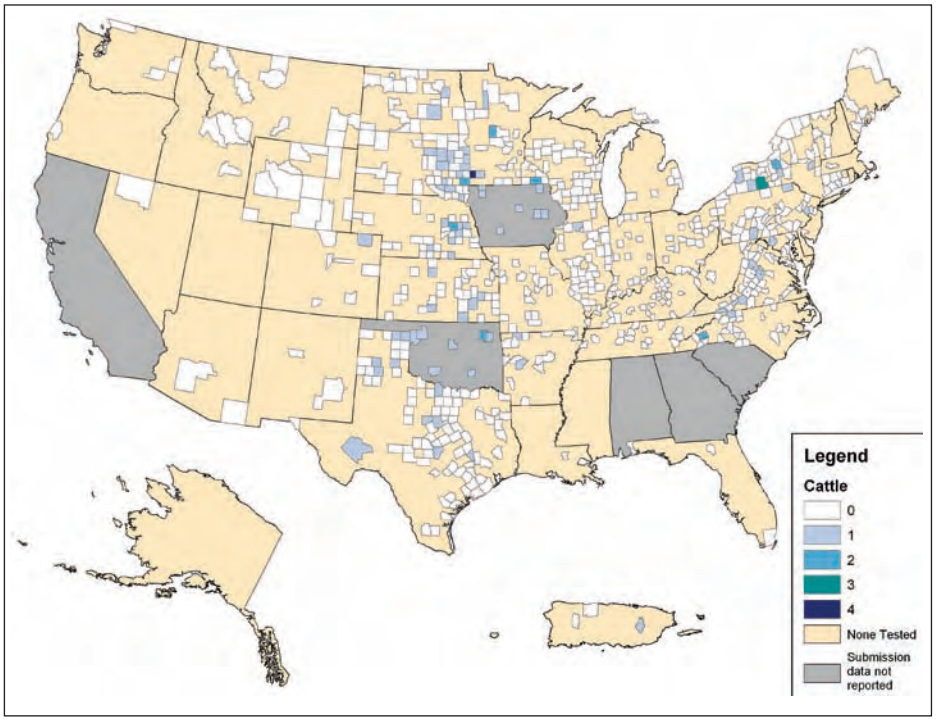

Figure 13—Reported cases of rabies in cattle, by county and municipio (Puerto Rico), 2005.

The frequency of reported rabid foxes increased gradually through spring and early summer before gradually declining to a December low.

Reported cases in cats dipped slightly from January until March, before abruptly increasing to a peak during the early summer months of June-July, followed by a more gradual decline through fall to a low in December (**Figure 15**). Rabies reports in cattle increased during February before declining in March and then reaching a peak in May. After May, reported cases in cattle gradually declined until September before a slight secondary peak in November-December. The frequency of reported cases of rabies in dogs did not appear to have a strong seasonal pattern.

Rabies in Human Beings

One case of rabies in a human being was reported in the United States in 2005 (**Table 2**).[31] On September 27, 2005, a 10-year-old boy residing in Mississippi died from an unknown encephalitis, which was later attributed to rabies.

The case was referred by the state to the CDC's Unexplained Death Project (UNEX) for additional diagnostic testing. In October 2005, rabies was diagnosed at the CDC on the basis of an increase in rabies virus–specific IgG antibody titers from paired sera samples as well as the presence of rabies virus–specific antibodies in CSF. Rabies virus nucleic acid was not detected in CSF by reverse transcriptase–PCR, and no additional clinical specimens were available to allow virus characterization and identification of a likely animal source of infection.

Preliminary investigations did not reveal a definitive exposure. However, several persons reported that bats were commonly seen outside the home, and 2 bats had been removed from inside the home. The child was reported to have removed a live bat from his bedroom before releasing the animal during spring 2005. Considering the reported presence of bats in the home and that bats are the only known reservoir of rabies in Mississippi, the history of contact with a bat appears as the likely source of infection in this case.

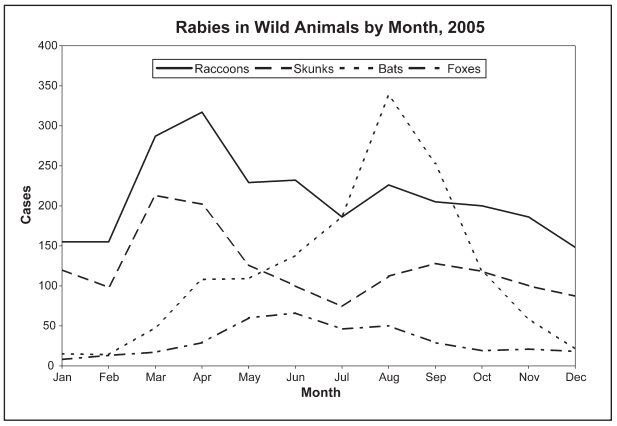

Figure 14—Cases of rabies in wild animals in the United States, by month, 2005.

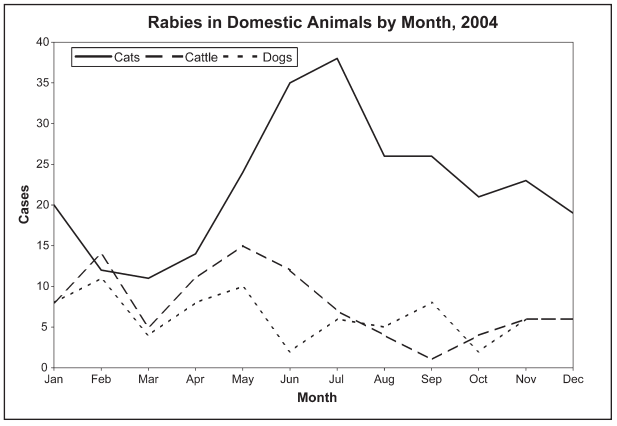

Figure 15—Cases of rabies in domestic animals in the United States, by month, 2005.

Rabies in Canada and Mexico

Canada reported 248 laboratory-confirmed cases of rabies in domestic and wild animals in 2005. This number represents a 5.0% decrease from the 261 rabies cases reported in 2004. Eighty-six percent (214) of reported cases were in wild animals, 7.2% (18) in livestock, and 6.4% (16) in domestic companion species. Bats (94) and skunks (94) each accounted for 37.9% of the total cases of rabies reported in 2005. The overall decrease in 2005 cases was mainly attributable to fewer reported cases of rabies in skunks and livestock. Reported cases of rabid raccoons also decreased during 2005 (5 cases in 2004 to 3 cases in 2005). One raccoon infected with the raccoon rabies virus variant strain was reported in Ontario during 2005. Reported cases in bats increased 13.3% (83 cases in 2004 to 94 in 2005), and cases in dogs increased 71.4% (7 to 12). Increases were also noted for cats (2 cases in 2004 to 4 cases in 2005), foxes (14 to 18), and other wild species (3 wolves in 2004 to 4 wolves and 1 bear in 2005). Canada did not report any cases of rabies in human beings during 2005.

Mexico reported 387 laboratory-confirmed cases of rabies in domestic and wild animals during 2005. This represents a 46.6% increase from the 264 cases reported in 2004. Domestic animals accounted for 95.6% of all reported cases in animals. Twenty-six percent (103/387) of rabies cases were reported in dogs. Other domestic animals reported rabid included 252 cattle (65.1% of all animals reported), 8 horses (2.1%), 4 swine (1.0%), and 3 goats (0.8%). Among the 17 reported cases in wild species confirmed positive for rabies, 10 were bats (1 insectivorous and 9 vampire bats [*Desmodus rotundus*]), and 7 were skunks. Eight cases of rabies were reported in human beings in 2005, compared with 3 cases in 2004. Bats were implicated as the source animal in 5 cases, dogs in 2, and a fox in the remaining case.

Table 2—Cases of rabies in human beings in the United States and Puerto Rico, 2000 through May 2006,* by circumstances of exposure and rabies virus variant.

Date of death	State of residence	Exposure history†	Rabies virus variant‡
20 Sep 00	CA	Unknown§	Bat, Tb
9 Oct 00	NY	Bite-Ghana	Dog, Africa
10 Oct 00	GA	Unknown§	Bat, Tb
25 Oct 00	MN	Bite	Bat, Ln/Ps
1 Nov 00	WI	Unknown§	Bat, Ln/Ps
4 Feb 01	CA	Unknown§-Philippines	Dog, Philippines
31 Mar 02	CA	Unknown§	Bat, Tb
31 Aug 02	TN	Unknown§	Bat, Ln/Ps
28 Sep 02	IA	Unknown§	Bat, Ln/Ps
10 Mar 03	VA	Unknown§	Raccoon, eastern United States
5 Jun 03	PR	Bite	Dog/mongoose, Puerto Rico
14 Sep 03	CA	Bite	Bat, Ln/Ps
15 Feb 04	FL	Bite	Dog, Haiti
3 May 04	AR	Bite (organ donor)	Bat, Tb
7 Jun 04	OK	Liver transplant recipient	Bat, Tb
9 Jun 04	TX	Kidney transplant recipient	Bat, Tb
10 Jun 04	TX	Arterial transplant recipient	Bat, Tb
21 Jun 04	TX	Kidney transplant recipient	Bat, Tb
Survived 04	WI	Bite	Bat, unknown
26 Oct 04	CA	Unknown§	Dog, El Salvador
27 Sep 05	MS	Unknown§	Bat, unknown
12 May 06	TX	Unknown§	Bat, Tb
2 Nov 06	IN	Bite	Bat, Ln/PS

*All laboratory-confirmed cases of rabies in human beings who developed the disease in the United States and Puerto Rico, 2000 through May 2006. †Data for exposure history are reported only when the biting animal was available and tested positive for rabies, when plausible information was reported directly by the patient (if lucid or credible), or when a reliable account of an incident consistent with rabies exposure (eg, dog bite) was reported by an independent witness (usually a family member). ‡Variants of the rabies virus associated with terrestrial animals in the United States and Puerto Rico are identified with the names of the reservoir animal (eg, dog or raccoon), followed by the name of the most definitive geographic entity (usually the country) from which the variant has been identified. Variants of the rabies virus associated with bats are identified with the names of the species of bats in which they have been found to be circulating. Because information regarding the location of the exposure and the identity of the exposing animal is almost always retrospective and much information is frequently unavailable, the location of the exposure and the identity of the animal responsible for the infection are often limited to deduction. §In some instances where the exposure history is unknown, there may have been known or inferred interaction that, especially for bats, could have involved an unrecognized bite.

Ln/Ps = *Lasionycteris noctivagans* or *Pipistrellus subflavus*, the silver-haired bat or the eastern pipistrelle. Tb = *Tadarida brasiliensis*, the Brazilian (Mexican) free-tailed bat.

Discussion

The number of reported cases of rabies represents only a fraction of the total cases that occur each year. Cases of rabies included in this report are only those that were confirmed by laboratory diagnosis and reported to the CDC by state and territorial health departments. States have different algorithms for submission of specimens for rabies diagnosis, and levels of surveillance vary. The predominantly passive nature of rabies surveillance and lack of estimates of animal populations dictate that prevalence and incidence of rabies cannot be determined for most species. Many rabid animals are never observed and, therefore, go undetected and untested.[32] To better estimate regional trends, determine surveillance effort, and investigate detection bias, states are encouraged to submit denominator data (ie, data for animals tested, but found negative by DFA) by species, county, and temporal occurrence.

The public health surveillance system in the United States is neither intended nor sufficient to characterize accurately the distribution of rabies in wildlife. Passive surveillance is reliant on the interaction of human beings with animal reservoirs and the subsequent possible exposure of a person to rabies. Additionally, there is a strong spatiotemporal dynamic to rabies. Moreover, reporting at a political boundary (eg, counties) complicates the ability to detect and analyze detailed relationships between any environmental variables and the spread of rabies. The active surveillance performed by several state health departments and the USDA WS acts to collect additional data in areas where surveillance has not been optimal in the past. Combined with a new real-time, coordinate-based surveillance system (RabID) and the use of the direct rapid immunohistochemical test[33] by USDA in the field, such enhanced surveillance is important in defining accurately the leading edge of the raccoon rabies virus variant reservoir as well as providing input for the various ORV programs along this front.[34]

The number of cases of rabies in raccoons in 2005 decreased 1.2% from those reported in 2004; the 2,534 cases reported in 2005 are the lowest annual total of rabid raccoons since the record 5,912 cases reported in 1993. Although raccoons continued to account for the highest percentage (39.5%) of rabies cases reported among animals in the United States in 2005, the magnitude of this ratio and numbers of reported cases of rabies in raccoons continued to decline (Figure 2). Nevertheless, enzootic transmission of rabies among raccoons, and from rabid raccoons to other species, was ongoing in 20 states, New York City, and the District of Columbia in 2005. States enzootic for raccoon rabies reported 98.9% (2,506/2,534) of all documented cases of rabies in raccoons and accounted for 67.1% (4,305/6,418) of the national total of rabid animals (76.3%; 3,822/5,010 of total cases in terrestrial animals). Periodic increases in numbers of reported cases of rabies in states where the disease is enzootic occur when populations of raccoons decimated by a previous epizootic again reach densities sufficient to support sustained transmission of rabies virus.[9,10]

Oral vaccination programs may have limited raccoon rabies expansion. The first field release of the V-RG vaccine in the United States began during 1990, on Parramore Island in Virginia.[35] The vaccine was conditionally licensed in April 1995 and was fully licensed in April 1997. Vaccine distribution in each state remains limited to authorized state or federal rabies control programs. Interventions using the V-RG vaccine distributed within baits to vaccinate wild raccoons to prevent or slow the dissemination of rabies continue in a number of states and are being expanded to additional states. The effectiveness of these programs remains under assessment in multiple states, including Alabama, Florida (Pinellas County), Georgia, Maine, eastern Massachusetts (Cape Cod),[23] New Hampshire, southern New Jersey (Cape May),[22] New York, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia.

During 2005, multiple state agencies, the USDA WS, and the CDC continued partnerships and cooperation in a massive undertaking to maintain and expand an "immune barrier" beginning on the shores of Lake Erie in Ohio, Pennsylvania, and New York and intended to reach the Gulf of Mexico in Alabama, in an attempt to curtail the spread of raccoon rabies. In Ohio, Pennsylvania, Maryland, West Virginia, Virginia, North Carolina, and northeastern Tennessee (otherwise known as the Appalachian Ridge ORV zone), approximately 4.9 million doses of V-RG–laden baits were distributed over a total of 76,800 km^2. In addition, 547,000 doses of oral vaccine were distributed again in the GAT ORV zone over an area of 8,600 km^2.[b] Enhanced surveillance conducted by the USDA WS and routine surveillance by state public health agencies continue to determine the placement of new ORV zones as well as the extent of baiting in current zones each year.[36] This barrier will be extended further south and eastward over time in an attempt to contain and reduce the area of enzootic rabies in raccoons.[36,37] Concerns regarding vaccine safety, efficacy, ecologic impact, and physical bait variables, which were raised during earlier trials, continue to be assessed.[24,25,36–40] Novel products are also being developed as potential candidates for new vaccines to overcome the limited efficacy of the V-RG vaccine in certain animal species (eg, skunks and mongooses).[41–44] Extended baiting activities continued in 2005, where cases were identified in raccoons west of the Ohio-Pennsylvania border in 2004, and enhanced surveillance and evaluation of the baiting strategy continued in relation to a breach of the ORV barrier on Cape Cod, Mass. In addition, the GAT ORV zone was expanded in 2005 to include Hamilton County, Tennessee, after animals infected with the raccoon rabies virus variant were identified in 2004. During 2005, a single skunk was the only animal reported from Hamilton County infected with the raccoon rabies virus variant.

Control efforts consisting of ORV (approx 2.6 million baits delivered over 86,800 km^2)[b] continued in Texas in an attempt to contain and eliminate the gray fox rabies virus variant and prevent the reintroduction of rabies virus variants associated with coyotes and dogs from Mexico during 2005.[3–5] No cases of the Texas gray fox rabies virus variant were reported outside the 2005 baiting area.[5] Past translocations of animals

infected with canid rabies virus variants found in Texas have been documented.[6,7] These events involved infected animals placed in enclosures prior to their release at the intended location. Rapid responses to these previous events may have prevented establishment and spread of the involved variants.

Reports of rabid skunks in 2005 decreased 20.4% from the number reported in 2004 (Figure 6; Table 1). More states reported decreases in 2005 (25/40 states) than in 2004 (22/40). However, the total number of states reporting rabid skunks did not change. Texas reported the greatest number of rabid skunks during 2005 despite reporting 142 fewer cases than in 2004. Of the 16 states reporting increases in rabid skunks, 2 (Illinois and Louisiana) did not report any rabid skunks in 2004. The 6 rabid skunks reported from Illinois represent the first cases reported in skunks since 1998. In the Southwest, Arizona again reported a dramatic increase (175%) in the number of rabid skunks (66). A new focus in northern Arizona (Flagstaff) related to a big brown bat rabies virus variant was recognized in 2001 as having sustained transmission among skunks in Coconino County; 1 case of this variant was reported in a skunk in 2005.[26] Wyoming (650%; 2 cases in 2004 to 15 cases in 2005), New York City (300%; 1 to 4), and New Mexico (200%; 1 to 3) reported increases in numbers of rabid skunks. Rhode Island reported more rabid skunks (n = 10) than rabid raccoons (9) for the eighth consecutive year in 2005. However, based on antigenic typing of the virus from a sample of rabid skunks collected in areas where raccoon rabies is enzootic, most rabid skunks in these states are presumed to be infected with the raccoon rabies virus variant. To date, studies have been unable to demonstrate evidence of unique adaptation, circulation, or maintenance of the raccoon rabies virus variant in skunks.[45] States where the raccoon rabies virus variant is enzootic continue to report > 40% of the total cases of rabies in skunks. As such, < 60% of all reported skunks are infected with skunk rabies virus variants.

Cases of rabies in foxes in 2005 decreased 3% from 2004. Rabies resulting from the red fox rabies virus variant in Canada and New England has been controlled. The red fox virus has not been detected in the northern United States in more than 5 years. Most other cases of rabies in foxes reported by eastern states were most likely related to the rabies virus variant associated with raccoons, as supported by samples further tested by antigenic and molecular methods. Rabies in gray foxes in Arizona and Texas is typically the result of infection with gray fox variants found in each of those states.

No reservoir species have been identified for any small mammals, such as rodents. Rabies among rodents and lagomorphs reflected spillover infection from regional terrestrial reservoir species. Reported cases among rodents occur primarily in groundhogs (25 cases reported in 2005) in areas of the country affected by the raccoon rabies virus variant.[46] Rabies is occasionally reported in other large members of this group, such as beavers (3 cases in 2005) and rabbits (1 case in 2005). Larger species of rodents or those kept captive in outdoor cages or pens may become infected and survive long enough to pose a risk to other species.[47] Rabies is seldom reported in smaller rodents, presumably because of the higher mortality rate and severe trauma that result from an attack by a rabid carnivore. There has been no documentation of rabies transmission from a rodent to a human being.

Rabies in domestic animals decreased 9.2% in 2005. Reported cases of rabies in cats (269), cattle (93), and dogs (76) decreased 4.3%, 19.1%, and 19.2%, respectively. The number of cases of rabies reported in cats was more than 3.5 times the number reported for dogs and nearly 3 times the number reported for cattle. The number of cats reported annually showed a marked increase in 1992, and cats have remained the leading domestic species reported each year. Cases of rabies in cats and dogs have been attributed to spillover from local terrestrial reservoirs.[48] Likewise, a study[49] indicates cats are a leading domestic animal source of possible human exposure to rabies requiring postexposure prophylaxis. Continued low numbers of reported cases of rabies in dogs and cattle attest to the effectiveness of the public health strategy aimed at preventing rabies spillover to domestic animals from infected wildlife. Further reduction in the number of rabies cases in companion species, especially cats, may require stricter observance and enforcement of vaccination and leash laws. Vaccination remains a crucial element in this effort.

Vaccination of pet mammals and livestock that have regular contact with people provides a barrier to protect the human population from infection with rabies. A single incident involving a case of rabies in a companion species can result in large economic expenditures and public health efforts to ensure that human disease does not occur.[50–52] Although widespread vaccination of livestock is neither economically feasible nor justifiable on public health grounds, vaccination of valuable livestock or livestock that may have regular contact with human beings (eg, in a petting zoo) in rabies epizootic areas should be considered.[53]

The occurrence of rabies in different species of bats varies by geographic region. The increasingly reported association of bat rabies virus variants with human infections in the United States during recent years has yielded increased publicity and changes in public health recommendations for potential rabies exposures involving bats.[53,54] This increased publicity toward bats and rabies has increased awareness to the public and likewise has increased the rate at which individuals submit bats for diagnostic testing because of a potential exposure. Despite an increase of 47 bats reported from 2004 to 2005, the rate of positive bats reported by states providing denominator data declined over this period (6.1% positive in 2004, compared with 5.8% positive in 2005). This finding underscores the importance of collecting denominator data from all states to correct for increasing submission rates.

With the 1 human rabies case reported in 2005, the total number of cases of rabies diagnosed in human beings in the United States since 1990 increased to 48 (including 1 case reported from Puerto Rico). Ten (20.8%) of these 48 individuals were infected outside

the continental United States (9 abroad, 1 in Puerto Rico). The majority of human rabies infections that occur in foreign countries where dog rabies is enzootic involve regional canine rabies virus variants. Six of 9 such cases and the case from Puerto Rico (7/10) involved a reported history of dog bite. Thirty-eight (79.2%) of the 48 individuals were infected with rabies virus variants indigenous to the United States. Analysis of monoclonal antibodies and genetic sequencing data indicated that 35 (92.1%) of these 38 persons were infected with bat rabies virus variants (4 received transplants from a rabid donor). Although rabies infection of human beings from bats remains a rare occurrence, the prevention of such infections remains an important public health concern.

Rabies in bats is epidemiologically distinct from terrestrial rabies maintained by mammalian carnivores. Understanding the circulation of rabies virus variants in bat species remains less well developed than that in carnivores. Successful control of terrestrial rabies in the United States through the use of oral vaccines, as has been accomplished in Europe[55] and southeastern Canada,[16] will have no effect on enzootic rabies in bats and the associated risk of human disease.

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Several ORV projects in Texas, Florida, Alabama, and Ohio have released 4.1 million baits over an area of 108,000 km^2 as of July 2006. Baiting will be conducted in the Appalachian Ridge, GAT, and northeast baiting regions in fall 2006. These areas coincide with areas baited previously in 2005, with consideration toward moving the Appalachian Ridge barrier eastward in West Virginia and expanding the GAT barrier eastward to take advantage of the Blue Ridge mountain range in northern Georgia and western North Carolina.[b]

On May 12, 2006, a 16-year-old male from Texas died of acute encephalitis, which was later confirmed by the CDC as rabies. The individual reported awakening to find a bat on his face approximately 4 to 6 weeks before the onset of symptoms. Antigenic and genetic sequencing of the virus indicated a rabies virus variant associated with Mexican free-tail bats.

On October 11, 2006, a 10-year-old girl from Indiana was reported to the CDC with compatible clinical signs of rabies. Antemortem samples were submitted to the CDC, and rabies was confirmed on October 13. The virus was isolated and typed as a rabies virus variant associated with the silver-haired bat. Initial investigations indicated that approximately 11 to 12 weeks before onset of symptoms, the child had been bitten on her arm by a bat, but had not received any rabies postexposure prophylaxis. The patient underwent experimental treatment, but died on November 2, approximately 33 days after onset of symptoms.

During July 2006, a *Myotis keenii* (Keen's bat) was collected as part of an ecologic study on Prince Wales Island in Alaska. The bat exhibited abnormal behavior and was euthanatized and submitted for rabies testing in August. The Alaska Division of Public Health laboratory determined the bat was positive for rabies, and samples were later antigenically typed as a rabies virus variant associated with *L borealis* (red bat) at the CDC. This represents the second bat confirmed positive for rabies in Alaska to date. During June 1993, an *M lucifugus* (little brown bat) was found positive for rabies with a rabies virus variant associated with *Lasionycteris noctivigans* (silver-haired bat).

If current trends continue, as is suggested by an early analysis of data submitted during the first 6 months of 2006, the overall number of reported rabid animals can be expected to remain steady or continue to decline in 2006. Specifically, if trends continue among bats and skunks, the total number of reported rabid bats may exceed the number of rabid skunks. However, this increasing trend among bats is most likely due to increasing submission rates and does not reflect a true increase in the incidence of rabies among bats.

a. ArcMap, version 8.3, ESRI, Redlands, Calif.
b. Forbes J, United States Department of Agriculture, Wildlife Services, Morgantown, WV: Personal communication, 2006.

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