

**NATIONAL RABIES MANAGEMENT PROGRAM  
SUMMARY REPORT 2010**

**United States Department of Agriculture  
Animal and Plant Health Inspection Service**



Protecting People | Protecting Agriculture | Protecting Wildlife

USDA-APHIS-Wildlife Services  
National Rabies Management Program  
59 Chenell Drive, Suite 2  
Concord, NH 03301 USA

WRITTEN BY:  
Kathy Nelson  
Staff Biologist

REVIEWED BY:  
Dennis Slate  
Science Advisor

APPROVED BY:  
Richard Chipman  
Coordinator



Oral rabies vaccination (ORV) programs in the United States began in the early 1990s in New Jersey and Massachusetts with the goal of preventing the raccoon (*Procyon lotor*) variant of rabies from spreading to populated vacation areas of Cape May and Cape Cod, respectively. The U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (WS) program's initial involvement in cooperative ORV was in 1995 in south Texas to prevent canine rabies in coyotes (*Canis latrans*) from gaining a larger foot-hold in the U.S. One year later, an ORV program began in west-central Texas to prevent rabies in gray foxes (*Urocyon cinereoargenteus*). In 1997, WS began involvement in cooperative ORV projects in Ohio and Vermont to prevent the spread of raccoon rabies. Since 1998, when WS' National Rabies Management Program (NRMP) received its first federal funds explicitly for rabies control, the ORV program expanded and in 2010 focused on raccoon rabies in 15 eastern states, canine and gray fox rabies in Texas, and gray fox rabies in New Mexico and Arizona. Wildlife Services participated in coordinated ORV programs that led to the distribution of more than 8.7 million baits containing Raboral V-RG<sup>®</sup> vaccine (Merial Limited, Athens, Georgia, USA) over 190,387 km<sup>2</sup> in 2010, an area larger than the State of Washington (Table 1 and Figure 1).

Table 1. Oral rabies vaccination (ORV) bait distribution and area baited by Wildlife Services and cooperators in the United States, 2010 (all ORV baits were Raboral V-RG<sup>®</sup> vaccine [Merial Limited, Athens, Georgia, USA]).

State	Target species	ORV baits distributed	Area baited (km <sup>2</sup> )	Bait distribution methods
Alabama	Raccoon	215,321	3,607	Fixed-wing, ground
Arizona	Gray fox	129,600	4,105	Fixed-wing, ground
Florida <sup>a</sup>	Raccoon	260,640	1,664	Ground, helicopter, bait station
Georgia	Raccoon	205,864	3,315	Fixed-wing, ground
Maine	Raccoon	137,376	2,331	Fixed-wing, ground
Maryland	Raccoon	72,245	1,086	Ground, helicopter
Massachusetts	Raccoon	61,442	953	Ground, helicopter, bait station
New Hampshire	Raccoon	15,031	226	Fixed-wing, ground
New Mexico	Gray fox	8,146	362	Fixed-wing
New York	Raccoon	695,761	10,691	Fixed-wing, ground, helicopter
North Carolina	Raccoon	240,458	4,028	Fixed-wing, ground
Ohio	Raccoon	774,714	11,399	Fixed-wing, ground, helicopter
Pennsylvania	Raccoon	614,725	7,999	Fixed-wing, ground
Tennessee	Raccoon	586,385	9,812	Fixed-wing, ground
Texas	Coyote	466,920	20,104	Fixed-wing, ground, helicopter
Texas	Gray fox	2,433,655	80,050	Fixed-wing, ground
Vermont	Raccoon	369,231	5,398	Fixed-wing, ground
Virginia	Raccoon	300,856	4,904	Fixed-wing, ground
West Virginia	Raccoon	1,115,993	18,353	Fixed-wing, ground, helicopter
Total		8,704,363	190,387	

<sup>a</sup> Includes 87,840 baits distributed by county officials in Broward County.

In the Northeast, WS continued cooperation with state agencies and international partners in New Brunswick, Quebec, and Ontario, Canada to try to prevent the northern and western spread of raccoon rabies. These ORV zones extended along a portion of the New Brunswick border with Maine; the Quebec border with New Hampshire, Vermont and New York; and the Ontario border in northern and western New York (Figure 1). To help maintain raccoon rabies free status in Ontario and Quebec, Vermont and New York WS implemented trap-vaccinate-release (TVR) along the U.S.-Canada border in 2010. These TVR programs resulted in the hand vaccination of 4,248 animals in Vermont (2,027), New Hampshire (22) and northern New York (2,199) (Table 2).

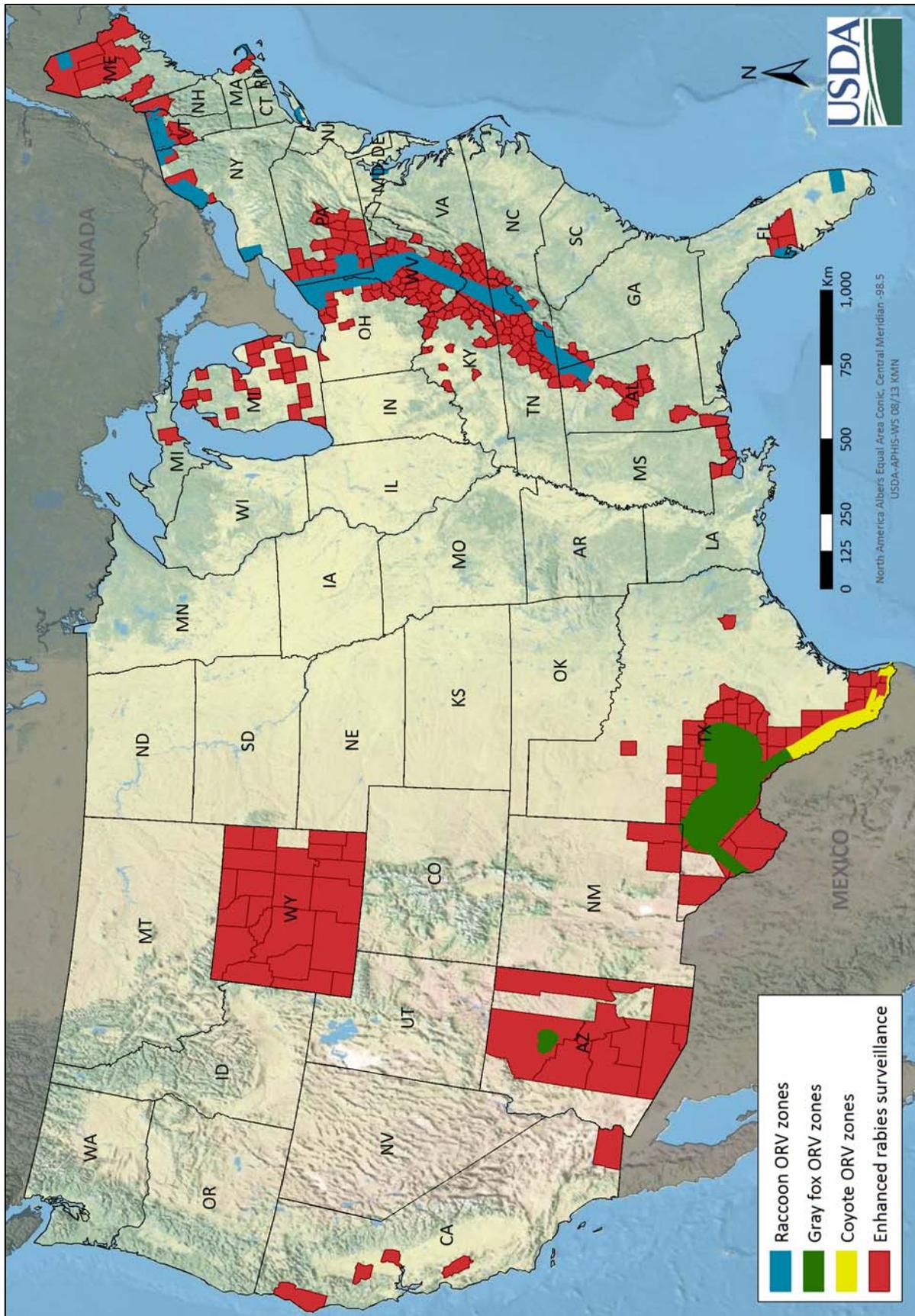


Figure 1. Cooperative oral rabies vaccination (ORV) zones and Wildlife Services enhanced rabies surveillance counties in the United States, 2010.

As a component of the greater Appalachian Ridge ORV zone, Ohio continued baiting the Contingency Action ORV zone (east of Cleveland) in the fall of 2010. This was the first time since 2003 that there was no spring baiting in Ohio; however, throughout the summer of 2010, WS continued to integrate TVR into the rabies control campaign within the Contingency Action zone to prevent the spread of raccoon rabies. These TVR efforts resulted in the hand vaccination of 2,486 animals in northeastern Ohio (Table 2). The number of rabid animals with raccoon variant in this Contingency Action zone in 2009 remained at 3 cases in 2010 (all in striped skunks).

In addition to coordinated TVR in Vermont, New Hampshire, northern New York and Ohio, WS vaccinated and released 1,905 animals in strategic urban/suburban areas where ORV baiting is supplemented by hand vaccination. These areas included: Flagstaff, Arizona; Pinellas County, Florida; Anne Arundel County, Maryland; Cape Cod, Massachusetts; New York City, New York; and Allegheny County, Pennsylvania (Table 2).

Table 2. Animals live trapped, hand vaccinated with rabies vaccine, and released by Wildlife Services in the United States, 2010.

State	Raccoons	Skunks	Cats (feral)	Fishers	Foxes (red)	Foxes (gray)	Coyotes	Minks	Total
Arizona	1	106							107
Florida	270								270
Maryland	297		14		1	2			314
Massachusetts	52								52
New Hampshire	22								22
New York (northern)	1,927	212	12	21	17	8	1	1	2,199
New York City	452	1							453
Ohio	2,486								2,486
Pennsylvania	708		1						709
Vermont	1,939	77	4	6	1				2,027
Total	8,154	396	31	27	19	10	1	1	8,639

An outbreak of raccoon rabies emerged in Manhattan (New York City) beginning in December 2009. By year end, 12 rabid raccoons had been confirmed in association with the Central Park outbreak. Prior to this epizootic, the last confirmed case of raccoon rabies in Manhattan was in 2001. Given the human and domestic animal health implications, and the robust raccoon population in Central Park, the New York City Department of Health and Mental Hygiene convened a task force to review rabies control options and strategies. The task force began by requesting assistance from NY WS, developing messages for the public and specific groups, creating and posting signs in Central Park, reaching out to trap-neuter-release groups, sending alerts to medical and veterinary communities, issuing press releases, and reviewing 311 messaging regarding rabies. In February 2010, NY WS began live trapping in Central Park and nearby Morningside and Riverside Parks to conduct TVR in apparently healthy wildlife. Raccoons or other wild carnivores exhibiting abnormal behavior suggestive of rabies were euthanized for rabies testing. From mid-February to mid-April, NY WS administered TVR to 235 raccoons and 1 skunk. In addition, they trapped and euthanized 52 raccoons with lesions or signs suggestive of rabies. Five raccoons behaving abnormally were captured with a catch pole and 6 raccoons were found dead in the parks. Of the 63 raccoons killed or found dead, most were submitted for rabies testing or transferred to cooperators to submit; 45 were submitted by WS and 23 (51%) were confirmed rabid. A second round of TVR was conducted from late-September to early-November with the goal of vaccinating juvenile raccoons born that spring. During this effort, 217 raccoons were trapped, vaccinated and released, totaling 453 animals for the year (Table 2). Wildlife Services collected blood serum samples from 42 of the trapped raccoons; 23 (55%) had detectable rabies virus neutralizing antibodies (RVNA) prior to ORV in Central Park. Such a high percentage of RVNA positive raccoons suggests that these unmarked animals had experienced sub-lethal exposures to rabies virus from within the local carnivore community. On 29 November 2010, WS cooperated to distribute 1,080 fishmeal polymer baits by hand throughout the 840-acre (3.4 km<sup>2</sup>; 1.3 mi<sup>2</sup>) Central Park (approximately 318 baits/km<sup>2</sup>). By year end, 196 raccoons had been tested for rabies from Manhattan, and 123 (63%) were confirmed positive (almost all from Central Park). In light of these findings, TVR is planned to continue in Central Park in 2011.

The greater Appalachian Ridge ORV zone extended from Ohio and Pennsylvania, through West Virginia and Virginia, northeastern Tennessee and western North Carolina, and into southeastern Tennessee, northwestern

Georgia, and northeastern Alabama in 2010 (Figure 1). This 800 km (500 mi) long zone, interfaces with high mountainous habitats that generally do not support robust raccoon populations based on WS density indices. The integration of ORV with the Appalachian Mountains bolsters the overall “barrier effect” to rabies spread. There were no cases of raccoon rabies confirmed west of these zones in 2010.

In 2010, WS continued participation in cooperative ORV in Barnstable County, Massachusetts; Anne Arundel County, Maryland; and Pinellas County (and adjacent counties), Florida (Figure 1). These projects provided information on ORV effectiveness and surveillance strategies. Future contingency actions may be planned to integrate TVR with ORV to attempt to restore Cape Cod to raccoon rabies free status. The current strategy is to systematically conduct control from Provincetown (the eastern end of the Cape) back to the central part of the Cape, with the objective of eliminating raccoon rabies that emerged in 2004 and spread rapidly east through the susceptible raccoon population. There has been a marked reduction in the number of terrestrial cases in Barnstable County since the intervention with TVR and ORV (high of 157 in 2005 to 11 in 2010). The long-term goal is to eliminate rabies from the Cape and reestablish an ORV zone west of the Canal sufficient to prevent raccoon rabies reemergence on Cape Cod. All of these projects have peninsular geography in common, which represents a more favorable landscape (surrounded by water on three sides thus restricting raccoon movements) for evaluating rabies status and if elimination could be achieved on a relatively small scale. Although raccoon rabies elimination in these areas via traditional ORV baiting strategies (aerial and ground distribution) remains a challenge, bait stations continued to be deployed as part of the Massachusetts and Florida projects in 2010. If bait station field trials show promise, plans are to possibly expand their use.

Wildlife Services fills an important cooperative role with the Texas Department of State Health Services (TDSHS) and several other agencies and organizations in ORV efforts that began in Texas in 1995, by providing funding, field expertise, infrastructure, and equipment to help obtain samples for continued monitoring and evaluating of ORV status targeting coyotes in south Texas and gray foxes in west Texas. The rabies control program in coyotes is a balance of enhanced surveillance applied in tandem with an ORV zone maintained along the Rio Grande River (Figure 1) to prevent reemergence of this rabies virus variant from dog (*Canis lupus familiaris*) or coyote sources in Mexico. Single cases were confirmed in dogs near Laredo in 2001 and 2004 within 1.6 km (1 mi) of the U.S.-Mexico border. No additional cases have been reported since 2004. The Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) declared the United States free of canine rabies in 2007 (Velasco-Villa et al. 2008). This status remained unchanged in 2010.

Wildlife Services is also an important funding and operational partner with the TDSHS in conducting ORV efforts to eliminate a unique gray fox rabies variant in west-central Texas (Figure 1). In 2010, WS and the TDSHS continued enhanced surveillance and baiting in response to fox cases that emerged west of the ORV zone in 2007. In 2010, WS cooperated to distribute more than 2.4 million baits over approximately 80,000 km<sup>2</sup> (31,000 mi<sup>2</sup>) to prevent gray fox rabies from spreading from Texas (Table 1). For the first time, ORV baits (8,146) were distributed in the southeastern portion of Lea County, NM to ensure a sufficient buffer around previous cases in Texas. As a result, no cases of the fox variant unique to Texas were confirmed in 2010, with the last case reported in a domestic dog in May 2009.

In July 2009, Arizona WS implemented its first operational ORV program in Flagstaff to control an outbreak of rabies in gray foxes that had been occurring since November 2008. Twenty-two gray foxes, 6 striped skunks and 1 ringtail (*Bassariscus astutus*) had been confirmed with a rabies variant associated with big brown bats (*Eptesicus fuscus*). These were the first terrestrial cases of rabies in Flagstaff in over two years, with previous outbreaks primarily in skunks. In June 2010, WS and the Coconino County Health Services District cooperated to distribute 129,600 coated sachets surrounding the city of Flagstaff (Table 1). There were 4 rabid bats in Coconino County (Flagstaff) in 2010 and no rabies confirmed in terrestrial animals.

Also, in 2010, Arizona WS continued a TVR program to vaccinate animals (specifically skunks) in and around Flagstaff. TVR efforts resulted in the hand vaccination of 106 striped skunks and 1 raccoon (Table 2). Over the multi-year TVR effort (2001 and 2004-2010), 747 animals have been trapped, vaccinated, and released: 673 striped skunks, 48 raccoons, 21 gray foxes, 3 bobcats (*Lynx rufus*), and 2 Western hog-nosed skunks (*Conepatus mesoleucus*). The significance of spillover of other rabies virus variants in skunks is not well understood, but the apparent inability to orally vaccinate a sufficient segment of skunk populations with the currently licensed oral rabies vaccine-bait hampers our ability to apply this strategy to control rabies in skunks and potentially confounds progress toward control and elimination of raccoon rabies in the eastern U.S. The Arizona program remains critical

to an enhanced understanding of the role the striped skunk may play in rabies outbreaks and the nationwide efforts to reduce and eventually eliminate rabies in wild carnivores from the U.S.

In 2010, WS continued sampling free-flying insectivorous bats in Arizona to determine presence of RVNA. Arizona has 28 bat species for at least a portion of each year. This allows for sampling diverse bat species with widely varying life histories (i.e. colonial or solitary, migratory or non-migratory). This effort began in 2007 with the Arizona Game and Fish Department, Bat Conservation International, Northern Arizona University, the CDC, and others to obtain and analyze serum samples to better understand rabies and bat dynamics.

The rabies virus is virtually global in distribution and the mammalian orders *Carnivora* and *Chiroptera* are its principal hosts, with bats acting as a primary reservoir on all inhabited continents (Rupprecht et al. 2002). Molecular characterization of rabies has revealed multiple unique rabies virus variants circulating within bats (Smith 1996, Nadin-Davis et al. 2001, Shankar et al. 2005). Thus, the highly diverse bat fauna of the New World (9 families and more than 250 species) serves as host to a diverse group of rabies virus variants.

As vaccination programs have reduced rabies in terrestrial carnivores (De Mattos et al. 2000, Rupprecht et al. 2002) bats will continue to provide an important ecological niche for rabies perpetuation and diversification of new variants. Additionally, although human rabies deaths in the U.S. are low (2 to 3 deaths/yr), in recent decades, bat-associated variants of rabies have been responsible for most cases (Smith 2002). Urbanization and changing landscapes continue to put bats and humans in direct contact, suggesting a continued risk. Consequently, understanding rabies and its distribution in bat species is of increasing importance. The fear of rabies and our lack of knowledge about its distribution and prevalence in bat species make them targets of control based on fear. Therefore, an examination of rabies prevalence, distribution, and diversity in wild bat populations will serve to inform management and control efforts that aim to protect humans from rabies.

In this multi-year study, bats were captured by partnering organizations using mist nets, funnel traps or harp traps beginning at approximately sunset and continuing for at least 3 hours. Each bat was assessed for age, weight, sex and reproductive status. Blood was collected by WS from the uropatagium/interfemoral vein between the leg and tail using methodologies described in Wimsatt et al. (2005).

In 2010, WS collected 567 serum samples from 15 bat species in Arizona. Currently, 390 of the 567 samples have been analyzed. Twenty of the 390 bats (5.1%) sampled had detectable RVNA. Fifteen percent (n=20) of long-legged myotis (*Myotis volans*) had RVNA, the highest of any species sampled in 2010. Seroprevalence rates for the big brown bat was 12.1% (n=58), while other species ranged from 0% to 15% RVNA. Results from this multi-year study will lead to a better understanding of bat rabies in wild populations. This study will continue in 2011.

A GonaCon™ trial in captive dogs was initiated on the Navajo Nation in 2008. This initiative was taken under the North American Rabies Management Plan. GonaCon™ vaccine, developed by WS' National Wildlife Research Center (NWRC), stimulates the production of antibodies that bind to the gonadotropin-releasing-hormone (GnRH). By binding to the GnRH, the antibodies reduce GnRH's ability to stimulate the release of sex hormones, inhibiting sexual activity. GonaCon™ has shown to elicit an immune response that contracepts both males and females in several species for at least two years. Simultaneous injection of rabies vaccine and GonaCon™ may have the potential to improve our ability to control rabies by additive effect of reduced dog fecundity in the control strategy. In 2010, Arizona WS cooperated with NWRC and the Navajo Nation to continue following vaccinated female dogs through several breeding cycles in the presence of reproductively competent males to determine if they were contracepted.

Parenteral vaccination campaigns and dog population control are integral to the elimination of canine rabies. EsterilSol™ (Ark Sciences Inc., New York, New York, USA), a chemical sterilant composed of zinc gluconate neutralized by arginine has been used parenterally with success to contracept male dogs. In 2010, the Navajo Nation evaluated the contraceptive effects of EsterilSol™ and rabies vaccine administered parenterally. Eighteen feral dogs, collected from routine animal control programs on the Reservation, were included in this initial study: 6 were given EsterilSol™ only, 6 were given rabies vaccine only, and 6 were given EsterilSol™ and rabies vaccine. Sera were collected to determine RVNA levels at days 0, 7, 14, 21, and 33. All dogs vaccinated for rabies developed RVNAs and all dogs given EsterilSol™ stopped sperm production. Thus, administration of EsterilSol™ in tandem with a rabies vaccine may provide a new integrated approach in rabies management. The value of sterilizing male dogs may be manifest through reduced aggression that may help spread rabies during breeding cycles and impact public health through direct contact between breeding aggressive males and people.

In 2010, the Navajo Nation applied to the USDA, APHIS, Center for Veterinary Biologics and received a research and evaluation permit to study the safety of the Ontario rabies vaccine bait (ONRAB) in feral dogs. ONRAB, a live recombinant human adenovirus serotype 5 (HAd5)-rabies glycoprotein vaccine, has been used in extensive field trials in Canada for several years to determine the safety and immunogenicity of the vaccine in target species (striped skunk, raccoon, and red fox). These trials also determined that the most common non-target species that may ingest baits are dogs, making the Navajo Nation an ideal study area. Twenty feral dogs, kept in isolation at the Navajo Nation Veterinary Program facilities, were offered ONRAB vaccine contained in "Ultralite" baits (Artemis Technologies Inc., Guelph, Ontario, Canada). Throughout the study, general health status was monitored. To determine vaccine uptake, serum samples were collected at day 0 and at 2-week intervals for the duration of the study to monitor for antibody titers against HAd5 and rabies. Oral swabs collected at 2, 12, and 24 hours post-bait consumption, and rectal swabs at 48 and 72 hours post-bait were assayed for adenovirus (AdRG1.3) by real time polymerase chain reaction analysis (qPCR) to evaluate potential environmental virus shedding. Two human subjects (investigation veterinarian and one animal caretaker), two non-study investigator-owned dogs, and one unvaccinated dog kept in intimate contact with four vaccinated dogs, were assessed pre- and post-study for HAd5 and rabies titers to monitor for potential horizontal transmission. Uptake of ONRAB and immune responses were observed in a majority of dogs, with no adverse health effects from vaccination noted during the course of the study. Viral shedding was detected by the swabs, but horizontal transmission to humans, non-study dogs, or the dog in intimate contact was not observed. This study may add to other data previously collected in Canada to support use of ONRAB in the United States.

Wildlife Services and cooperators implemented contingency actions in New York, Ohio, and Vermont in 2010. Contingency actions often include an integration of ORV, TVR, and increased enhanced rabies surveillance. Enhanced surveillance is designed to complement public health surveillance and provide greater intensity and scope in suspect animal testing to delineate the leading edge of rabies distribution, allowing for sound ORV decisions. Enhanced surveillance includes samples from: animals exhibiting behaviors suggestive of rabies but not implicated in human or domestic animal exposures, road kills, other animals found dead, animals with wounds or lesions suggestive of rabies, and animals removed near locations where rabies has recently been confirmed. In 2010, WS continued to enhance rabies surveillance in the states conducting ORV for raccoons, as well as emphasizing surveillance in adjacent states west of the raccoon ORV zone, including: Michigan, Kentucky, Mississippi and Louisiana (Figure 1). Texas and New Mexico collected 1,436 and 86 animals, respectively, in support of coyote and gray fox ORV programs. Arizona collected 367 animals in support of gray fox ORV and bat-skunk studies. In addition, California and Wyoming collected and submitted animals for testing to determine the presence of skunk variants of rabies. In 2010, WS' collected and submitted 9,231 samples for enhanced rabies surveillance testing (Table 3) by WS, the CDC, local health department laboratories, and local agriculture department laboratories. From these samples, 223 rabid animal locations were identified and improved rabies management decisions.

Since 2005, 55 WS personnel have attended direct rapid immunohistochemistry test (dRIT) training at the CDC in Atlanta, Georgia. The dRIT is an unlicensed procedure designed for consideration as a potential confirmatory measure of the direct fluorescent antibody (dFA) test (the test most frequently used to diagnose rabies). In addition, the dRIT may be used to enhance field surveillance in suspect wildlife, particularly in support of ORV programs. The dRIT may be used in remote locations to improve sample turnaround and not overburden rabies laboratories, but it is not used for public health surveillance in the U.S. Animals involved in potential or actual human or domestic animal rabies exposures are evaluated through standard procedures by public health experts at established local, state, or federal laboratories. From 2005-2010, WS implemented the dRIT in 19 states. In 2010, WS (and the TDSHS) tested 7,294 (79.0%) animals collected for enhanced surveillance using the dRIT; 145 tested positive for rabies (Table 3).

Table 3. Wildlife Services enhanced rabies surveillance and use of the direct rapid immunohistochemistry test (dRIT) as part of rabies management programs in the United States, 2010.

State	Enhanced surveillance animals	WS tested by dRIT	Rabid by dRIT
Alabama	135	135 (100%)	1
Arizona	367	367 (100%)	24
California <sup>a</sup>	21	0	
Florida	247	236 (95.5%)	2
Georgia	110	110 (100%)	0
Kentucky <sup>a</sup>	118	117 (99.2%)	0
Louisiana <sup>a</sup>	0		
Maine	136	0	
Maryland	2	2 (100%)	1
Massachusetts	73	72 (98.6%)	9
Michigan <sup>a</sup>	71	71 (100%)	2
Mississippi <sup>a</sup>	40	40 (100%)	0
New Hampshire	4	0	
New Mexico	86	0	
New York	76	0	
North Carolina	67	66 (98.5%)	10
Ohio	559	559 (100%)	3
Pennsylvania	2,980	2,934 (98.5%)	37
Tennessee	892	876 (98.2%)	16
Texas <sup>b</sup>	1,436	253 (17.6%)	0
Vermont	107	1 (0.9%)	1
Virginia	264	264 (100%)	20
West Virginia	1,216	1,191 (97.9%)	19
Wyoming <sup>a</sup>	224	0	
Total	9,231	7,294 (79.0%)	145

<sup>a</sup> ORV not applied in this state.

<sup>b</sup> Includes samples tested by the Texas Department of State Health Services using the dRIT.

In all states conducting ORV (Raboral V-RG<sup>®</sup> vaccine), WS continues to take the lead on post-ORV monitoring to evaluate program effectiveness by collecting blood and tooth samples for determining RVNA and bait uptake (when biomarker is available) in raccoons, skunks, coyotes, foxes, and bobcats. Density indexing is also used to characterize raccoon and skunk populations and to provide post-ORV serum samples for analysis. Typically, WS presents ORV program evaluation data (serology, tetracycline, and age results) from the previous year's monitoring activities to provide time for laboratory analyses. At the time of this report, however, all states had received 2010 results so they are included in this report.

All animals captured by WS in 2010 were trapped in accordance with federal, state, and local laws and handled according to the American Society of Mammalogists, Animal Care and Use Committee guidelines. All animals that had to be euthanized by WS in 2010 were done so in accordance with the American Veterinary Medical Association's Panel on Euthanasia recommendations.

In 2010, a mean positive antibody response of 34±17% was observed for 3,776 raccoon serum samples collected post-ORV (Table 4); 208 of the positive samples had a previous record of hand vaccination. Post-ORV sera were also collected from 48 striped skunks, 3 gray foxes, 1 fisher (*Martes pennanti*) and 1 red fox (*Vulpes vulpes*) during raccoon rabies management programs. Six skunks (13%) and all foxes (100%) had a detectable RVNA response; 1 skunk had a prior record of hand vaccination. Texas collected sera from 116 coyotes and 151 gray foxes to evaluate seroconversion in those species in south and west-central Texas, respectively; 87 (75%) coyotes and 132 (87%) gray foxes had RVNA (Table 4). Texas also collected post-ORV sera from 125 coyotes, 2 bobcats and 2 raccoons during evaluation of the gray fox ORV program; 89 coyotes (71%) and 1 raccoon (50%) had detectable RVNAs. To evaluate the second year of an ORV program targeting gray foxes around Flagstaff, Arizona,

sera were collected from 34 skunks and 9 coyotes post-ORV (unfortunately, no gray fox samples were obtained). Eight skunks (24%) and 1 coyote (11%) showed detectable rabies antibodies; 4 skunks had a prior record of hand vaccination. No post-ORV evaluation was conducted in New Mexico in 2010.

Table 4. Wildlife Services post-oral rabies vaccination (ORV) sampling efforts as part of rabies management programs targeting various species in the United States, 2010 (all ORV baits were Raboral V-RG<sup>®</sup> vaccine [Merial Limited, Athens, Georgia, USA]).

State	All post-ORV serum samples	Positive rabies antibody response ( $\geq 0.05$ IU)	4-12 weeks <sup>a</sup> post-ORV samples	Positive rabies antibody response ( $\geq 0.05$ IU) <sup>b</sup>
Raccoon <sup>c</sup>				
Alabama	221	49 (22.2%)	122	47 (38.5%)
Florida	298	85 (28.5%) <sup>d</sup>	99	27 (27.3%)
Georgia	128	28 (21.9%)	128	28 (21.9%)
Maine	130	29 (22.3%)	130	29 (22.3%)
Maryland	307	120 (39.1%) <sup>d</sup>	307	120 (39.1%)
Massachusetts	51	41 (80.4%) <sup>d</sup>	37	32 (86.5%)
New Hampshire	22	12 (54.5%)	22	12 (54.5%)
New York	399	166 (41.6%) <sup>d</sup>	399	166 (41.6%)
North Carolina	106	38 (35.8%)	81	35 (43.2%)
Ohio	359	125 (34.8%) <sup>d</sup>	111	47 (42.3%)
Pennsylvania	721	125 (17.3%) <sup>d</sup>	283	69 (24.4%)
Tennessee	304	90 (29.6%)	304	90 (29.6%)
Vermont	177	72 (40.7%) <sup>d</sup>	172	70 (40.7%)
Virginia	200	32 (16.0%)	114	22 (19.3%)
West Virginia	353	80 (22.7%)	234	57 (24.4%)
Total	3,776	1,092 (28.9%)	2,543	851 (33.5%)
Mean $\pm$ St. Dev.		34 $\pm$ 17%		37 $\pm$ 17%
Arizona (gray fox)	0			
Texas (coyote)	116	87 (75.0%)	116	87 (75.0%)
Texas (gray fox)	151	132 (87.4%)	151	132 (87.4%)

<sup>a</sup> Samples taken during optimal evaluation period of 4-12 weeks post-ORV bait distribution.

<sup>b</sup> Sera collected in all states but Texas are positive at  $\geq 0.05$  IU; sera collected in Texas are positive at  $\geq 0.04$  IU.

<sup>c</sup> Non-raccoon samples collected during raccoon rabies management programs are not represented in this table.

<sup>d</sup> In these states, some raccoons with a positive rabies antibody response had a record of previous hand vaccination by Wildlife Services (FL=3, MD=56, MA=10, NY=48, OH=66, PA=1, VT=24) either through a coordinated trap-vaccinate-release effort (as in NY, OH and VT) or in urban/suburban areas where ORV baiting is supplemented by hand vaccination (as in Pinellas Co., FL; Anne Arundel Co., MD; Cape Cod, MA and Allegheny Co., PA).

Teeth were submitted to Matson's Laboratory and Johnston's Biotech in 2010 for tetracycline biomarker analysis and aging. Tetracycline biomarker results for the raccoon rabies management program are not presented because 76% of the 5.7 million ORV baits distributed for raccoons in 2010 were coated sachets that do not contain tetracycline biomarker. Texas continued limited distribution of dog food and fishmeal polymer baits containing biomarker for gray fox in west Texas and collected teeth for ORV program evaluation: 53 of 151 gray fox teeth (35%), 75 of 126 coyote teeth (60%); and 2 raccoon teeth (100%) tested showed a presence of tetracycline, supporting that RVNA was oral vaccine induced. Teeth were not collected in the south Texas (coyote) ORV zone as 86% of ORV baits distributed were coated sachets, or in the Arizona gray fox ORV zone (only coated sachets were distributed). Age results for target species sampled during raccoon, coyote and gray fox rabies management programs were similar to previous year's results (Figure 2). Median raccoon age was 1 year suggesting the importance of young in the overall population, but ages ranged from <1 to 13 years (a lactating female from Ohio). Nineteen raccoons were aged at  $\geq 10$  y.o.: 13 at 10 y.o., 2 at 11 y.o., 3 at 12 y.o. and 1 at 13 y.o. Median coyote age was 3 years and ranged from 1 to 12 years. Six coyotes were aged at  $\geq 10$  y.o.: 4 at 10 y.o., and 1 each at 11 and 12 y.o. Median gray fox age was 2 years and ranged from 1 to 8 years.

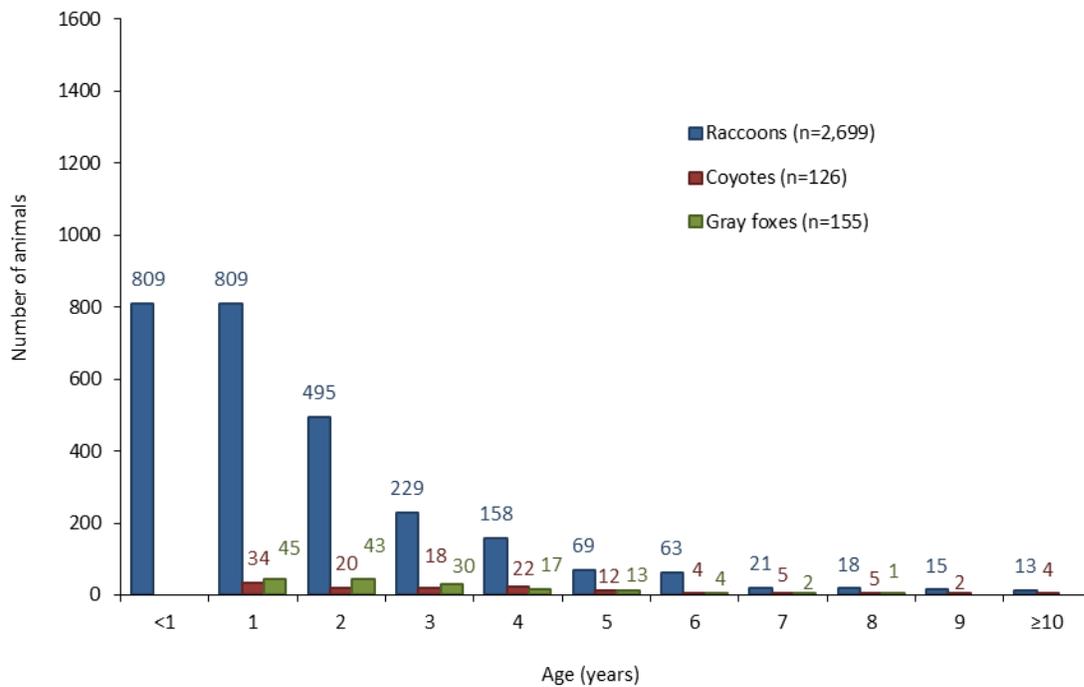


Figure 2. Age class distribution of 2,699 raccoon, 126 coyote and 155 gray fox tooth samples collected by Wildlife Services during cooperative rabies management programs in the eastern United States (raccoons) and Texas (coyotes and gray foxes), 2010.

In addition, during raccoon rabies management programs in 2010, WS collected teeth for aging from: 143 striped skunks (median age: 1 year, range: 0-5 years); 11 gray foxes (median age: 1 year, range: 0-3 years); 6 red foxes (median age: <1 year, range: 0-3 years); 16 coyotes (median age: <1 year, range: 0-11 years); 2 bobcats (median age: 2.5 years, range: 0-5 years); and 1 fisher aged at <1 year.

The need for a bait-vaccine combination producing higher levels of RVNA in wild meso-carnivore species serving as rabies reservoirs remains the highest priority and requires continued systematic research. In 2010, research at Thomas Jefferson University in Philadelphia, Pennsylvania and at the CDC continued to focus on the development of new, safe, and effective oral rabies vaccines with canine adenovirus (CAV) as a prospective vector for expression of the rabies glycoprotein. Captive challenge trials in skunks and raccoons at the CDC demonstrated strong CAV2-RG (canine adenovirus2-rabies glycoprotein recombinant) performance. In 2009, a field sero-survey among raccoons (n=500) was completed and showed low prevalence of canine adenovirus antibodies, suggesting low interference for CAV2-RG seroconversion in this species. In 2010, however, WS began a field sero-survey in skunks, coyotes and gray foxes to determine CAV antibodies. This initial work in other species suggests that CAV antibodies are naturally occurring at much higher levels and may interfere with CAV2-RG seroconversion. Field sero-surveys will continue and be expanded to mongoose (*Herpestes javanicus*) in 2011.

Wildlife Services' NWRC in Fort Collins, Colorado continued or initiated several pen, laboratory, and field studies to investigate the ecology, control, and prevention of terrestrial rabies in free-ranging wildlife. This marked the end of the last 5-year review (2006-2010) of rabies research projects. During that period, 33 studies were initiated, many of them multi-year in focus; 22 studies were completed by the end of 2010 and 11 will continue into 2011 (Table 5). Studies were conducted under one of the following 4 research objectives: 1) Determine the significance of demography, behavior, movements, and dispersal of raccoons and striped skunks as they may relate to the transmission and rabies virus trafficking across ecosystems; 2) Develop and evaluate methods and technologies for use by the ORV program to increase effectiveness in vaccinating free-ranging wildlife against rabies, which may reduce or eliminate the transmission of rabies from wildlife to humans, livestock, and other wildlife; 3) Obtain information on the ecology of the gray fox for possible development of improved baiting

strategies for the oral rabies vaccination program in Texas; and 4) Evaluate long-term efficacy of the V-RG vaccine and factors that may interfere with or reduce rabies vaccination rates in free-ranging raccoons.

Table 5. Wildlife Services' National Wildlife Research Center (NWRC) conducted 33 studies to investigate the ecology, control, and prevention of terrestrial rabies in free-ranging wildlife from 2006-2010 in support of the oral rabies vaccination (ORV) program in the United States.

QA	Objective	Completed	Brief study description	Citation
1105	1	Yes	Alabama raccoon movements and effects of natural barriers on preventing rabies spread	Arjo et al. 2008
1359	1	Yes	Movements of raccoons within the ridge-and-valley system of central Pennsylvania	Root et al. 2009; Puskas et al. 2010
1375	1	Yes	Raccoon movements, dispersal, habitat, and population genetics in northern Ohio	Berentsen et al. 2010
1663	1	No	Trapping point transects and spatially explicit capture-recapture to estimate raccoon density	Ongoing
1683	1	No	Using spatial data to increase trap-based detection probabilities for raccoons	Ongoing
A	1	Yes	Genetic analysis to evaluate effects of natural barriers on preventing rabies spread	Johnson et al. 2009
B	1	Yes	Zoogeography of raccoons in Pennsylvania	Compton et al. 2007
C	1	Yes	Skunk behavior and ecology in suburban and urban environments in Texas	Ruffino 2008
1334	2	Yes	Vitrification of Raboral V-RG for improved vaccine stability	Unpublished NWRC report
1410	2	Yes	The utility of rhodamine B as a biomarker in raccoons	Fry et al. 2010
1458	2	Yes	Exploratory development of an orthopoxvirus detection assay	Unpublished NWRC report
1483	2	Yes	Acceptance by raccoons to fishmeal polymer baits containing rhodamine B	Fry et al. 2010
1497	2	Yes	Evaluation of nine scented oils to attract raccoons	Unpublished NWRC report
1508	2	Yes	Mucosal adjuvants to increase the efficacy of Raboral V-RG in raccoons	Submitted for publication
1557	2	Yes	Ability of three doses of rhodamine B to biomarker raccoon whiskers	Fry et al. 2010
1583	2	Yes	Field test of rhodamine B as part of the WS ORV Program	Fry et al. 2009
1585	2	No	Efficacy of GonaCon and IMRAB rabies vaccine in raccoons	Ongoing
1617	2	Yes	Usefulness of rhodamine B as a biomarker for gray fox in Texas	Unpublished NWRC report
1639	2	No	Mouse models to evaluate the immunogenicity of Raboral V-RG in various matrices	Ongoing
1653	2	No	Field evaluation on the use of infrared thermography to screen for rabid animals	Ongoing
1656	2	No	Hormone antibody levels to evaluate the effectiveness of GonaCon in raccoon kits	Ongoing
1700	2	No	Quantifying seasonal fluctuation in sex hormone levels in free-ranging raccoons	Ongoing
1725	2	No	Health evaluation of select African carnivores and risks of disease transmission	Ongoing
D	2	Yes	Evaluation of the effectiveness of Raboral V-RG in captive arctic foxes	Submitted for publication
1223	3	Yes	Ecology of gray fox in relation to ORV programs in Texas	DeYoung et al. 2009
1577	3	Yes	Rabies virus concentration in bobcats after experimental inoculation with gray fox variant	Unpublished NWRC report
1599	3	No	Spatial ecology of gray foxes, coyotes, and bobcats relative to rabies spread in west Texas	Ongoing
1707	3	No	Landscape epizootiology of fox-variant rabies in Texas and New Mexico	Ongoing
1218	4	Yes	Antibody response of raccoons after doses of Raboral V-RG prior to rabies challenge	Unpublished NWRC report
1354	4	Yes	Evaluation of orthopoxviruses on Raboral V-RG vaccination in raccoons	Root et al. 2008
1377	4	Yes	Investigation of serologic crossreactivity to rabies virus in wild raccoons	Unpublished NWRC report
1501	4	Yes	Significance of neutralizing antibodies to rabies virus in non-vaccinated raccoons	Unpublished NWRC report
1660	4	No	Ability of Raboral V-RG to elicit an immune response in young raccoons	Ongoing

Throughout 2010, WS continued to participate in formal meetings with counterparts from Canada, Mexico, and the Navajo Nation in the context of the North American Rabies Management Plan (NARMP) that identifies information exchange, enhanced surveillance, rabies control, and research as key areas of focus toward meeting continental goals for rabies management. The NARMP was formally recognized by Canada, Mexico, the U.S. and Navajo Nation at a signing ceremony during the XIX International Conference on Rabies in the Americas held at the CDC in Atlanta, Georgia in September 2008.

In 2011, WS and cooperators will continue to focus on implementing enhanced rabies surveillance in conjunction with ORV to determine areas at risk of rabies spread and to monitor program success. Adjustments to ORV zones may occur as a result of improved surveillance information. Contingency actions are expected to continue in New York, Ohio, and Vermont. Commitments will continue toward improvements to the existing bait-vaccine and development of new vaccine-baits that may perform better and are effective in all meso-carnivore reservoirs. Wildlife Services continues to work with cooperators and collaborators toward field trials with vaccine-baits that can increase program effectiveness in achieving rabies management goals, including elimination of raccoon rabies.

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