

NATIONAL RABIES MANAGEMENT PROGRAM SUMMARY REPORT 2011

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
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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 has expanded, and in 2011 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 coordinated ORV programs that led to the distribution of more than 7.9 million baits over 190,537 km², an area larger than the State of Washington (Table 1 and Figure 1). Most of those baits contained Raboral V-RG[®] vaccine (Merial Limited, Athens, Georgia, USA); however, a field trial was conducted in southeastern West Virginia to evaluate the safety and immunogenicity of a live recombinant human adenovirus-rabies glycoprotein vaccine (AdRG1.3) (ONRAB [Artemis Technologies, Inc., Guelph, Ontario, Canada]) in wild raccoons and skunks (*Mephitis mephitis*). It was the first field trial of this type in the U.S. in over 20 years (Roscoe et al. 1998). This field trial was conducted to evaluate a vaccine that may be integrated into strategic rabies management to more aggressively meet the goal of raccoon rabies elimination.

Table 1. Oral rabies vaccination (ORV) bait distribution and area baited by Wildlife Services and cooperators in the United States, 2011 (all ORV baits were Raboral V-RG[®] vaccine [Merial Limited, Athens, Georgia, USA] except for ONRAB [Artemis Technologies, Inc., Guelph, Ontario, Canada] in West Virginia as part of a field trial).

State	Target species	ORV baits distributed	Area baited (km ²)	Bait distribution methods
Alabama	Raccoon	284,016	4,215	Fixed-wing, ground, helicopter
Arizona	Gray fox	133,650	4,105	Fixed-wing, ground
Florida	Raccoon	3,624	44	Bait station
Georgia	Raccoon	217,977	3,286	Fixed-wing, ground
Maine	Raccoon	124,120	2,331	Fixed-wing, ground
Maryland	Raccoon	72,180	1,086	Ground, helicopter
Massachusetts	Raccoon	46,347	1,007	Ground, bait station
New Hampshire	Raccoon	18,389	230	Fixed-wing, ground
New Mexico	Gray fox	7,716	324	Fixed-wing
New York	Raccoon	681,115	10,674	Fixed-wing, ground, helicopter
North Carolina	Raccoon	223,647	3,931	Fixed-wing, ground
Ohio	Raccoon	863,215	12,808	Fixed-wing, ground, helicopter
Pennsylvania	Raccoon	530,350	6,378	Fixed-wing, ground
Tennessee	Raccoon	606,901	10,538	Fixed-wing, ground
Texas	Coyote	500,906	20,111	Fixed-wing, ground, helicopter
Texas	Gray fox	1,916,225	79,481	Fixed-wing, ground
Vermont	Raccoon	375,742	5,472	Fixed-wing, ground
Virginia	Raccoon	277,355	4,913	Fixed-wing, ground
West Virginia	Raccoon	1,019,156	18,169	Fixed-wing, ground, helicopter
West Virginia (ONRAB)	Raccoon	79,027	1,435	Fixed-wing, ground
Total		7,981,658	190,537	

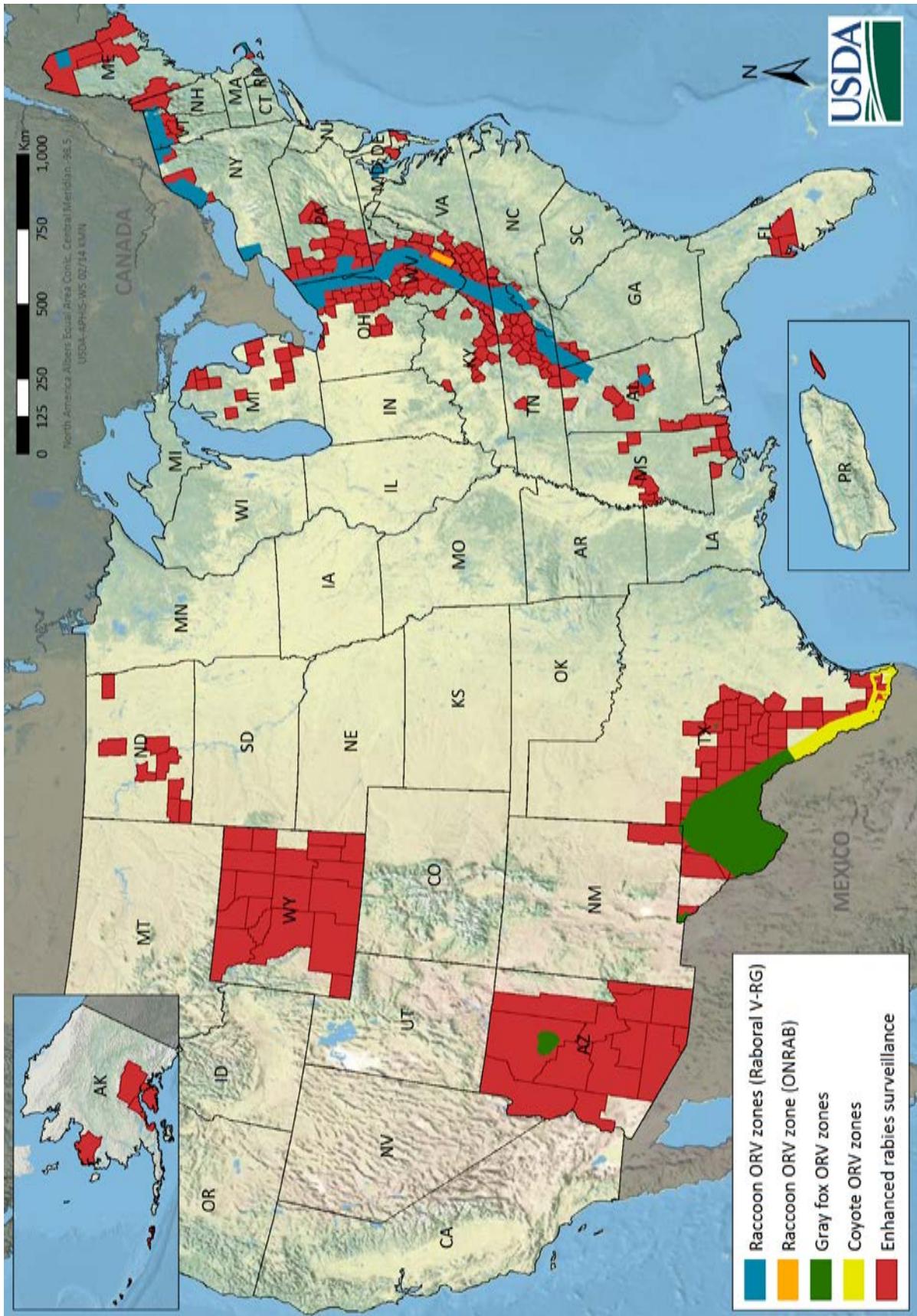


Figure 1. Cooperative oral rabies vaccination (ORV) zones and Wildlife Services enhanced rabies surveillance counties in the United States and Puerto Rico, 2011.

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 Quebec and Ontario, Vermont and New York WS implemented trap-vaccinate-release (TVR) along the U.S.-Canada border in 2011. These TVR programs resulted in the hand vaccination of 3,948 animals in Vermont (2,046), New Hampshire (30) and northern New York (1,872) (Table 2).

As a component of the greater Appalachian Ridge ORV zone, Ohio continued baiting the Contingency Action ORV zone (east of Cleveland) in the spring and fall of 2011. There was no spring baiting in Ohio in 2010 for the first time since 2003, but in 2011 funding was available to bait the western-most half of the Contingency Action zone (nearest Cleveland). Throughout the summer of 2011, 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 1,685 animals in northeastern Ohio (Table 2). The number of rabid animals with raccoon variant in this Contingency Action zone rose to 8 in 2011 (all in striped skunks). In addition, a 3-year old Siberian husky from Summit County was confirmed rabid in October 2011 with raccoon variant. This was the first rabid dog in Ohio since 1990, and the first known animal infected with the raccoon variant in Summit County. It also represented the western-most case of raccoon rabies in Ohio since 2006. As a result, the Summit County Health Department worked closely with Ohio WS to enhance surveillance; no further raccoon rabies cases were detected through December 2011.

In addition to coordinated TVR in Vermont, New Hampshire, northern New York and Ohio, WS vaccinated and released 1,252 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, 2011.

State	Raccoons	Skunks	Cats (feral)	Fishers	Foxes (gray)	Foxes (red)	Coyotes	Other ^a	Total
Arizona	8	80			6			1	95
Florida	111								111
Maryland	255		18		3	1			277
Massachusetts	112	5							117
New Hampshire	30								30
New York (northern)	1,722	105	23	12	2	6	2		1,872
New York City	133							1	134
Ohio	1,678		6			1			1,685
Pennsylvania	518								518
Vermont	1,974	69		3					2,046
Total	6,541	259	47	15	11	8	2	2	6,885

^a AZ=1 bobcat, NYC=1 opossum.

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 2010, NY WS conducted TVR on apparently healthy wildlife in Central Park and nearby Morningside and Riverside Parks. Raccoons or other wild carnivores exhibiting abnormal behavior suggestive of rabies were euthanized for rabies testing. By year's end, NY WS had hand vaccinated 453 animals over two trapping sessions; and 123 rabid animals were confirmed in Manhattan. Additionally, as part of control efforts in 2010, WS cooperated to distribute 1,080 fishmeal polymer baits by hand throughout the 840-acre (3.4 km²; 1.3 mi²) Central Park (approximately 318 baits/km²). As a continued response to this large epizootic, NY WS again conducted TVR in 2011 and vaccinated 134 wild carnivores

in Central Park. No ORV baits were distributed, but by year's end the number of rabid animals confirmed in Manhattan had declined dramatically to only 2 (both raccoons). This marked the end of the epizootic and WS' involvement in rabies control in New York City.

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 and central Alabama in 2011 (Figure 1). This 800 km (500 mi) long zone, interfaced 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 2011.

In 2011, the first phase of a 3-year field trial to evaluate the safety and immunogenicity of ONRAB in raccoons and skunks was conducted in southeastern West Virginia. The study area selected was enzootic for raccoon rabies but had never been treated with ORV (ORV naïve). The study area included 4 cells (127 km² each), separated by a 5-km buffered perimeter to reduce potential dilution effect from sampling raccoons with home ranges that extended into ORV naïve areas. An 11-km buffer was established from the western edge of the ONRAB sampling cells to the Raboral V-RG[®] zone baited at 75 baits/km² since 2001, to reduce the chance of confounded serologic results. Prior to ONRAB distribution in August, WS set 150 live traps within 800 m of 25 preselected random points in each sampling cell. Traps were checked for 10 consecutive days and biological samples collected from raccoons and skunks to determine bait uptake and rabies virus neutralizing antibodies (RVNA). In September, approximately 80,000 ONRAB baits were distributed at 75 baits/km² mostly by fixed-wing aircraft. In October, the same sampling protocol employed during August pre-bait work was used to sample raccoons and skunks 5-6 weeks post-ORV.

The greater Appalachian Ridge ORV zone included the first phase of a 3-year study in central Alabama to evaluate a baiting strategy called pulse or cluster baiting. A pulse of 8 baits/13.6 seconds is released by helicopter as opposed to 1 bait/1.7 seconds by the traditional fixed-wing baiting strategy. In October, 81,000 Raboral V-RG[®] coated sachets were distributed by helicopter in central Alabama based on promising results of pulse baiting in southeast Ohio along the West Virginia border in 2008 and 2009. Pulse baiting is conducted to enhance uptake of baits by family groups of raccoons that encounter bait clusters. At the time of annual ORV baiting (late summer), adult female raccoon movements normally include young of the year. Each reproductively competent female has an average litter of 4 young. The goal of this baiting strategy trial was to determine if greater levels of seroprevalence could be established by reaching a larger segment of the juvenile cohort of raccoons. Serological results from these efforts have been encouraging and plans are to continue evaluating this baiting method through 2013.

In 2011, WS continued participation in cooperative ORV in Barnstable County (Cape Cod), Massachusetts; Anne Arundel County, Maryland; and Pinellas County (and adjacent counties), Florida (Figure 1). These projects continue to provide information on ORV effectiveness and surveillance strategies. In an 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) 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 twice a year ORV (high of 157 cases in 2005 to 7 in 2011). 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 can 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 2011. If bait station field trials show promise, plans are to possibly expand their use in similar habitats.

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 evaluation of ORV in 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 2011.

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 2011, WS and the TDSHS continued enhanced surveillance and baiting in response to fox cases that emerged west of the ORV zone in 2007. In 2011, WS cooperated to distribute more than 1.9 million baits over approximately 79,500 km² (30,700 mi²) to prevent gray fox rabies from spreading from Texas (Table 1). For the second year, ORV baits (7,716) 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 2011, 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 began in November 2008. Twenty-two gray foxes, 6 striped skunks and 1 ringtail (*Bassariscus astutus*) had been confirmed rabid with a virus 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 August 2011 (for the third year), WS and the Coconino County Health Services District cooperated to distribute 133,650 coated sachets surrounding the city of Flagstaff (Table 1). There were 4 rabies cases in Coconino County in 2011: 2 bats from Flagstaff and 2 gray foxes from a ranch within Grand Canyon National Park, approximately 110 km (70 mi) north of Flagstaff. The foxes were confirmed with a rabies variant associated with big brown bats. In response, WS collaborated with the National Park Service to opportunistically enhance rabies surveillance within the Park.

Also, in 2011, Arizona WS continued a TVR program to vaccinate skunks in and around Flagstaff. TVR efforts resulted in the hand vaccination of 80 striped skunks, 8 raccoons, 6 gray foxes, and 1 bobcat (*Lynx rufus*) (Table 2). Over the multi-year TVR effort (2001 and 2004-2011), 842 animals have been trapped, vaccinated and released: 753 striped skunks, 56 raccoons, 27 gray foxes, 4 bobcats, 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 skunks may play in rabies outbreaks and the nationwide efforts to reduce and eventually eliminate rabies in wild carnivores from the U.S.

In 2011, WS continued sampling insectivorous bats in Arizona to determine prevalence 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). Sampling 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.

In this multi-year study, bats were captured during summer months 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 2011, WS collected 158 serum samples from 13 bat species in Arizona. Currently, 156 of the 158 samples have been analyzed. Ten of 156 bats (6.4%) sampled had detectable RVNA. Thirty-three percent (n=6) of California myotis (*Myotis californicus*) had RVNA, the highest of any species sampled in 2011. The next highest RVNA seroprevalence was observed for Brazilian free-tailed bats (*Tadarida brasiliensis*) at 19% (n=26). RVNA was not detected in big brown bats (n=31), while other species ranged from 0-33% RVNA. Results from this multi-year study will lead to a better understanding of bat rabies in wild populations. This study will continue in 2012.

A GonaCon™ trial in captive dogs was initiated on the Navajo Nation in 2008 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). The anti-GnRH antibodies inhibit 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 2011, Arizona WS cooperated with NWRC and the Navajo Nation to conclude a study that monitored vaccinated female dogs through several breeding cycles in the presence of

reproductively competent males to determine if they were contracepted. Six female dogs were monitored for 3 years by the Navajo Nation Veterinary Program and did not become pregnant. The study was terminated after 3.5 years when one dog became pregnant. This study led to an international collaborative study on an improved formulation of GonaCon™ in captive dogs in Hidalgo, Mexico in 2011. Twenty female dogs were assigned to one of three groups: Group A (6 controls), Group B (7 given only GonaCon™), and Group C (7 given GonaCon™ and rabies vaccine). Vaccines were delivered intramuscularly. Animals were placed under observation and evaluated during the 61-day trial. Clinically, all dogs behaved normally. No limping or prostration was observed, in spite of minor muscle atrophy post-mortem in the left hind leg of dogs that received GonaCon™. Two dogs that began the study pregnant give birth to healthy pups. Dogs that received a GonaCon™ injection had macro and microscopic lesions consistent with prior findings, but the adverse injection effects were less frequent and lower in intensity. Both vaccines were immunogenic based on significant increases in rabies virus neutralizing antibodies and anti-GnRH antibodies in treatment Groups B and C. Simultaneous administration of GonaCon™ and rabies vaccine in Group C did not affect immunogenicity. Progesterone was suppressed significantly in comparison to controls. Future studies that monitor fertility through multiple breeding cycles represent a research need to determine the value of integrating this vaccine into dog rabies management.

Wildlife Services and cooperators continued to implement enhanced rabies surveillance in 2011 in 25 states and Puerto Rico. 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 2011, 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 1,331 and 23 animals, respectively, in support of coyote and gray fox ORV programs. Arizona collected 413 animals in support of gray fox ORV and bat-skunk studies. Wyoming and North Dakota (for the first time) collected and submitted animals for testing to determine the presence of skunk variants. Also for the first time, Alaska and Puerto Rico WS began enhanced surveillance to monitor for the arctic fox variant (Alaska) and domestic dog variants in mongoose (Puerto Rico). In 2011, WS collected and submitted 9,485 samples for enhanced rabies surveillance testing (Table 3) by WS, the CDC, local health department laboratories, and local agriculture department laboratories. From these samples, 174 rabid animal locations were identified and improved rabies management decisions.

Since 2005, 63 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) (Lembo et al. 2006). 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 2005-2011, WS implemented the dRIT in 20 states. In 2011, WS (and the TDSHS) tested 7,574 (79.9%) animals collected for enhanced surveillance using the dRIT; 141 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 and Puerto Rico, 2011.

State	Enhanced surveillance animals	WS tested by dRIT	Rabid by dRIT
Alabama	190	189 (99.5%)	7
Alaska ^a	105	105 (100%)	0
Arizona	413	413 (100%)	25
California ^a	0		
Florida	178	175 (98.3%)	4
Georgia	126	126 (100%)	0
Kentucky ^a	92	92 (100%)	0
Louisiana ^a	40	40 (100%)	0
Maine	120	0	
Maryland	61	61 (100%)	3
Massachusetts	113	113 (100%)	7
Michigan ^a	49	49 (100%)	0
Mississippi ^a	101	101 (100%)	0
New Hampshire	10	0	
New Mexico	23	0	
New York	173	0	
North Carolina	51	51 (100%)	2
North Dakota ^a	17	0	
Ohio	911	910 (99.9%)	6
Pennsylvania	2,642	2,605 (98.6%)	19
Puerto Rico ^a	38	38 (100%)	0
Tennessee	923	922 (99.9%)	5
Texas ^b	1,331	18 (1.4%)	0
Vermont	83	0	
Virginia	432	432 (100%)	28
West Virginia	1,030	1,013 (98.3%)	35
Wyoming ^a	233	0	
Total	9,485	7,574 (79.9%)	141

^a ORV not applied in this state/territory.

^b Includes samples tested by the Texas Department of State Health Services using the dRIT.

In all states conducting ORV, 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. All animals captured by WS in 2011 were trapped in accordance with federal, state and local laws, and were handled according to the American Society of Mammalogists, Animal Care and Use Committee guidelines. All animals that had to be euthanized by WS in 2011, were done so in accordance with the American Veterinary Medical Association's Panel on Euthanasia recommendations. Density indexing was 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 monitoring activities due to lag time in sample analyses by cooperating or contracted laboratories. However, all states had received 2011 results by the time of this report so they are presented in the following portion of this report.

In the West Virginia field trial conducted to evaluate the safety and immunogenicity of ONRAB in wild raccoons and skunks, WS trapped and sampled 395 raccoons that had a 9.6% RVNA seroprevalence pre-ONRAB in an ORV naïve area (Table 4). Based on other WS trapping since 1997, the background seroprevalence was consistent with ORV naïve areas that have enzootic raccoon rabies. Antibody prevalence was significantly higher at 49.2% (n=262) in raccoons after ONRAB distribution. This was the highest RVNA level observed among raccoons

by WS for areas with similar management histories evaluated prior to and after an initial ORV campaign at 75 baits/km² with Raboral V-RG[®].

Table 4. Prevalence of rabies virus neutralizing antibodies (RVNA) by species sampled for pre and post-ONRAB (Artemis Technologies, Inc., Guelph, Ontario, Canada) bait distribution in a field trial in West Virginia, USA, 2011^a.

Species	Pre-ONRAB		Post-ONRAB	
	Number of sera	Positive RVNA	Number of sera	Positive RVNA
Raccoons	395	38 (9.6%)	262	129 (49.2%)
Striped skunks	20	1 (5.0%)	28	2 (7.1%)
Gray foxes	1	0	2	2 (100%)
Red foxes	0		1	1 (100%)
Coyotes	0		1	1 (100%)
Total	416	39 (9.4%)	294	135 (45.9%)

^a One skunk and 1 coyote were collected as road kills within sampling cells during the post-ONRAB period.

The remainder of the RVNA analysis in this report is based on ORV with Raboral V-RG[®]. In 2011, a mean positive antibody response of 30±13% was observed for 3,063 raccoon serum samples collected post-ORV (Table 5); 151 of the positive samples had a previous record of hand vaccination. Post-ORV sera were also collected from 59 striped skunks, 4 gray foxes, 3 fishers (*Martes pennanti*), and 2 red foxes (*Vulpes vulpes*) during raccoon rabies management programs. Five skunks (9%), all gray foxes (100%), 2 fishers (67%), and 1 red fox (50%) had a detectable RVNA response; 3 skunks and the red fox had a prior record of hand vaccination.

Table 5. Wildlife Services post-oral rabies vaccination (ORV) sampling efforts as part of rabies management programs targeting various species in the United States, 2011 (all ORV baits were Raboral V-RG[®] vaccine [Meriel Limited, Athens, Georgia, USA]).

State	All post-ORV serum samples	Positive rabies antibody response (≥0.06 IU)	4-12 weeks ^a post-ORV samples	Positive rabies antibody response (≥0.06 IU) ^b
Raccoon				
Alabama	372	55 (14.8%)	208	52 (25.0%)
Florida	205	62 (30.2%)	177	50 (28.2%)
Georgia	121	44 (36.4%)	121	44 (36.4%)
Maine	123	24 (19.5%)	123	24 (19.5%)
Maryland	254	80 (31.5%) ^c	254	80 (31.5%)
Massachusetts	105	57 (54.3%) ^c	105	57 (54.3%)
New Hampshire	29	6 (20.7%)	6	0
New York	290	93 (32.1%) ^c	290	93 (32.1%)
North Carolina	120	21 (17.5%)	107	19 (17.8%)
Ohio	307	111 (36.2%) ^c	307	111 (36.2%)
Pennsylvania	505	87 (17.2%)	505	87 (17.2%)
Tennessee	245	57 (23.3%)	245	57 (23.3%)
Vermont	189	54 (28.6%) ^c	153	48 (31.4%)
Virginia	198	107 (54.0%)	198	107 (54.0%)
West Virginia		No sampling done post-ORV in Raboral V-RG [®] zone		
Total	3,063	858 (28.0%)	2,799	829 (29.6%)
Mean ± St. Dev.		30±13%		29±14%
Arizona (gray fox)	6	2 (33.3%)	6	2 (33.3%)
Texas (coyote)	104	74 (71.2%)	104	74 (71.2%)
Texas (gray fox)	177	162 (91.5%)	177	162 (91.5%)

^a Samples taken during optimal evaluation period of 4-12 weeks post-ORV bait distribution.

^b Sera collected in all states but Texas are positive at ≥0.06 IU/ml; sera collected in Texas are positive at ≥0.04 IU/ml.

^c In these states, some raccoons with a positive rabies antibody response had a record of previous hand vaccination by Wildlife Services (MD=41, MA=9, NY=51, OH=36, VT=14) 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 Anne Arundel Co., MD and Cape Cod, MA).

Texas collected sera from 104 coyotes and 177 gray foxes to evaluate seroprevalence post-ORV in those species in south and west-central Texas, respectively; 74 coyotes (71%) and 162 gray foxes (92%) had RVNA (Table 5). Texas also collected post-ORV sera from 110 coyotes, 10 raccoons, 10 striped skunks, and 6 bobcats during evaluation of the gray fox ORV program; 101 coyotes (92%), 8 skunks (80%), 3 raccoons (30%), and 2 bobcats (33%) had detectable RVNAs. To evaluate the third year of an ORV program targeting gray foxes around Flagstaff, Arizona, sera were collected from 19 skunks, 9 coyotes, 7 raccoons, and 6 gray foxes post-ORV. Two foxes (33%), but no other animals, showed detectable rabies antibodies. No post-ORV evaluation was conducted in New Mexico in 2011.

Teeth were submitted to Matson’s Laboratory in 2011 for tetracycline biomarker analysis and aging. Tetracycline biomarker results for the raccoon rabies management program are not presented because 80% of the 5.4 million ORV baits distributed for raccoons in 2011 were coated sachets that do not contain tetracycline biomarker. Texas stopped collecting teeth in 2011, as 97% of their baits were coated sachets, with only fishmeal polymer baits used in ground baited areas. Teeth were not collected in the Arizona gray fox ORV zone, as only coated sachets were distributed. Age results for target species sampled during raccoon rabies management programs were similar to previous years (Figure 2). Median raccoon age was 1 year suggesting the importance of young in the overall population, but ages ranged from <1 to 12 years (a lactating female from West Virginia). Four raccoons were aged at ≥10 y.o.: 2 at 10 y.o., 1 at 11 y.o. and 1 at 12 y.o., but the population of aged raccoons was predominately <3 y.o.

In addition, during raccoon rabies management programs in 2011, WS collected teeth for aging from: 36 striped skunks (median age: <1 year, range: 0-3 years); 2 gray foxes (median age: 1.5 years, range: 0-3 years); 2 red foxes (median age: <1 year, range: 0 years); 1 coyote aged at 8 y.o. and 1 fisher aged at 6 y.o.

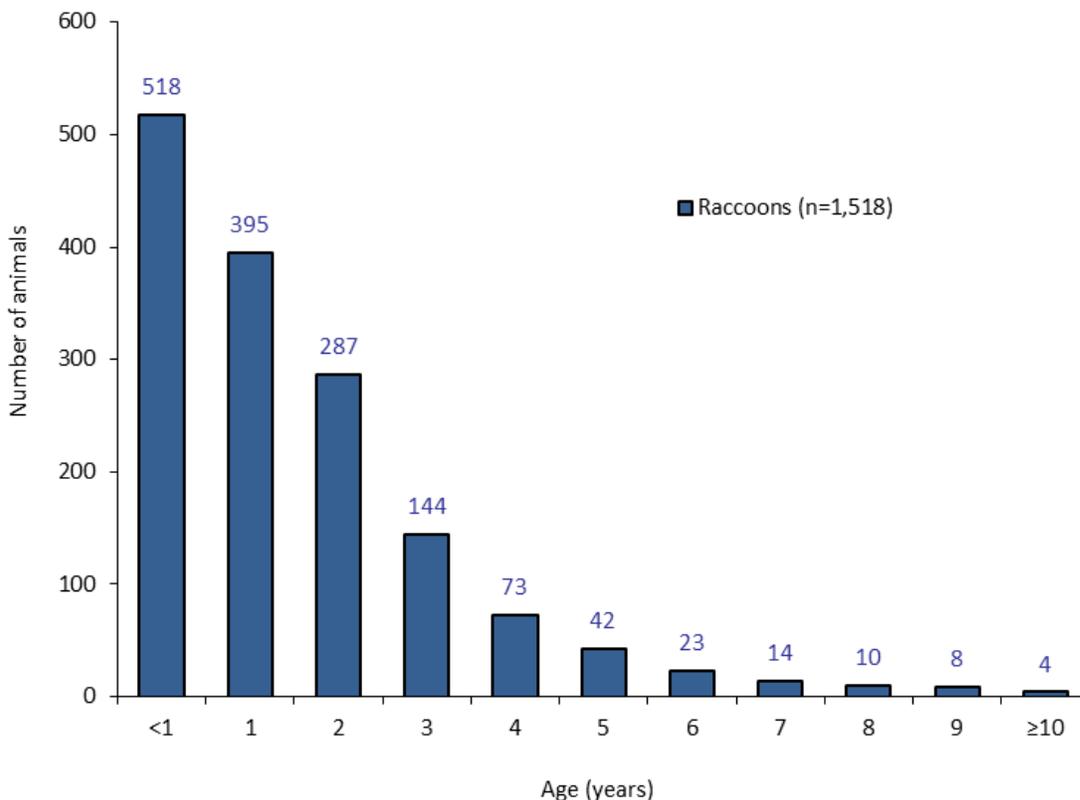


Figure 2. Age class distribution of 1,518 raccoon teeth collected by Wildlife Services during cooperative rabies management programs in the eastern United States, 2011.

The need for a bait-vaccine combination that produces higher levels of RVNA in wild meso-carnivore rabies reservoir species remains the highest priority and requires continued systematic research. In 2010, research at Thomas Jefferson University in Philadelphia, Pennsylvania and at the CDC focused 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. However, in 2010, 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, especially in canids, and may interfere with CAV2-RG seroconversion. Field sero-surveys were expanded in 2011 to include mongoose (*Herpestes javanicus*). Of the 1,128 animals included in this analysis, 256 (22.7%) tested positive for CAV neutralizing antibodies, with the lowest level in raccoons (3.4%, n=610) and the highest in coyotes (78.4%, n=116). Gray foxes (39.7%, n=116), striped skunks (37.3%, n=201) and mongooses (27.1%, n=85) also showed significantly higher CAV neutralizing antibody levels than raccoons. These findings suggest that meso-carnivores more phylogenetically distant from *Canis* species may respond more favorably to field application of CAV2-RG presented in a proper bait formulation. However, due to background antibody levels, CAV2-RG may not be equally effective in ORV campaigns in all meso-carnivore rabies reservoir species in North America, irrespective of bait formulation. This limitation, together with the current economic climate and other limiting factors, underscore the need for access to a single, safe, inexpensive oral rabies vaccine in the U.S. that is efficacious in all meso-carnivore rabies reservoir species.

Wildlife Services' NWRC in Fort Collins, Colorado completed, 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 beginning of the current 5-year plan (2011-2015) for rabies research projects. Eleven studies were carried over from the previous 5-year plan; 5 of those were completed in 2011 and six will continue into 2012 (Table 6). Eight new studies were initiated, many of them multi-year in scope. All studies were conducted under one of the following 15 research objectives: 1) Economic evaluation of the WS ORV program; 2) Investigation of diagnostic tools for rabies surveillance in target species; 3) Improvements of vaccines and baits to increase rabies vaccine uptake by target species; 4) Evaluation of ONRAB in target and non-target species; 5) Investigation into the ecology of rabies in Puerto Rican mongoose; 6) Development of baiting strategies to maximize vaccine uptake; 7) Evaluation of non-target uptake of ORV baits; 8) Investigation of long distance movements of raccoons; 9) Use of modeling in rabies research and ecology; 10) Understand rabies host ecology; 11) Density estimation; 12) Evaluation of raccoon movements on Cape Cod; 13) Investigation into the use of infrared thermography; 14) Prevention of rabies transmission from domestic animals to wildlife; and 15) Efficacy of Gonacon™ in raccoons.

Throughout 2011, 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 in New York, Ohio, and Vermont/New Hampshire will be limited in scope as efforts are being planned to expand ONRAB field trials into these states. Wildlife Services will continue to commit to improving the existing vaccine-bait and collaborating in the testing and enhancement of new vaccine-baits and strategies to increase program effectiveness in achieving rabies management goals, including elimination of raccoon rabies.

Table 6. Wildlife Services' National Wildlife Research Center (NWRC) conducted 19 studies to investigate the ecology, control, and prevention of terrestrial rabies in free-ranging wildlife in support of the oral rabies vaccination (ORV) program in the United States in 2011.

QA	Objective	Completed	Brief study description	Citation
1585	15	No	Efficacy of GonaCon and IMRAB rabies vaccine in raccoons	Manuscript in preparation
1599	6	No	Spatial ecology of gray foxes, coyotes, and bobcats relative to rabies spread in west Texas	Atwood et al. 2011
1639	3	Yes	Mouse models to evaluate the immunogenicity of Raboral V-RG in various matrices	Unpublished NWRC report
1653	13	No	Field evaluation on the use of infrared thermography to screen for rabid animals	Continued/Ongoing
1656	15	No	Using hormone antibody levels to evaluate the effectiveness of GonaCon in raccoon kits	Continued/Ongoing
1660	2	Yes	Ability of Raboral V-RG to elicit an immune response in young raccoons	Unpublished NWRC report
1663	11	Yes	Trapping point transects and spatially explicit capture-recapture to estimate raccoon density	Submitted for publication
1683	11	Yes	Using spatial data to increase trap-based detection probabilities for raccoons	Submitted for publication
1700	15	Yes	Quantifying seasonal fluctuation in sex hormone levels in free-ranging raccoons	Manuscript in preparation
1707	9	No	Landscape epizootiology of fox-variant rabies in Texas and New Mexico	Continued/Ongoing
1725	14	No	Health evaluation of select African carnivores and risks of disease transmission	Continued/Ongoing
1758	8	No	Using genetics to examine connectivity in raccoon populations from AL, MS, and LA	Initiated/Ongoing
1831	13	No	Evaluation of infrared thermography for detecting rabies in captive big brown bats	Initiated/Ongoing
1856	5	No	Evaluation of mongoose population density and disease exposure in Puerto Rico	Initiated/Ongoing
1859	6	No	Evaluating strategies for distributing vaccine baits in fragmented landscapes	Initiated/Ongoing
1871	6	No	Space use of raccoons relative to vaccine bait distribution	Initiated/Ongoing
1872	1	No	Economic evaluation of the WS oral rabies vaccination program	Initiated/Ongoing
1882	4	No	Safety of ONRAB in select non-target species	Initiated/Ongoing
1883	3	No	Immunogenicity of RABORAL V-RG when combined with thickening agents in raccoons	Initiated/Ongoing
D ^a	2	Yes	Evaluation of the effectiveness of Raboral V-RG in captive arctic foxes	Follmann et al. 2011

^a Study from 2006-2010 project plan with publication in 2011.

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