

# Synopsis of the Shoshone River Skunk Rabies Epizootic in Northwestern Wyoming

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**ABSTRACT:** The most important reservoir of wildlife rabies on the American Great Plains is the striped skunk. A rabid striped skunk taken in August 1988 near Deaver, WY became the index case for a subsequent epizootic in a previously skunk rabies free area. In 1989, more rabid skunks occurred and the epizootic was moving throughout Sage Creek and in later years (1990-1993) through the entire Shoshone River basin. Federal, state, and local officials cooperated in a rabies program with the goal of addressing the health and safety of the region's citizens, domestic animals, and livestock. Three areas of focus in the program were: 1) immunization of pets and livestock, 2) public education, and 3) skunk population monitoring and control. Rabies immunizations were re-emphasized by the local veterinarians and public health officials for pets to decrease potential rabies spillover to other species. Public education emphasized the dangers of rabies and the behavior of rabid animals using local news media and assemblies at area schools. This paper provides a synoptic overview of the third component – skunk population monitoring and control provided by USDA/APHIS's Wyoming Wildlife Services (WS). WS provided trapping expertise starting in 1990 with rabid specimens identified by the Wyoming State Veterinary Laboratory. Starting in 1990, WS's National Wildlife Research Center provided data analysis of rabid locations for the entire epizootic (i.e., 1988-1993). These analyses demonstrated the epizootic's movements through the novel first use of a Geographic Information System that merged a wildlife disease (i.e., rabies) case/capture locations and dates with additional GIS data layers including hydrology, human population density, and land use. The epizootic ended in 1994 with striped skunks, bats, cats, and one horse affected. Studying this epizootic should benefit officials in planning future surveillance and/or depopulation programs. This study demonstrated the need for a skunk rabies vaccine and effective delivery system, and if the latter had been available maybe this epizootic would have been more limited in its scope and duration.

**KEY WORDS:** epizootic, geographic dispersal, GIS, *Mephitis mephitis*, rabies, Shoshone River, striped skunk, surveillance, Wyoming

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## INTRODUCTION

Rabies is an acute viral encephalomyolytic disease of the central nervous system primarily in mammals, persisting in nature as a salivary gland infection of carnivores. It occurs in the U.S. most frequently in wildlife (Neizgoda et al. 2002); since 1960 (McLean 1970), the majority of cases have occurred in skunks, foxes, raccoons, and bats. Its transmission requires high enough vector densities to ensure easy animal-to-animal transmission, and it has public health, agricultural, and economic significance (Sikes 1981). In the area of public health, almost 6300 cases were reported in humans in the United States (U. S.) and Puerto Rico in 2004 (Krebs et al. 2005). Although only about 3 rabies deaths occur annually in the U.S. human population, the direct and indirect costs of each human exposure has been estimated to be about \$3,700 in 2 southern California counties from 1998-2002 (Shwiff et al. 2007). Rabies transmission from wildlife to pets (i.e., dogs and cats) and livestock, especially cattle, has been a recurring problem in the U.S. (Sikes 1981) with total costs in pets and livestock even higher than for humans. Thus, rabies is an important disease to humans, pets, livestock, and wildlife in America.

One of the earliest reports of wildlife rabies occurred in striped skunks (*Mephitis mephitis*) in California in 1826 (Parker 1975). Subsequently, striped skunks have

become the most important reservoir of wildlife rabies on the Great Plains of North America (Charlton et al. 1991). In Wyoming, Thorne and McLean (1982) reported that wildlife rabies has been recorded since 1938, with most cases involving striped skunks (61%) and to a lesser extent bats (*Chiroptera* spp.) (26%). They reviewed 29 cases from the state between 1975 and 1979, and all were east of the Rocky Mountains, with 27 from the northeastern two counties of the state. Across the Bighorn Mountains to the west lies the Shoshone River Basin (hereafter 'Basin') in northwestern Wyoming. This area historically was considered "rabies-free" for skunks by the Centers for Disease Control and Prevention (CDC 1985), also by Reid-Sanden et al. (1990), the Wyoming State Veterinary Laboratory (WSVL), and local veterinarians.

In 1988, the first rabid skunk was identified by the WSVL in the Basin (Ramey et al. 2007). The public became very concerned during the following year when more cases were identified in the vicinity of the index case. Initially, the Wyoming Department of Agriculture (WDA), public health officials, local veterinarians, and others began assisting the towns, ranchers, and farmers in the immediate area and others possibly "in harm's way". They provided vaccines, post exposure treatment, and public health and other information upon request. Later, the state and the county predator boards provided funds for rabies testing

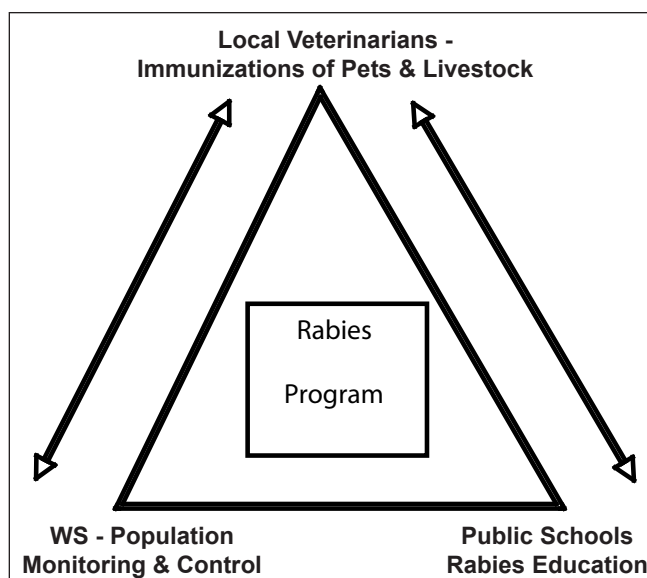
and public education through the school systems. Shortly thereafter, the United States Department of Agriculture's (USDA), Animal and Plant Health Inspection Service (APHIS), Wyoming Wildlife Services (WS) program was asked for assistance with the epizootic. The primary goal of all agencies and groups including WS was to address the public's concerns about health and safety in humans and domestic animals (W. Rightmire, WS State Director, pers. commun., 1991). Starting in 1990, WS undertook a skunk trapping program to monitor and control (i.e., lower the density of striped skunks) the spread of rabies (Davis 1991, Ramey et al. 1992). As a headline in the *Powell Tribune* (newspaper) from May 2, 1991 indicated, "Trapper kills skunks to help control spread of rabies" (Davis 1991). Following several rabid skunk attacks on humans (e.g., a skunk attacked a fisherman and another chased a child [Davis 1991]), and a horse died of rabies near Cody (Cloudwalker 1991), a more responsive approach was sought to monitor the location of rabid animals. Grouping rabid skunk locations by counties for CDC (i.e., Bighorn and Park Counties), as provided by the WSVL, did not provide much comfort to the Basin's citizens.

A wildlife biologist with training in public health was recruited from the National Wildlife Research Center (NWRC) by the Wyoming WS State Director in 1991 to review the trapping data and to monitor the location of rabid animals. The biologist employed 2 technologies in his analyses that were in their infancy: 1) Global Positioning System (GPS), and 2) Geographic Information System (GIS) (Ramey et al. 2007). A few rabid skunk GPS locations were obtained either directly using Sony equipment (discussed below) or a few from citizen input, but most were formed using digital map locations as representations of the WS's trappers map locations and notes. Next, the rabid skunk GPS locations were placed in a novel database using SAS (SAS Institute 1987) (SAS, Cary, NC) for not only surveillance and/or depopulation purposes, but also for anticipating future areas of the public's concern about the spreading rabies epizootic. This paper provides an overview of the entire 1988-1993 epizootic, and summarizes some of the novel methods and procedures used to analyze the data.

### AGENCIES AND GROUPS INVOLVED

Various agencies and groups were involved in one of the three primary functional areas identified to limit the effects of the skunk rabies epizootic: 1) immunization of pets (primarily dogs and cats) and some livestock, 2) public education about rabies and rabid skunk behavior, and 3) skunk population monitoring and control (i.e., depopulation) (Figure 1) (Ramey and Mills 1995). Although several agencies and/or groups may have functioned in more than one of these areas, most worked primarily in one. The two federal programs involved were CDC and WS; state agencies included the WDA, WSVL, and Wyoming Department of Health (WDH); and local groups that assisted in the skunk rabies epizootic were private veterinary clinics, county predatory animal boards, and the local school systems.

CDC trained the personnel, primarily WS trappers, involved in the submission of specimens to the WSVL regarding safe procedures for capturing, immobilizing,



**Figure 1. The primary roles and interconnected functions that produced the synergistic approach of Wildlife Services (WS) and others involved in limiting the Shoshone River skunk rabies epizootic.**

handling, and forwarding the specimens to the WSVL. WS provided rabies population surveillance, monitoring, control, and the specimens from various species for rabies analysis. WDA provided funding for the identification and surveillance for rabid skunks and general assistance to the trappers, local veterinarians, and the public in the rabies program. Bighorn and Park County health departments were involved with the dissemination of information about human interaction with some of the rabies cases, but they worked primarily in the educating the public about rabies. WSVL tested about 1,200 animals for rabies during the epizootic until the funding began to dissipate in 1992 and 1993, when the WSVL instituted a policy change in mid-year 1992. The new policy supported rabies testing for only those skunks that behaved unusually or came in contact with humans, pets, or livestock. This policy change coincided with the decrease in rabies cases, and by 1993 only 4 cases were identified.

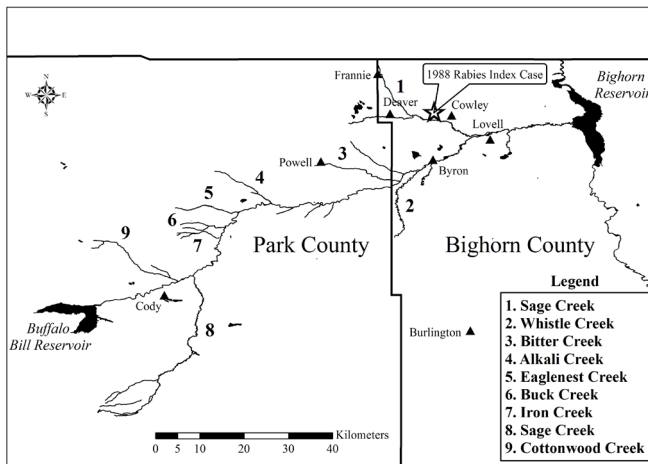
### STUDY AREA

The Shoshone River Basin occurs in the northwestern corner of Wyoming in Bighorn and Park Counties with the Shoshone River headwaters originating near the eastern entrance to Yellowstone National Park. The river flows eastward between arid benches, ending at Bighorn Lake, about 20 km east of the town of Lovell. The Shoshone River's is ~180 km (i.e. ~112 mi) long, and it flows near several towns – Cody, Powell, Frannie, Byron, Cowley, Deaver, and Lovell (Ramey et al. 2007) (Figure 2). This Basin has been described as marginal skunk habitat, and the skunks are restricted to the river's flood plain (L. Dickerson, Superv. Wildl. Biologist, pers. commun., 1991).

### METHODS

#### Population Surveillance and Control

Although most of the citizens living in the Basin were involved in surveillance, this responsibility was pri-



**Figure 2. Hydrologic areas of skunk rabies occurring in the Shoshone River Basin from 1988 to 1993, with the major towns and tributaries identified.**

marily under the purview of the WS's trappers. Initially, they applied their knowledge of striped skunks with citizen sightings to capture skunks for both surveillance (e.g., trapping ahead of the epizootic) and depopulation purposes. The former purpose was to alert the citizens of rabid skunk locations, and the latter was to help control the epizootic. They tried to trap specifically for skunks, and they limited the capture of other wildlife and feral animals by trap design, size, bait, and placement. Additional details of WS's live trapping methods can be found in Ramey et al. (2007).

Although WS trappers tried to stay ahead of the spreading rabies epizootic, by 1991 they were trapping the majority of the Shoshone River and its watershed (~110 km up from its mouth to a few km west of Cody). A few additional rabid skunk carcasses were submitted by the public and were either roadkills or "collected". An additional 5 rabid skunks were obtained in October 1991 by NWRC personnel using the USDA's registered Gas Cartridge for Coyotes (EPA Reg. No. 56228-21) (Ramey 1992).

All rabid skunks were identified during this epizootic by the WSVL, and their capture locations were provided to the participating landowners, veterinarians, and various wildlife and public health officials. However, compilation of the skunk rabies epizootic data for additional analyses was not being done at that time. The delay was caused by the need to combine several different sources of information into a database for analysis. These separate sources of information included: in 1989, WDA began keeping a log of rabies cases submitted by the public; in 1990, WS started their trapping records; and in 1991, the NWRC derived data from the use of APHIS's Gas Cartridge for Coyotes on skunks (Ramey 1992). These three sources of information were combined into the SAS database utilized for the time series analyses of the Shoshone River rabid striped skunk epizootic.

### Defining Shoshone River Locations

During the study, a satellite-based methodology, which was in its infancy and employed GPS locations, was utilized. This technology was developed and maintained by the U.S. Department of Defense and provided

latitude, longitude, and altitude data in a coordinate system called the World Geodetic System (Sony 1991). Five rabid skunk locations were obtained directly using GPS equipment (Ramey et al. 2007); however, most locations were plotted by hand using either information from the appropriate public submission carcass tags or trappers' notes. Initial analyses from 1990-1992 illustrated rabid skunk locations along the Shoshone River and its main tributaries, and they were grouped as: upper Shoshone River (i.e., headwaters down to Sage Creek [Park County] and Polecat Creeks), middle (i.e., Sage Creek down to Bitter Creek), and lower (i.e., Bitter Creek down to Big Horn Lake) (Ramey et al. 1992).

## RESULTS

### First Use of GPS and GIS during a Wildlife Epizootic

During a NWRC pilot study to determine the usefulness of GPS coordinates in the study of rabies movements, 22 skunks were used, of which 5 were rabid. Their locations were recorded by a NWRC scientist (C. Edward Knittle, NWRC, pers. commun., 1991) in October 1991, using a Sony GPS portable receiver (Ramey et al. 2007). This equipment determined their global position using 4 DOD satellites (Sony 1991). Although the Sony GPS receiver provided quicker, more accurate, and analyses-friendly data, it required 25-30 minutes to set up to record data at each animal's capture location. The WS trapper(s) felt that although the GPS information would be useful, they believed that spending an additional 25-30 minutes at each animal's capture site would be too time consuming. Also, they had budget constraints for personnel and equipment that were utilized to meet their primary goals of surveillance and depopulation. Because all animals caught by WS's trappers potentially could have been rabid, including skunks, feral cats and dogs, bats, foxes, raccoons, porcupines, and coyotes (>1,200 animals), direct GPS data were not obtained. The initial yearly map locations for rabid skunks were provided by WS personnel on BLM Edition 30 x 60-Minute Quadrangle maps showing elevation contours, highways and roads, and water features and provided to NWRC. In January 1996, these maps were redone by NWRC using digitization from then current geographic GIS maps. The usefulness of this technology in the study of wildlife epizootics was demonstrated and presented at a national scientific meeting (Ramey et al. 1994) and an international meetings (Ramey and Mills 1995, Ramey et al. 2003). The development and usefulness of this rabid skunk database using capture locations and dates with the hydrology of the Basin was emphasized.

### The Shoshone River Rabies Epizootic

The index case was a "friendly" skunk that was shot on August 18, 1988, 4 miles east of the town of Deaver near Sage Creek (Bighorn County), a tributary northwest ~9 miles from the lower Shoshone River (Figure 2). This skunk tested positive for rabies at the WSVL, and it was the only rabid skunk identified in 1988. During 1989, skunk rabies was found throughout Polecat Creek and other tributaries of Sage Creek. It had spread outward from the Index Case in all directions but was limited to areas containing good skunk habitat. During 1990, the epizootic included not only Polecat and Sage Creeks but also

the lower Shoshone River and its tributaries. By the end of 1991, the epizootic had left Sage and Polecat Creeks and was in the remainder of the Shoshone River, including the lower and middle sections, and was just starting to move into the upper section of the river. By the end of 1992, the epizootic was observed throughout the Basin from Cody down to the Big Horn Lake, but was mainly near Heart Mountain between Powell and Cody. Only 4 rabid skunks were referred to the WSVL by the public in 1993, and public health officials and others believed the epizootic was ending. Their suspicions were confirmed by personnel from the WSVL who have stated the epizootic had ended by 1994 with no additional rabid skunks identified in either 1994 or 1995 (A. Boerger-Fields, WSVL, pers. commun., 2007). Anecdotal observations by WS personnel, cooperating landowners, and wildlife and public health officials, who had participated in the epizootic, further indicated that very few striped skunks were observed in the Shoshone River basin in 1994 and 1995.

The initial "GIS" maps summarized by Ramey and co-workers demonstrated the epizootic's movements over its history (Ramey et al. 1994, Ramey and Mills 1995, Ramey et al. 2003). The information analyzed over the 6-year period of the epizootic demonstrated that it covered ~110 km of the Shoshone River Basin (i.e., except most of the headwaters). Subsequently, digitization of all the rabid skunk locations was accomplished, and a more detailed hydrologic layer was added and is being published separately. These changes plus the subsequent derivation and use of various software packages adding more detailed GIS data from federal, state, and county agencies have provided additional assistance in our understanding of the movement of the Shoshone River epizootic.

## SUMMARY AND DISCUSSION

The rabies epizootic covered an area ~400 km<sup>2</sup> along the Shoshone River basin including its tributaries. Rabies was diagnosed in >200 skunks between 1988 and 1993 during the epizootic. The first use of GPS locations and "GIS" hydrology data to study the spreading rabies in wildlife (i.e., skunk and bat rabies) assisted in our understanding of the Shoshone River epizootic by delineating not only current areas but also future areas of concern (Ramey et al. 2007). Our analyses were helpful for forecasting not only where the epizootic was heading for surveillance purposes, but also areas of higher prevalence for skunk depopulation work. Both efforts assisted in alerting the public about the spreading rabies.

The usefulness of the GPS and GIS technologies in wildlife studies of habitat was presented about this time (Gagliuso 1991); however, our first use of these technologies during an epizootic demonstrated their usefulness in the investigation and understanding in wildlife disease and in planning future surveillance, control, or vaccination programs. Later, others such as Nicholson and Mather (1996) demonstrated areas of Lyme disease risks using geographic information systems and geospatial analysis. We concluded, like other investigators in later studies (Lynch 1997), that using GPS and GIS data had enhanced our investigative outcomes. However, our limited use of both GPS and GIS pale in comparison to subsequent wild-

life disease research, but it was a beginning (Ramey et al. 2007).

Our initial scientific publication search about GPS and GIS in 1991 and again in 2007 in NISC, Wildlife and Ecology Studies Worldwide database using "GIS and rabies" revealed no publications with prior or concurrent use of GPS and/or GIS in the study of wildlife diseases. Therefore, we believe we were the first to use GPS and GIS techniques in the study of a wildlife disease (i.e., skunk rabies) during an epizootic (L. Paulik, Librarian, NWRC. pers. commun., 2007) (Ramey et al. 2007).

## MANAGEMENT IMPLICATIONS

Johnston et al. (1988) had proposed limiting the spread of rabies through the aerial distribution of attenuated or recombinant rabies vaccine ahead of the epizootic. We believed if such a vaccine and delivery system had been available, that correlating skunk habitat and associated hydrology (i.e., GIS) during the spreading rabies epizootic used in association with placement of vaccine laden baits might have geographically limited this epizootic. Furthermore, if such vaccine laden baits had been available during this epizootic and used in conjunction with several natural barriers (arid benches north and south of the Basin and the Bighorn Reservoir and Canyon to east, and lack of habitat to the west), this epizootic might have been more limited in its scope. For instance, the rabies may have stopped around the index case if vaccines were used in 1989, at the lower Shoshone River if utilized early in 1990, or at the middle Shoshone River if used early in 1991. The benefits that could have been derived by stopping the epizootic from spreading to the larger towns of Powell and Cody are probably immeasurable. However, even a proposed use of trap-vaccinate-release for urban skunk rabies control (Rosatte et al. 1992) would have helped lessen the concern in the 6 towns involved in the Shoshone River epizootic; however, such a vaccine and delivery system had not yet been developed.

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