

OVERVIEW OF THE FIRST USE OF GPS 1991/GIS 1992 DURING A WYOMING SKUNK RABIES EPIZOOTIC

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Abstract: Striped skunks (*Mephitis mephitis*) are one of the most important reservoirs of wildlife rabies on the Great Plains of North America. During a skunk rabies epizootic in a previously rabies-free area of northwestern Wyoming, we studied the spread of rabies from the index case occurring in 1988 until the Shoshone River epizootic ended in 1993. All specimens were sent to the Wyoming State Veterinary Laboratory for Fluorescent Antibody Testing for rabies. The goal of federal, state, county, and local agencies was to address the public's fear about the health and safety of humans and animals. Following several rabid skunk attacks reported to authorities and recounted in local newspapers, a more proactive and responsive approach was sought by the public. As a result, the United States Department of Agriculture's Wyoming Wildlife Services program began, in cooperation with other state and local offices, a rabies monitoring and control program in 1990. A scientist from the National Wildlife Research Center (NWRC) in 1991 was the first to employ global positioning satellites (GPS) for identifying rabid skunk capture locations. In 1992, an epidemiologist from NWRC was the first to utilize a "geographic information system" (GIS) using geographic hydrology to analyze the spread of skunk rabies. This paper presents an overview of this first use of GPS/GIS that combined rabid skunk locations, geographic hydrology, and time to better understand the epizootic's movements along the Shoshone River.

Key words: epizootic, geographic hydrology, *Mephitis mephitis*, rabies, Shoshone River, striped skunks, Wyoming

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INTRODUCTION

Rabies is a viral encephalomyolytic disease primarily of mammals (Neizgoda et al. 2002), and presently in the U.S. it occurs most frequently in wildlife (Neizgoda et al. 2002). Rabid striped skunks (*Mephitis mephitis*) have been reported in North America since 1826 (Parker 1975), and they are the most important reservoir of wildlife rabies on the Great Plains (Charlton et al. 1991). In Wyoming, wildlife rabies had been reported since 1938, with most cases involving striped

skunks (61%) and bats (*Chiroptera* spp.) (26%) (Thorne and McLean 1982). They found that rabid skunks occurred east of the Rocky Mountains. Of the 29 cases they located from 1975-1979, 27 were from the northeastern corner of the state (Campbell and Crook Counties). To the west across the Big Horn Mountains occurs the Shoshone River Basin in northwestern Wyoming. This area had been historically considered "rabies-free" for skunks Centers for Disease Control and Prevention (CDC) (CDC 1985, Reid-Sanden

et al. 1990, Charlton et al. 1991).

However, all that changed with the public's concern over a skunk rabies outbreak in 1989. The United States Department of Agriculture's (USDA) Wyoming Wildlife Services program (WS) was asked for assistance with the rabies outbreak. Starting in 1990, WS provided a skunk rabies trapping program to monitor and control the spread of rabies (Davis 1991). The primary goal was to address the public's concerns about human and domestic animals' health and safety (W. Rightmire, WS's State Director, pers. commun., 1991). As a headline in the Powell Tribune (newspaper) from May 2, 1991 correctly stated, "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 tractor [Davis 1991]) and the death of a rabid horse in the Cody area (Cloudwalker 1991), a more responsive approach was sought to monitor the location of rabid animals.

An epidemiologist from the National Wildlife Research Center (NWRC) reviewed and analyzed the trapping data. He decided to employ 2 technologies in the analyses that were in their infancy – a Global Positioning System (GPS) and Geographic Information System (GIS). Although this paper provides a synoptic overview of the entire 1988-1993 epizootic, the primary purpose of this paper is the evaluation of the novel use of both rabid skunk trap locations (e.g. from trapper's notes or a few directly using GPS) and the hydrologic features of the Shoshone River. As a result, rudimentary "GIS" information was used to analyze the spread of rabies during the epizootic for the public's health and safety.

STUDY AREA

The Shoshone River Basin (i.e. Basin) occurs in the northwestern corner of Wyoming in Bighorn and Park Counties. Its

headwaters occur near the Eastern Entrance to Yellowstone National Park at an elevation of ~2750 m and flows eastward between arid benches down to the Big Horn Lake (i.e. Yellowtail Reservoir) at an elevation of ~1200 m. The Shoshone River's length is ~180 km (i.e. ~112 mi), and it flows near several towns – Cody, Powell, Byron, Cowley, Deaver, and Lovell. This Basin has been described as marginal skunk habitat generally restricted to the river's flood plain (L. Dickerson, Superv. Wildl. Biologist, pers. commun., 1991).

METHODS

Trapping Rabid Skunks

WS trapped striped skunks along the Shoshone River, for ~110 km up from its mouth at Big Horn Lake up to within a few km west of Cody. The WS trapping program began in January 1990 and ended in May 1992. Striped skunks were captured in primarily 3 habitats: riparian, pastures, and agricultural (i.e. predominately irrigated alfalfa). Rabid skunks (~73%) were caught in Tru-catch live traps (#30 Wildcat, 30"X9"X11") (Tru-Catch Traps/Manufacturing Systems, Inc., Belle Fourche, SD) baited with sardines. Additional rabid skunk carcasses were submitted by the public and were either roadkills or had been shot. Also, 5 rabid skunks were obtained in October 1991 by a NWRC scientist using the USDA's registered "gas cartridge for coyotes" (EPA Reg. No. 56228-21) (Cloudwalker 1991, Ramey 1992).

Processing Rabid Skunk Data

All rabid skunks were identified by the Wyoming State Veterinary Laboratory (WSVL), and their capture locations were provided to the participating landowners, veterinarians, various wildlife and public health officials. However, compiling the skunk rabies epizootic data for analysis required the utilization of several different sources of information. First, the Wyoming

Department of Agriculture (WDA) began compiling rabies data in 1989. Second, the WS began providing trapping records in 1990. Third, in 1991 NWRC was asked by the Wyoming State Director of WS to participate in the rabies epizootic by testing the gas cartridge for coyotes on skunks (Ramey 1992). A NWRC epidemiologist compiled these 3 sources of rabid skunk information into a database (SAS 1987) (SAS Campus Drive, Cary, NC) for not only surveillance and/or depopulation purposes, but also for projecting future areas of concern for the spreading rabies epizootic.

However, on June 1, 1992, the WSVL initiated a new policy of testing only skunks that may have come in contact with humans or were suspected of having rabies. This policy change obviated WS's further involvement in surveillance although 95% of the rabid skunks that were submitted to WSVL were caught by WS trappers in 1992 prior to the change. Most of the other agencies also curtailed their involvement about this same time. In summary, the rabid skunk locations were obtained from 3 independent sources: WS trapper's maps and notes, the public's carcass submission tags, and a NWRC scientist using GPS equipment.

Defining Shoshone River Locations

Identifying geographic locations in the Basin have changed over the years. Early trappers and settlers often utilized compass bearings and distances from natural landmarks along the river to identify locations such as Heart Mountain (west), Abe Lincoln's facial silhouette (center), or the mouth of the Bighorn Canyon (east). Surveyor's measurements later replaced these locations. During this study, we utilized a satellite based method that was in infancy that employed GPS which was developed and maintained by the U.S. Department of Defense. Data such as the latitude, longitude, and altitude were provided in a coordinate system called the

World Geodetic System (Sony 1991). A few rabid skunk locations were obtained directly using GPS equipment; however, most locations were plotted by hand using either public submission carcass tags or trappers notes. Rabid skunk locations along the Shoshone River and its main tributaries were grouped for analysis purposes as: upper Shoshone River (i.e. head waters down to Sage Creek) (~95 km), middle (i.e. Sage Creek down to Bitter Creek) (~65 km), and lower i.e. Bitter Creek down to Big Horn Lake, ~20 km, Figure 1.

GPS/GIS Use during the Epizootic

Five rabid skunks were obtained in October 1991 using the USDA's registered gas cartridge. Their locations were recorded using a Sony (Sony Corporation of America) GPS portable receiver (Model IPS-360, Sony Drive, Park Ridge, NJ). This equipment determined their global position (location) using 4 DOD satellites with a published location accuracy ranging from 30 m to 100 m (Sony 1991). However, the remaining location data (~98%) were derived from either public submission tags of rabid skunks sent to WSVL (~25%) or WS trappers' notes (~73%). A 1991 US West telephone book was used when necessary to call people identified on the specimen submission tags for more detailed locations.

All the rabies locations data derived from the public, WS trappers, and GPS for 1989 – 1993 were placed into a rudimentary "GIS" database. It included ~200 rabid skunks (i.e. out of a total of ~700 skunks and ~180 other animals) and is being published elsewhere. However, a synopsis of the analytical procedures follows. Rabid skunk locations were recorded on BLM 1987 edition 30 X 60 Minute Quadrangle maps of Powell and Cody. Next, a rabid skunk database was developed using their capture locations and associated dates. This information was the first data layer in the "GIS" analysis. The

hydrology of the Shoshone River Basin was the second layer of analysis and included our

arbitrary groupings of the Shoshone River and its major tributaries (Figure 1).

Figure 1. The Shoshone River Basin study area during the rabid skunk epizootic in Big Horn and Park Counties, Wyoming 1988-1993.



RESULTS

First Use of GPS

In October 1991, a NWRC scientist used a Sony GPS receiver during the epizootic for more direct and accurate rabid skunk capture locations. These 5 GPS locations were obtained by a scientist (C. Edward Knittle, NWRC, pers. commun., 1991) and included: none from the upper river; 4 from the middle river (i.e. 1 near Heart Mountain, 2 SW of Powell, and 2 on Bitter Creek near Abe Lincoln's silhouette); and 1 from the lower river near Lovell. He estimated that setting up the Sony equipment required ~25 min and that initializing (i.e. acquiring initial orbital data about the unit's location) the Sony equipment

to NW Wyoming location required ~30 minutes for its first use and thereafter it required ~1-2 minutes. Although the WS trapper(s) felt the GPS information would be useful, they believed that spending another 25-30 minutes at each animal's capture site would be too time consuming to warrant its use, and so they declined to use it. The potentially rabid animals that WS's trappers caught included: feral cats and dogs, bats, foxes, raccoons, porcupines, coyotes (a total of ~125 animals) and skunks (an additional total of ~450 animals).

First Use of GIS

Land use maps and designating riparian, pastures, and agricultural areas

provided a general skunk habitat delineation that covered ~400 km² area along the Shoshone River during the epizootic. The index rabies case was a "friendly" skunk that was shot on August 18, 1988 in the town of Deaver. The location was near Polecat Creek a tributary ~9 miles from the lower Shoshone River (Figure 1). Although this skunk tested positive for rabies at the WSVL, it was the only rabid skunk identified in 1988. During 1989, skunk rabies was found throughout Polecat and Sage Creeks having spread outward from the Index Case in all directions but limited to areas with skunk habitat. In 1990, the epizootic included not only Polecat Creek but also the lower Shoshone River and its tributaries. By 1991, the epizootic left Polecat Creek and was in the remainder of the Shoshone River including the lower, middle, and the beginning of the upper section of the river. In 1992, the epizootic was observed mainly in the middle section of the Shoshone River. Only 4 rabid skunks were referred to the WSVL by the public in 1993, mainly from the lower Shoshone River, and public health officials and others believed the epizootic was ending. Personnel from the WSVL have stated the epizootic ended by 1994 with no

rabid skunks identified by the Laboratory in either 1994 or 1995 (A. Boerger-Fields, WSVL, pers. commun., 2007). Anecdotal observations by WS personnel, cooperating landowners, wildlife and public health officials that had participated in the epizootic program indicated that very few skunks were observed in the Shoshone River system in 1994 and 1995.

The initial hand generated "GIS" maps summarized above demonstrated the movement of the epizootic over its history, and they were shared with WS personnel and then with the public. 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 Ramey et al. 1992, 1994). Subsequently, digitization of all the rabid skunk locations was accomplished, and a more detailed hydrologic layer was added. These changes plus the subsequent derivation and use of various software packages and GIS data from federal, state, and county agencies have provided additional assistance in our understanding of the movement of the Shoshone River epizootic (Table 1).

Table 1. Chronology of NWRC's GPS and GIS data processing of the Shoshone River rabid skunk rabies epizootic, February 1991-January 1996.

Date	Description
February 1991	Discussed with Wyoming State Director NWRC's involvement in the skunk rabies epizootic (i.e. testing the lethality of USDA, APHIS's gas cartridge for coyotes on skunks and rabies epizootic data analysis).
August 1991	Funding provided by the National Wildlife Research Center (formerly the Denver Wildlife Research Center, Denver, CO), USDA Pocatello Supply Depot, Pocatello, ID, and Wyoming Wildlife Services, (formerly Animal Damage Control), Casper, WY
October 1991	First use of GPS equipment during the rabid skunk epizootic on 22 trapped skunks by a DWRC (NWRC) scientist.
November 1991	Requested the WS trappers to plot their capture data on Bureau of Land Management (BLM) 30 X 60 Minute Quadrangle maps of Powell and Cody.
March 1992	WS trappers provided their hand-generated 1991 skunk data 30 X 60 Minute Quadrangle maps of Powell and Cody identifying rabid capture locations.
September 1992	NWRC obtained the 1989 and 1990 data from the Wyoming Department of Agriculture, Wyoming WS and also the records of two local veterinarians.
October 1992	First visual depictions of rudimentary "GIS" maps of the epizootic's movements from 1990-1992 grouped by a hydrologic layer along the Shoshone River System including its major tributaries (Ramey et al. 1992). SAS (SAS 1987) was used for database manipulation and analysis.
1994	Added the 1992 epizootic data from the Wyoming Department of Agriculture and incorporated it into a SAS (SAS 1987) analysis for presentation at the Wildlife Disease Association meetings (Ramey et al. 1994)
November 1995	Purchased NWRC's first GIS software package, 1995 AtlasGIS Software (Strategic Mapping, Santa Clara, CA). First computer generated map using 74 rabid skunk capture locations digitized by a company in Fort Collins, CO.
January 1996	In December 1995-January 1996, the first digitized product was imported into AtlasGIS and analyzed the spread of the skunk rabies epizootic.

DISCUSSION

Our first use of GPS locations and "GIS" information (i.e. hydrology data) to study the movement of skunk rabies assisted in our understanding of the Shoshone River epizootic. One advantage derived from the use of our hydrology information was the delineation not only of areas currently in the epizootic but also of areas of future concern. Forecasting where the epizootic was heading was especially helpful in alerting the public about the spread of rabies and in reducing their concerns. We concluded, like other

investigators in later studies (Lynch 1997), that using GPS and GIS data enhanced our investigative outcomes.

Because GPS and GIS were in their infancy as wildlife technologies, our literature review indicated very limited use prior or concurrent with our research. One of the early wildlife uses for the new GIS technology was habitat delineation and utilization. Gagliuso (1991) may have been the earliest to utilize GIS in wildlife studies when he analyzed cougar habitat utilization in southwestern Oregon. Later, Clark et al.

(1993) used GIS in a multivariate model of female black bear habitat utilization. However, in the study of wildlife diseases the use of GIS may have begun later with the risks analysis of Lyme disease (Nicholson and Mather 1996). Our limited use of both GPS and GIS pale in comparison to subsequent wildlife disease research, but at that time the use of these technologies was just beginning. For example, only 7-8 satellites of the 24 proposed, when the final GPS constellation was to be completed in 1993, were available for us to record the Geodetic data we needed.

Similarly, all types of GIS data were just being compiled for the multitude of proposed uses including wildlife studies. Thus, our initial scientific publication searches in 1991 and later 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 our use of GPS and GIS techniques were a first in the study of a wildlife disease (i.e. skunk rabies) during an epizootic (L. Paulik, Librarian, NWRC. pers. commun., 2007).

MANGEMENT IMPLICATIONS

Our first use of "GIS"/hydrology information with rabid skunk capture locations demonstrated the usefulness of the "GIS" technique for planning future surveillance, control, and/or vaccination programs. 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 a vaccine had been available) correlating skunk habitat (GIS) with the proposed placement of vaccine laden baits (GPS) might have geographically limited this epizootic to either the lower Shoshone River if utilized in 1990 or the middle and lower Shoshone River sections 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 were probably immeasurable. However, even a proposed use of trap-vaccinate-release for urban skunk rabies control (Rosatte et al. 1992) would have really helped lessen the concern in the 6 towns involved in the Shoshone River epizootic if a vaccine had been available.

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