8.13

USING GIS TO IMPROVE REAL-TIME SEVERE WEATHER VERIFICATION

Mike Rawles, Tanja Fransen, Thomas Salem, Julie Adolphson
NOAA's / National Weather Service, Glasgow, Montana

1. INTRODUCTION

Geographic Information System (GIS) applications are becoming increasingly popular in many organizations, including the federal government. Emergency operations have taken advantage of these capabilities. "GIS can be beneficial in many ways, but in the simplest of terms, it connects people to information through geography. Government can use GIS to store, manage, and access information about its facilities, people, and environment. It gives government officials a way to visualize data that helps them make decisions about project planning and economic development. It also allows them to disseminate a large quantity of information to the public in terms of where things and events are located." (AGIO 2005)

The National Oceanic and Atmospheric Administration (NOAA)'s mission includes the protection of life and property through their National Weather Service's (NWS's) issuance of severe weather warnings. Over the past two spring and summer seasons, NOAA's NWS Weather Forecast Office (WFO) in Glasgow, Montana has employed GIS information to significantly improve real-time verification.

This paper will discuss severe weather operations, the methodology employed in using GIS, during operations, compare verification from previous years to the present GIS-enhanced operations, and discuss specific case in July 2005 in which GIS was particularly helpful in severe weather operations.

* *Corresponding author address*: Julie Adolphson, NOAA/NWS WFO Glasgow, 101 Airport Road, Glasgow, MT 59230; e-mail: julie.adolphson@noaa.gov

2. SEVERE WEATHER OPERATIONS

During significant thunderstorm activity, NOAA's National Weather Service WFOs issue severe thunderstorm and tornado warnings using state-of-the-art observation tools (e.g., doppler radar) and computer and communications systems. At WFO Glasgow during and at the conclusion of a severe weather event, storm reports from law enforcement, trained spotters and property owners throughout northeast Montana are incorporated into the warning process. These reports assist warning meteorologists with "ground truth" verification of warnings. This ground truth proves particularly useful in assisting warning meteorologists in determining performance of remote observing tools; specifically, these reports are used in making warning decisions downstream. In northeast Montana, WFO Glasgow has warning responsibility for 12 counties across approximately 35,000 square miles, with a population of around 50,000 (Fig. 1). The rural nature of this area represents a significant challenge to operational verification.

At the conclusion of each event, the confirmed severe reports of greater than equal to .75 inch hail, or 58 mph winds, or tornadoes are entered into a national database, known as "Storm Data" (NOAA 2005). This database is widely used for severe storm climatology, forensic meteorology, and other research and training activities.

The trained network of spotters mentioned above, known as "Skywarn" spotters, includes about 1200 residents of northeast Montana. At WFO Glasgow, a master Skywarn spotter list is maintained in a Microsoft Access® Database. The database includes the name, spotter number, address, phone, reference location to the nearest town, equipment at the site (e.g., rain gage and/or wind sensor), and the site latitude and longitude. The severe weather operations staff correlate the location of the spotters with the pertinent severe weather observations from surface observations, satellite imagery, and radar imagery. A more complete description of the database and its

Geographic Information System (GIS) application is given in the next section.

3. HARDWARE AND SOFTWARE

In order to prepare the office for use of GIS mapping capabilities, a new server was purchased with a half a terabyte of storage. Also, 1 gigabit (Gb) network cards were installed on all operational PC's to allow a faster loading of the large map files onto the PC's. ArcReader® (see below) was loaded on all of the operational PC's so that the staff could view the maps and get the information that was needed.

There are several vendors who offer GIS applications software. WFO Glasgow chose to employee ESRI's ArcPublisher® ArcReader®, and ArcGIS 9.1® to enhance severe weather operations in real-time. The hardware and software were purchased through a grant from the National Oceanic and Atmospheric Administration (NOAA) Climate Transition Program (NCTP) NCTP is a comprehensive program with a well-defined management structure for expanding regional climate services. It provides a mechanism for supporting research that addresses user needs and requirements, transitioning the research to operations, and providing education and outreach capacity for new products. (NOAA/NWS 2005).

4. GIS Methodology

The Access database is then imported into ArcGis and becomes a "layer" on the maps that are created for each county.

Other GIS "layers" include roads, rivers/streams, towns, reservations, lakes, topography, and rural addressing. A critical layer that has been recently added is "land use." This layer proved particularly useful in locating residents to provide "ground truth" information on severe weather events.

When the program is started, the user opens the file for the desired county. When it loads, the entire county can be seen, along with layers that can be turned on or off including topography (useful for hydrological reasons), towns, roads, rivers and streams, lakes and reservoirs, and property ownership maps.

A user begins by choosing an icon from a menu that is shown in Fig. 2. Magnification/de-magnification is accomplished through placing the mouse on the image and using the left mouse button, or through depressing and holding the left mouse button while moving over a desired area and releasing the mouse button. A complete magnification/de-magnification functionality also is available on the task bar. The "white hand" icon allows the user to pan the map. Choosing the globe provides the user with an image that spans the full extent of the map onto the screen. Finally, the forward and backward arrows are similar to those commonly found in web browsers, which allow the user to view previous images.

5. VERIFICATION STATISTICS

After each severe weather event, WFO Glasgow prepares statistics that include: Probability of Detection of severe weather and advance warning time (lead time). In comparing the verification statistics during events prior to the use of ArcGIS there is a definite improvement (Fig. 3). It should be noted, however, that this new methodology has been used for only one season; therefore, WFO Glasgow will continue to take advantage of this technology to further enhance the warning verification and operational applications, and further document statistics to demonstrate its usefulness.

5. EXAMPLE

In the following example, severe weather occurred in areas where no trained spotters were located. In the past, no verification of these types of events was possible, given the lack of spotters in northeast Montana.

Specifically, on the evening of 2 July 2005, a severe thunderstorm moved across the northern parts of Phillips and Valley counties. At 2356 UTC in the radar image of reflectivity (Fig 4), warning meteorologists suspected severe weather was occurring over northern Phillips County but no trained spotters lived in the area (Fig 5). Therefore, operations staff used the arcGIS maps to locate the landowner in the area to determine the extent of severe weather which occurred in the area (Fig. 6). Over the next two hours the thunderstorm tracked east toward town of Thoeny; the storm remained north of the Frenchman Reservoir. Figures 5 and 7 illustrate that there are relatively few spotters (green triangles) in northern Phillips and Valley Counties. Using the land use ArcGIS maps (Fig. 8). WFO Glasgow was able to verify the storm as severe before it reached any of the spotters. Note that landownership is marked

on the ArcGIS maps with red square areas, as further described below.

Before the storm moved into Valley County on 2 July 2005, the operations staff used the ArcGIS maps to find a landowner that the storm had passed; as shown by the land area circled in Fig. 8. The "i" button allowed the forecast staff to retrieve the landowner's name and several other pieces of information about the land owner. Once this information was obtained, the forecaster was able to retrieve the resident's phone number from a library of phone books, and upon calling, find out the "ground truth" activity in the area.

Throughout the severe weather season in 2005, the ArcGIS maps proved invaluable, as WFO experienced the busiest severe weather season in over 50 years of record keeping. This suggests that in many other rural areas across the US, the ArcGIS maps could prove to be a highly useful source for severe weather verification.

6. FUTURE PLANS

WFO Glasgow intends to expand the use of GIS applications in operations. For example, additional maps with more detailed hydrologic information will be used during significant flash flooding events to discern areas of greatest impact due to land use.

In addition, more detailed information concerning planned development could be used for targeting areas that may be more or less vulnerable to natural disasters.

Finally, the unlimited capabilities of customizing GIS maps for research and case study development will be further developed. The research and case studies will lead to improvements in warning and forecasts with the ultimate goal of improved customer satisfaction.

7. ACKNOWLEDGEMENTS

The authors wish to thank the following individuals for their support of this work: Jeff Zeltwanger, Information Technology Officer (ITO) WFO Glasgow, MT; Andy Pohl, currently ITO WFO Gray, ME; Brian Burleson, Hydrometeorological Technician (HMT) WFO Glasgow, MT, The WFO Glasgow's Hazardous Weather Operations Team, Dr Fiona Horsfall, Deputy Chief of the Climate Services Division, National Weather Service Headquarters, Silver Spring, MD.

REFERENCES

ESRI, cited 2005: ArcGIS Site. [Available online at http://www.esri.com/index.html.]

Arkansas State GIS Office, cited 2005: The Benefits of Using GIS. [Available online at http://www.gis.state.ar.us/AGIO_index.htm.]

NOAA , cited 2005: NOAA Climate Transition Program (NCTP). [Available online at http://www.ogp.noaa.gov/mpe/nctp/index.html.]

Montana State Library, cited 2005: Montana GIS Data. [Available online at http://nris.state.mt.us/gis/default.htm.]

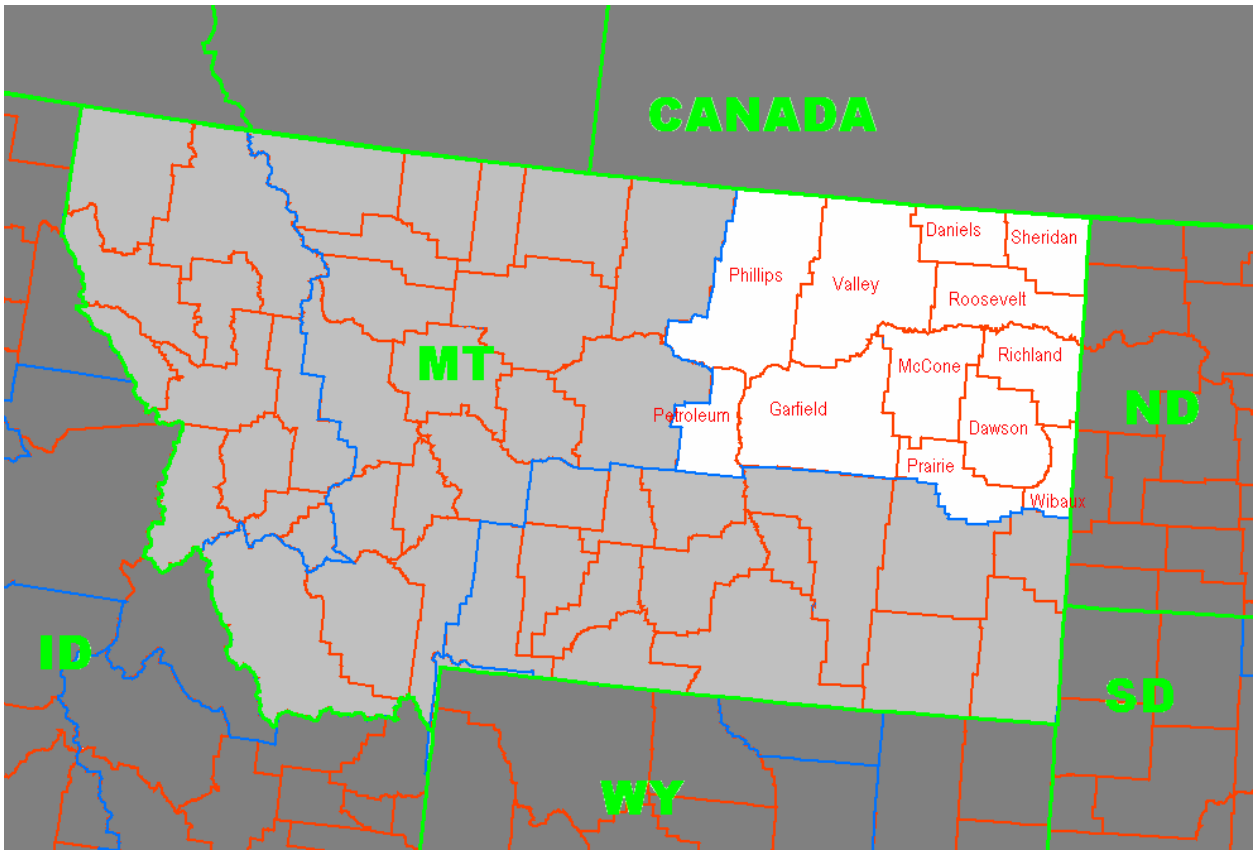

Figure 1. Area map of Montana and surrounding states. WFO Glasgow's area of responsibility is in white with county names in red.

Figure 2. ArcReader® task (icon) bar.

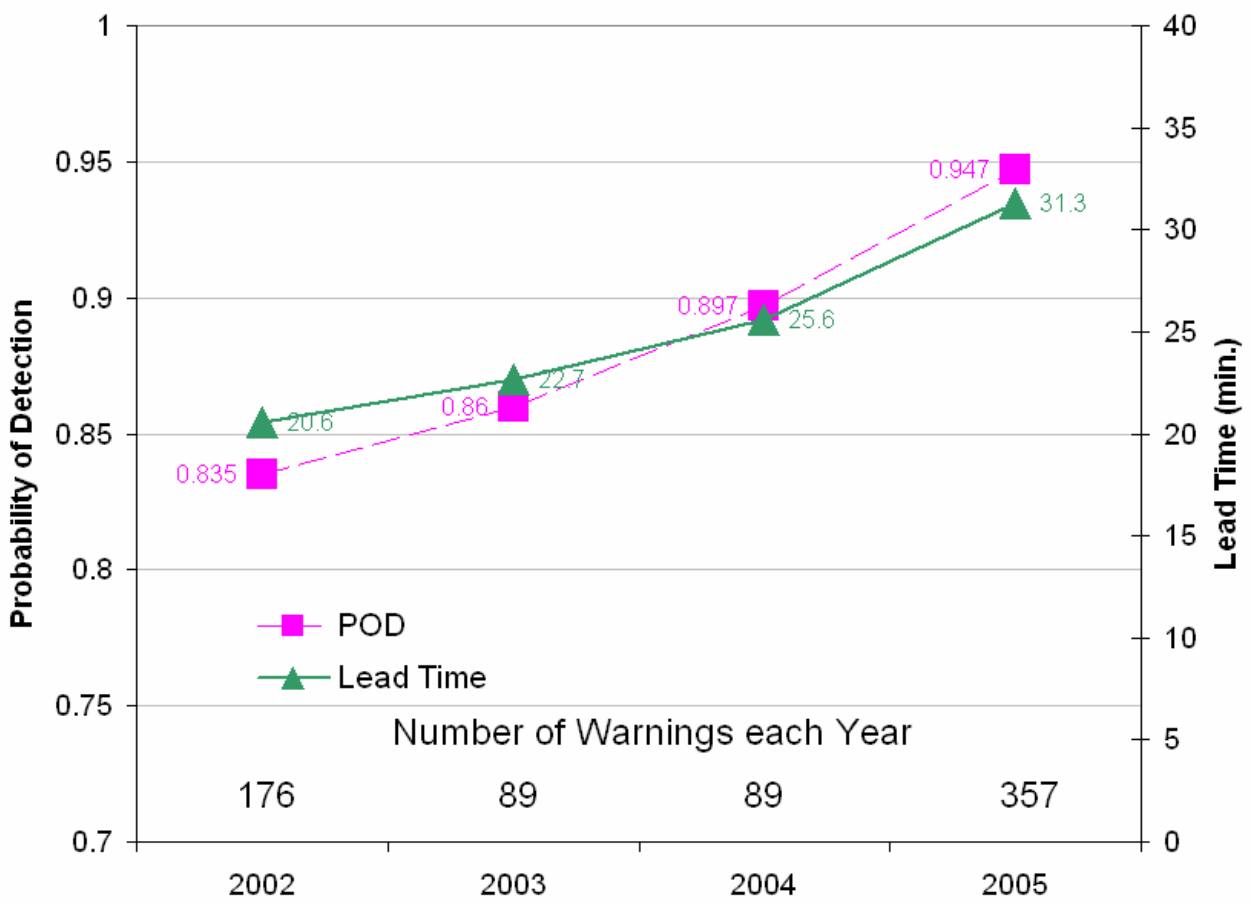

Figure 3. Severe weather verification statistics for WFO Glasgow for 2002 through 2005. The probability of detection (POD) is shown for each year in purple, the POD values are printed to the left of each square. The warning lead time is shown in green with the lead time values printed to the right of each triangle. The number of warnings issued each year is printed near the bottom of the figure for each year.

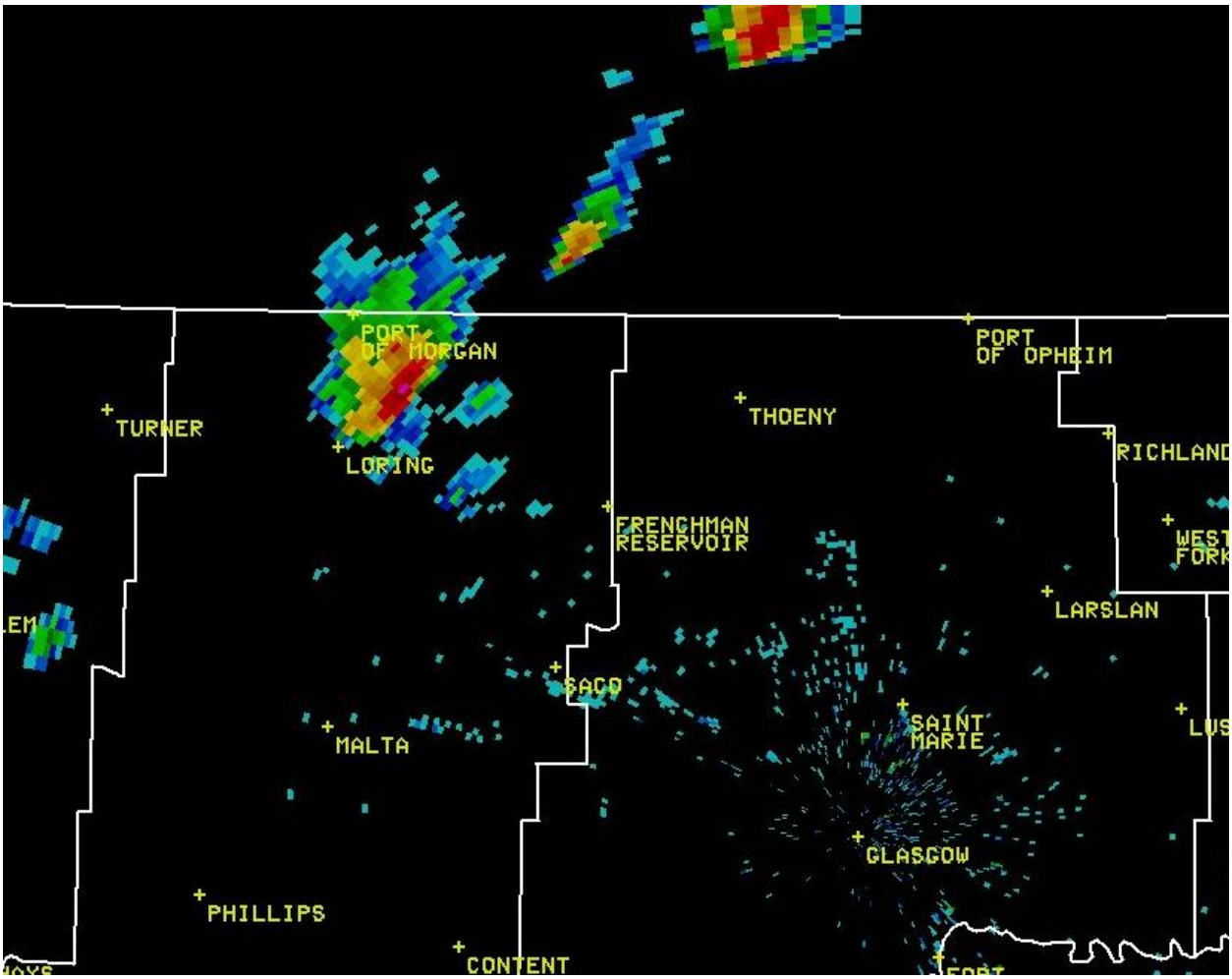

Figure 4. Reflectivity image from the Glasgow radar from 2356 UTC 2 July 2005 showing a possible severe thunderstorm in northern Phillips County, south of the Port of Morgan.

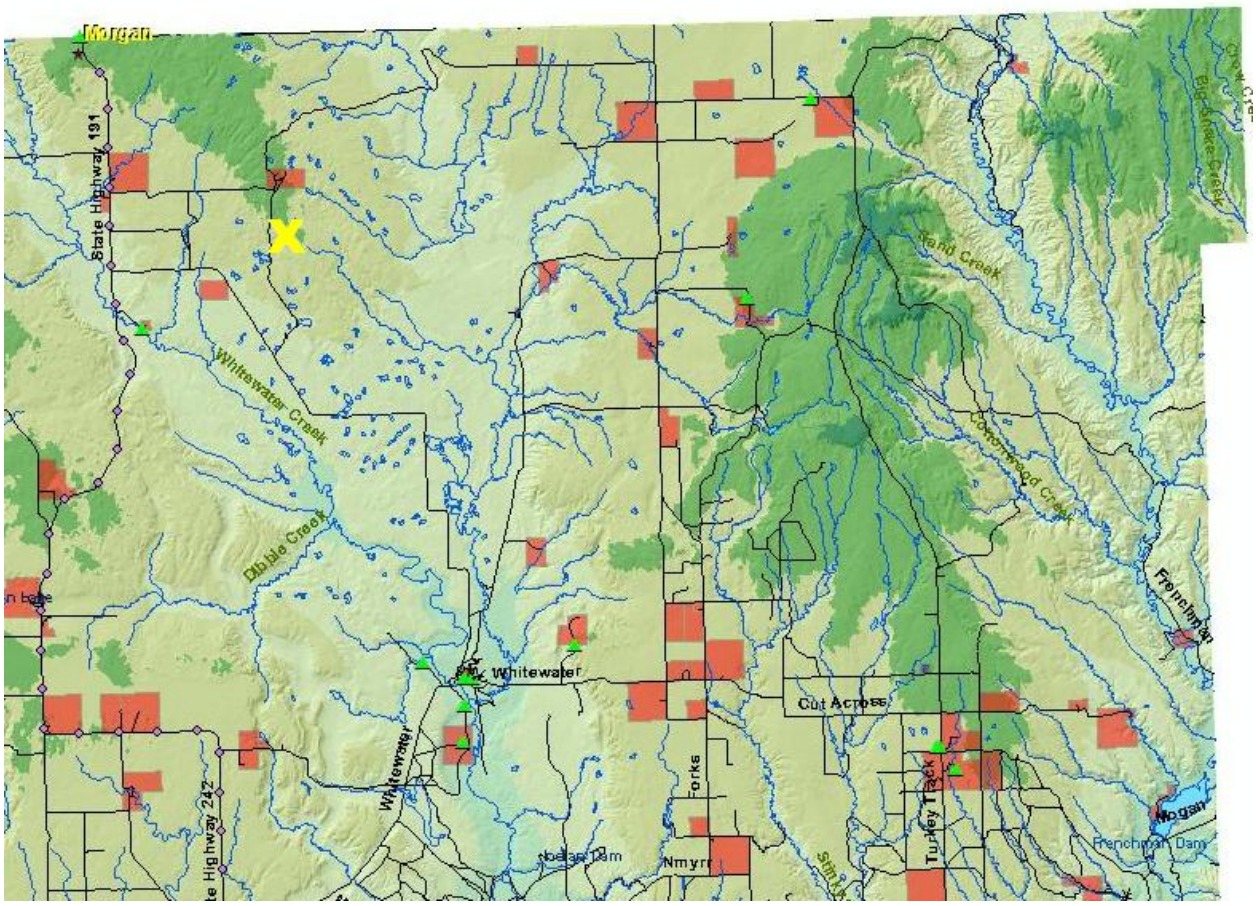

Figure 5. ArcGIS map of Northern Phillips County map with the trained spotters shown in green triangles. The approximate location of the storm, in Fig. 4, is located at the yellow "X".

Figure 6. Hail from the 2 July 2005 storm with a nickel as a reference.

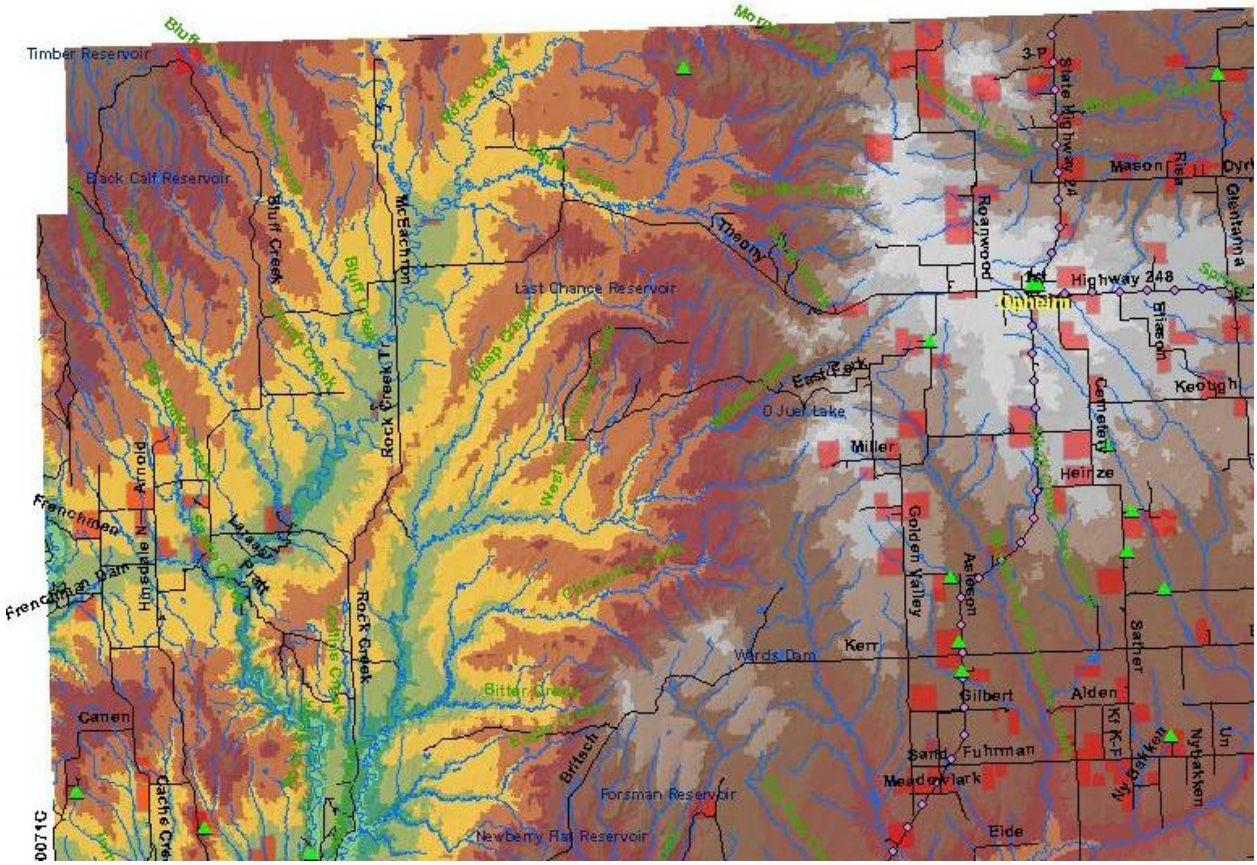

Figure 7. ArcGIS map of Northern Valley County map with the trained spotters shown in green triangles.

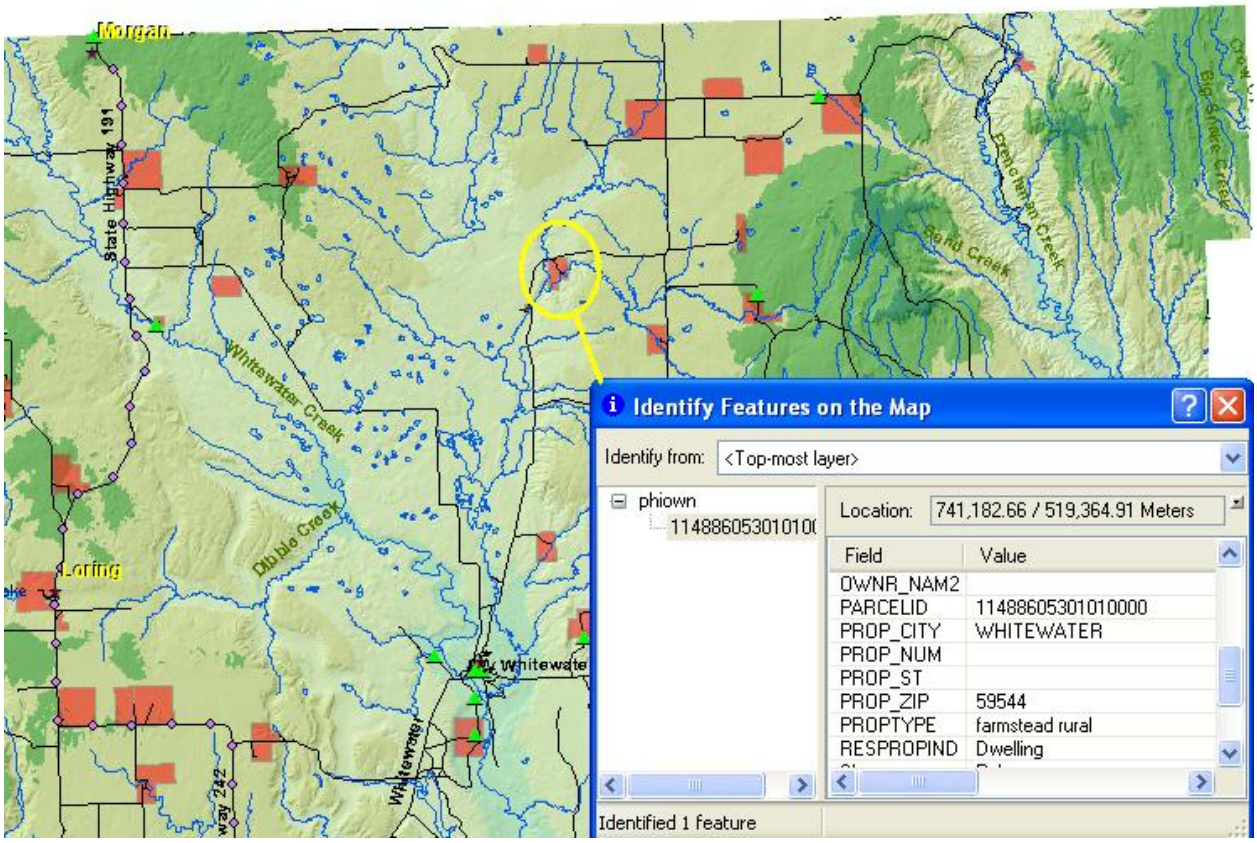

Figure 8. Land use ArcGIS map of northeast Phillips County with spotters with green triangles and landownership shown by red blocks. The window insert provides information about the landowner.