Paper Title:
Web-Based Disease Tracking: A West Nile Virus Example (1131)

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Paper Abstract:
In 2003, the State of Colorado had more diagnosed cases of West Nile Virus than any other state in the country. In order to educate the public, provide information to the media, and target spraying activities, the department developed a simple ArcIMS site that tracked the results of animal testing in near-real time. This site was very successful. Future plans include ArcIMS sites to display real-time animal testing results and real-time human cases (to authorized users).

Introduction:
West Nile virus has emerged in recent years in temperate regions of Europe and North America, presenting a threat to public and animal health. The most serious manifestation of West Nile virus infection is fatal encephalitis (inflammation of the brain) in humans and horses, as well as mortality in certain domestic and wild birds.

The first appearance of West Nile virus in North America occurred in 1999, with encephalitis reported in humans and horses. In subsequent years, the virus spread throughout much of the United States. As of April 2004, West Nile virus has been documented in 46 states and the District of Columbia.

West Nile virus first appeared in Colorado during the 2002 season. Public health agencies began testing birds, horses and mosquitoes to track the spread of this disease, and to identify areas where humans may be at risk for contracting the disease. By the end of the 2002 season, the West Nile virus had been detected in animals in some parts of the state (*figure 1*). Less than 10 human cases of the disease were diagnosed during the 2002 season.

West Nile virus was much more widespread in Colorado during the 2003 season. As the 2003 season progressed, large numbers of animals tested positive for the disease. By the end of the season, 2944 humans had been diagnosed as having contracted West Nile virus, and 54 people died of complications from this disease.

For more information about West Nile virus in Colorado, visit:
http://www.cdphe.state.co.us/dc/zoonosis/wnv/wnvhom.html

Mapping the spread of the West Nile virus:
GIS has played a role in combating the West Nile virus during the 2002, 2003 and 2004 (current) season. During the 2002 season, maps were posted to the web showing the areas where testing was being done, and where animals tested positive for the virus.

During the 2002 season, The Colorado Department of Public Health and Environment (CDPHE) collected and mapped West Nile virus animal data. From these maps, it was determined that the animals that tested positive were being collected primarily in the two eastern Colorado river drainages (the South Platte and the Arkansas). It was apparent that the virus had spread into the front-range communities by the end of the season, and that these communities would be vulnerable during the upcoming 2003 season.

Static maps continued to play a role during the subsequent West Nile virus seasons. These maps are a "snapshot" of conditions at any particular moment, and can be an effective way to communicate information about the spread of this virus in both animals and humans.

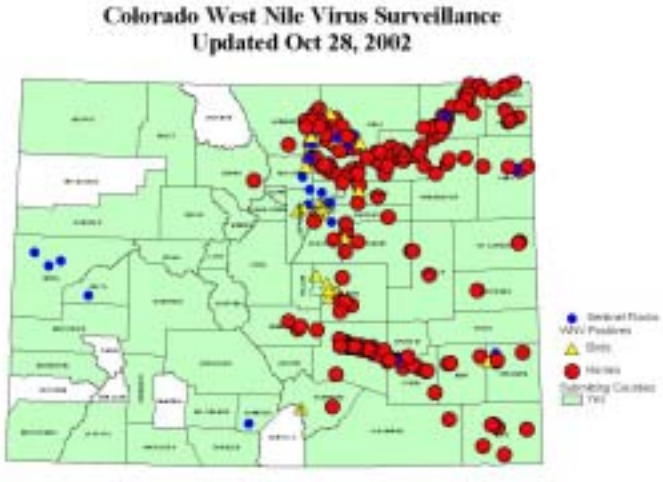

Figure 1: The 2002 end of season map showing the results of the West Nile virus animal testing program.

Interactive maps.
Prior to the onset of the 2003 season, a database was put in place that allowed the sharing of animal testing information among the agencies

working on the West Nile virus problem. Persons responsible for entering data could access the database on the web. Data was made available to the various participants via web pages, email and ftp. The net result of this effort was that during the 2003 season, public health workers, the press and the public had access to a great deal of current information regarding the spread of this virus.

Prior to the start of the 2003 season, a simple ArcIMS site was built to map the animal testing data (*http://emaps.dphe.state.co.us/wnv3/viewer.htm*). ArcIMS had been recently installed at CDPHE, and the site was kept simple, in order that the site could be adequately supported during the season.

A "location" table was automatically exported from the animal testing database and ftp'ed to the GIS web server. This location table was used to manually prepare the shapefiles that were used by the ArcIMS website. Using this manual process, the mapping website was updated 1-2 times per week for most of the season.

The interactive map allowed the user to view information about a particular species, or a particular area. The map was especially useful for identifying areas where the virus was prevalent.

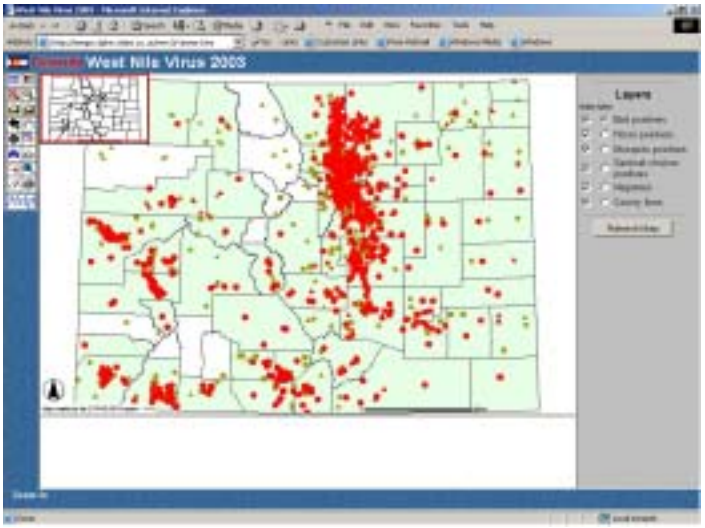

Figure 2: Screen capture of the West Nile Virus 2003 "Interactive map". The site was functional, and was widely used by public health workers and the press. However, the public seemed to find the site difficult and confusing.

Dynamically updated interactive maps:
Prior to the start of the 2004 season, an application was developed for CDPHE by ESRI contractors. This application was developed for a CDPHE Intranet site, where authorized users could map infectious diseases.

The code from the infectious diseases mapping site was used to develop the modified 2004 West Nile virus animal testing site (*http://emaps.dphe.state.co.us/wnv04/default.asp?DSN=Animals*). This new mapping site is more intuitive and easier to use by all types of users – vastly expanding the overall usability of the application.

The 2004 site also connects directly to the location table that is ftp'ed from the testing database to the GIS web server. The application builds "acetate" layers from the location table, eliminating the need to manually re-build the points shapefiles. The net result is that the new application is much easier to maintain, and is always "sync-ed" with the testing database.

Lastly, the plotting/printing features are enhanced, replacing the need to manually generate the static maps. Now, any user can build "snapshots" directly from the interactive mapping application.

Figure 3: The improved 2004 Interactive mapping site showing detail of area south of Denver. Some sample locations (yellow) have been selected.

The supporting infrastructure in 2004:

Even though the end products seem relatively simple, being able to dynamically map public health data can require a great deal of infrastructure. Often, the tabular data is found on different machines. Sometimes security of machines and security of the data can be a big concern. The infrastructure supporting the web-based mapping solution described here is complex (and clearly, this is not the only solution to this problem). However, it is important to note that most of the infrastructure described here also supports a number of other public health and environmental programs.

The author believes that even a small amount of infrastructure can be expensive if it supports one or two applications and is not fully utilized. Infrastructure is cheap and deemed necessary if it supports a wide range of applications and a wide range of users.

The following items make up the infrastructure that supports the West Nile virus dynamic interactive map (the 2004 application);

- Database server.
- Database programmers and support staff.
- GIS web server.
- ArcIMS software.
- A mature GIS program and a complete "suite" of GIS software tools.
- Web and ArcIMS applications development.

Future plans:

Initially, the role that GIS played in the efforts to combat West Nile virus was simply to prepare static maps, or "snapshots" of the data. As the virus became more widespread, GIS was also used to visualize and map the data as soon as it became available in the database.

Presenting point data as interactive maps on the web can be a difficult problem. A great deal of infrastructure and effort was required to "automate" the transfer of information between the database and the mapping website, and then to display the information in a way that could be easily understood by all types of users.

Clearly, the basic functionality found in dynamically updated, interactive web-based mapping has important implications for many public health issues. At CDPHE, the work done for West Nile virus has inspired other efforts related to anti-bioterrorism, disease surveillance. This work has also contributed to the adoption of GIS by a number of public health workers in the state. Some public health professionals in the state are starting to see the ability to interactively map point data on the web as a fundamental part of managing almost any disease outbreak, as well as some homeland security issues.