Visualising livestock movement in near real-time

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Abstract
Knowledge of animal movements is vital to the control of disease spread. Both the number of movements and the volume of animals can have important ramifications on the likelihood of disease being transferred as a result of these movements. In the case of disease control programmes, it is valuable to be able to visualise this information in a map context, so that the relationship between animal movements and other significant factors for disease (animal populations, human populations etc) can be assessed rapidly.

We set out to identify the animal movements occurring in two parts of the world (Western Australia and the Greater Mekong Subregion of South East Asia) by capturing movements in a database and displaying the movements through an interface in both map and tabular form.

We were able to create a low cost system which allows display of the movements of animals as they are entered. Although there are limitations inherent in the collection of this data in different circumstances, it provides a valuable tool for enhancing our understanding of livestock movements, and provides animal health managers with the capacity to assess and analyse movements over time to aid decision making for disease control programs.

Keywords
Livestock Movement GIS Mekong Australia NLIS Animal Health Information System

Introduction
The presence of a susceptible population is essential for the spread of infectious disease. Although in a disease control context the ideal situation would appear to be the immediate halting of all livestock movements, this is not necessarily practical or possible. In reality, given that many disease control programs are primarily based on the economics of improving human or animal health and production, significant reductions in normal animal trade volumes can penalise those involved in the trade, potentially for little or no improvement in the disease situation. The creation of such negative perceptions will serve only to erode public support for the disease control programme (and potentially any future programmes).

Nonetheless, knowledge of animal movements is vital to the control of disease spread. Both the number of movements and the volume of animals can have important ramifications on the likelihood of disease being transferred as a result of these movements. In the case of disease control programmes, it is valuable to be able to determine which movements present a greater risk of spreading disease, and which are unlikely to impact on the spread of disease into new areas. To do this credibly we need to have a solid understanding of the movements which are occurring, or likely to have occurred in the contemporary period of interest for the pathogen of interest.

Given the enormous amount of livestock movement that take place on a daily basis globally, a useful tool to interpret this information is to visualise it in a map context, so that the relationship between animal movements and other significant factors for disease (animal populations, human populations etc) can be assessed rapidly.

Normally this is done by taking a data set and inputting it into a Geographic Information System (GIS) for analysis. We felt that developing a system to generate these outputs on demand would be a more valuable approach, allowing the generation of 'near' real-time views. The term 'near' is appropriate as there are unavoidable restrictions on how long it takes for data to be collected.

A key consideration for the development of this system (especially pertinent for use in the Greater Mekong Subregion countries) was the need to develop a low entry-cost solution in an environment with limited regulatory or resource support for ongoing data collection and analysis. Thus the use of large scale proprietary systems was unlikely to be viable.

Methods

We set out to identify the animal movements occurring in two parts of the world (Western Australia and the Greater Mekong Subregion of South East Asia) by capturing movements in a database, and developing an interface to allow users to query this data. In addition, as a part of the project which won't be discussed any further here we held consultations with traders to identify what contributed to their activity patterns, and looked into the opportunities for regional collaboration on animal movement management.

In Western Australia, we used the data available from the Australian National Livestock Identification System in a format where individual animal information was retained but properties were de-identified to satisfy privacy requirements. Animal movements were consequently analysed at the level of a shire or local government area, which is the secondary administrative unit in Australia (below states), although any individual animal could be traced at this limited resolution. In a rare display of national unity, property codes in Australia are identified using a consistent format (although there is some variation in the conventions used between states).

In the Greater Mekong Subregion, we used data from movement permits issued for inter-province and international movements in Cambodia and Lao PDR. This information only recorded movements at a provincial level of resolution, similar to our Western Australian data. This data was captured as part of project funded by the Australian Centre for International Agricultural Research, by entry into a centralised computer database.

There are a number of issues associated with this approach, the most obvious being that movements that did not have a permit issued were 'invisible'. Although estimates of the number of movements likely to be officially recorded varied by province, there appeared to be some similarities across the region, suggesting that relative values may still be important. This contrasts with Australia, where nearly all movements are required by legislation to be recorded in the NLIS database.

Additionally, other movement data was collected at abattoirs, road checkpoints and through interviews with traders, particularly focusing on international borders with Vietnam and Thailand. This data may be queried through the interface, and was use in analysis and validation of the movements data.

This database was then linked to a web interface which allowed the selection of different information to suit the user. It was not our intention to offer a full online GIS, but there are a number of useful enquires which can be undertaken, and the opportunity exists to examine data in more greater detail by drilling down.

Of most interest, given concerns about the accuracy of the underlying data are the mapping facilities, which feature a number of different data layers - background geography, political layers, roads and urban development, livestock density layers (from the FAO Gridded Livestock of the World) , and different options for displaying the livestock movement data (aggregate, individual movements, and movements in either 'direct' (as the crow flies) or 'routed' (using the most likely

road based on various algorithms).

Some other interesting data layers we are developing are the integration of prices 'surfaces' for the commodities of interest, which serve to indicate where supply and demand may not be balanced (created the discrepancies which drive the trade); and the incorporation of trader networks, showing which traders are significant in regional trade, and where the are operating.

Additionally, with some knowledge of the data structure and Structured Query Language (SQL) it is also possible for users to define their own examination. The system is using standard SQL (ANSI and Open Geospatial Consortium) for the spatial queries. Geometry data is stored as points, lines and polygons, allowing linking of data at the highest resolution appropriate for the data being displayed.

The technical stuff!

While cost was a significant factor in developing the system architecture, it was linking standard data entry formats with advanced analytical capacity that was the primary concern. The choice to use entirely open source software was based on the interoperability of the individual components. Additionally, we wanted to provide visual outputs which were generated on the fly, which required the use of a spatial database and web server. These are by their nature computationally expensive, and the per CPU licensing model of most proprietary solutions could have impacted significantly on the project bottom line.

The data is stored in a PostgreSQL database, using the PostGIS spatial extension. The entire system is hosted on a FreeBSD Server using the Apache Web Server. Primary CPU and bandwidth is currently donated by one of the project partners, however slave servers are currently located in Phnom Penh and Lao PDR. These are running on old laptops which were no longer required by another of the project partners, and also handle SMS traffic for both countries as another part of the project. The data entry interface is predominantly coded in PHP with limited javascript, as page size is very important for most users due to bandwidth limitations in non-urban areas.

Conclusion

With this approach we have successfully provided a low cost system which allows near real time visual display of animal movements in the Greater Mekong Sub-region. Additionally, we have created an interface which would allow for rapid appraisal of animal movements and risks in Western Australia in the event of a disease outbreak or the need to trace livestock. In order to achieve a sustainable output, and due to cost constraints in Cambodia and Laos PDR, the system was developed using entirely open-source solutions. This allows ongoing use without the need to pay licensing fees or royalties.

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