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On saleyards and surveillance – using livestock movement records for risk-based surveillance planning

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ABSTRACT

Our study examined all movements to and from cattle saleyards within Australia during 2006-07. When combined with property geo-references, we were able to delineate catchment and service areas for each saleyard, and using a road network, to estimate travel distances. A grid based analysis then allowed a visualisation of those parts of Australia with both high density of movements involving saleyards, and large median travel distances. Such analyses, combined with network modelling might enable the formulation of enhanced spatially explicit risk-based approaches to minimise disease spread as part of preparedness for an incursion of an exotic animal disease.

INTRODUCTION

Saleyards (or livestock auction markets) are critical points in the transmission of infectious animal disease. Not only is there mixing of animals from different farms, but the stress of travel and intermingling can lead to increased shedding and/or susceptibility to infection. In addition, where saleyards receive and dispatch animals over long distances, the possibility for rapid spread over wide areas becomes possible. This was the case of the foot-and-mouth disease incursion in the UK in 2001, where sheep markets were a critical determinant in allowing the initial outbreak to become an epidemic (Mansley et al., 2003).

One of the lessons learnt from the 2001 epidemic in the UK was the need for animal disease managers to understand the scale and extent of movements to and from saleyards as part of exotic animal disease (EAD) incursion preparedness. Traditionally this could only be approximated through surveys or expert opinion exercises, but the existence of national livestock tracing systems has made complete data analyses possible.

Following closely the spatial approaches used by Durr *et al.* (2006) in characterizing the abattoir catchment areas for cattle in the UK, we undertook an analysis of Australian cattle saleyards, using Australia's national cattle tracing system, the National Livestock Identification System (NLIS). A key objective of this analysis was to develop insight into how systems for enhanced risk-based surveillance might be applied to cattle movement and saleyard activity restrictions within Australia in the event of an EAD event.

METHODS

The data for the movement of cattle to and from the saleyards was obtained as an extract from the NLIS database for the period January 2006 to December 2007 from NLIS Ltd. The NLIS identifies each movement via the unique RFID number assigned to each animal, the properties (farms, saleyards, abattoirs etc.) which it moves to and from via a Property Identification Code (PIC), and the date of the movement. The NLIS does not however store details of the type of PIC or its location, and this was obtained from state and territory departments of agriculture from their farm registry databases.

All the data from the eight separate sources (NLIS Ltd and the seven department of agriculture) was reorganized into a project specific database, using the *Oracle Spatial 11g* spatial data management system (www.oracle.com/technology/products/spatial/), and the database queried using either standard SQL queries or Oracle's procedural language extension, PL/SQL. Explicitly spatial analyses of the composite dataset included estimating the road network distance of the supplying and receiving PICs to each saleyard (assuming that the movement would be along the shortest main road); calculating the 90th percentile catchment area, defined as the land area containing the geo-locator of 90% of PICs after ordering by distance from the saleyard; and the direction of the supplying and receiving PICs to and from each saleyard. For the latter analysis we used the *Manifold System 8.0* GIS (www.manifold.net/), with the proportion of the total number of PICs using a given saleyard allocated to 22.5° segment and visualized using *WindRose PRO* (www.enviroware.com/windrose.htm).

A separate set of analyses looked at the total aggregated dataset from the perspective of the supplying and receiving PICS, aggregated to an optimal, variable sized grid to allow for the greatly varying density of PICs throughout Australia. This optimal grid was generated using a custom written algorithm within *Oracle Spatial*, and followed closely the procedure outlined in Kauppi, & Mörtvik (2000). For each grid square estimates were made for both the number of animals supplied (per km^2) to any saleyard within Australia and the number of animals received from any saleyard. In addition, median distances travelled by the supplied and received cattle within the grid were calculated. Theses distances were overlaid onto the grid of movements per km^2, to enable visualization of areas of both high movement and large median distance travelled.

RESULTS

During the study period there were 230 active, permanent saleyards, which received for sale an average of 6.2 million cattle per year. Based upon the estimate of the 90th percentile convex hull, the median terrestrial catchment (supplying to the saleyard) area was 10,896 km^2, and the median terrestrial service (supplied from the saleyard) area was 66,472 km^2. *Figure 1* shows a plot of the 90th percentile catchment and service areas for the suppling and receiving PICs for the predominant cattle saleyard in southeastern Australia (Wodonga), along with a windrose visualisation of the direction and volume of supply.

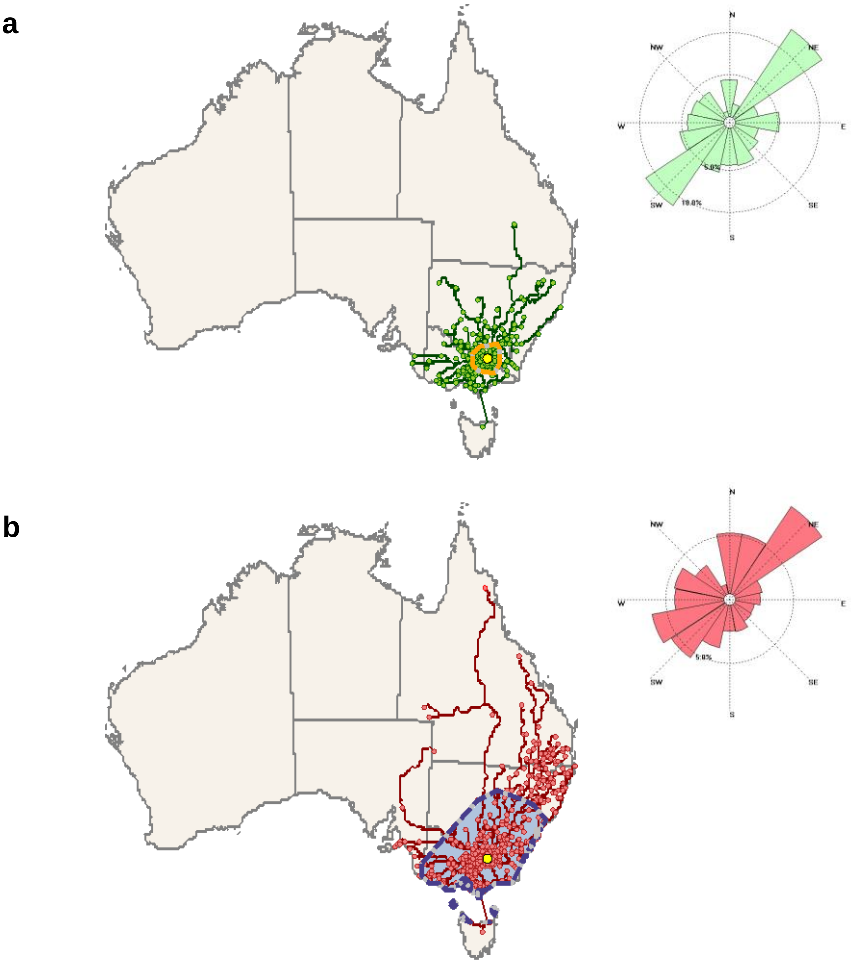

Figure 1. The Wodonga saleyard, showing the location of the supplying (a) and receiving (b) PICs, the assumed network on which the animals were transported to and from this saleyard, the 90th percentile catchment and service area and a windrose visualisation of the direction and relative proportion of movements per 22.5° segment.

The optimal grid-based analyses demonstrated a pattern for median travel distances and density of movements to and from saleyards to be inversely related (*Figure 2*), with a high density of short range movements involving saleyards in the south and east, whilst long range movements arise predominantly from the arid centre of Australia. However areas with high values for both variables were identified.

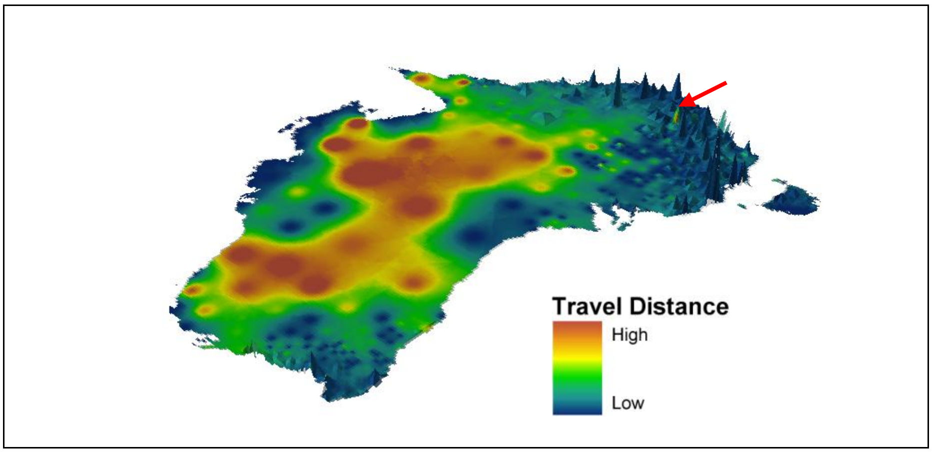

Figure 2. Overlay of median distance travelled per optimal grid over the number of saleyard movements per km^2, to enable the identification of an area with high values for both variables (red arrows).

DISCUSSION

Previously, almost all the rural towns of Australia possessed a saleyard, but in the past 10 years there has been a strong tendency for amalgamation into large regional hubs. This has resulted in some saleyards having extremely large supply and service areas, and animals being transported large distances to and from them. This has obvious risks for rapid dissemination of an exotic infectious disease, particularly if the disease initially went unnoticed.

During the 2001 FMD epidemic in the UK, auction markets were closed as part of a nationwide livestock movement ban, and following it, a series of mandatory restrictions on livestock movements were introduced including a ban on saleyard-to-saleyard movements and a “standstill” period of 6 days during which no “off “movements are allowed following the purchase of stock onto a farm (Robinson and Christley, 2007). If Australia ever experienced a comparable EAD event, then current plans would similarly close saleyards in affected zones, but the rules for gradually re-opening these and permitting farm-to-farm movements following the successful control of the EAD are yet to be defined (Anon, 1999). The type of analyses we have presented here potentially provides a step in enabling a data-driven approach to help define these rules, and fit within the paradigm of data-driven, spatially-explicit “risk-based” surveillance approaches to animal health planning (Stark et al., 2006).

The introduction of cattle tracking systems in many countries in the past 10 years is permitting sophisticated analyses of entire movement datasets at a population level. To date the commonest analytical method has been social network analysis (SNA), which has enabled a characterisation of saleyards according to their connectivity (Robinson and Christley, 2007). Our approach is substantially different, in being explicitly spatial and provides a more readily interpretable output to non-specialists. However, SNA does provide useful insight, and development of ways to combine the two would be a useful advance, particularly if the output of such analyses provided parameters for simulation models.

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