Developing a spatial-statistical model and map of the horse population in Australia

B. A. AbdelHamid[1], A. L. Griffin[2], P. Durr[3]

[1] School of Physical, Environmental and Mathematical Sciences and Defence and Security Applications Research Centre
University of New South Wales-ADFA
Canberra ACT 2600
Australia
Telephone: (+61) 430511739
Fax: (+61) 2 6268 8786
Email: bahaa.aly@gmail.com

[2] School of Physical, Environmental and Mathematical Sciences and Defence and Security Applications Research Centre
University of New South Wales-ADFA
Canberra ACT 2600
Australia
Telephone: (+61) 2 6268 8949
Fax: (+61) 2 6268 8786
Email: a.griffin@adfa.edu.au

[3] Australian Animal Health Laboratory
CSIRO Livestock Industries
Geelong, Australia, 3220
Telephone: (+61) 3 5227 5139
Email: Peter.Durr@csiro.au

1. Introduction

Geostatistical analysis has been extensively used in modelling and mapping disease data to interpolate estimates of disease occurrence or risk from various database sources into continuous surfaces. The study of geographical distributions of diseases is known by several synonymous terms in the literature, "medical geography" (Meade and Earickson 2005), "geographical epidemiology" (Bithell, 2000) and "spatial epidemiology" (Berke, 2004). A disease map is the main product of such analyses. Disease maps are exploratory analysis tools used to get an impression of the geographical distribution of disease or its corresponding risk (Berke, 2004); they have several other benefits including reporting the results of a geographical correlation study or highlighting cluster locations in a cluster study (Diggle, 2000).

Craig et al., (2007) developed a risk map and a model for malaria in Botswana using point-referenced data from prevalence survey of malaria infection in 1–14 year old children. Goovaerts (2006) developed isopleth risk maps of cancer mortality using a generalization of Poisson kriging. Griffith (2005) conducted a comparative analysis of disease mapping techniques (e.g., spatial autoregressive modelling and spatial filter modelling) as applied to West Nile Virus in the United States, where he found that that no single spatial statistical model specification provided a preferred description of these data.

In addition to disease and risk maps, modelling / mapping the distribution of susceptible populations across space is especially important because spatiotemporal modelling predictions from simulation models that predict possible spread scenarios of a disease through a population are profoundly affected by the estimated spatial distribution of susceptibles (Highfield et al., 2008). Therefore, developing a good understanding of the susceptible population's location is a fundamental component of spatially explicit disease modelling.

2. Methodology

A variety of spatial estimation methods have been used in the literature for modelling the density and distribution of populations including dasymetric mapping, regression-based approaches and remotely sensed image analysis (Highfield et al., 2008). Regression approaches used include ordinary least squares, logistic, Poisson, and more recently, geographically weighted regression (Fotheringham et al., 2002) and kriging (Buckland and Elston, 1993; Rossi et al., 1994).

This research aims to develop a model of the density and distribution of the horse population across Australia. A model of the density and distribution of the horse population across NSW and QLD is developed first using several geostatistical methods including GWR and kriging and employing agricultural census data, the horse population dataset collected during the 2007 EI outbreak for NSW and QLD, and spatially explicit variables related to horse ownership including land-use and human population distribution as model inputs. The model will be then applied to other parts of Australia and validated using data from Victoria, Tasmania and Western Australia (Figure 1). In this paper, we present the initial results of our work to develop a comprehensive, spatially explicit model of the horse population in Australia.

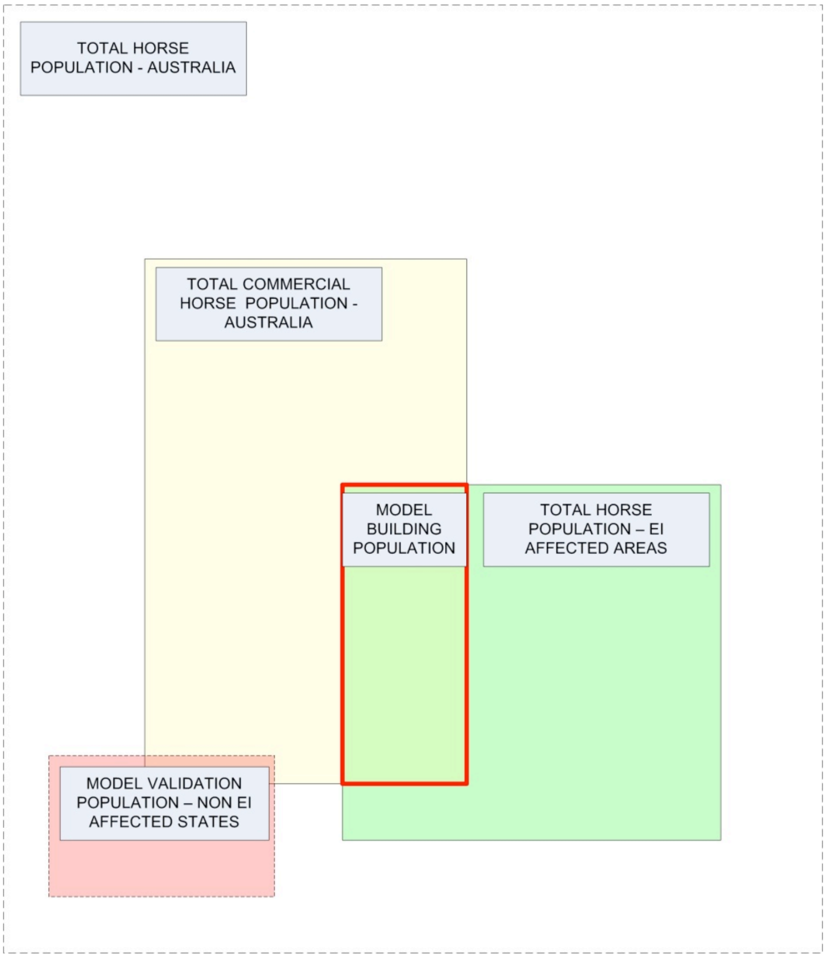

Fig 1: Different datasets used in building and validating the horse population model

3. Data Sources

Official (government) records on the numbers and locations of all premises with horses in Australia did not exist until the 2007 equine influenza outbreak. Although various Departments of Agriculture hold horse data collected at different levels of detail and spatial resolutions, and whilst Australian census data exist on "commercial" horses, other types of horses such as pleasure / backyard horses and those domiciled at hobby farms do not have their locations systematically collected and recorded. During the EI outbreak, veterinary health authorities compiled a database of all horse premises in affected areas. The objective of the database was to provide contact details to assist the disease management process (e.g., vaccination). Although the database was not collected specifically to feed into predictive disease models, it can provide an indicative idea of the numbers and locations of horse premises in New South Wales and Queensland. Records for the database were largely sourced from four external databases[1]:

1. Rural Lands Protection Board database;

[1] EI post outbreak data analyses and modelling workshop, Department of Agriculture, Fisheries and Forestry-Tuesday 29 July 2008.

2. Australian Horse Industry Council Database;
3. Equine Influenza Registration Database;
4. ANEMIS database[2].

4. Uses/benefits of the model:

The spatial distributions of animal populations provide decision makers with valuable information such as the locations of the population at risk in cases of disease outbreaks or other catastrophes (e.g., bushfires).

In the case of a potential or actual widespread disease outbreak (e.g., the 2007 EI outbreak), the availability of a model of the spatial distribution of the horse population is a critically important input to simulation models of the spread of that disease. Such modelling predictions are used to: guide decision makers and evaluate mitigation strategies prior to the outbreak (Durand and Mahul, 2000; Ward et al., 2007) and to inform response strategies during the outbreak. These predictions also help answering many questions that may be of interest to policy and decision makers either before or during an outbreak.

5. References

Berke O, 2004, Exploratory disease mapping: kriging the spatial risk function from regional count data. *International Journal of Health Geographics*, 3:18.

Bithell J, 2000, A classification of disease mapping methods. *Statistics in Medicine*, 19:2203-2215.

Buckland ST and Elston DA, 1993, Empirical models for the spatial distribution of wildlife. *Journal of Applied Ecology*, 30:478–495.

Craig MH, Sharp BL, Mabaso MLH and Kleinschmidt I, 2007, Developing a spatial-statistical model and map of historical malaria prevalence in Botswana using a staged variable selection procedure. *International Journal of Health Geographics*, 6:44.

Diggle PJ, 2000, Overview of statistical methods for disease mapping and its relationship to cluster detection. In: *Spatial Epidemiology: Methods and Applications* Edited by: Elliot P, Wakefield JC, Best NG, Briggs DJ. Oxford University Press, Oxford, 87-103.

Durand B and Mahul O, 2000, An extended state-transition model for foot and mouth disease epidemics in France. *Preventive Veterinary Medicine*, 47:121–139.

Fotheringham AS, Brunsdon C and Charlton M, 2002, *Geographically Weighted Regression, the analysis of spatially varying relationships*. John Wiley & Sons Ltd., West Sussex, England.

Goovaerts P, 2006, Geostatistical analysis of disease data: accounting for spatial support and population density in the isopleth mapping of cancer mortality risk using area-to-point Poisson kriging. *International Journal of Health Geographics*, 5:52.

Griffith DA, 2005, A comparison of six analytical disease mapping techniques as applied to West Nile Virus in the coterminous United States. *International Journal of Health Geographics*, 4:18.

[2] The Animal Emergency Management Information System (ANEMIS) software is a relational database system designed to store and retrieve information about disease control activities carried out at a local or wider level in Australia.

Highfield L, Ward MP and Laffan SW, 2008, Representation of animal distributions in space: how geostatistical estimates impact simulation modelling of foot-and-mouth disease spread. *Veterinary Research*, 39:17.

Meade, M, and Earickson, RJ, 2005, *Medical Geography, Second Edition*, Guilford Press, New York.

Rossi RE, Dungan JL and Beck LR, 1994, Kriging in the shadows: geostatistical interpolation for remote sensing. *Remote Sensing of Environment*, 49:32–40.

Ward MP, Laffan SP and Highfield LD, 2007, The potential role of wild and feral animals as reservoirs of foot-and-mouth disease. *Preventive Veterinary Medicine*, 80: 9–23.