PRELIMINARY SPATIAL ANALYSIS OF HENDRA DISEASE OUTBREAKS IN SOUTH EAST QUEENSLAND

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Abstract: Hendra Virus was first reported in the suburb of Hendra, Brisbane in 1994. It is proven to be fatal to both humans and equine with the first outbreak resulting in the death of 13 horses and a trainer. Since then, there have been several other outbreaks reported across Queensland, from Cairns to the New South Wales border at Murwillimbah. Due to the frequent incidents of the virus outbreak, the Queensland Government (Department of Agriculture, Fisheries and Forestry) stated that there is a pressing need for current research on the spatial and temporal occurrences of the virus infections (DAFF 2012). This paper presents an overview of the research and the preliminary results of the relationship between the Hendra disease outbreaks and the roosting sites of flying-foxes in the South-east Queensland. The results show a strong relationship (92% of the incidents) between temporary and seasonal roosting sites (rather than the permanent continuous roosting sites) and the outbreak locations. This finding suggests the need for detailed cluster analysis and regression models to identify the risk factors for the spread of the disease.

Introduction:

Hendra Virus is considered as one of the rarest diseases in the world. The scientific evidence suggests flying foxes are the host of the Hendra virus, and the susceptible horses get infected by the virus, resulting in a 70% mortality rate (CSIRO 2011). There are strong evidences suggesting the bat to-horse to-human transmission of virus but there are no evidences suggesting the bat-to-human, human-to- human or human-to-horse transmissions (Edmondston & Field 2009, 1). As there are subsequent incidents reported time to time since the outbreak in 1994, the government announced a pressing need for current research on the spatial and temporal occurrences of the virus outbreaks and further study into ecological & environmental factors causes of the disease (DAFF 2012).

The introduction and implementation of GIS technology in public health and epidemiology benefits in analysing the prevalence and geographic distribution of a disease outbreak in a space-time sense (Lawson & Williams 2001, 107). GIS technology is being widely used for disease monitoring, research hypotheses generation and identifying populations at risk for its high capability in data interpretation, manipulation and modelling (Seng et al 2005, 2 and Gupta et al 2003, 1). GIS serves as an effective tool for spatial analysis, modelling and visualisation of epidemiological and environmental data; and recent studies have shown significant and increasing use of GIS applications in public health and epidemiology (Shittu et al 2010, 152, Busgeeth & Rivett 2004, 10, and Gupta et al 2003, 1). The powerful analytical modelling and mapping capabilities of GIS can serve as a good decision-support and decision-making tool for disease investigations, monitoring, simulation, predictions, preventions and resource allocations (Davenhall 2002).

In the case of rare outbreaks like the Hendra Virus, GIS is a vital tool to identify the main factors (geographical, environmental and other factors) of disease transmission, for disease monitoring, identifying at-risk populations, producing prediction models and generating warning systems according to spatial distributions. GIS is a great source to plan and implement the public health surveillance activities by determining the spatial trends. Due to its ability to identify and map environmental factors associated with disease vectors, GIS is increasingly important in infectious and vector-born disease surveillance (Stone 2001) and in analysing the spatial patterns by employing various techniques. Investigating potential clusters with an appropriate spatial technique(s) could help in identifying the high risk groups and implementing appropriate public health management practices.

A simple spatial analysis technique has been incorporated in this paper to analyse the distribution of the flying-fox roosting sites and the outbreak events across the study region. Buffer analysis revealed a strong spatial relationship between outbreak sites and presence of flying-foxes. This preliminary study concentrates on investigating, analysing, and visualizing Hendra Virus outbreak in the study area using GIS techniques. However, the aim of the PhD research project is to produce a feasible and effective spatio-temporal regression model that can predict and forecast the disease outbreaks.

Study Area:

The study area for this research is South-East Queensland. There are 11 outbreak incidents recorded in the study area over the period of time. South East Queensland is classified as an interim Australian bioregion, which contains of 11 city and regional councils (Queensland Government 2009). Figure 1 shows the map of the study area.

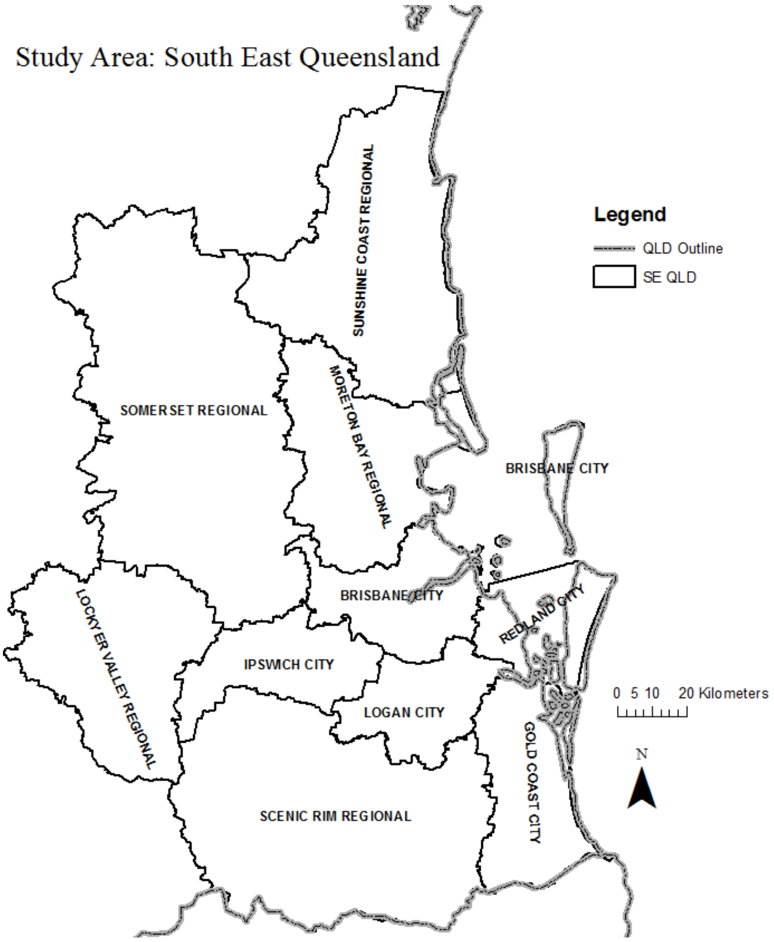

Figure 1: Map of South East Queensland.

Data:

Figure 2 shows the Hendra Virus incidents in the study region that are used in determining the preliminary spatial relationships and disease patterns.

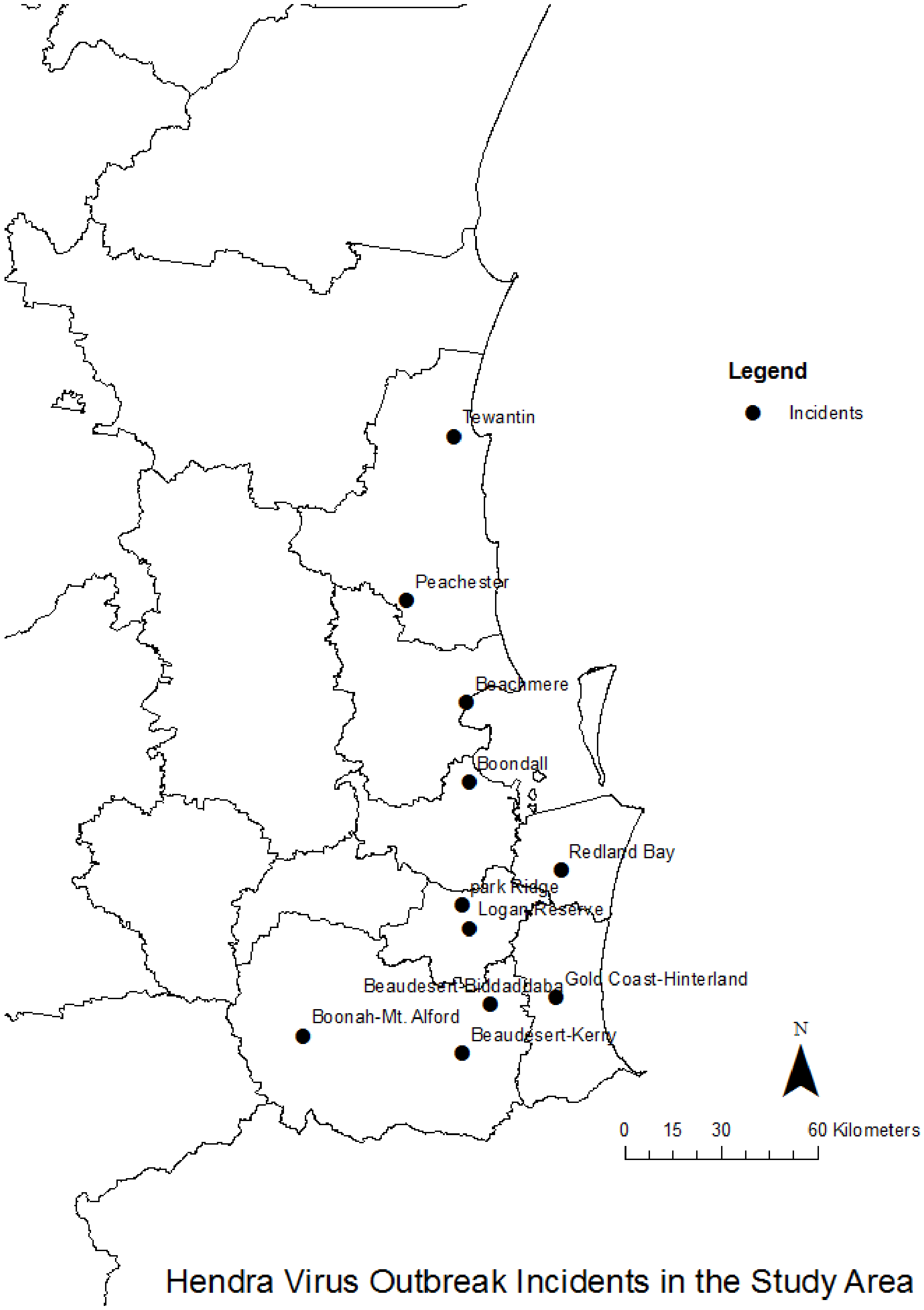

Figure 2: Hendra virus outbreak incidents in the study area.

The flying-fox roosting sites are classified into six categories – permanent continuous use, permanent seasonal use, temporary occupied, temporary unoccupied, abandoned and destroyed by the Department of Environment and Heritage Protection (EHP). Table 1 explains the roost classification criteria.

Camp type	*Status*	*Description*
Permanent	continuous use	90% of all records include the presence of flying-foxes Roost has been known for 2 years or more
	Seasonal	80% of all records include the presence of flying-foxes Roost has been known for 2 years or more
Temporary	Occupied	Roost doesn't satisfy permanent classification. Most recent record includes the presence of flying-foxes
	Unoccupied	Roost doesn't meet permanent/abandoned/ destroyed category. Most recent record has absence of flying-foxes
Abandoned	-	Roost on database but no record of use in the last 5 years
Destroyed	-	This would be manually entered based on the vegetation being destroyed either legally or illegally

Table 1: Description of the status of flying-fox roosting sites. (Source: EHP)

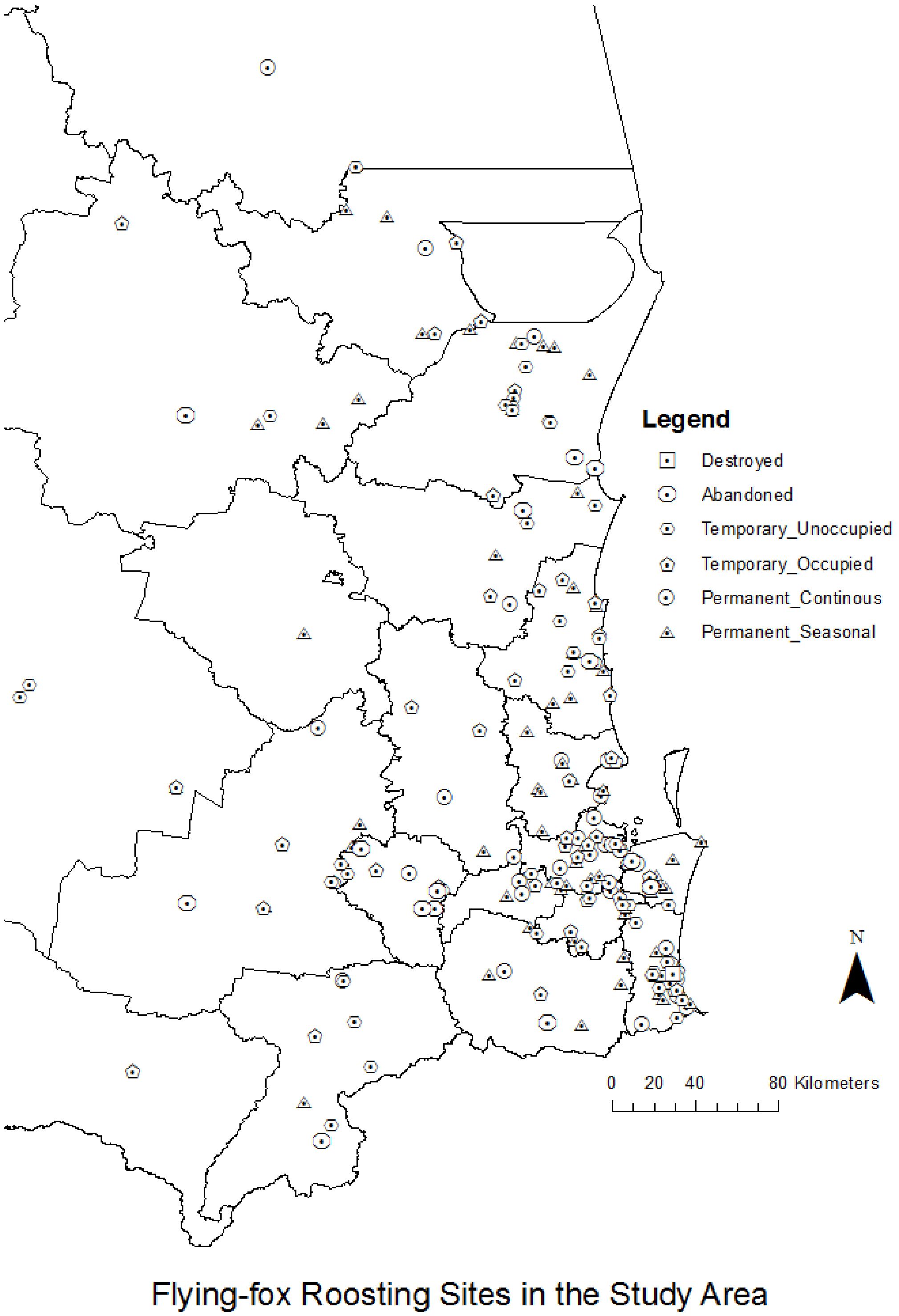

Figure 3: Flying-fox roosting sites in the study area.

Figure 3 shows the flying fox roosting sites present in south east Queensland.

Analysis:

A buffer analysis was carried out on the Hendra Virus outbreak locations with a 20 kilometre radius to determine the presence of the roosting sites within the outbreak region. The specific radius has been used after the study of the flying-fox characteristics (Wildlife Preservation Society of QLD 2013) and their travel distances 'foraging range'. The forage range for the four types of flying-foxes – black, grey-headed, little red and spectacled flying-foxes vary. Black flying-fox groups travel up to 50 kilometres from their camps to foraging areas and use the same camp for many years, whereas little-red flying-foxes and spectacled flying-foxes only travel 20–30 kilometres from camp to feed. Grey headed flying-foxes nightly feeding range is 20-50 kilometres from their camps. The minimum home range distance is used for initial buffer analysis. The study area has all four types of mainland species present in Australia and there is no scientific proof of which species carry Hendra virus.

The roosting site data has been further divided according to the status of the individual site for better understanding. Abandoned and destroyed sites are not considered for the initial analysis. Figure 4 shows the significance presence of the roosting sites in the buffer range and the presence of permanent seasonal sites in almost every incident's buffer range. The statistics are as follows:

Table 2: The percentage of the roosting sites in each category.

Status	*Percentage of roosting sites*
Permanent Seasonal Use	30.98%
Temporary Unoccupied	23%
Temporary Occupied	22.53%
Permanent Continuous Use	15.95%
Abandoned	7.04%
Destroyed	0.5%

Figure 4: A 20-kilometres radius buffer of the outbreak incidents.

A further analysis of 10 kilometre radius buffer is conducted on the temporary and permanent seasonal sites (Figure 5). It is easy to determine from Figure 5 that these sites display a stronger spatial relationship to outbreak incidents as approximately 92% of the incidents have one or both of these two site types in their buffer range.

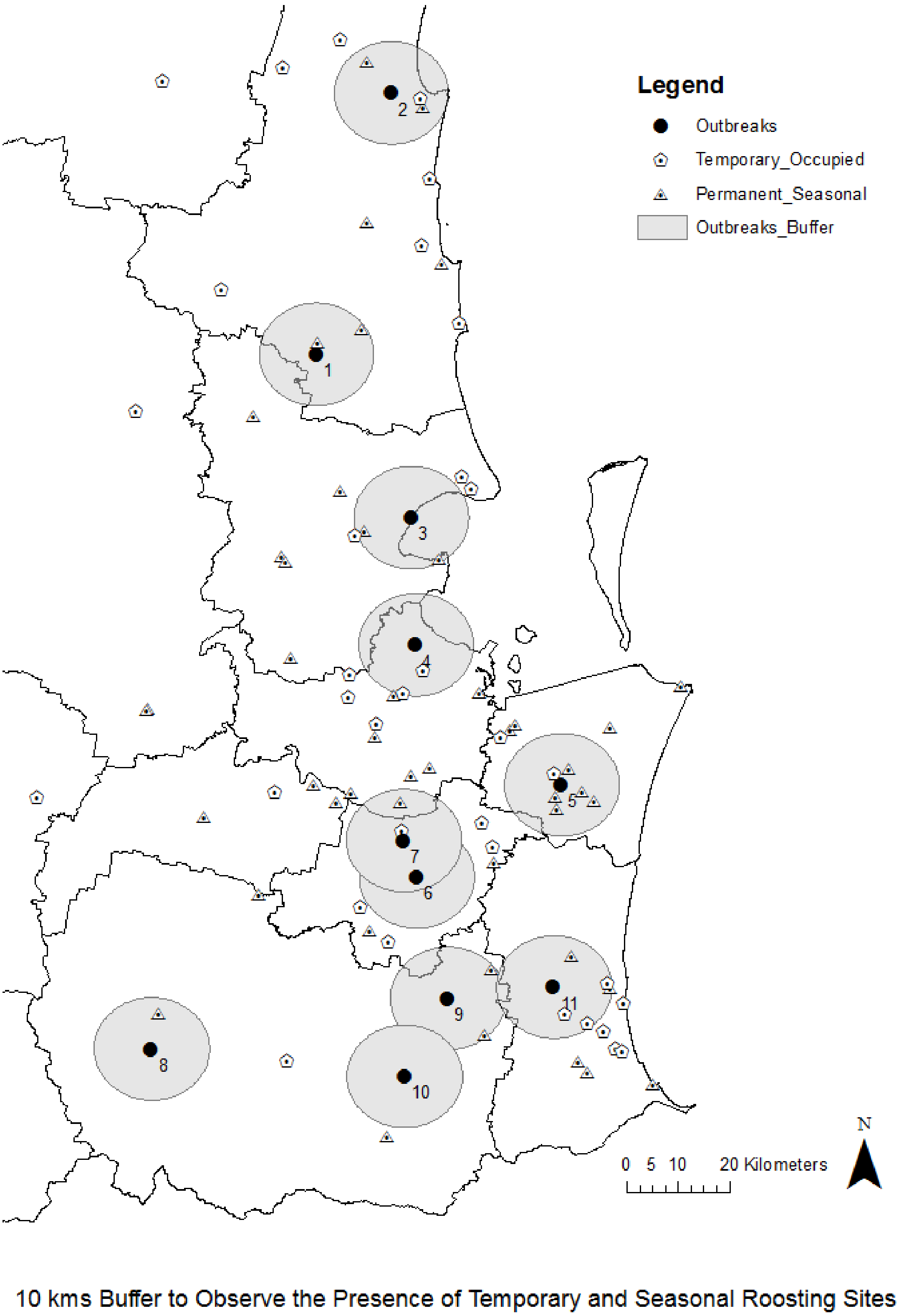

Figure 5: A 10-kilometres buffer with respect to temporary and seasonal roosting sites.

Figure 6 shows a 10-kilometres buffer of the incidents. Permanent continuous roosting sites fall within the buffer in less than half of the incidents suggesting a lower probability.

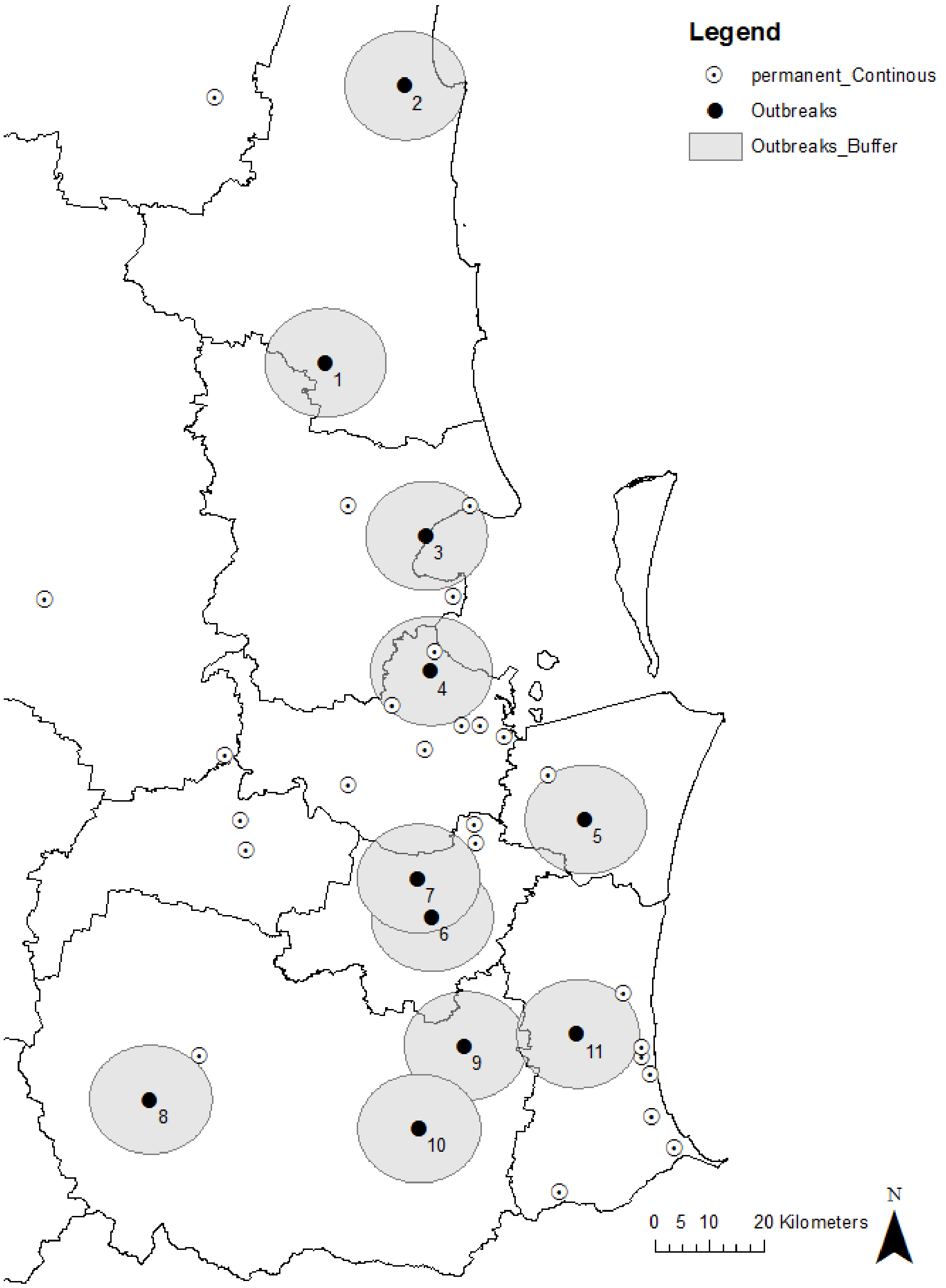

Figure 6: A 10-kilometres buffer with respect to permanent continuous roosting sites.

Results:

The preliminary results show a strong relationship between the outbreak events and the existence of temporary and seasonal flying-fox roosting sites within a 10km range. But very few disease outbreak incidents have a permanent roosting site in their buffer range. The results provide a strong case for research into the seasonal behaviour of flying-foxes, particular in breeding season. . The analysis shows that variables such as species, breeding times, seasonal changes, equine data, and environment aspects such as types of vegetation, heights of the trees and catchments could provide suitable factors for the determination of detailed cluster information.

Future Work:

The next stage of the research includes detailed cluster analysis based on individual factors such as flying-fox types and their characteristics, vegetation types, breeding times and seasons of the outbreaks. However, the variables for a forecasting model would remain the same or they may be modified when the original analysis is done according to the results produced by the spatial regression techniques. The accuracy of the model generated, efficiency of these parameters as significant factors and confidence levels of the above parameters would play important roles in considering them in a forecasting model. The research will incorporate and implement an accurate combination of parameters/factors to yield the most suitable predictive model for the Hendra virus outbreaks in the study area.

Conclusion:

This paper presented an overview of the research on the Hendra Virus outbreak events, the data collected so far and the preliminary research results. A straightforward spatial analysis technique has been conducted on the available data to provide a direction for further in-depth analysis. The research found that the significant presence of temporary and seasonal flying-fox roosting sites within the buffer range provides a strong basis for detailed cluster analysis and regression models.

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