Report Cover Page

ACERA Project
1004

Title
Post-border surveillance techniques: review, synthesis and deployment

Author(s) / Address(es)
Dr Susie Hester, School of Business, Economics and Public Policy, University of New England, Armidale NSW
Dr Graeme Garner, Director, Animal Health Epidemiology Program, Animal Health Policy Branch, Department of Agriculture, Fisheries and Forestry, Canberra, ACT

Material Type and Status (Internal draft, Final Technical or Project report, Manuscript, Manual, Software)
Final Project Report

Summary

This report summarises Phase 2 of *Post-border surveillance techniques: review, synthesis and deployment* in which aspects of general surveillance were investigated. This type of surveillance relies on members of the public, industry groups, plant or animal health professionals and their networks, and/or laboratories reporting suspected cases of plant or animal disease or the presence of a pest at their discretion. The research consisted of a review of new technologies for rapid, field-based (point-of-care) testing in the detection of emergency animal diseases and three case studies:

1. The first case study assessed the requirements for Australia's ongoing surveillance for detection of ruminant diseases by (i) identifying and ranking factors that most influence the probability of early detection of various significant diseases of ruminants; and (ii) outlining surveillance programs that provide options for the early detection of diseases for different levels of confidence.

2. The second case study assessed the value of wildlife surveillance data gathered through zoo-based veterinary hospitals in Australia through (i) a one-year trial to integrate zoo-based wildlife health information reporting formally into the national surveillance system; and (ii) an analysis of the data obtained.

3. The third case study investigated the value of engaging the community in biosecurity surveillance. It reviewed the utility of data provided by the community in existing pest or disease eradication programs. This case study aimed to provide guiding principles on measuring (i) the likelihood that particular members of the community will detect a new or emerging pest or disease; and (ii) the reliability of reports submitted by particular members of the community.

ACERA Use only	Received By:	Date:
	ACERA / AMSI SAC Approval:	Date:
	DAFF Endorsement: ( ) Yes ( ) No	Date:

Post-border surveillance techniques: review, synthesis and deployment

ACERA Project No. 1004 B

Susan Hester, University of New England
Graeme Garner, Department of Agriculture, Fisheries and Forestry

Final Project Report

28 June 2012

Acknowledgements

Table of contents

List of Figures

1. Executive Summary

A variety of available methods and tools can aid biosecurity managers with the planning, implementation and evaluation of post-border surveillance activities and these tools were reviewed in Phase 1 of this project (Hester *et al.* 2010). Among the methods discussed in the review was general surveillance, also known as passive surveillance or community surveillance. This type of surveillance relies on members of the public, industry groups, plant or animal health professionals and/or laboratories reporting suspected cases of plant or animal disease or the presence of a pest at their discretion. Although public and industry funds are routinely invested in collecting surveillance information from these diverse sources, few studies have investigated the collection, use or value of such surveillance information.

The purpose of the second phase of this project was to investigate and evaluate how general surveillance information may be captured and used in a variety of circumstances of relevance to biosecurity in Australia. Stage 1 of Phase 2 reviewed the use of new technologies for rapid, field-based testing ('point-of-care' or 'penside' tests) in the early detection of major emergency animal diseases. When used correctly these tests have the potential to save money and time in surveillance of certain animal diseases and this review explores the appropriate use of such tests to ensure early detection and reporting of major emergency animal diseases.

Stage 2 of Phase 2 used three case studies to assess the value of general surveillance:

1. The first case study assessed the requirements for Australia's ongoing surveillance for detection of ruminant diseases;
2. The second case study assessed the value of wildlife surveillance data gathered through zoo-based veterinary hospitals in Australia; and
3. The third case study investigated the value of engaging the community in biosecurity surveillance using data from red imported fire ant eradication program in Queensland.

This report fulfils the requirements of Stage 3 of Phase 2 by synthesising the findings of the review of new technologies and the case studies.

2. Introduction

The primary purposes of post-border surveillance are to provide evidence of absence of a pest or disease, and where a pest or disease is present, to determine prevalence or distribution of pests and diseases and any changes that may have occurred. From a biosecurity perspective, the desired outcome is a reduction in the likelihood that particular pests and diseases will become established or spread in a country or region, particularly those pests and diseases that have the potential to cause considerable harm to agricultural production, trade opportunities, human health, or valued ecosystems.

A variety of available methods and tools can aid biosecurity managers with the planning, implementation and evaluation of post-border surveillance activities and these were reviewed in Phase 1 of this project (Hester *et al.* 2010). General surveillance, as discussed in the Review, is an important part of post-border pest and disease management. . This type of surveillance (also known as passive surveillance and encompassing community surveillance) relies on members of the public, industry groups, plant or animal health professionals and their networks, and/or laboratories reporting suspected cases of plant or animal disease or the presence of a pest at their discretion. General surveillance complements the active surveillance undertaken by pest management agencies and informs the treatment of the pest or disease as shown in Figure 1. General surveillance cannot be controlled directly, rather, it is activated by community engagement programs which might involve information and education campaigns, media exposure about the incursion or maintenance of telephone hotlines for reporting. The effective of these activities will depend on a range of factors,
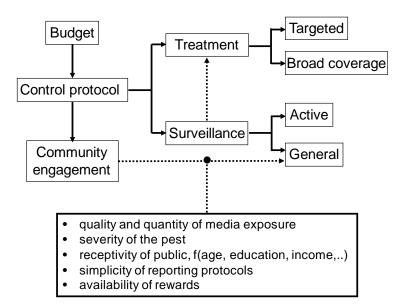

Figure 1. Diagramatic representation of how general surveillance fits into the pest/disease management problem (Source: Cacho *et al*. 2012)

including attributes of the pest, individual attributes of people who receive the information and attributes of the areas in which people live (Cacho *et al.* 2012).

Examples of general surveillance include:

- reports on the disease status of livestock may be collected from producers, abattoir staff or private veterinarians and might be derived from simple observation, from the results of laboratory tests, or from the results of new rapid, field-based tests for major emergency animal diseases;

- reports on the disease status of wildlife could come from zoo-based veterinary hospitals which regularly treat injured wildlife. In the past, information from this source has led to the detection of diseases that are potential threats to human and livestock health; and

- reports from members of the public are often responsible for initial detections of new pests and diseases (e.g. red imported fire ant in Queensland, European wasp in Western Australia) and for detections of new loci of pests and diseases that are being managed in control or eradication programs (e.g. tropical weeds in Queensland).

The purpose of Phase 2 of this project was to investigate and evaluate how general surveillance information is captured and used in a variety of circumstances relevant to biosecurity in Australia. Although public and industry funds are routinely invested in collecting surveillance information from diverse sources, few studies have investigated the collection, use or value of such surveillance information. Studies that have assessed some aspect of passive surveillance include Hernandez-Jover *et al.* (2008) where detection sensitivity of foot and mouth disease in pigs post-farm-gate was assessed; Hammond (2010) who demonstrated that passive surveillance can provide significant confidence in freedom from karnal bunt (*Tilletia indica)* in wheat; and Froud *et al.* (2008) who analysed the value of New Zealand's exotic disease and pest emergency hotline. Several studies have demonstrated the value of including general surveillance in the management of invasive species using a spatial model (Hester and Cacho 2012; Cacho and Hester 2011; Cacho *et al.* 2010 and Spring *et al.* 2010), although lack of data meant parameter values were hypothetical albeit plausible. Improving our understanding of general surveillance should allow improved targeting of resources to produce the greatest reduction in the likelihood or consequences of a pest or disease outbreak, with the least cost to the community.

In Stage 1 of Phase 2 the use of new technologies for rapid, field-based testing ('point-of-care' or 'penside' tests) in the early detection of major emergency animal diseases was reviewed.

Stage 2 of Phase 2 used three case studies to assess different aspects of general surveillance. Each case study illustrates the value of surveillance information as it applies to a particular industry or community sector:

- the first case study assessed the requirements for Australia's ongoing surveillance for detection of ruminant diseases by (i) identifying and ranking factors that most influence the probability of early detection of the various significant diseases of ruminants; and (ii) outlining surveillance programs that provide options for the early detection of diseases for different levels of confidence.

- the second case study assessed the value of wildlife surveillance data gathered through zoo-based veterinary hospitals in Australia through (i) a one-year trial to integrate zoo-based wildlife health information reporting formally into the national surveillance system; and (ii) an analysis of the data obtained.

- the third case study investigated the value of engaging the community in biosecurity surveillance by reviewing the utility of data provided by the community in existing pest or disease eradication programs. This case study aimed to provide guiding principles on measuring (i) the likelihood that particular members of the community will detect a new or emerging pest or disease; and (ii) the reliability of reports submitted by particular members of the community.

This report fulfils the requirements of Stage 3 of Phase 2 by synthesising the findings of the review of new technologies and the three case studies. It provides recommendations from each subproject and among these are guiding principles for collection and use of information to improve the cost-effectiveness of surveillance activities.

3. The use of rapid, field-based (point-of-care) tests in the detection of emergency animal diseases

3.1. Background

Until relatively recently, diagnosis of emergency animal diseases (EADs) involved taking a sample from an animal and sending the sample to a specialised laboratory for diagnosis, a process that could take several weeks. Today, many of those testing techniques have been adapted or are in the process of being adapted for use in the field, changing the way that diagnostic tests are viewed and performed. These rapid, field-based tests are known as 'point-of-care' tests (POC) or 'pen-side' tests, and are performed at or near the animal from which a sample has been collected. Importantly, diseases that were once detected only by culture (and some that could not even be cultured), and that previously took days or weeks to isolate and identify, can now be identified in a few hours and, in some cases, a few minutes, with these POC and near-POC tests.

As more POC tests become available, and particularly if they are in a format suitable for use by producers, they will create a number of risks that will need to be managed. These include (from Sims 2012):

- the many factors that can lead to misclassification of animals as infected or not infected;

- failure by private users to report results of POC tests for EADs (positive and negative) or to send samples for confirmation to veterinary authorities; and

- premature announcement of incorrect results.

These risks, many of which also apply to existing tests, need to be balanced against the advantages offered by POC tests especially in the management of outbreaks once they occur. In this project, these POC tests and their current and future uses were reviewed. The following summary of the review draws heavily on the project report (Sims 2012).

3.2. Method

Various types of POC tests were reviewed in this project. The three main test types that are currently used, or that are expected to be used in the near future at POC for infectious diseases are:

- tests for antibody;

- tests for antigen detection; and

- tests based on amplification and detection of microbial nucleic acids usually following amplification.

The review focused on the use of POC and near-POC testing for the diagnosis of EADs, with an emphasis on new technologies and their application for EADs of production animals. The review provided further information on POC tests for five important EADs:

- avian influenza, including highly pathogenic avian influenza;

- foot-and-mouth disease (FMD);

- classical swine fever;

- anthrax; and

- bovine spongiform encephalopathy.

These were chosen as examples of different EADs and pathogen types where POC tests are available or are being developed.

3.3. Recommendations

It is difficult to predict which of the specific technologies available now or undergoing development will become commercially available as POC tests for EADs. A crucial factor in this development is the presence of a suitable market for the end-product. Despite the economic importance of some EADs, demand for tests designed to detect them is often low until an outbreak occurs. It is expected that in the future, once POC tests become widely available and affordable, some producers will use these tests to assess the health status of their animals.

When used correctly these tests have the potential to save money and time in surveillance of certain animal diseases and the review explored the appropriate use of such tests to ensure early detection and reporting of major emergency animal diseases. The areas where suitable POC tests could be deployed advantageously for EADs in Australia include (from Sims 2012):

- for pre-outbreak surveillance and preliminary diagnosis, with some testing conducted by producers using multiplexed test kits (these test for a range of pathogens simultaneously on one sample);

- to test the index case for disease outbreaks in remote locations where delays in sample submission to a laboratory beyond 24 hours are expected;

- as a triage tool for determining which samples to submit to a laboratory from an index farm;

- to support decisions on management of diseases of potential public health significance, especially if a positive result is obtained using a highly specific test;

- to assist in taking early decisions on the fate of animals on dangerous contact premises or other high risk premises within the restricted area around the index case, including the use of POC tests to detect latently infected animals or confirm the status of animals with equivocal clinical signs;

- for surveillance and investigation of farms in the restricted area and control area during the response to an outbreak;

- as a tool for assessing integrity of zones and compartments;

- to assist in assuring the safe movement of animals or product during an outbreak; and

- to demonstrate freedom from infection.

If POC tests are to be used during an outbreak or suspected outbreak, protocols for use of these tests must be included in operational manuals and the required test kits and equipment will have to be stockpiled in appropriate locations. The costs of this stockpiling and the benefits of early diagnosis and reduced risk of laboratory overload need to be weighed against the costs of sending samples to a laboratory for testing.

Use of POC tests offers advantages but also creates a set of risks that have to be managed, some of which are unique to POC tests. Given the small number of POC tests available for EADs at present, this process is relatively easy to regulate and manage. It is expected to become more difficult once simple, user-friendly, accurate, multiplexed POC tests for livestock diseases become available and are used by producers.

4. Case study 1: Surveillance needs for early detection of livestock diseases in Australia

4.1. Background

Australia has a favourable animal health status, being free of many of the diseases of concern in other parts of the world. Its animal health surveillance system relies on effective interactions and cooperation between a range of stakeholders, including state and territory governments, the Commonwealth Government, Animal Health Australia, peak industry bodies, livestock owners and industry workers, and the general public (Animal Health Australia 2011).

Both *active* and *general* surveillance are important parts of animal health surveillance in Australia. Active surveillance involves deliberate surveys or special purpose programs for the detection of one or more diseases; and general surveillance refers to the reporting of animal health information by those coming into contact with animal industries, including animal owners, producers, processors and veterinarians.

The general surveillance system for animal health begins with a producer or other animal owner or worker noticing signs disease in the animals under his or her care and reporting this to an appropriate animal health professional. This should lead to investigation by private or government veterinarians, collection of appropriate samples and testing of samples in a diagnostic laboratory. For a disease of concern, the results of any positive tests and other relevant information are collated and reported to the jurisdictional Chief Veterinary Officer, so that appropriate action can be taken.

Australia's Animal Health Committee (AHC) identified the need to review Australia's general surveillance system to develop a consistent national approach. The General Surveillance Epidemiology Working Group[1] (GSEWG) was formed at the request of AHC to take a fresh look at requirements for Australia's ongoing general surveillance system for detection of significant diseases, unconstrained by current and historical capacities and practices among jurisdictions.

This ACERA subproject is contributing to the activities of the GSEWG. The following summary of the research draws heavily on the project report (Garner 2012).

---

[1] Members of the CSEWG working Group were Tony Higgs (Chair), Department of Agriculture and Food Western Australia, (DAFWA); Malcolm Anderson, Department of Primary Industry and Resources (South Australia); Mark Cozens, Department of Employment, Economic Development and Innovation (Queensland); Iain East, Australian Government Department of Agriculture, Fisheries and Forestry Australia (DAFF); Graeme Garner, DAFF; Ian Langstaff, Animal Health Australia; Tony Martin, DAFWA; Roger Paskin, Department of Primary Industries (Victoria); Bill Scanlan, DAFF; Evan Sergeant, AusVet Animal Health James Watson, Australian Animal Health Laboratory; and Rachel Wicks, DAFF.

4.2. Objectives

The ultimate aim of the CSEWG project is to find ways to allocate limited surveillance resources according to 'risk profiles' at a regional scale, rather than the traditional approach of operating along jurisdictional boundaries. More specifically, the working group's objectives were to:

- identify and describe the risk of occurrence of significant diseases in Australia on a regional basis;

- evaluate the actual or potential contribution of all general surveillance activities to the detection of significant diseases in each region; and

- outline possible future surveillance programs, which should involve consideration of alternative options and approaches, rather than simply modifying existing jurisdictional surveillance programs.

4.3. Method

Given that general surveillance requirements were to be assessed on a regional basis rather than by using state and territory boundaries, the first task was to divide Australia into 12 appropriate livestock production regions on the basis of geography, livestock production and marketing systems (Figure 2). Next, a subset of significant diseases from the Australian notifiable diseases list was selected for analysis. The diseases selected were foot and mouth
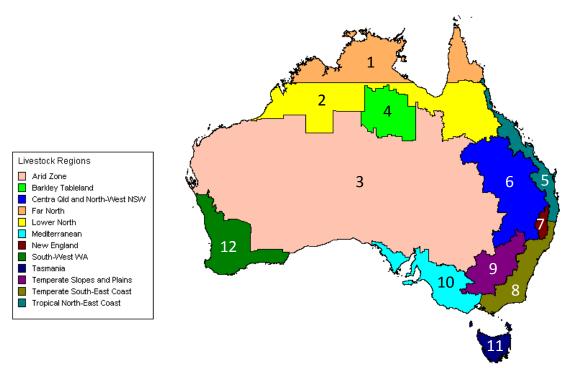

Figure 2 Livestock production regions used in the analysis of general surveillance (source: Garner 2012)

disease (FMD), rabies, bluetongue disease, Hendra virus disease, sheep pox, highly pathogenic avian influenza, classical swine fever and Japanese encephalitis.

The overall likelihood of disease occurrence was split into the likelihood of introduction, establishment and spread. To assess the relative risks across Australia a spatial approach was required, where spatial data layers would be used to represent risk factors that influence the likelihood of introduction, establishment and spread. The Multi-Criteria Analysis Shell spatial analysis system (MCAS-s[2]) was the spatial tool used for the analysis. This tool allows the application of spatial multi-criteria analysis to a range of problems that involve a choice between multiple alternatives where benefits and costs may be in non-monetary units, where alternatives have both qualitative and quantitative dimentions and where multiple stakeholders are present. Weighting and combining data to construct map layers is a critical part of using MCAS-s (Lesslie *et al.* 2008).

For the current analysis, primary raster data layers representing risk factors (such as farm numbers, distance from introduction points, presence of vectors, etc.) were produced and prepared for use in MCAS-s. Potential pathways for both introduction and establishment and spread were identified for each disease, and data layers representing the factors contributing to each pathway were assembled. A likelihood score was estimated for each grid cell for each pathway, and the pathways were combined using weightings to reflect relative importance of each pathway to produce likelihood scores for introduction, or for establishment and spread. These were then combined to calculate an overall likelihood score of an outbreak for each grid cell, which were displayed as 'national disease likelihood maps'.

To produce an overall assessment of relative risk of occurrence of any significant disease, the final likelihood maps for each disease were grouped according to their likely consequences (FMD disease on its own, zoonotic diseases grouped together, 'other' diseases grouped together) and with the weightings of 50 for FMD, 5 for zoonotic and 1 for others as a crude indication of relative consequences, on advice from Animal Health Committee.

The MCAS-s program was also used to assess the distribution of current surveillance activities in each region. Primary data layers were constructed for government veterinary disease investigations, distance from government veterinary offices, and distance from private veterinary practitioners and wildlife disease investigations. These were combined using MCAS-s to produce a map of current surveillance coverage. This was compared to the combined disease risk map to see how current surveillance related to the risk areas.

---

[2] MCAS-S was developed by ABARES to analyse, combine and present complex spatial information in a transparent and readily understood manner. It can be downloaded free from http://www.daff.gov.au/abares/data/mcass

To assess the effectiveness of current general surveillance, the working group developed a *general surveillance assessment tool* that could be used in each region to assess the likelihood and speed of reporting of specific significant diseases. The tool was created as a Microsoft Excel application using the PopTools add-in for stochastic simulation. The user is required to answer a series of questions on the likelihood or frequency of producers, abattoir inspectors or saleyard inspectors recognising and reporting disease outbreaks. The tool uses these inputs and in-built datasets to calculate the probability that a single infected farm will be identified and reported to the relevant jurisdiction's Chief Veterinary Officer (the single farm sensitivity), the likely time taken for notification if it does occur, and the number of infected farms that would need to be present to be 95% confidence that at least one would be detected. A workshop was held to train representatives from each jurisdiction in the use of the tool. They were then asked to use the tool to assess the performance of the general surveillance system for FMD in the regions within their jurisdiction, collaborating with representatives from other jurisdictions when necessary. FMD was used as the indicator disease for this assessement.

Modelling studies were conducted to assess the effects of delays in detection of disease. Datasets were assembled for each region and included farm and animal numbers, management practices (such as frequency and timing of turn off of animals), locations of saleyards, and weather station data. FMD was again chosen as the indicator disease, and the AusSpread FMD model (Garner and Beckett 2005) was used to simulate an outbreak over five weeks for each of the 12 regions. To quantify the effects of delays in detection the key outputs of the modelling were size of outbreaks within regions and number of high risk movements to other regions. The results from the general surveillance assessment tool and the modelling studies were then used to estimate the likely size of an outbreak of FMD at earliest time of expected detection for each region under current conditions.

Finally, each region was ranked for three criteria – likelihood of introduction, establishment and spread; surveillance sensitivity; and potential extent of spread. Based on this ranking, an assessment of the relative vulnerability of each region to FMD was made.

4.4. Outcomes

Using MCAS-s, likelihood scores for introduction, for establishment and spread were combined to calculate an overall likelihood score of an outbreak and are displayed as national likelihood maps. An example of the maps for bluetongue and Japanese encephalitis are shown in Figure 3. For the individual disease likelihood assessments, there were marked regional differences. In the northern regions, the vector-borne diseases such as Japanese encephalitis and bluetongue disease had the highest likelihood scores (Figure 3), whereas

Figure 3 Relative likelihood of an outbreak of (A) FMD and (B) Japanese encephalitis in Australia. Colours indicate relative risks based on likelihood scores: blue is low risk (0), red is high risk (1). Source: Garner (2012).

southern regions had higher likelihood scores for diseases such as FMD, sheep pox and classical swine fever (data not shown).

When diseases were grouped according to their likely consequences, a map showing combined disease risk was produced (Figure 4). This modelling showed the greatest risk is in regions 5, 7 and 8 along the eastern seaboard, and region 1 in the north.

Figure 4 Combined disease relative risk (FMD: zoonoses: other = 50:5:1), blue is low risk, red is high risk. Source: Garner (2012).

The assessment of general surveillance coverage showed that spatial distribution of surveillance the central and southern regions was generally appropriate. However, for regions 1 and 2 (in the north) surveillance coverage along the coastline is low (see Garner 2012 for maps of individual regions).
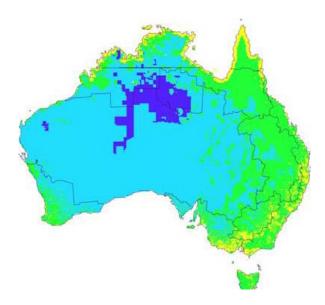
The general surveillance assessment tool showed that regions 2, 4 and 5 had the greatest single farm sensitivity for FMD, and regions 5–12 had the shortest time to reporting (see Garner 2012 for maps). Overall, region 5 performed the best and region 3 the worst. The modelling studies showed that regions 5–12 all had at least a 75% chance of FMD spreading from the first infected farm. By the expected time of detection, regions 5 and 7–12 could all be expected to have on average at least 10 infected farms, and at least one high risk contact in another region. Regions 5, 8 and 10 were judged to be the most vulnerable to FMD.

A series of surveillance 'benchmarking' studies was performed to assess the potential scale of an outbreak by the time of detection on the farm where the initial outbreak occurred. This provided the basis for identifying regions that have the greatest likelihood of outbreaks of significant diseases, and assessing both surveillance coverage and effectiveness of current surveillance efforts. The regions that are considered most vulnerable to FMD may require improvements to their general surveillance system for an outbreak to be detected early enough that it could be effectively contained and eradicated.

Garner (2012) also identified a number of issues that have arisen from this research including:

- using a regional approach: current data about livestock industries or surveillance activities are not collected on a regional basis leading to difficulties obtaining and combining data.

- assessing surveillance performance quantitatively: given that outbreaks of exotic disease are rare in Australia it is difficult to quantify what is 'enough' surveillance. It was not possible to derive a simple formula that links the regional disease profile to the optimal investment in surveillance; qualitative assessment is still required to make this link.

- the contribution of active surveillance: because this project only collected general surveillance data the important contribution of some active surveillance programs to mitigating the risk of an outbreak is not captured.

- data quality: good quality data were not available for all aspects of this analysis, particularly for the general surveillance assessment tool. These data might be available from other sources or could be generated through surveys.

- interpretation of results: it is important to note that only one indicator disease – FMD – was used in the general surveillance assessment tool and benchmarking studies. Extending the approach to other diseases would allow broader conclusions to be drawn on the effectiveness of the general surveillance system.

4.5. Recommendations

This project has resulted in new tools and innovative approaches to evaluate general surveillance for animal diseases in Australia. These approaches have been endorsed by AHC. This research has been able to identify the regions with the greatest likelihood of an outbreak of significant diseases, and the regions with the best surveillance performance (albeit only using FMD as the indicator disease).

The key recommendations (summarised from Garner 2012) are that:

- surveillance programs be regionally focussed and risk-based;
- programs to enhance general surveillance be targeted and managed on a regional basis, and based on partnerships between government, producers and service providers;
- periodic spatial likelihood assessments be undertaken, using the methods designed for this project;
- a broader range of diseases be considered for assessment using the general surveillance assessment tool;
- alternative information sources be investigated to inform the general surveillance assessment tool for each region;
- modelling studies for diseases other than FMD be considered to assist with benchmarking the results of the general surveillance assessment tool;
- sensitivity analysis be applied to the general surveillance assessment tool to identify the key steps in the reporting chain, so that investment in improvements to future surveillance programs can be appropriately targeted;
- response capacity to manage disease outbreaks in each region be evaluated, to inform the requirements of effective surveillance programs; and
- future work be considered to address the performance of the general surveillance system.

5. Case study 2: Zoo-based surveillance

5.1. Background

There is now global recognition of the role that feral and wild animals may play in spreading diseases, especially those that can be detrimental to the health of livestock and humans (Daszak *et al.* 2000). Information on the health status of feral and wild animals is required if Australia's freedom from particular diseases is to be maintained. However, adequate active surveillance of this group of animals would be a costly exercise. One potentially cost-effective way that information on the health status of wildlife can be obtained is through zoo-based veterinary hospitals that routinely treat sick and injured animals brought to them by members of the public. Results from this type of general surveillance, on the disease status of wild and feral animals, is not routinely reported to the authorities unless a notifiable disease is present (e.g. FMD, Hendra virus, avian influenza). If a notifiable disease were present, then reporting would occur via the web-enabled Wildlife Health Information System (eWHIS).

This second case study assessed the value of wildlife surveillance data gathered through zoo-based veterinary hospitals in Australia through a one-year trial to integrate zoo-based wildlife health information into the national surveillance system, eWHIS. The following summary of the research draws heavily from the reports submitted for this project (Cox-Whitton 2011; Cameron and Hutchison 2011).

5.2. Objectives

The objectives of the case study were to:

- perform a one year trial to integrate wildlife disease information from zoos into the national wildlife health information system;

- improve the information flow between zoo veterinarians and the relevant State/Territory agencies within their jurisdiction;

- collect 12 months of data on wildlife disease events presented at zoo based wildlife clinics into the central web-enabled database of national wildlife health information administered by the Australian Wildlife Health Network (AWHN), eWHIS;

- determine, through assessment of the pilot project, the potential for expansion of the program into other zoos and wildlife parks around Australia; and

- analyse the data obtained from the pilot project to assess its usefulness for informing resourcing decisions about risks of emerging diseases from wildlife and for adding value to Australia's surveillance capacity.

5.3. Collaborators

Collaborators were from AWHN, DAFF and the Zoo and Aquariam Association (ZAA)[3]. Six major Australian zoos were selected to participate in the pilot project and provided significant inkind contributions:

- Adelaide Zoo, South Australia;

- Australia Zoo, Queensland;

- Healesville Sanctuary, Victoria;

- Melbourne Zoo, Victoria;

- Perth Zoo, Western Australia; and

- Taronga Zoo, New South Wales.

5.4. Method

The one-year trial commenced 1 November 2010. From this date, the six participating zoos entered wildlife 'event' information into eWHIS from their previous month's caseloads, and continued this reporting for the duration of the pilot project. Veterinarians at each of the six zoos were responsible for coordinating the project and for data entry. Ongoing training was provided to project particpants by AWHN and the ZAA, covering the scope and intent of the project, selection of suitable events for reporting, and eWHIS data entry.

The AWHN project officer maintained detailed records of communication amongst participants, wildlife disease information that was collected as part of the project, and project activites such as training sessions and meetings.

The 12-month trial period ended on 30 October 2011 and the project was evaluated by an independent reviewer. Participants decided to continue the project until June 2012 while the outcome of the independent review was considered and while additional funding opportunities were explored. Due to interest in the project from other zoos and wildlife parks, three new participants were added — Currumbin Wildlife Sanctuary, Queensland; Sea World, Queensland; and the Territory Wildlife Park, Northern Territory.

5.5. Outcomes

Before this project, Australian zoos were reporting wildlife disease events into the national system only on an *ad hoc* basis. During the trial, details of 210 wildlife events from a total of 10 418 cases seen by the six zoos were entered into eWHIS. Of these, 61 cases were OIE (World Organisation for Animal Health)-reportable diseases including psittacine beak and feather disease (PBFD), avian chlamydophilosis, toxoplasmosis and sarcoptic mange.

---

[3] Dr Keren Cox-Witton (AWHN); Dr Rupert Woods, AWHN; Dr Tiggy Grillo, AWHN; Dr Lyndel Post, Wildlife Health and Environment Program, DAFF; Dr Andrea Reiss (ZAA); and Mr Martin Phillips, ZAA.

The pilot data contributed to Australia's OIE report and were included in several *Animal Health Surveillance Quarterly* reports. Data on PBFD were given to the Department of Sustainability, Environment, Water Population and Communities in September 2011 as background information to the PBFD Threat Abatement Plan Review.

The pilot data differed from routine eWHIS data in two respects:

- the catchment area for the pilot project appears to extend beyond that covered by the routine submissions; and

- the species' distributions, diseases, diagnoses and reporting reasons were different (Cameron and Hutchinson 2011).

5.6. Recommendations

The pilot project was evaluated independently by AusVet Animal Health Services (Cameron and Hutchinson 2011) by (i) using a stakeholder survey, discussions with pilot project leaders and coordinators; (ii) analysing the data collected during the project; and (iii) examining project logs and other project-related documentation.

The key recommendations were to continue and expand the project through finding additional funding, improve efficiency of data collection and recording, and expand the interpretation and publication of data.

6. Case study 3: Valuing community engagement in biosecurity surveillance

6.1. Background

The public can play an important role in invasive species management by reporting encounters with pests and diseases to the authorities. This type of general surveillance (often called passive surveillance or community surveillance) is activated and maintained through public awareness campaigns (community engagement) and these campaigns have become an integral part of invasion management programs even though little is known about the return on investment of these awareness activities or the reliability of reports from the public. An improved understanding of these issues would lead to improvements in the allocation of resources between to public engagement activities and the active surveillance undertaken by pest-management authorities.

This case study provides estimates of some of the factors that influence the response of the public to community engagement activities using data from eradication program for the red imported fire ant (RIFA), *Solenopsis invicta*, in Brisbane. The program is managed by Biosecurity Queensland Control Centre (BQCC) and public awareness activities play a central role in management of RIFA. The program has nine years of spatial data on searches, treatments and detections as well as whether detections resulted from active or passive surveillance. These data were made available for this case study. The following summary of the research draws heavily on the report submitted as part of this research (Cacho *et al.* 2012)

6.2. Objectives

The overarching objective of this project was to contribute towards an understanding of the value of community engagement in surveillance of invasive species, using data from one of Australia's ongoing pest-eradication programs. More specifically, objectives of this work were to:

- determine the value of passive surveillance as a component in a control protocol;

- estimate a quantitative relationship between public reports and demographic factors of households as reported in Census data; and

- explore relationships between community engagement events and public reports of suspected pest presence.

6.3. Collaborators

Collaborators were the University of New England and Biosecurity Queensland.[4]

6.4. Method

The objectives were addressed using several types of spatial and temporal analysis and a series of local case studies to provide useful insights into the value of general surveillance.

The main source of data for this case study was the Client Contact System (CCS). The CCS goes back to 2002 and contains details of all contact with the public about RIFA. The database contains the geographical location of both the person reporting and of the reported nest (not necessarily the same). It also contains follow-up information so it is possible to distinguish positive from negative samples. The CCS is a complex database that has evolved with the needs of the RIFA control program and as a result the emphasis has been on designing a practical system for entry and retrieval of information on a case-by-case basis, rather than on the ease of undertaking statistical analysis. Before any data analysis could take place a significant amount of time was devoted to data clean-up. In some cases the dataset that remained was not ideal for particular types of analysis and thus some compromises were necessary.

The CCS data provided by BQCC were organised spatially based on census collector districts and made compatible with the Australian Bureau of Statistics (ABS) Census data for 2006. These data were analysed statistically in a number of stages:

- Data compilation and aggregation to Census Collector District level (CCD, which is the ABS basic spatial unit and contains approximately 200 households).

- Data visualisation and exploratory analysis, where maps of total reports and positive reports were produced, together with maps of demographic attributes from ABS Census data.

- Spatial trends and autocorrelation were examined. Since contact, event and detection data span a nine-year time period, and Census data are for a point in time, examination of time trends in data were undertaken to identify optimum periods for analysis.

- Other statistical techniques were applied to answer specific questions.

---

[4] Professor Oscar Cacho, School of Business, University of New England; Dr Ian Reeve, Institute for Rural Futures, University of New England; Dr Jamie Tramell, Institute for Rural Futures, University of New England; Dr Susie Hester, School of Business, University of New England; and Mr Craig Jennings, Biosecurity Queensland.

- The effectiveness of community surveillance was measured in terms of positive predictive value (PPV), the proportion of the total number of reports that are actually positive (Froud *et al.* 2008).

- The return on investment in community engagement was calculated based on savings in active search to achieve a given level of coverage.

6.5. Outcomes

Through simulation it was estimated that there is a $52 million return per $1 million invested in general surveillance, measured as the savings in active surveillance caused by the presence of general surveillance.

The research also demonstrated there are considerable returns to expenditure in passive surveillance and the effectiveness of this surveillance seems to have increased over time when measured as the number of 'passive' detections per $1000 (Figure 5).
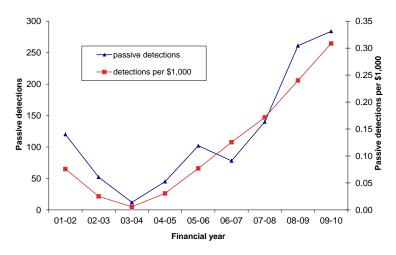

Figure 5 The number of passive detections and passive detections per $1,000 per financial year. Source: Cacho *et al.* (2012).

The impact of public engagement activities on public awareness decreases as distance from an event increases −the 'distance threshold' at which recent public engagement events lose their effect on public awareness was calculated to be around 4.2 km (Figure 6A). Further, the effect of public engagement events was found to depreciate over time, so that the estimated radius of influence of all previous events (1 km) is smaller than the influence of more recent events (Figure 6B).
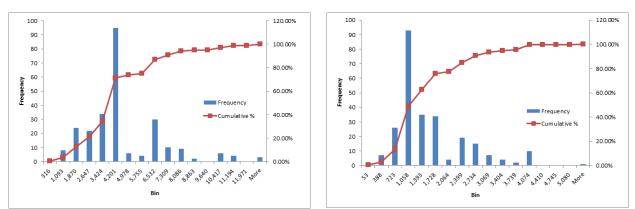
Figure 6 (A) histogram of distances from events in 2007 to colonies passively detected in 2008; there appears to be a distance threshold at ~4.2km at which the average event loses its effect on public awareness. (B) histogram of distance from all events prior to 2008 to passively detected colonies in 2008; again there is a clear threshold, but this time at just over 1km. Source: Cacho *et al.* (2012).

The influence of a reward scheme, in place between April and June 2008, was also quantified. The scheme resulted in a noticeable increase in the number of public reports and this effect lasted for several months, reducing gradually over time.

Data analysis was not able to demonstrate that knowledge of the demographic characteristics of an area enables prediction of the levels of passive detection, probably due to spatial autocorrelation and bi-directional causal effects, rather than to a lack of relationships.

6.6. Recommendations

The richness and complexity of the datasets mean that considerable statistical work would be required to make full use of data available in decision analysis. This work would have spin-offs beyond the RIFA program by providing information that could help improve the efficiency of invasion management in general. Key recommendations from the project are:

- Issues related to data capture and analysis identified in this report should be considered when designing or updating contact databases of public reports, ensuring that the work cycles that affect data entry patterns do not introduce errors in dating of actual contact events. Accurate geographical coordinates should also be obtained for all contacts when possible.

- Negative samples indicate public awareness of the problem and willingness to cooperate with BQCC. Additional analysis is required to make better use of these data to calculate confidence levels of ant absence for particular sites.

- Further analytical work should be undertaken to look at the interrelationship between spatial and temporal correlations to disentangle the possible relationships.

- Future studies on RIFA management should consider the urban ecology of Brisbane (better land use maps, property values, bare soil assessment etc.) to help explain some of the spread and detection patterns found.

- The habitat suitability map for RIFA should be updated at regular intervals taking account of patterns of land disturbance.

- Interviewing people who reported nests would help determine how the colony was found and their motivation for reporting. This would help fine-tune the mix of community engagement and active surveillance required in different areas.

- Finally, this type of study could be extended to other infestations to determine how the environment invaded and the type of invader may affect the contribution of public response to biosecurity events.

7. Conclusion

The four subprojects summarised in this report have investigated how information from general surveillance may be captured and used to improve biosecurity outcomes for Australia. General surveillance is, and continues to be, a key component of Australia's biosecurity system. The insights provided by the subprojects are important because they give much needed guidance for decision-makers who routinely decide how public and industry funds should be invested into engaging the public and industry to achieve biosecurity goals.

Although each case study had issues with data − availability, consistency or accessibility − this was most problematic for case studies 1 and 3. In these case studies the data used in the analysis data were not originally collected with an analysis of general surveillance in mind, so difficulties were encountered and some compromises were necessary. In case study 3, this also meant a significant amount of time was spent cleaning up the dataset ready for analysis. If datasets are to be used for analysis of general surveillance, it is recommended that they be initially assessed according to the following criteria:

- Accessibility − that there are no ownership issues that will hinder their use, and that the cost of their retrieval (or collection) is not prohibitive;

- Reliability − that the frequency and magnitude of errors of recording and missing data be low and will not bias the analysis;

- Relevance − that the data fit the purpose of the analysis, including consideration of their spatial and temporal relevance.

Individual subprojects contain specific recommendations and also identified important future work on general surveillance. The time allocated for each subproject was short − 12 months or less − so although each subproject achieved its stated aims, more insights into general surveillance would occur if funding can be secured to continue data analysis in all of them.

8. References

Animal Health Australia (2011) Animal Health in Australia 2010', Canberra, Australia.

Cacho OJ, Reeve I, Tramell J and Hester S (2012) Post-border surveillance techniques: review, synthesis and deployment - subproject 2d Valuing community engagement in biosecurity surveillance, Final Report, ACERA project 1004B2d, University of Melbourne.

Cacho OJ and Hester SM (2011) Deriving efficient frontiers for effort allocation in the management of invasive species. *Australian Journal of Agricultural and Resource Economics* 55: 72–89.

Cacho OJ, Spring D, Hester SM and MacNally R (2010) Allocating surveillance effort in the management of invasive species: a spatially-explicit model. *Environmental Modelling and Software* 25(4): 444–454.

Cacho O, Reeve I, Tramell J and Hester S (2012) *Post-border surveillance techniques: review, synthesis and deployment — subproject 2d Valuing community engagement in biosecurity surveillance.* Final Report, ACERA project 1004B 2d, University of Melbourne.

Cameron A and Hutchison J (2011) *Review of the zoo based wildlife disease surveillance pilot project*, Ausvet Animal Health Services 56p.

Cox-Whitton K (2011) *Post-border surveillance techniques: review, synthesis and deployment – subproject 2c Zoo based wildlife disease surveillance pilot project*, Final Report, ACERA project 1004 B 2c, University of Melbourne.

Daszak P, Cunningham AA, Hyatt AD (2000) Emerging infectious diseases of wildlife — threats to biodiversity and human health. *Science* 287: 443–448.

Froud KJ, Oliver TM, Bingham PC, Flynn AR and Rowswell NJ (2008) Passive surveillance of new exotic pests and diseases in New Zealand. In KJ Froud, AI Popay and SM Zydenbos (eds.) *Surveillance for biosecurity: pre-border to pest management.* Pp. 97–110. New Zealand Plant Protection Society Inc., Hastings, New Zealand.

Garner G and Beckett S(2005) Modelling the spread of foot and mouth disease in Australia, Australian Veterinary Journal 83(12): 30–38.

Garner G (2012) *Post-border surveillance techniques: review, synthesis and deployment – subproject 2a Surveillance needs for early detection of livestock diseases in Australia.* Final Report, ACERA project 1004 B 2a, University of Melbourne.

Hammond NE (2010) *Evaluation of emergency plant pathogen surveillance and surveillance methods for demonstrating pest freedom in Western Australia*, PhD Thesis, Murdoch University, Australia.

Hernandez-Jover M, Cogger N, Martin PAJ, Schembri N, Holyoake PK and Toribio J-ALML (2011) Evaluation of post-farm-gate passive surveillance in swine for the detection of foot and mouth disease in Australia, *Preventive Veterinary Medicine* 100: 171-186.

Hester, S, Hauser, C, Kean, J, Walshe, T, and Robinson, A (2010). *Post-border surveillance techniques: review, synthesis and deployment*, Milestone Report, ACERA project 1004A, University of Melbourne.

Hester SM and Cacho OJ (2012) Optimising search strategies in managing biological invasions: a simulation approach. *Human and Ecological Risk Assessment* 18(1): 181–199.

Lesslie, RG, Hill, MJ, Hill, P, Cresswell, HP and Dawson, S (2008), The Application of a Simple Spatial Multi-Criteria Analysis Shell to Natural Resource Management Decision Making in Landscape Analysis and Visualisation:Spatial Models for Natural Resource Management and Planning, (Eds. Pettit, C, Cartwright, W, Bishop, I, Lowell, K, Pullar, D & Duncan, D), Springer, Berlin, pp 73–96.

Sims (2012) *Post-border surveillance techniques: review, synthesis and deployment - subproject 2b Review of new technologies.* Final Report, ACERA project 1004B 2b, University of Melbourne.

Spring D, Cacho OJ and Jennings C (2010) The Use of Spread Models to Inform Eradication and Control of Invasive Species. Working paper 10-03, International and Development Economics, Crawford School of Economics and Government, The Australian National University.
http://www.acbee.anu.edu.au/pdf/publications/2010/IDEC10-03.pdf.