Tourist flows, lagged arrivals and environmental consonance as factors in biological exchange risk in Aotearoa New Zealand

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Abstract

This extended abstract addresses the nature of the biosecurity risk involved in large scale tourism movement, and the capabilities of existing geospatial data sets to indicate areas of elevated risk that are candidates for targeting in surveillance and intervention exercises. Biosecurity in New Zealand is defined as the exclusion, eradication or effective management of risks posed by organisms to the economy, environment and people's health. Exclusion in its turn implies barring access to a specific space, which implicitly acknowledges that movement, or its denial, is a key element in most biosecurity threats. International tourism dominates human movement into New Zealand with over 2.4 M visitor arrivals in 2007, and is important to New Zealand's economy as a leading export sector. However it also comes with an acknowledged biosecurity risk (Hall 2006). This document is about the nature of that threat as it relates to tourist flows, and how geospatial technologies enable the analysis and visualisation of the potential threat in time and space, and consequently may enhance our ability to react to it.

Introduction

Intervening distance has traditionally been a major constraint on unwanted biological exchange because:

1. organisms or the vectors that may carry them have a limited range;
2. flow volumes usually diminish with distance;
3. mortality rates rise with length of journey in terms of distance or duration, particularly where travel conditions are unfavourable to the organism or vector;
4. there is a greater probability that over long distances the environment at their arrival will differ significantly enough from their origin to preclude immediate survival or longer term establishment.

However, all of these relationships are dynamic over time and space, particularly where vectors are associated with human movement systems such as maritime trade, long-run truck haulage, transport of raw materials and recreational travel. All of these exhibit major structural shifts in the long-term as new economic patterns emerge, and cyclic fluctuations in the short-term, such as business cycles or seasonal shifts. This situation is further complicated by the fact that the practical meaning of 'distance' is often best expressed not by physical mileage but by the duration of the journey in units from hours through to years.

Notwithstanding this, the level of biosecurity risk associated with any particular organism from a specific origin should at least be open to mapping and ranking, and consequently to the establishment of priorities for intervention or increased surveillance. To achieve this we would need to gain a sound knowledge of the four factors identified above by answering questions such as these:

- What is the range of the organism (or the vector/organism combination) and the capabilities of its movement mode in respect of terrain or water?
- What is the overall spatial and temporal pattern of movement by this organism?
- How quickly does the pattern of such movement attenuate with distance?
- How robust is the organism to transit conditions, and to different conditions it may encounter upon arrival?

Such a model is simple but for full implementation it requires a substantial volume of data, much of which is currently unavailable or unrecognised.

Tatem & Hay (2007) exemplify this when they identify long distance mass tourism as an area of increasing biosecurity risk due to the emergence of high volume/low travel time movement patterns between places up to 13,000 km apart. Tourism activities can represent biosecurity risks at their worst in terms of the unintentional transfer of pests and diseases that threaten biological resources, biodiversity, natural environments and human health (Curry et al. 2002; Hall 2005, 2006; Turton 2005). This leads to tension between encouraging tourism in New Zealand (complete with risks) and protecting the environment and its inhabitants (Parliamentary Commissioner for the Environment 2000). Using international air travel data, Tatem & Hay (2007) demonstrate the complex outcomes of such a model, many of which arise from seasonal patterns in both the movement of vectors or organisms and the climatic and/or environmental similarity at each end of the journey (Tatem & Hay op. cit. Figure 3). As individuals chase the sun during the year, and the sun transforms the seasonal climates in different hemispheres, the patterns of higher risk links are highly differentiated and global, a feature most notable where continental masses generate significant seasonal contrasts in who links with who. These results, while generalised and simplified, illustrate a differentiated and changing web of rapid, long distance passenger and associated airline luggage flows representing potentially favourable conduits for biological exchange (e.g. Wilson 1995; Liebhold et al. 2006).

Aotearoa New Zealand, Tourists and Biosecurity Risks

New Zealand is constantly under threat from unwanted violations of its biosecurity (Parliamentary Commissioner for the Environment 2000; Kriticos et al. 2005). In response, the Ministry of Agriculture and Forestry Biosecurity New Zealand (MAFBNZ) is responsible for operating surveillance systems to detect and where possible eliminate unwanted organisms before they become established (Ganev & Braithwaite 2003; Wilson et al. 2004; Kriticos et al. 2005). Long distance tourism is one of a number of threats it faces at its borders. At New Zealand's international airports, MAFBNZ manage a system that aims to reduce the risk from arriving tourists. Amnesty bins, detectors dogs, item search and X-ray function to screen and relieve air passengers of at-risk organisms. However, screening cannot be relied upon to be 100% effective and strategies are needed to cope with possible violations of the barrier at the border. In considering this there is a distinct geography of threats of different severity, which is important in everyday risk assessment and the establishment of monitoring priorities just as much as for surveillance programmes initiated as a response to national crisis events such as red imported fire ant (*Solenopsis invicta*), painted apple moth (*Teia anartoides*) and didymo (*Didymosphenia geminata*).

Tatem & Hay (2007) demonstrate this dynamic phenomenon at an international level, with a climatic focus and with a relatively coarse spatial resolution. As human beings are potential vectors of unwanted organisms, then knowledge of their ongoing movement once inside the border would appear to offer very valuable information. Our focus of interest concerns the risk model related to the more detailed movement of international visitors <u>within</u> New Zealand. The main tool for this is the New Zealand International Visitor Survey (IVS – www.tourism.govt.nz), which is used here to extract patterns of visitor presence by location at 130 sites around New Zealand, including their dates of presence, time lag from arrival in New Zealand, country of origin, and likelihood of close environmental contact and thus high risk. Results reported here are based on a ten year sequence of IVS surveys covering approximately 55,000 tourist itineraries.

Research on these data has already yielded significant insights into the nature of international tourist movements while in New Zealand (Forer 2005) and has mapped annual patterns of tourist movements by different classifications of tourists, revealing patterns that differ by factors such as country of residence, nature of accommodation, length of stay, and nature of transport used (Figure 1). A full range of such maps can be found in Forer (2005). The maps include straight line flow volumes between overnight stays, the imputed flows along roads, and the timing of tourists' stay-overs across New Zealand in terms of days into their holiday. More detailed data are held at an hourly level for the West Coast of the South Island in 2000. These patterns all clearly show major differentiation in the nature and volume of flows between different destination areas in New Zealand in terms of raw numbers of tourists. They also show (Figure 2) that in terms of immediate or deferred arrival at destinations within New Zealand some areas are more often visited within the '5 day frontline' of early contact with tourists than others and are therefore arguably more open to greater risk per tourist. Northland, non-remote North Island destinations, international airport gateway cities and Methven (for skiers) appear to be the main targets in this respect, whereas destinations such as Hokitika and Kaikoura have much later exposure to the majority of their tourists. However, note that the map associated with this distribution (Figure 2) does not show absolute numbers.

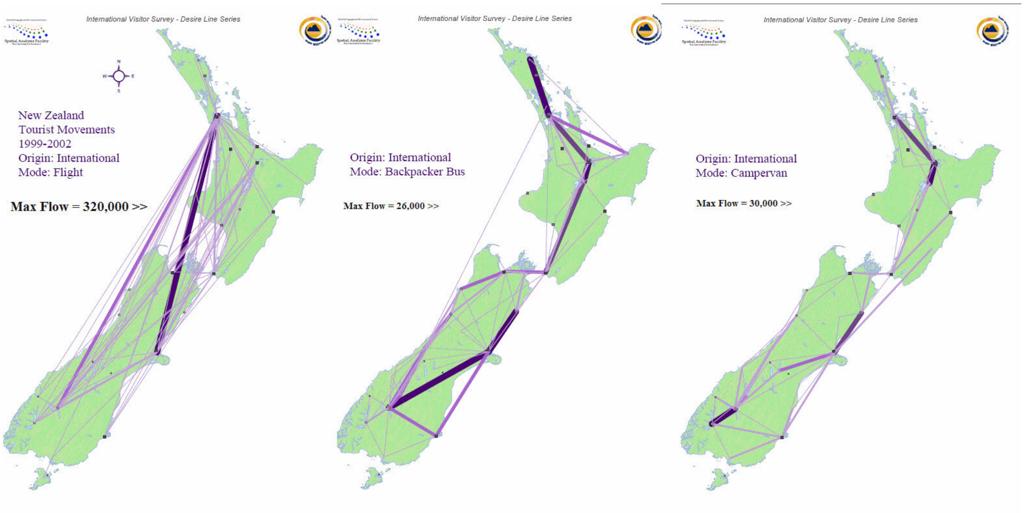

Figure 1. Comparative structure of international visitor flows by three transport modes: aeroplane, backpacker bus and campervan. Flows represented by line thickness. Colour differentiation is simply for emphasis. Source: International Visitor Survey 2006.

These earlier analyses have extended our understanding of patterns of potential biosecurity risk represented by large numbers of tourists who are potential vectors of alien pests and diseases. The current work focuses more on the question of how well certain potential high risk tourist types can be identified and positioned in time and space, which is to say we can assess where they are likely to be, what stage in their holiday they are at, and consequently what likelihood exists of an unwanted organism remaining alive. The methodology adopted for this has utilised the IVS surveys between 1996 and 2007 as a core resource and has then extracted individual respondent groups with certain characteristics (profiles) that identify them as potentially higher risks. In the present example our chosen profile is aimed at individuals or groups likely to interact closely with the natural environment, and sufficiently recently arrived that they could be vectors for alien organisms. Membership of this group was defined as survey respondents staying at camp grounds or backpacker hostels within 5 days of their arrival. For comparison purposes, a complete tally of all respondents within their first five days visiting was also extracted. This was used to illustrate the day by day gross movement patterns of tourists and the degree of short-term penetration radiating out from the three main arrival points of Auckland, Wellington and Christchurch. That pattern of mixing proved to be considerable in extent and quite complex in terms of regional patterns. To some degree the early day tourists simply diffuse out from the international airports to more distant locations over time, but a major dispersion due to the combination of a hierarchy of attractions and the use of long distance inter-Island hops results in a much more early mixing than might be expected.

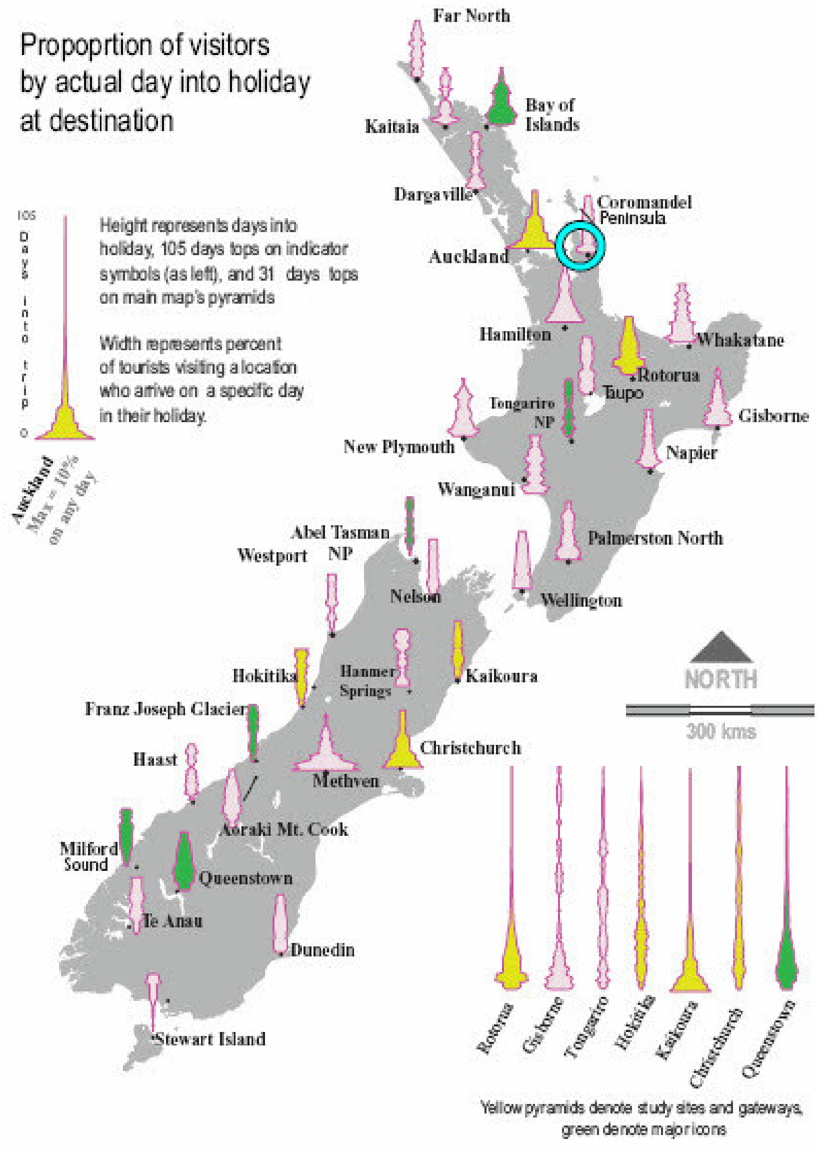

Figure 2. The time lag profiles of tourist destinations in New Zealand: the proportion of a destination's overnight visitors that arrive on particular days of their holiday. The symbols are akin to population pyramids, showing the proportion of visitors at any one location by the number of days they had been in New Zealand. Auckland is dominated by 'early stage' visitors, contrasting strongly with Hokitika. Source: International Visitor Survey 1996.

Overall, for the decade, 5,300 respondents met the accommodation criterion for high risk, between them generating 38,000 stops during their stays. The estimated number of actual visitors and overnight visits per annum from this is around 160,000 and 650,000 respectively. However, a significant portion of these visitors (mainly backpackers) were staying in areas where contact with natural environment was unlikely, and of these many of the visitations took place after the 5 day limit. To show visitation patterns for the sum of the first 5 days, the gross numbers for the aggregated 10 year span were mapped for 130 IVS visitation sites that have been constantly represented over the 10 year period of our data. The aggregate results of this were subdivided into winter and summer seasons and are shown in Table 1. Values for three 3-year periods were also calculated from this to get a sense of trend while ensuring the retention of a maximum of sites with adequate sample numbers. Further analysis on the specific days of tourists' arrivals allowed the parallel creation of a surface of relative risk index. This analysis (Figure 3) provides an interesting, and generally close, comparison with the existing MAFBNZ surveillance deployment map (MAFBNZ 2007).

On the other hand, the mapping of seasonal contrasts revealed some unexpected outcomes, including a proportionately wider spread of high risk individuals in winter than during summer, although at much lower numbers. This pattern requires further investigation. The results from the 3-year averages are encouraging in that they show stability across time, with most sites exhibiting constant proportions of profiled visitors. Those that reported changes generally showed a strong trend that was consistent with the location history or nearby sites (for instance growth in the Coromandel). One final insight from the analysis was provided by tabulation of the country of residence of individuals in our primitive 'at risk' category. As the results indicate (Table 1), certain origins dominate and provide a further focus for assessing risk in terms the anticipated behaviour and exposure of travellers from those countries of residence. The IVS collects some information on whether individuals come direct from their normal residence or visit potential areas of concern en route but more information on this area would be helpful in constructing a risk profile of tourists at the border.

Conclusions

These exploratory results provide a working sketch of spatial and temporal variations in risk according to a simple traveller profile (different profiles will, of course, yield different geographies of risk). The patterns they reveal also encourage further research. Significant issues for this further research include:

- robustness of results where a small sample size is problematic
- an appropriate spatial scale for aggregation, to reduce the issue of small samples
- assessment of the nature of the environment in which the tourists/organisms find themselves in respect to its exposure to invasion.

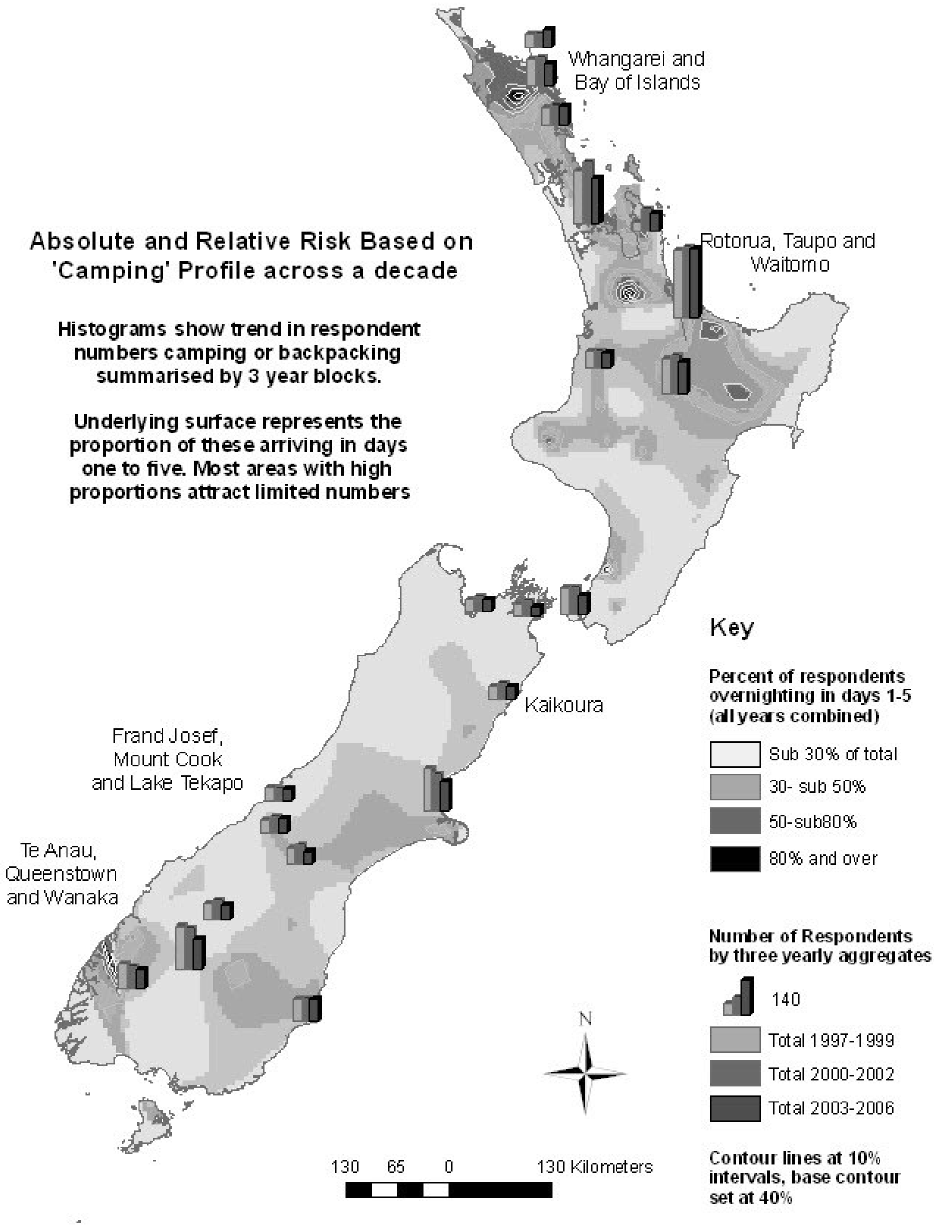

Figure 3. Tourist volumes, lag times since arrival, and patterns of relative risk. Source: IVS survey 1996-2007.

Table 1. Average proportion (%) of high risk tourists by country of residence for winter, summer and the whole year, along with the ratio of winter to summer visits and the proclivity for camping (defined as the share of those in the identified accommodation categories for a particular country as a ratio of the share in those categories for the total of all visitors).

Country of current residence	Winter share (%)	Summer share (%)	Ratio of share (W/S)	Annual share (%)	Proclivity for 'camping'
Australia	25.2	10.6	2.4	15.1	0.9
UK	29.4	22.9	1.3	25.6	1.9
USA	11.8	12.0	1.0	12.1	1.0
Japan	0.3	1.8	0.1	1.5	0.2
Korea	0.7	1.7	0.4	1.2	0.3
China	0.3	0.0	1.0	0.1	0.0
Germany	0.8	14.9	0.1	10.2	3.5
Canada	5.4	5.0	1.1	5.2	1.6
Taiwan	0.6	0.1	4.5	0.3	0.1
Singapore	2.7	1.5	1.8	1.8	0.6
Other	22.8	29.4	0.8	26.9	1.0

Geographic information systems and a wider range of spatial data will assist with addressing some of these issues. Most notably it should be possible to identify environments at destinations of low risk, for instance urban areas, and account for these. It should also be possible to identify more closely, using geocoded trade directories, where a particular kind of accommodation would exist in an IVS location, and thus where nights might be spent. Not enough is known about likely stopping behaviour between nights, except on the West Coast, but some notion of the areas visited can possibly also be imputed by allocating tourists to surface routes (includes main and dirt roads, ferries and off-road tracks), linking these data to known visitation figures and modelling tourist movements more precisely.

Further spatial aggregation of the 130 locations may well be required for robust analysis. At the same time more specific areas of concern may be recognisable from spatial analysis. Overall, these results extend the concept of placing tourists into climate zones at their destination, as identified by Tatem & Hay (2007) by providing a far finer spatial and temporal perspective. The framework can also be extended to ecological zones, using a combination of the existing land cover data bases. However, our research says far less about the originating zone of tourists and the role of that in defining risk. Understanding risk can partly be seen as knowing the chance of a vector/organism breaching border security, knowing where such a vector might travel post-border, and knowing something of its engagement with the environment. The difficult factor is knowing what risk a tourist is going to represent at the border, which is likely to relate not just to the culture of the country of residence but their home and work environments and intermediate travel. The IVS offers only limited scope to pursue this line, although it provides better data than passenger flight volumes. We need to acknowledge that risk on the ground from a given tourist reflects both risk generated at their origin and the success or failure of quarantine or inspection policies both pre-border and at the border. A high risk tourist who meets a highly effective screening process should no longer be a high risk tourist by the time any map analysis is run.

In the end multiple factors feed into creating and then assessing a risk map. One requirement of such a map if compatibility of origin and destination environments is important, is improved knowledge of the prior movement of incoming tourists and their exposure to natural environments, possibly by linking arrival card information to IVS profiles in some way. Each map is also likely to be organism specific, and knowing the real threat post-border may well depend on better knowledge of the porosity of the border for particular vectors or organisms. In that respect, our present contribution reports the exploration of a framework for dynamic and specific analyses rather than the presentation of an estimate of general biosecurity risk. Ongoing work is planned to situate the concept of post-border biosecurity risk maps within the wider framework of diverse biosecurity pathways.

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