Potential for using a generalised random tessellation stratified (GRTS) survey design to monitor rabbits in Southland

Envirolink 1050 – ESRC150

Landcare Research
Manaaki Whenua

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Bruce Warburton

Landcare Research

Meghan Williams

Cawthron Institute

Prepared for:

Environment Southland

Corner of North Road and Price Street, Waikiwi
Private Bag 90116
Invercargill 9810
New Zealand

May 2012

Landcare Research, Gerald Street, PO Box 40, Lincoln 7640, New Zealand, Ph +64 3 321 9999, Fax +64 3 321 9998, www.landcareresearch.co.nz

Cawthron Institute, Private Bag 2, Nelson 7042, New Zealand

Reviewed by:	*Approved for release by:*
Andrew Gormley Statistician Landcare Research	Phil Cowan Team Leader Wildlife Ecology & Management
Landcare Research Contract Report:	LC 1005

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1 Introduction

Environment Southland (ES) has monitored rabbit abundance and population trends across its region since 1997 using a survey design based on fixed transects allocated to three strata of rabbit proneness (McGlinchy & Barker 1997). However, because of significant land-use changes (e.g. increase in irrigation associated with dairy farms), ES has become concerned that there has been a shift in rabbit distribution and abundance throughout the region and that the fixed-transect method used may no longer be providing an accurate current measure of changes in rabbit distribution and abundance. Consequently, ES requested, through Envirolink funding (1050- ESRC150), that Landcare Research, in collaboration with the Cawthron Institute, review the council's current methodology for carrying out rabbit monitoring surveys and assess the potential of a new sampling methodology – based on a spatially balanced, generalised random tessellation stratified (GRTS) design – to address any deficiences identified in the current methodology.

GRTS sampling is an alternative to grid and spatially-random sampling. It is ideal for environmental and landscape-scale surveys. Although grid-based designs have spatial coverage, they are inflexible in relation to changes in the area sampled (i.e. the sample frame) or the number of sample points. On the other hand, spatially random designs are flexible but may provide spatially-clumped data, and are not cost-effective for large-scale surveys (Stevens and Olsen 2004). GRTS designs are flexible to change and the spatial pattern of a GRTS design closely mimics the spatial pattern of the resource being surveyed, which makes the design efficient.

Specifically, the GRTS site-selection method is useful for environmental surveys because it is more flexible than standard designs, for accommodating:

1. *Stratification and unequal probability designs based on GIS information*. This allows for areas of more or less sampling effort based on habitat models, land-use categories, or conservation value, etc.

2. *Contingency (oversample) sites*. Some field sites may be too dangerous to access, landowners may refuse access, or sites may fall on non-target habitat; it is therefore important to have available extra (contingency) sites that can be used to maintain sample size if some original sites are dropped. This increases field efficiency.

3. *Groups of sites (panels) for surveying over time*. Panels consist of a selection of spatially-balanced sites allotted to groups for sampling at regular intervals (most likely annually).

4. *Two-stage sampling*. Two-stage sampling is a site-selection technique for increasing field efficiency. An example is limiting travel time and cost by selecting a sample of river reaches within a few catchments, instead of sampling across an entire watershed. This would entail a GRTS selection of catchments followed by a GRTS selection of river reaches within those catchments. This design would allow for inference at the reach level (e.g. average reach condition) as well as at the catchment level.

5. *Nested subsampling. If the sampling protocol requires multiple levels of data collection, GRTS can be used to identify multiple spatially-balanced batches of*

sampling locations. For example, one batch of sites follows the common protocol (i.e., day-time observation) and another batch of sites includes the more expensive protocol (e.g., hair/blood/scat collection for DNA testing, night-time observation). Both batches would be spatially-balanced over the sample frame.

6. *Sample size changes*. The spatial balance of the design can be maintained with either an increase or decrease in sample size.

2 Background

Rabbits (*Orytolagus cunniculus*) are classified as a suppression pest in Environment Southland's Regional Pest Management Strategy (ES 2007), and landowners are required to ensure rabbit abundance is kept at or below level 3 on the modified McLean Index (Bell 1991). In 1997 ES reviewed its rabbit management programme (McGlinchy & Barker 1997) and established a regional monitoring programme to measure trends in rabbit abundance and, to a lesser extent, changes in distribution. Over the past decade a large area of the Southland Region has been transformed to intensive dairy farms with irrigation, and the council has concerns that its current regional sampling of rabbit abundance (based on permanent transects allocated according to a stratified random survey design) may be missing new areas of rabbit-prone habitat.

The current survey design was based on three strata of rabbit-proneness (high, medium and low) that were in turn based on a classification of rabbit-prone land (Kerr & Ross 1990). A total of 150 survey lines were initially established but this was subsequently reduced to 100. Ten percent of these were allocated to the low-proneness stratum, 30% to medium, and 60% to highly-prone lands. Each randomly-located transect has five circular plots of 10-m radius spaced at 50-m intervals. Rabbit sign – including scratchings, droppings, fresh burrows – and any rabbits seen are used to score each plot and the immediately surrounding area using the modified McLean Index (McGlinchy & Barker 1997).

In addition to managing pest animals (such as rabbits), ES's Regional Pest Management Strategy includes objectives for the management of pest plants. Because of similar needs for region-wide information on pest plant distribution, ES has already successfully adopted a probability-based, spatially-balanced survey design for a regional long-term pest plants distribution survey (Brown et al. 2007). A generalised random tessellation stratified (GRTS) approach (Stevens 1997; Stevens & Olsen 2004) was used to develop a long-term regional design of 100 new sites per year with survey effort focused on pathways of spread such as roadsides and riversides. A selection of sites was also distributed across Southland's agricultural and environmental landscapes. To balance the need for estimates of both trend and status, partial replacement of sites was recommended as follows: 100 new sites are visited each year in Years 1 through 5; sites for Years 6, 11, 16, etc., comprise 85% of Year 1 sites and 15% newly generated sites; sites for Years 7, 12, 17, etc., comprise 85% of Year 2 sites and 15% newly generated sites; sites for ensuing years continue in the same pattern.

Results of the pest plant survey include a spatial database of presence/absence results for nearly 200 pest plant species, population estimates (with known certainty) of pest plant occurrence and distribution, and measures of change and trends in pest plant occurrence and distribution. These survey results provide a solid foundation for sound statistical inference in the form of spatial models of species' distributions and habitat proneness.

3 Objectives

- To determine the potential of a GRTS-based survey design for improved monitoring of rabbit abundance and distribution across the Southland Region.

4 Methods

A workshop at Landcare Research in March 2012 reviewed ES's rabbit management objectives, its current regional rabbit survey design, the council's concerns about the current design, and the potential benefits of replacing the current survey design with a GRTS-designed survey.

5 Findings

5.1 Generalised Random Tessellation Stratified (GRTS) sampling

The GRTS survey design has been successfully implemented by ES for surveying plant pests in the Southland Region, and workshop participants agreed the method has potential for monitoring rabbits across the region and over time. Workshop discussions raised both survey and plot-level design issues. 'Survey design' addresses the process for the selection of sites to visit during any particular sampling cycle; the survey design specifics need to be finalised before a GRTS sample can be developed. 'Plot-level design' addresses what data are to be collected and the data collection methods; the few plot-level design issues raised also need to be finalised before fieldwork commences.

5.2 Survey design / Site selection considerations

1. *Sample frame*. This is the geographic region within which all areas of interest have a chance of being sampled, and for which inferences of rabbit abundance estimates will be able to be made. In practical terms, the sample frame will be an ESRI shapefile outlining the rabbit-survey area of interest. This may include areas of modelled rabbit proneness. Since the frame will cover a broad region of Southland, it is also important to determine areas to be excluded from the sample frame (e.g. land-use types such as dairy land clear of habitat, lake boundaries, urban areas).

2. *Number of sites visited each year*. The current survey design has 100 site visits each year. ES could increase the number of sites visited each year as budget or priority permits. A decrease in the number of site visits per year would require further analysis to ensure acceptable confidence levels are maintained.

3. *Cycle time*. The current survey design has yearly sampling and the same sites are visited each year. This allows for precise estimates, but the design may be lacking in accuracy. If a design has completely new sites each year, results may be accurate, but not very precise. A balance between the accuracy and precision of an environmental design can be achieved by combining repeat site visits (increasing precision) and new sites (increasing accuracy). Workshop discussions suggested a 3-, 4-, or 5-year cycle.

Thus, new sites would be generated each year during the first cycle, and depending on the cycle chosen, those sites would be revisited every 3, 4, or 5 years. The selection of cycle time should take into account what is known about natural variation in rabbit numbers and their potential rates of increase.

4. *Number of partial replacement sites*. Partial replacement sites replace a portion of initial sites. They may be introduced to increase design accuracy (e.g. given a 3-year cycle, 10% or another percentage of partial replacement sites could be added starting in Year 4).

5. *Number of current survey sites to incorporate into the new GRTS design*. A spatially-balanced portion of the current 100 sites may be included in the new design (e.g. 5, 10 or 20 sites per year) to ensure continuity with past monitoring data.

6. *Incorporating compliance inspections in the GRTS survey*. It may be desirable to incorporate into the rabbit survey any efforts spent on compliance inspections. This is only possible if it is practical to have compliance inspections include the plot-design protocol. A second sample frame for compliance sites would need to be developed.

5.3 Plot-level design / Collection Protocol considerations

1. Which key environmental descriptors should be collected at each survey point to test for correlation with rabbit abundance (i.e. for updating the rabbit-proneness model)?

2. Defining rules (e.g. Standard Operating Procedure) to ensure the allocation of lines and actual field procedure of measuring plots or using contingency lines are carried out consistently.

6 Conclusions

Although the current rabbit monitoring data indicate rabbit numbers are not increasing in Southland, ES staff still have concerns about the accuracy of the data provided by the fixed-transect survey design. Their concern that rabbit distribution might now be more influenced by land-use factors other than rabbit proneness (as it was historically – Kerr & Ross 1990) could be addressed by use of GRTS survey methodology to deal with these potential spatial changes. Additionally, GRTS provides sampling flexibility to balance accuracy and precision. Conducting the survey within a GRTS framework is unlikely to cost more than the current survey methodology, and the advantages provided by GRTS outweigh any minimal establishment costs.

Before ES implements a GRTS survey design the council needs to consider the factors detailed above, including:

1. *Sample frame*. ES needs to clarify which areas are in and which are outside the sample frame. Those included have a chance of being sampled, and the estimates obtained then apply to that sample frame. Excluded areas cannot be sampled and cannot have any inference made for them of rabbit abundance.

2. *Number of sites sampled*. The number of sites visited will generally be constrained by funding available, but should be at least 100 (as are currently surveyed). As data are collected, the number of sites may be varied depending on the actual and desired precision of the estimates.

3. *The cycle time, partial replacement sites and number of current sites included.* These need to be selected based on a balance between spatial accuracy, precision, and continuity with historical data. We recommend a cycle time of 3 years with 100 total sites per year, including 10% replaced sites and 10% historical sites, be implemented. This framework increases the accuracy and precision of rabbit status estimates, allows precise trend analysis every 3 years, and introduces a small portion of entirely new sample sites each year (see Appendix 1).

4. *Plot-level design.* ES staff need to clarify what additional environmental data are to be collected if they wish to carry out a future correlation of such data with rabbit abundance.

5. If replacement (oversample) lines are to be available there need to be strict rules developed for when such lines can be chosen.

7 Recommendations

- Environment Southland should consider implementing a GRST-based survey design for monitoring rabbits using the design proposed in Appendix 1 as a recommended starting point.
- If the rabbit abundance data collected are to be used to gain a better understanding of the key drivers of current rabbit abundance and distribution then ES needs to agree on a set of environmental descriptors most likely to affect rabbit abundance and distribution.
- Clear rules must be developed for the use of contingency (oversample) lines.

8 Acknowledgements

We thank Richard Bowman, Amy Rush and Tim Riding (Environment Southland) for providing an update of current rabbit monitoring data and contributing to the workshop discussions, and Andrew Gormley and Phil Cowan for reviewing a draft of this report. This work was funded by the Ministry of Science and Innovation via Envirolink Small Advice Grant 91050 to Environment Southland (ESRC150).

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Appendix 1 – GRTS survey design proposed for monitoring rabbit distribution and abundance in Southland

A Long-term Regional Survey Design: 15 Years at a Glance																
	YR 1	**YR 2**	**YR 3**	**YR 4**	**YR 5**	**YR 6**	**YR 7**	**YR 8**	**YR 9**	**YR 10**	**YR 11**	**YR 12**	**YR 13**	**YR 14**	**YR 15**	
240 ‘Core’ GRTS sites	80 (A)	80 (B)	80 (C)	A	B	C	A	B	C	A	B	C	A	B	C….	A–C: each site visited every 3rd year
100 GRTS Selection of historical sites	10 (A)	10 (B)	10 (C)	10 (D)	10 (E)	10 (F)	10 (G)	10 (H)	10 (I)	10 (J)	A	B	C	D	E….	A–J: each site visited every 10th year
150 ‘Replacement’ GRTS sites	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10 new sites visited each year
300 Back-up/Oversample GRTS sites	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	A pool of sites to provide ‘fall-back’ sampling locations in case the original sample locations need to be thrown out
At YEAR 15: A total of 390 new sites, as well as 100 historical sites, will have been visited.																
240 Core GRTS sites will each have been visited 5 times (providing great trend estimates); the historical sites will have been visited at least once, with half having been visited twice (providing historical continuity); an additional 150 sites will have been visited at least once (providing continual accuracy over the long term). Overall, the design increases the precision and accuracy of estimates of rabbit levels in the Southland Region.																