Modelling Invasive Species and Weed impact

NZIMA Funded University of Canterbury Research Programme 2007 - 2009

Case Study 3 – Optimizing monitoring strategies

Aims:
The aims of the research will be to:

- Develop mathematical models to estimate site-occupancy.
- Identify optimal adaptive sampling strategies for detecting new weed incursions and for monitoring ongoing weed populations.
- Develop a decision framework to allocate resources between surveillance for new incursions, monitoring of existing weeds and control of weed infestations.

A new weed incursion is considered a rare event. Sampling for rare events is not a new area of statistics, but only recently has there been increased interest by statisticians in the application of this theory to ecology. Recent applied developments in sampling rare events include the book edited by Thompson (2004), the growing interest in adaptive sampling (eg., Thompson and Seber 1996), the work on resource selection functions (Manly et. al. 2002) and the work by Darryl MacKenzie on site-occupancy models (MacKenzie 2005, Mackenzie et. al. 2003). This, and other work by J. Brown on adaptive multi-stage sampling (Smith et. al. 2004), has mostly been focused on sampling animal populations and there are few applications to plant and weed populations. The focus of this research will be on application to weeds. Much of the research in this area has been initiated in NZ (Seber, Manly, McKenzie) and it seems appropriate that it is developed further in NZ.

Methods
This research will combine the site-occupancy modelling and resource selection approach in defining the probability of occupancy by a weed with adaptive multi-stage sample designs. In sampling large areas of land for a rare event (a new weed incursion) the optimal design is one where initial sample effort is focused to locations where there is a high likelihood of a weed being present. The analytical methods in site-occupancy modelling and resource selection will be used to design initial surveillance surveys that maximise detection probability and minimise sample variance.

These initial surveys will be the first stage of an adaptive multi-stage surveillance and monitoring weed plan. In adaptive sampling the plan is adapted as more information becomes available on the likelihood of a location being occupied. The changing sample-plan is an efficient way to focus survey effort into weed hotspots. There are many multi-stage adaptive sample designs and many possibilities for developing new designs. This research will develop adaptive multi-stage sampling designs that are efficient for detecting new incursions and for monitoring existing weed populations. The sample designs will include a measure of the tradeoff between the cost of failing to detect a weed at a site, and the cost of failing to visit all sites. In addition, the designs will incorporate practical issues related to economics, sociology and field logistics.

The final step in optimizing monitoring is building a decision framework to allocate resources among surveillance for new incursions, monitoring of existing populations and control (Brown et al. 2004). Weed control is rarely a once-off event and resources need to be allocated between initial knock-down and follow-up control. The decision about which weeds to control where needs to be based on information on both weed-specific and site-specific impacts. We will use a modelling approach to incorporate site information (site quality, vulnerability, spatial location), weed information (species- and site-specific detection probabilities, impacts, growth, spread) and control information (effectiveness) with

information on the cost of surveillance, monitoring and control. This decision process can be used to rank sites and weeds to allow resources to be better targeted.

- Brown, J.A. Harris, S., and Timmins, S.M. 2004. Estimating the maximum interval between repeat surveys. Austral Ecology 29(5): 1-6
- MacKenzie, D.I. 2005. Was it there? Dealing with imperfect detection for species presence/absence data. Australian and New Zealand Journal of Statistics 47:65-74.
- MacKenzie, D.I., J.D. Nichols, J.E. Hines, M.G. Knutson and A.D. Franklin. 2003. Estimating site occupancy, colonization and local extinction when a species is detected imperfectly. Ecology 84: 2200-2207
- Manly, B.F.J., L.L. McDonald, D.L. Thomas, T.L. McDonald, and W.P Erickson. 2002. *Resource Selection by Animals: Statistical Design and Analysis for Field Studies, Second Edition. Kluwer Academic Publishers, Dordrecht.*
- Smith, D.R., Brown, J.A. and Lo, N.C.H. 2004. Application of Adaptive Cluster Sampling to Biological Populations. Chapter in Sampling Rare and Elusive Species, ed. W.L. Thompson, pp. 75-122.
- Thompson, S.K. and Seber, G.A.F. 1996. *Adaptive Sampling.* New York: Wiley.
- Thompson, W.L. 2004. Sampling Rare or Elusive Species: Concepts, Designs, and Techniques for Estimating Population Parameters, Island Press, Washington.

Proposed time line:
It is anticipated that both studentships will start in 2006 before the key workshop. This will allow the students an initial period of familiarization with their chosen subject so they can participate fully in the workshop.

Potential candidates:
The Mathematics and Statistics department at Canterbury runs honours level courses on mathematical modelling in biology and bioinformatics. This will provide a pool of students who would make excellent candidates for the studentships. The studentships will also be advertised both nationally and internationally.