ACERA Project 0905

1. **Project Title**: Combining GIS and Bayesian Networks in test-action strategies for risk assessment

2. **Theme**: Risk analysis methods; Surveillance and monitoring

3. **Rationale**:

Bayesian networks (BNs) are a probability-based method for representing and reasoning with uncertain knowledge. This situation arises in risk analysis where it is necessary to evaluate and communicate the nature and extent of uncertainty (Burgman, 2005). Such problems are non-trivial as they require making decisions based on incomplete information and they need to consider a multitude of actions with uncertain effects. Statistical and modeling approaches for risk assessment have had varying success (Haines, 2004), but BNs are seen as offering solutions with greater potential. This is because: i) BN tools are now available with intuitive graphical interfaces, ii) BN models are based upon well-founded probability theory, and BN's integrate heterogeneous knowledge (numerical and qualitative) in a single model specification. For these and other reasons BNs are now considered the most important tool for solving real problems in artificial intelligence (Larrañga and Moral, 2008).

Many biosecurity problems involve complex pathways for the spread of invasives over time and space (Hayes, 2003). A sequence of decisions to detect and control invasions is made contingent upon further sampling, information gathering and tests. There are costs and efficiencies associated with these contingent activities (Panetta and Lawes, 2007). BN's may be extended to *analyse decisions networks* (also called influence diagrams) which include ex-ante actions and estimate the utility of outcomes. The project will *research and develop state-of-the-art risk analysis* tools for weed surveillance using decision networks. As an experimental test-bed we will focus on a declared weed of national significance; namely Chilean Needle Grass, which has recently been discovered and actively treated on the Darling Downs in Queensland. Other environmental weeds and pests found in parks in Queensland will also be targeted. We will develop Bayesian decision networks to model surveillance and treatment strategies. Models will be spatially explicit, implemented in a GIS, and deal with the timing and utility of discovery and monitoring efforts to detect and treat weeds. These models will contribute to *practical risk assessment* with a good balance of efficient and simple ways to target weeds with mapping technology and BN's. We will *collaborate with sections of government involved in risk assessment*, namely Biosecurity Queensland and the BRS, to share and transfer any developments. In particular we will *review protocols*, such as 'Statements of Pest Management Intent (SPMI)' used in Queensland and assess its effectiveness to prioritise and treat invasives over the long term using decision networks tested with data. This will lead to *better documentation and standards for risk assessment.*

4. **Outputs**

The project will produce: i) a software tool integrated within GIS, ii) research papers on methods and performance tests, and iii) application of the methods and tools to real weed surveillance problems. The project will achieve the following milestones.

1. Interim Report on decision network for risk assessment (December 2008)

Report will be the fruition of conceptual development for decision network after consultation with a number of key stakeholders; including BRS, Biosecurity Queensland and other ACERA Projects (08/06, 06/04). Report will describe application of a BN for test-action sequence to assess utility of surveillance and treatment decisions to control weeds. It will explore possible surveillance measures, uncertainties associated with detection and decision pathways to control weeds. Test cases for invasions of a declared weed (Chilean Needle grass on Darling Downs, see Fox et al. 2007) and an environment weed (Glycerine in SEQ Parks) will be given.

Journal paper (aim for Biological Invasions) with outcomes from above report. Objective of paper is to show decision options for weed control (surveillance, detection, treatments, etc) and their expected utility over long term.

2. Software development and web tutorial (February 2009)
A software tool will be implemented as an extension to ArcGIS. It will read a Netica BN that implements the generic form of the test-action decision network. An easy-to-use wizard will make the linkage between decision nodes and data sources in GIS tables and spatial layers. End-users interact with the BN model through form dialogs and a tree-view of the spatially explicit variables in the GIS. A similar approach was used by the author to implement the Land Use Impact Model (LUIM) for the Victorian DPI (McNeill et al., 2007). The ArcGIS extension will be made freely available with user documentation from University and ACERA websites. A user manual and tutorial will also be provided on website.

3. Final Report on decision network for risk assessment (June 2009)
The final report will evaluate weed surveillance protocols using the test-action decision network. For instance to assess the Statements of Pest Management Intent (SPMI) used in Queensland to prioritise and treat invasives. It will utilize related ACERA projects (08/06, 06/04) on weed eradication strategies to set utility cost (Cacho et al. 2007) and identify optimal strategies. Other applications and evaluations will be made based upon discussions with collaborators from the BRS and DAFF.

Journal paper (aim for Diversity & Distributions) with outcomes from above report. Objective of paper is to review surveillance protocols and describe application of tool to evaluate monitoring and treatment strategies.

5. **Time frame:** Commencing: June 2008; finishing: June 2009

6. Project leader(s)

Title	First name	Surname	Location	Organisation	% Time per year
Dr	David	Pullar	Brisbane	University of Qld	15
Dr	Carl	Smith	Brisbane	University of Qld	5
Dr	Carmel	Pollino	Canberra	ANU	5

7. Resources

A. Funds

Financial years of requested funding	06/07	07/08	08/09
Project Total			**$39,000**

B. Funds obtained from other sources for this project
(Participant, Industry or Third Party support (cash or in-kind)

Financial years of requested funding	**07/08**	**08/09**
Total		$30,000

8. End Users