International Pest Risk Mapping Workshop (IPRMW)

Tuesday, 9 September – Friday, 12 September, 2014

CSIRO Ecosystem Sciences Building 101, Waterhouse Lecture Theatre,

Clunies Ross St, Acton, Canberra, ACT 2601, Australia

Program

Please meet at reception of Ecosystem Sciences building at 9am on the first morning (Tuesday, 9 Sept) – see photos below. Coffee and tea will be available each morning from 9am

	Session 1 (9:30am -10:50am)	**Morning tea (30 min)**	**Session 2 (11:20am – 12:40noon)**	**Lunch (1 hour)**	**Session 3 (1:40pm – 2:40pm)**	**Afternoon tea (30 min)**	**Session 4 (3:10pm – 4:10pm)**
Tuesday (9 Sept)	Presentations (Intro and 3 talks)		Presentations (4 talks)		Presentations (3 talks)		Presentations (3 talks)
Wednesday (10 Sept)	Presentations (4 talks)		Presentations (4 talks)		Field trip		
Thursday (11 Sept)	Focus groups		Focus groups		Focus groups		Focus groups
Friday (12 Sept)	Focus groups		Focus groups		Focus groups		Focus groups

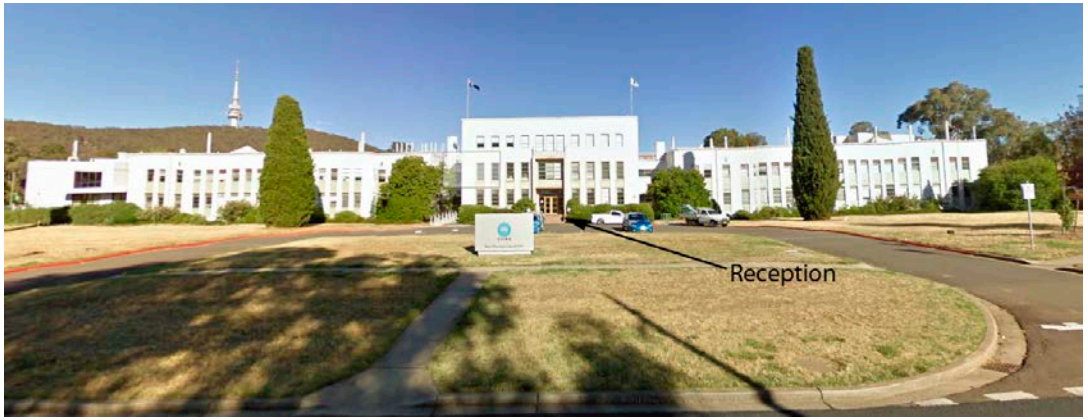
Presentations (20 minutes) – 15 minutes for talk + 5 minutes for questions

Focus groups (to run concurrently)

1. Model inter-comparison (chair Roger Magarey)
2. Climate adaptation/scenario analysis (co-chairs Frank Koch and Darren Kriticos)
3. Economics and pest impact (chair Alan Burnie)

CSIRO, Ecosystem Sciences Building – Satellite view

CSIRO, Ecosystem Sciences Building – Street view



Program Sessions

Distribution modelling (Session 1, Tuesday 9 Sept, 9:30am – 10:50am)

1. Kriticos, Darren. **Welcome and introduction.**
2. Magarey, Roger. **Update on the Generic Pest Forecasting System.**
3. Senay, Senait. **Multi-scenario species distribution modelling: an essential framework to quantify prediction uncertainty.**
4. Burgman, Mark (talk given by Tony Arthur). **An expert opinion based evaluation of species distribution modelling tools for biosecurity decision making in marine and terrestrial environments.**

Modelling (Session 2, Tuesday 9 Sept, 11:20pm – 12:40pm)

1. Koch, Frank. **Modeling urban host tree distributions for forest pests using a two-step approach.**
2. Kean, John. **Mapping the risks of fruit fly entry and establishment in New Zealand.**
3. Caley, Peter. **When propagule pressure fails – updating invasion beliefs.**
4. Kriticos, Darren. **New tools in CLIMEX to explore climate variability and model uncertainty.**

Community engagement and economics (Session 3, Tuesday 9 Sept, 1:40pm – 2:40pm)

1. van Klinken, Rieks. **Bringing decision-makers on board: a participatory approach to risk modelling.**
2. Murray, Justine. **Modelling environmental and economic impacts of invasive species: the next step in risk mapping.**
3. Beddow, Jason. **Stripe rust: the global occurrence and economic consequences.**
4. Nghiem, Le (talk given by Roman Carrasco Torrecilla). **Economic and Environmental Impacts of Harmful Non-Indigenous Species in Southeast Asia.**

Risk (Session 4, Tuesday 9 Sept, 3:10pm – 4:10pm)

1. Soliman, Tarek (talk given by Roman Carrasco Torrecilla). **A regional decision support scheme for pest risk analysis in Southeast Asia.**
2. Macfadyen, Sarina. **Grains pests and climate change: preparing for the future we want.**
4. Beautrais, Josef. **WRASP: A spatial weed risk assessment tool.**

Dispersal (Session 1, Wednesday 10 Sept, 9:30am – 10:50am)

1. Froese, Jens. **Incorporating animal home range behaviour into spatial habitat suitability models of feral pigs in northern Australia.**
2. Senay, Senait. **Landscape recoding for targeted species dispersal modelling.**
3. Yemshanov, Denys. **Optimal allocation of invasive species surveillance with the maximum expected coverage concept.**

Modelling and general 'stuff' (Session 2, Wednesday 10 Sept, 11:20pm – 12:40pm)

1. Yonow, Tania. **Common mistakes in modelling.**
2. Kriticos, Darren. **Neobiota invasive species profiles: A new publication vehicle for pest risk models.**
3. Koch, Frank. **Constitution and next meeting**
4. Kriticos, Darren. **Introduction to focus groups**

Attendees

Acosta, Hernando. New Zealand Ministry for Primary Industries

Arthur, Tony. Australian Department of Agriculture

Beautrais, Josef. New Zealand AgResearch

Beddow, Jason. University of Minnesota

Burnie, Alan. USDA

Caley, Peter. CSIRO

Carrasco, Roman. National University of Singapore

Froese, Jens. CSIRO

Kean, John. New Zealand AgResearch

Koch, Frank. US Forest Service

Kriticos, Darren. CSIRO

Macfadyen, Sarina. CSIRO

Magarey, Roger. North Carolina State University

Murray, Justine. CSIRO

Robinson, Andrew. University of Melbourne

Senay, Senait. Lincoln University

Suiter, Karl. NSF Center for Integrated Pest Management

van Klinken, Rieks. CSIRO

Welvaert, Marijke. CSIRO

Yemshanov, Denys. Natural Resources Canada

Yonow, Tania. HarvestChoice

Abstracts

Josef R. Beautrais and Darren J. Kriticos.

WRASP: A spatial weed risk assessment tool.

The number and diversity of introduced plants, coupled with limited weed management budgets requires biosecurity managers to employ a system akin to triage. To help identify appropriate targets for management attention, an analytical protocol and spreadsheet tool has been developed for post-border weed risk management (PBWRM), and published as an Australian and New Zealand standard. It is an important and widely-used tool. The PBWRM tool utilises a framework that ignores spatial variation in risk factors within the geographical area of concern of the risk assessor. However, invasive plants vary in risk factors such as invasiveness, potential impacts, and feasibility of control across space. Logically, the assessment of weed risks should also be spatially explicit in order to best understand risks and to target management concern. In order to use the current PBWRM, the risk assessor has to firstly define their area of concern and then make subjective judgements that distil the spatial variation within that area into a single answer to each of the questions in the tool. At the national level, this method is wasteful, requiring each Regional Council to repeat an analysis, tailoring it to their own environmental conditions, or perhaps worse simply applying the results of analyses conducted in different jurisdictions without considering the different environmental conditions. To address these concerns we took the PBRWM logic and spatialised it, to allow weed managers to assess weed risks and management across geographical space. We illustrate this new spatial system using a case study of *Senecio glastifolius* in New Zealand, comparing the results of a spatial and an aspatial analysis. The spatial view of risks revealed locations of higher and lower risk and suitability for management attention that were hidden by blanket, aspatial weed risk scores of the current PBWRM system. The national level risk was also significantly higher when considered in the light of the results from the spatial tool. Answering the risk factor questions using the spatial system involved far less subjectivity, and hence the resulting risks and management classifications are likely more robust and usable to Regional Councils and the National Government. The spatial tool, WRASP, is presently being packaged for general use, and will shortly become available for testing by Regional Councils.

Jason Beddow, Hans Joachim-Braum, Yuan Chai, Darren Kriticos, Philip Pardey.

Stripe Rust: The Global Occurrence and Economic Consequences.

There is emerging evidence that the geographical footprint of stripe rust is expanding, opening up prospects for an increase in the economic losses attributable to this disease worldwide. Drawing on newly compiled data, along with insights obtained from a survey initiated at the BGRI meeting in Delhi in August 2013, this talk will report on efforts to model the global occurrence and persistence of stripe rust in a spatially sensitive fashion. Using the available data in conjunction with newly developed climate suitability maps, we will present probabilistic crop production losses associated with the disease and place an economic value on those prospective losses. Given changes in the geographical spread of this disease, and the associated uncertainties about its likely wheat yield and economic effects, various scenarios will be assessed to inform and thereby help shape the research investment decisions regarding crop breeding and other options for ameliorating these prospective losses over the longer run.

Burgman, M, Arthur, T., Hollings, T., Elith, J., Barry, S., Kriticos, D., Kearney, M., Yemshanov, D., Brown, P., ten Have, J., Summerson, R., Starkey, C., Hennecke, B..

An expert opinion based evaluation of species distribution modelling tools for biosecurity decision making in marine and terrestrial environments.

Governments make various biosecurity decisions that require spatial estimates of the likelihood of pest occurrence or the suitability of potential habitat. A number of modelling tools can inform these decisions, which can be broadly characterised as correlative approaches and process-based approaches. The project used marine and terrestrial case studies to explore their 'defensibility', which focussed on their performance, and their 'usability', which focussed on their ease and cost of use. Results were based on the responses from experts experienced in the development and application of spatial habitat modelling tools and a subsequent workshop. Responses sometimes differed considerably. The project provided no clear consensus that currently available spatial tools will always provide adequate solutions. For estimating the risk of introduction and establishment of pests to marine ports it was concluded that a method is required that considers the degree of environmental similarity between source and sink environments. To predict potential distributions of invasive terrestrial species it was concluded that process-based models are currently more appropriate for making defensible predictions, but may be more difficult to implement for more routine government decision making. The development of new approaches was proposed that use expert opinion, either to define the functional forms of species responses, or to provide hypothetical presence/absence data that would be used in correlative models to estimate these functional forms. New research should explore the relative performance of these new approaches and compare the practicalities of implementing them. Whatever methods are adopted, agencies will need to build capability to be able to use the methods appropriately. This project is the basis for two upcoming CEBRA projects that will implement the ideas that emerged.

Peter Caley, Daniel Heersink, Dean Paini, Simon Barry

When propagule pressure fails – updating invasion beliefs

The extent of successful incursions of exotic species is often compared and contrasted with pre-invasion beliefs of habitat suitability based on species distribution models. Less attention has been given to updating invasive beliefs in the absence of an incursion. When can the absence of an incursion be inferred as evidence that an incursion is more difficult (possibly arising from habitat being less suitable) than previously thought? This question is explored using with reference to the Asian green mussel (*Perna viridis*), the feral ferret (*Mustela furo*) and exotic insects.

Jens Froese, Carl Smith, Clive McAlpine, Peter A. Durr, Rieks van Klinken.

Incorporating animal home range behaviour into spatial habitat suitability models of feral pigs in northern Australia

Large, mobile vertebrate pests such as feral pigs (*Sus scrofa*) have extensive home ranges, which they regularly traverse to satisfy resource and shelter requirements, and to find mating partners. We hypothesise that for such pests the suitability of a habitat site is determined not only by the conditions at that site, but influenced by the conditions within the "home range" neighbourhood. However, to our knowledge, this landscape-scale influence has not previously been considered in habitat suitability, or species distribution, models. Here, we test whether a regional-scale habitat suitability model of feral pigs in northern Queensland that incorporates home range behaviours performs better than a conventional model that is "blind" to conditions in the surrounding landscape.

We employ a process-based, participatory modelling approach using Bayesian networks, where causal relationships between key explanatory variables, habitat requirements and habitat suitability are identified and quantified in a structured expert elicitation process. Bayesian networks are integrated with high resolution GIS data representative of model variables. All variables and their spatial representations are identical for the home range-based and cell-based models. However, in the former, we 1) model habitat requirements at the cell scale, 2) calculate the availability of each requirement within a "home range" neighbourhood around each cell, and 3) model how the combined availability of requirements influences habitat suitability. We evaluate the different models' predictive performance against independent data sets sourced from collaborators.

Predicted habitat suitability values will subsequently be used as an input into investigations of functional connectivity corridors between habitat patches using a spatially-explicit graph-theoretic modelling approach. This research is conducted in collaboration with the Northern Australia Quarantine Strategy and ultimately aims to inform risk-based early detection surveillance of exotic animal diseases involving feral pigs as a wildlife host.

John Kean and Craig Phillips.

Mapping the risks of fruit fly entry and establishment in New Zealand.

New Zealand maintains an extensive trapping surveillance system to maintain freedom from damaging fruit flies. We developed geospatial maps for the relative risks of entry and establishment in New Zealand of three key lure-responsive fruit fly species: Mediterranean fruit fly (*Ceratitis capitata*), Queensland fruit fly (*Bactrocera tryoni*) and oriental fruit fly (*Bactrocera dorsalis*).

Detailed consideration of pathways of entry for fruit flies into New Zealand identified that entry sites are closely linked to human habitation. Therefore, residential human population density was assumed to be representative of the spatial distribution of the risk of entry. Following entry, establishment was assumed to require suitable host plants and a favourable climate. Host availability was quantified from land cover types and climate suitability was quantified at ~5 km resolution using previously published CLIMEX models. From these layers we developed composite maps for the relative risk of entry and establishment for each fruit fly species. Separate maps were developed for the risks of seasonal and persistent establishment under current and future climate scenarios.

These risk maps are currently being used by the New Zealand government and horticultural industries for preparedness planning. They also form the basis for a risk-based assessment of current surveillance activities using stochastic scenario tree methods, and this is helping to further optimise the sensitivity of fruit fly trapping systems for early detection of incursions. However, it is clear that New Zealand's current surveillance trapping is already closely aligned with the spatial risk of entry and establishment of fruit flies.

Darren Kriticos, Eric Zurcher, Neville Herrmann, Gunter F. Maywald, Jason Beddow, Myron P. Zalucki

New tools in CLIMEX to explore climate variability and model uncertainty

In Version 4 of CLIMEX we introduce tools to explore parameter sensitivity, model (parametric) uncertainty, and excitingly, the impacts of climate variability. Modelling uncertainty has become a popular topic in the pest risk community, but until now the process of exploring the uncertainties has been laborious. Whereas parameter sensitivity is a well-known technique, model uncertainty is a relatively poorly developed area of science. Critical to the success of the exercise is a realistic estimate of the confidence with which parameters are known. Automating the generation of maps portraying uncertainty carries the danger of misrepresenting uncertainty if parameter ranges are poorly specified. We explore some issues and opportunities concerning uncertainty mapping for pest risk modelling. For the first time, CLIMEX provides a means of looking at pest risks as a temporal phenomenon, exploring the effects of seasonality and inter-annual variation in climate on the factors that allow or limit the population growth of species. These new tools for automating repetitive tasks and visualising pest risk as a dynamic process are presented using a case study of Helicoverpa armigera, which has recently invaded South America, and appears poised to invade North America.

Darren Kriticos, Jason Beddow, Tania Yonow, Lyubo Penyev & Ingolf Kühn

Neobiota invasive species profiles: A new publication vehicle for pest risk models

A new initiative from the journal Neobiota will simplify and fast-track publication of pest risk models. Pest risk modelling is an intellectually demanding activity that typically produces results of wide interest amongst the scientific, donor and biosecurity communities. However, researchers are faced with a range of challenges when publishing modelling results in scientific journals, including the need to demonstrate novelty, restrictive word limits, inflexible structures, limited subject-matter expertise among the pool of referees, slow review processes, and lengthy publication delays. These challenges limit publication of even high-quality work and, critically, delay dissemination of topical, policy-relevant information. Following on the heels of the successful publication of proceedings from the IPRMW meeting in Trømso, the journal Neobiota is developing a new publication type, tentatively called an "Invasive Species Profile" that addresses many of the challenges described above. The article type is structured around efficient reporting of pest risk models, including a streamlined workflow for getting such articles to press. The aim is to provide an open-access peer-reviewed journal outlet that is brief and highly structured in the main body, but with flexibility in the online materials to accommodate idiosyncratic material to support the model, the content and scope of which varies greatly across modelling applications. The format will likely have authors provide a high-level, policy-targeted summary in the main body text (including a pest risk map), with material that is attractive to a more specialized audience being made available in structured but flexible supplementary materials. The Pensoft publication framework provides a wealth of automated web-based features to enhance the presentation and usefulness of the journal papers. In this talk, we present an exemplar pest profile that we are using to frame the main document, along with an exploration of the Pensoft publication framework.

Frank H. Koch, Mark J. Ambrose, Denys Yemshanov, P. Eric Wiseman.

Modeling urban host tree distributions for forest pests using a two-step approach.

Many alien pest species currently impacting forested ecosystems in North America first appeared in urban forests. Unfortunately, despite serving as critical gateways for the human-mediated spread of these pests, urban forests remain less well documented than their "natural" forest counterparts: only a small percentage of the more than 26,000 communities in the US and Canada have completed any sort of urban forest inventory, and these inventories have commonly been restricted to street trees. We devised a two-step approach that utilizes the available inventory data to comprehensively model urban host tree distributions at a regional scale. We illustrate the approach for three tree genera – ash (*Fraxinus*), maple (*Acer*), and oak (*Quercus*) – that are associated with high-profile forest insect pests. First, based on existing inventories, we use a suite of explanatory spatial variables to estimate the proportion of the total basal area (as a proxy for forest volume) occupied by each genus in non-inventoried communities. Second, we apply a similar suite of spatial variables to estimate the total basal area of these communities. We then combine these estimates to construct region-wide urban distribution maps for each genus. By merging these maps with similar data on natural forests (e.g., distribution maps developed from national forest inventory plot data), we are able to provide a more complete host setting for spread modeling efforts.

Sarina Macfadyen.

Grains pests and climate change: preparing for the future we want

The sustainable management of invertebrate pests in Australian grains production systems is challenging for many reasons. Growers need to manage for pest species that regularly attack crops each year, as well as coping with species that often go un-detected but display sporadic outbreaks. A recent report estimates that losses due to invertebrate pests cost $359 million annually across six major grain crops, and pesticide treatments cost $159 million. Furthermore, there is concern that the changes to temperature, precipitation patterns, and greenhouse gases that we will experience as a result of global climate change will further exacerbate pest problems in grain crops. I have been investigating the potential impact of climate change on the distribution of key pest species, and use models to quantify the change in risk from these species the future. I would like to present some of the outputs from these models and discuss how we can use this information to help develop climate change adaptation strategies that include changes to pest risk.

Roger D. Magarey, Seung-Cheon Hong, and Daniel M. Borchert.

Update on the Generic Pest Forecasting System.

In 2002, we developed the NAPPFAST system, which uses an interactive template to allow users to create simple degree day, disease infection, and flexible models from U.S. and global weather databases for phytosanitary applications. The system of interactive templates enables biologists and those without programming skills to create new maps that estimate potential area of establishment by editing parameter values in the model template. These models suffered from a few limitations, including a reliance on daily weather inputs and a lack of biological complexity. Recently, the Generic Pest Forecast System (GPFS) was developed with the objective of providing an improved model framework for both pathogens and arthropods using hourly weather data as input, but still using the interactive template concept. The GPFS model has the following components: i) Developmental rate estimated from cardinal temperatures and relative humidity; ii) Mortality from cold, heat, and soil moisture; iii) Relative population based on developmental rate and mortality; iv) Infection module for plant pathogens; v) Pest and host growth stages based on degree days; and vi) Potential damage based on predicted pest population and host and pest growth stages.
We present results for the GPFS including case studies for arthropods and plant pathogens. Weather data for model simulations were obtained from the NCEP Climate Forecast Reanalysis System (CFSR) for global simulations and from the Real Time Mesoscale Analysis (RTMA) for U.S. simulations. The GPFS model was run for site-specific locations using excel code and C-code for spatial simulation. Predictions were compared to seasonal pest observations, pest distribution and known pest prevalence. The results show that GPFS has application to predict relative pest populations or potential disease prevalence. NAPPFAST was discontinued as an operational system in early 2014 but there is potential to include the GPFS model in other pest prediction systems.

Justine Murray, Rieks van Klinken, Pierre Audois, Vanessa MacDonald, David Berman, Darren Marshall.

Modelling environmental and economic impacts of invasive species: the next step in risk mapping.

Vertebrate pests can cause considerable damage to environmental assets and considerable resources are often directed towards minimising those impacts. Understanding key ecological and spatial relationships is critical for strategic management of pest species. Spatial understanding of pest threats and impacts is known at the local scale but is limited at the regional scale where much decision-making is undertaken. Similarly, the costs resulting from these impacts can vary spatially depending on different environmental, economic and social drivers, making it difficult to draw satisfactory conclusions from current state and national impact studies. We use the European rabbit (*Oryctolagus cuniculus*) as a case study within the Queensland Murray Darling Basin to determine the impact of rabbits on environmentally significant areas and agricultural landscapes. We previously combined expert knowledge and spatial data into Bayesian networks to create suitability and susceptibility maps and are currently incorporating these with impact judgement to identify areas of potential high impact from rabbit presence. Assessing the rate of impact is directly related to human social dimensions in how we value assets and the greatest impacts do not necessarily always occur where habitat is most suitable. We need to address this by assessing impact at a multitude of scales congruent to the key players affected by rabbit incursions. Land managers and decision-makers can then use this information to target areas for best use of limited management resources. Protection of environmental assets and management of vertebrate pests is most effective in natural and agricultural landscapes if we manage them at the right scales.

Le T. P. Nghiem, Tarek Soliman, Darren C. J. Yeo, Hugh T. W. Tan, Theodore A. Evans, John D. Mumford, Reuben P. Keller, Richard H. A. Baker, Richard T. Corlett, Luis R. Carrasco.

Economic and Environmental Impacts of Harmful Non-Indigenous Species in Southeast Asia.

Harmful non-indigenous species (NIS) impose great economic and environmental impacts globally, but little is known about their impacts in Southeast Asia. Lack of knowledge of the magnitude of the problem hinders the allocation of appropriate resources for NIS prevention and management. We used benefit-cost analysis embedded in a Monte-Carlo simulation model and analysed economic and environmental impacts of NIS in the region to estimate the total burden of NIS in Southeast Asia. The total annual loss caused by NIS to agriculture, human health and the environment in Southeast Asia is estimated to be US$33.5 billion (5th and 95th percentile US$25.8–39.8 billion). Losses and costs to the agricultural sector are estimated to be nearly 90% of the total (US$23.4–33.9 billion), while the annual costs associated with human health and the environment are US$1.85 billion (US$1.4–2.5 billion) and US$2.1 billion (US$0.9–3.3 billion), respectively, although these estimates are based on conservative assumptions. We demonstrate that the economic and environmental impacts of NIS in low and middle-income regions can be considerable and that further measures, such as the adoption of regional risk assessment protocols to inform decisions on prevention and control of NIS in Southeast Asia, could be beneficial.

Senait D. Senay, Susan P. Worner & Craig Phillips.

Landscape recoding for targeted species dispersal modelling

Choice of landscape characteristics like spatial extent, resolution and composition in species dispersal models usually depends on the species being modelled, its dispersal pathways and available data. Thus, optimum landscape characteristics cannot be generalized across multiple species and landscapes. In some cases, the characteristics of the available landscape data do not match the spatial requirements for modelling a specific species. In this study, the landscape was selectively recoded to focus on areas where the interaction between the target species and the landscape is expected to be high. Such landscape enhancement enables users to limit high resolution data acquisition to areas that affect dispersal dynamics the most. Potential benefits of the selective landscape recoding approach were investigated by simulating dispersal of *Pieris brassicae* (Lepidoptera: Pieridae) from Nelson, New Zealand, where it became established in 2010. The results from the recoded landscape closely matched the observed dispersal pattern, thus indicating that selective enhancing of the landscape could be instrumental in improving dispersal rate and pattern estimations derived from dispersal simulations. While the use of appropriate biological dispersal parameters based on valid assumptions is considered a major factor, employing realistic landscapes with appropriate spatial characteristics also has a role in improving species dispersal predictions using simulation models. The spread rate and pattern of dispersal estimations of *P. brassicae* from this study can be used to draw useful conclusions regarding future regional movements of the species and possible eradication and containment plans.

Senait D. Senay & Susan P. Worner.

Multi-scenario species distribution modelling : an essential framework to quantify prediction uncertainty.

Species distribution models (SDMs) are widely used in ecological research, especially in invasive species studies where understanding the potential geographical distribution of such species is paramount to the success of their control and management. The type of models and methods used to undertake species distribution predictions have significantly increased with the increasing availability of digital environmental data. As a result of variation among models and methods, numerous discrepancies are continually reported between geographic distribution predictions targeted for the same species and/or location. We undertook a factorial study to investigate the effect of modellers' choice of modelling components on model uncertainty and prediction accuracy. The factors analysed were, species data, dimension reduction methods and model types. The different combinations of the factors analysed amounted to 180 factor combinations which were replicated 20 times. Six model accuracy evaluation indices were used. The variation in model accuracy according to each model component was reported based on the appropriate model performance measure (selected based on statistical analysis) out of the six tested indices. Two newly developed evaluation indices, namely environmental relative occurrence ratio (eROR) and environmental relative absence ratio (eRAR) along with a previously used index, the relative occurrence area (ROA), were used to independently evaluate the appropriateness of modelling component combinations for each case study. Finally, global species distribution was produced for each species along with uncertainty associated with their distribution prediction. We found that model type is the major factor that caused variation in prediction accuracy among the various modelling components tested. However, two equally compelling observations were reported from this research: 1) it is important to undertake species distribution modelling within a multi-scenario framework, because even if model type is a major factor, it is shown that a different combination of modelling components can significantly increase or decrease the performance of a model, 2) it is important to employ additional pre-and post- prediction performance evaluation techniques to evaluate modelling component combinations and the actual predictions respectively, rather than using the confusion matrix based performance measures alone.

T. Soliman, A. MacLeod, J.D. Mumford, T.P.L. Nghiem, H.T.W. Tan, S.K. Papworth, R.T. Corlett, L.R. Carrasco.

A regional decision support scheme for pest risk analysis in Southeast Asia

A key justification to support plant health regulations is the ability of quarantine services to conduct pest risk analysis (PRA). Despite the supra-national nature of biological invasions and the close proximity and connectivity of the Southeast Asian countries, PRAs are conducted at the national level. Furthermore, some countries have very little experience of producing PRAs, exposing their plant resources to pests vectored via international trade. We review existing decision support schemes for PRAs and, following international standards for phytosanitary measures, propose a new scheme which adapts existing practices to suit the unique characteristics of Southeast Asia. Using a formal written expert elicitation survey a panel of regional scientific experts was asked to identify and rate the unique traits of the Southeast Asian region with respect to PRA. Subsequently, an expert elicitation workshop with plant protection officials was used to verify the potential applicability of the scheme that had been developed. Rich biodiversity, shortage of trained personnel, social vulnerability, tropical climate, agriculture-dependent economies, high rates of land-use change, and difficulties in implementing risk management options were identified as the traits of Southeast Asia. The scheme develops a procedure which emphasises local Southeast Asian conditions and demonstrates features that could be considered by authorities responsible for carrying out PRAs within the region.

Rieks van Klinken, Justine Murray, Vanessa MacDonald and Darren Marshall.

Bringing decision-makers on board: a participatory approach to risk modelling.

Modelling is often done with the purpose of guiding policy-making and directing on-ground management actions, but frequently fails through lack of transparency, trust and ownership. We describe a participatory approach to spatial modelling that has been developed in collaboration with a Natural Resource Management agency with the purpose of addressing these limitations. Spatial models were developed for several invasive plants and for feral rabbits to predict their potential distribution and abundance within the 260,000 km^2 region, and to compare possible policy options. With sufficient time the scientific community can generate such models using available data supplemented by experimental work, but this approach fails to engage policy-makers, and it also overlooks potentially important sources of knowledge. Instead, we co-developed spatial models with decision-makers that represented the combined functional knowledge of the wider community in a testable way. This included diverse scientists, landholders with generations of first-hand experience, and NRM decision-makers with broad regional expertise. A wide range of validation approaches were used to test model assumptions, and they found that modelling benefited from incorporation of diverse knowledge sources. Sometimes validation identified problems with existing knowledge, and this was subsequently addressed as a community, either through updating the model or presenting alternative models to reflect knowledge uncertainty. These models are now successfully being used for guiding responses to invasive organisms across the region. Successful application was assisted by the strong ownership by decision-makers that resulted from their participation in the model-building and validation process, and the emphasis on validation and ongoing learning.

Denys Yemshanov, Frank Koch, Robert G. Haight, Bo Lu¸ Robert Venette, Barry Lyons, Taylor Scarr and Krista Ryall.

Optimal allocation of invasive species surveillance with the maximum expected coverage concept.

Decision makers tasked with planning the surveillance of invasive species often have to rely on uncertain knowledge about the spread capacity of an invader of interest, and face the dilemma of scarce resources available to conduct surveys but the aspiration to cover all possible pathways of invasion. We present a pest survey model based on the Maximum Expected Coverage Problem (MECP) which meets two important decision-making objectives: it maximizes the expected number of potential pathways of species entry from already-infested areas, while also maximizing the likelihood that the survey system fully captures the subset of infested sources deemed high-threat. The model uses pathway-based estimates of species spread and is formulated as a linear programming problem.

We demonstrate the MECP approach by analysing pathways of the spread of the emerald ash borer (*Agrilus planipennis* Fairmaire), a major pest of ash trees in North America, with infested firewood that may be carried by visitors to campgrounds in central Canada and the U.S. Midwest. The survey allocation model was based on a pest transmission network that involved campers traveling from approximately 6500 infested domains to 266 uninfested campgrounds in three Canadian provinces (Ontario, Quebec and Manitoba) and three U.S. states (Michigan, Minnesota and Wisconsin).

Overall, the MECP approach offers a workable strategy for dealing with typical uncertainty about the human-mediated, long-distance spread of invasive species, and makes the geographical planning of pest surveillance campaigns less subject to possible errors in the long-distance spread estimates. The approach also helps assess the cost savings from planning a well-coordinated, multi-stakeholder survey campaign versus undertaking independent surveys for the same budget levels. The MECP concept is generic and is applicable in many practical situations where surveys target the human-mediated spread of invasive species.

Tania Yonow.

Common Mistakes in Modelling.

This talk will outline and address some of the more common mistakes made in CLIMEX modelling, although some of these issues will no doubt be valid with other modelling systems. Topics addressed will include identifying and working within the modelling paradigm, internal model consistency, identifying correct stress functions, and of course, the bane of all scientists' lives – documentation. I will attempt to illustrate how some of these errors can have quite significant impacts.