HG10700 (August 2010)

Final Report:

IVth International Pest Risk Modelling Workshop

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Darren J. Kriticos

October 2010

Horticulture Australia Limited

HAL Project Number: HG10700

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This is the report regarding the IVth International Pest Risk Modelling Workshop, held in Port Douglas, 23-25 August 2010.

The workshop was generously sponsored by the following organisations:

The Cooperative Research Centre for National Plant Biosecurity

Horticulture Australia

CSIRO Ecosystem Sciences

Plant Health Australia

Atlas of Living Australia

October 2010

Contents

Media Summary

The IVth International Pest Risk Modelling Workshop was held in Port Douglas 23-25 August 2010. This annual event brought together an international panel of 30 scientists and stakeholders to develop collaborative research projects and to report on progress. The focus of this informal group is to improve the methods by which we can assess pest risks and to communicate these risks more effectively to biosecurity, production and natural resource sector stakeholders so that the risks can be better managed.

Pest risk maps can help in the formulation of appropriate border biosecurity policies and procedures, and the development of industry biosecurity plans. The modelling and analytical techniques being developed by members of the International Pest Risk Modelling Workgroup can also inform the management of incursions by unwanted organisms, including those that threaten horticulture.

At this year's meeting, the workgroup developed a structured outline for a practitioner's guide to pest risk modelling and mapping. This multi-authored guide will act as a resource for both risk assessors and stakeholders wishing to gain a better appreciation of the meaning and limitations of pest risk assessment tools. It is intended that it will be drafted by the end of June 2011.

A clear benefit of the pest risk modelling workshops is that the case studies used by participants are frequently generally applicable. For example, the modelling work on the potential distribution of the peach fruit fly (*Bactrocera zonata*) conducted in China can be used to generate global risk maps, allowing biosecurity agencies elsewhere to understand the risks posed to their jurisdictions. This mutual sharing of effort at these workshops is highly cost-effective. Reliable pest risk models frequently involve a significant amount of research effort (AUD$20,000-50,000), compared with approximately AUD$1,000-3,000 to apply the model to a new jurisdiction and report on the results.

Knowledge shared during this workshop will be used in a CRC for National Plant Biosecurity project (Communicating Uncertainty in Biosecurity for Agriculture). This project involves Apple and Pear Australia Limited and the Banana Growers Council of Australia. These case study industries will be used to improve techniques for communicating uncertainty around pest risks to stakeholders.

Evaluation of effectiveness

The objectives of the workshop were to:

- showcase the cutting edge techniques and methods in pest risk modelling and mapping
- facilitate the sharing of these techniques and methods
- facilitate international collaboration on the further development of pest risk modelling and mapping methods, and
- progress the development of a best practice manual for pest risk modelling and mapping.

By all accounts these objectives were extremely well met.

Verbal feedback from delegates was extremely positive regarding the choice of venue and organisation of the workshop. This year we were seeking to broaden the international participation in the working group and we achieved this. This was the first time the event had been held outside of the USA, and it was felt that we needed to have a highly successful workshop in order to give participants the confidence to hold future workshops outside of the USA. We clearly achieved this aim, with unanimous support for future workshops to alternate between the USA and other countries.

The conference format with 2 days of "show and tell" presentations followed by a full day workshop focused on research planning and organisation was generally felt to be a bit onerous on participants. In future we agreed to break up the working component across two or more days.

Conference program

Sunday, August 22 2010

Time	Session	Activity	Presenter
18:00	Welcome / Orientation	Registration	Darren Kriticos, John Lovett
19:00	Self-organising dinner groups		

Monday, August 23 Morning Session

Time	Session	Paper	Presenter
8:00	Logistics / Conference Theme		Darren Kriticos
8:15	Opening the Meeting		Prof John Lovett
8:30	Retrospective on Pest Risk Modelling	Pest risk modelling: How did we get here and what lessons have we learnt?	Prof Bob Sutherst
9:20	1a	The art of modelling range-shifting species	Jane Elith
9:40	1b	A qualitative intercomparison model assessment: The case of *Bactrocera invadens*	Sarah Brunel
10:00	BREAK		
10:30	1c	Performance of nine models for predicting the distribution of *Diabrotica virgifera virgifera* (western corn rootworm)	Maxime Dupin
10:50	1d	Assessing the goodness of fit of species niche models: All species distribution points and statistics are not equal	Darren Kriticos
11:10	1e	Improving the predictive performance of correlative static species distribution models	Sue Worner
11:30	1 wrap-up		*Session moderator:* Roger Magarey
12:00	LUNCH		

Monday, August 23, Afternoon Session

Time	Session	Paper	Presenter
13:00	2a	Modelling the potential range of a distributionally-challenged pathogen - *Phytophthora ramorum*	Kylie Ireland
13:20	2b	Integrating CLIMEX, land-use data and economic theory in a weed risk analysis: *Nassella neesiana* in New Zealand as a case study	Graeme Bourdôt
13:40	2c	Modelling the recurrent seasonal risk from a migratory insect pest	Hazel Parry
14:00	2d	Risk analysis for *Rhopalosiphum padi*, an aphid species with variable reproductive modes	Sarina Macfadyen
14:20	2 wrap-up		*Session moderator:* Denys Yemshanov
14:45	BREAK		
15:15	3a	Including climate change in pest risk assessment: The peach fruit fly, *Bactrocera zonata* (Diptera:Tephritidae), in China	Wenlong Ni
15:35	3b	Grasshopper monitoring and forecasting in western Canada: Past, Present and Future	Ross Weiss
15:55	3c	Projected direct effects of climate change on some invasive forest pathogens	Robert Venette
16:15	3d	Uncertain uncertainty: exploring the effect of variation in underlying climate data on species modelling projections	Bruce Webber
16:35	3 wrap-up		*Session moderator:* Frank Koch
17:00	ADJOURN		
17:30	Depart hotel for river cruise		
18:00	River cruise		

Tuesday, August 24 Morning Session

Time	Session	Paper	Presenter
8:00	4a	Building the Australian Biosecurity Intelligence Network	David Miron
8:20	4b	A Framework for Modelling and Mapping Economic Impacts	Roger Magarey
8:40	4c	Blue triangles and pink boxes, the modellers' and end-users' dilemma	Paul De Barro
9:00	4d	Drafting a risk mapping decision support scheme for pest risk analysts	Richard Baker
9:20	4 wrap-up		*Session moderator:* Sue Worner
9:45	BREAK		
10:15	5a	A measure of climatic suitability, suitable for multispecies comparisons and ease of interpretation	Stephen Hartley
10:35	5b	A retrospective analysis of the use of ecological theory and pest species assemblages to prioritise pests	Sue Worner
10:55	5c	Analysing invasive pest assemblages (IPA) to rank species' likelihood of establishment	Dean Paini
11:15	5d	A multi-criteria risk mapping approach based on the Pareto frontier principle- A simpler alternative to the multi-criteria weighted averaging technique?	Denys Yemshanov
11:35	5 wrap-up		*Session Moderator:* Sarah Brunel
12:00	LUNCH		

Tuesday, August 24, Afternoon Session

	Session	Paper	Presenter
13:00	Workshop Proceedings	Publication of a set of invited papers from this workshop. Target journal? Interest? Participation?	Darren Kriticos
13:30	Upcoming Meeting 2011	It is proposed to hold the next meeting at Ft. Collins in 2011	Roger Magarey
13:45	Upcoming Meeting 2012	The following meeting (2012) may be held in Europe	Richard Baker
14:00	Publishing Pest Risk Models	The rise of bibliometrics is creating challenges for publishing good quality pest risk models that do not introduce methodological novelty. How do we share our results in a way that provides quality control and career rewards?	Darren Kriticos
14:30	BREAK		
15:00	6a	Modelling middle age spread: *Buddleja davidii* in New Zealand	Mike Dodd
15:20	6b	Wind trajectory and bioclimatic modelling to provide advance warning of the potential distribution and number of generations of diamondback moth, a serious pest of oilseed crops in western Canada	Ross Weiss
15:40	6c	Assessing Risk of Human-Assisted Spread of Invasive Forest Pests with Firewood Transport	Frank Koch
16:00	6d	Unveiling human-assisted dispersal mechanisms in invasive insect pests: integration of spatial stochastic simulation and phenology models	Roman Carrasco
16:20	6e	Modelling trade-associated pathways of alien forest insects establishments in Canada	Denys Yemshanov
16:40	6f	The Web-based Atlas of Living Australia	Lee Belbin
17:00	6 wrap-up		*Session Moderator:* Richard Baker
17:30	ADJOURN		
19:00	Conference Dinner		

Wednesday, August 25 – All Day

Time	Session	Paper	Presenter/Facilitator
8:00	IPRMW website	IPRMW website planning/discussion	Darren Kriticos
9:30	"Best" Practice Manual	Overview and background	Darren Kriticos
10:00	BREAK		
10:30	Breakout Organizing/Planning	Organizing breakout sessions around interest and topics (aka Cat Herding 101)	Rob Venette
11:00	BPM Breakout Session 1	Six breakout topics/groups in session 1	
12:00	LUNCH		
13:00	Award and Prizes	Best Paper, Best Poster, Best Hair, etc.	Rob Venette
13:15	Add'l Breakout Organizing	Cat herding 201 (if necessary)	Roger Magarey
13:30	BPM Breakout Session 2	Six breakout topics/groups in session 2	
14:30	BREAK		
15:00	Collation of Breakout Session Efforts	Collating info for manual	Darren Kriticos
16:30	Summary	Summary of breakout results, collation, take-home tasks, general debriefing	Darren Kriticos
17:00	ADJOURN		

Delegate list - including name and state

Firstname	*Surname*	*Organisation*	*Country*
Richard	Baker	FERA	UK
Lee	Belbin	Atlas of Living Australia	Australia
Graeme	Bourdot	Agresearch	New Zealand
Sarah	Brunel	EPPO	France
Roman	Carrasco	University of Singapore	Singapore
Karen	Castro	CFIA	Canada
Paul	De Barro	CSIRO	Australia
Mike	Dodd	Agresearch	New Zealand
Maxime	Dupin	INRA	France
Jane	Elith	University of Melbourne	Australia
Stephen	Hartley	Victoria University	New Zealand
Kylie	Ireland	CRC NPB/Murdoch University	Australia
Frank	Koch	USDA	USA
Darren	Kriticos	CSIRO	Australia
John	Lovett	CRC NPB	Australia
Sarina	Macfadyen	CSIRO	Australia
Roger	Magarey	USDA	USA
David	Miron	CSIRO	Australia
Wenlong	Ni	China Agricultural University	China
Dean	Paini	CSIRO	Australia
Hazel	Parry	CSIRO	Australia
Karl	Suiter	USDA	USA
Bob	Sutherst	University of Queensland	Australia
Rob	Venette	USFS	USA
Bruce	Webber	CSIRO	Australia
Ross	Weiss	AAFC	Canada
Sue	Worner	Lincoln University	New Zealand
Denys	Yemshanov	NRCAN	Canada

Financial Report

The financial report for the workshop and project is presented below.

CSIRO

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION

CSIRO

HORTICULTURE AUSTRALIA LTD

Certified statement of receipts and expenditure incurred by CSIRO Ecosytem Sciences : HAL Project HG10700 - IVth International Pest Risk Modelling and Mapping Workshop August 2010

RECEIPTS		EXPENDITURE	
Balance brought forward		Salaries	$0.00
		Travel and Conference Expenses	$16,470.21
Contribution received from HAL	$9,568.21		
Contribution received from CRC NPB	$2,000.00	Equipment	$0.00
Contribution received from CSIRO	$4,902.00		
		Operating	$0.00
TOTAL Contributions	$16,470.21	TOTAL Expenditure	$16,470.21
BALANCE TO BE CARRIED FORWARD	$0.00		

I certify that all of the Funds were received and expended for the purpose of and in accordance with the Agreement

08 /11 /2010 Amanda Walker Finance Manager

Key outcomes of the conference

Delegates were updated on recent developments in the field of pest risk modelling and mapping. The delegates were mostly scientists conducting cutting-edge research designed to improve our ability to gauge pest risk accurately. The presentations were of a very high quality and each session was completed with spirited discussion of the topic.

The final day of the workshop produced a draft outline for a practitioner’s guide to pest risk modelling. Delegates agreed to lead the writing of different sections of this guide. It was agreed that a significant feature of this publication would be a chapter focused on making the technology accessible to end-user stakeholders of pest risk models and maps. Such stakeholders include industry organisations such as HAL, as well as biosecurity agencies.

Recommendations

1/ **Hold the workshop over multiple days**

Where a multi-day conference and workshop are to be combined, consideration should be given to breaking up the workshop across multiple days. Delegates were fairly tired by the third day, and a full day at this stage demanding their continued engagement was felt to be excessively taxing.

2/ **Continue to support an annual international pest risk modelling workshop**

Pest risk modelling and mapping is a fast-moving field. Given the pace at which the field is changing, and the role of these workshops in maintaining this pace, an annual meeting appears to be desirable, at least for the next five years. A roadmap for improvement of pest risk mapping was produced by this group recently (Venette et al 2010). This roadmap provides an agenda for this group to develop collaborative international projects that have high value for stakeholders.

3/ **Explore options for clarifying and solving stakeholder communication issues**

It is clear that there are communication issues between scientists and risk analysts producing pest risk models on the one hand, and their intended audience for these information products on the other. In general terms this problem is not unique to pest risk modelling and mapping, but pervades all aspects of scientific endeavour. However, because of the central roles of problem framing and spatial maps in the communication of risk in this context, perhaps a special effort should be focused on teasing out the issues and attempting to solve them.

Acknowledgments

The success of the workshop was due to both generous sponsorship and the extended efforts of the organisation committee (Frank Kock, Darren Kriticos, Roger Magarey, Hazel Parry and Rob Venette).

Reference

Venette, R. C., D. J. Kriticos, R. Magarey, F. Koch, R. H. A. Baker, S. Worner, N. N. Gómez, D. McKenney, E. Dobesberger, D. Yemshanov, P. De Barro, W. D. Hutchison, G. Fowler, T. Kalaris, and J. Pedlar. 2010. Pest risk maps for invasive alien species: a roadmap for improvement. *Bioscience* **80**: 349-362.

Abstracts

Keynote Address

Pest risk modelling: How did we get here and what lessons have we learnt?

Prof. R. W. Sutherst

University of Queensland, St Lucia, Brisbane, Queensland, Australia 4072

Pest risk modelling has a history going back at least as far as Cook in 1929. It has had major contributions from biological, geographical and mathematical disciplines. The drivers of these activities were both agricultural protection against invasive species and protection of endangered species. Importantly, the context in which the biosecurity and biodiversity sectors operate has dictated the nature of the various attempts to describe species geographical distributions. These sectors function in a data-poor environment, with limited budgets and broad demands from policy makers that encompass numerous species and require rapid response times. Initially species distribution modelling was hindered by the lack of computational power but the onset of computing opened up transformative opportunities to address regional-scale risk assessments. Species mapping has now followed the traditional scientific pattern of becoming a band wagon with the usual mixture of wasted effort and useful new insights. While modelling tools are important, the need for both reliable spatial occurrence data and better understanding of the ecological processes involved in determining the distribution of species are just as important. I argue that the dream of automating species mapping for multiple species is an illusion that needs to be abandoned in favour of acknowledgement of our lack of understanding of species-specific responses to dynamic environments. More modest goals are needed to reflect the insuperable uncertainties that will exist for as long as pest risk modelling has been attempted in the past.

Presentation Abstracts

(Listed in order of appearance in programme)

The art of modelling range-shifting species

Jane Elith[1*], Michael Kearney[1], & Steven Phillips[2]

1-The University of Melbourne

2-AT&T labs, research.

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The biodiversity of many regions in Australia and globally is experiencing novel threats created by species invasions and climate change, prompting the need for tools for predicting future distributions of species. There has been increasing interest in, and application of, statistical modelling approaches ("species distribution models", SDM, or "ecological niche models") to infer species' ranges under global change. This is despite the well acknowledged assumption made by such approaches that the species being modelled is at equilibrium with the environments used to fit the models, and with the environments in the regions and times to which the model predicts. In this talk we will use an invasive species, the cane toad (*Bufo marinus*), as an example to illustrate the sensitivities of SDMs in non-equilibrial situations. This will show how sometimes subtle variations in model structure and data formulation affect predicted distributions across the Australian continent under current and future climate scenarios. In current climates, models from several modelling methods, data sampling approaches and weighting strategies predict potential distributions that differ substantially in areal extent and regional emphases. Under climate change, even models that predict similar ranges under current climate predict a spectrum of outcomes ranging from contraction to expansion. These issues can be addressed, at least partially, with careful model construction and with due consideration of the extent of extrapolation. We suggest and demonstrate useful approaches to tackle this problem that are consistent with the ecological and statistical features of species and models.

A qualitative intercomparison model assessment: The case of *Bactrocera invadens*

Sarah Brunel & colleagues

EPPO, PRATIQUE, sb@eppo.fr

In the framework of the PRATIQUE project and the current EPPO activities on Pest Risk Analysis, different models have been used to assess the potential distribution of the fruit fly *Bactrocera invadens* in European and Mediterranean countries. This species is very polyphagous and mango, Citrus spp., papayas, guavas are its main hosts. *Bactrocera invadens* is supposed to originate in India, and has spread in more than 32 sub-Saharan African countries since its first record in Kenya in 2003. It has very recently been recorded in irrigated crops in Sudan, and might be progressing North. There is a high uncertainty on the tolerance of this species to cold temperatures and dry conditions.

A qualitative model intercomparison has been undertaken by running inductive models such as Maxent, Openmodeller, Diva GIS, as well as integrated techniques with CLIMEX Compare Locations. An American risk analysis had been performed on *Bactrocera invadens*, using NAPPFAST. All these models provided different outputs, making the interpretation of this variety of results difficult. From a qualitative point of view, the level of understanding and of confidence of the assessor greatly varies. The criteria set by the PRATIQUE project are used to compare qualitatively these different species modelling techniques.

Performance of nine models for predicting the distribution of *Diabrotica virgifera virgifera* (western corn rootworm)

M. Dupin[1,2], D. Makowski[3], P. Reynaud[2], & V. Jarošík[4]

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2-LNPV, Pôle Expertise et Analyse du Risque Phytosanitaire, Angers F-49044, France; philippe.reynaud@agriculture.gouv.fr

3-INRA, UMR 211 INRA/AgroParisTech, Thiverval-Grignon F-78850, France; david.makowski@grignon.inra.fr

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Several different types of models can be used to predict the presence/absence of invasive species. Their performance depends on the model characteristics, the number and type of input variables, the extent of the presence area, and the size of the training dataset. In this paper, we compare the performance of nine models for predicting the presence of *Diabrotica virgifera virgifera* in North America and Europe. Ten types of training datasets of various sizes (from ten to 428 presence data) and three sets of input climatic variables (19 variables, six variables and three linear combinations of 19 variables derived from Principal Component Analysis) were evaluated. The nine models were fitted to each training dataset in turn and their performance was assessed using independent data located in North America and Europe. The models were ranked according to several criteria: Area under the ROC curve, likelihood ratio and proportion of the predicted presence area. The results showed that four models (Climate Space Model, Envelope Score, Desktop GARP, OM GARP) perform better than the others. Model performance was highly sensitive to the area used for calibration, but the effect of the size of the training dataset was also significant in some cases. The performance of some models was highly variable, but others, e.g. Envelope Score were more robust. In some situations, no model performed better than a random classification, especially when the training dataset was defined from a very restricted geographical area. Our results also showed that Principal Component Analysis was useful in reducing the number of model input variables for the models that performed poorly with 19 input variables. The methodological framework defined in this study could be used to assess other models and could be implemented with other invasive species in the future.

Assessing the goodness of fit of species niche models: All species distribution points and statistics are not equal

Darren J. Kriticos & Agathe Leriche

CSIRO Ecosystem Sciences and CRC National Plant Biosecurity, GPO Box 1700, Canberra, ACT 2601.

Statistics commonly used for assessing the accuracy of various tests from psychological responses to radio antennae have been applied to assessing the goodness of fit of niche models for invasive species. Such techniques include Kappa, True Skill Statistic and Area under the Receiver Operating Curve (either AUC or ROC), and Likelihood ratio. These tests have been used with apparent success to assess the goodness of fit of species distribution models, and there is pressure to apply them to niche models for pest risk assessment. These statistics all have one characteristic in common. They assume that each data point is equally informative and valuable. When using these statistics to seek an optimal model solution they tradeoff positive and putative negative allocation errors equally. However, for invasive species models, knowledge of a positive location is a critically important indicator of environmental suitability, and hence, by extension, pest threat. Evidence of environmental unsuitability is usually weak or non-existent. As model thresholds are adjusted upward to accommodate tradeoffs between areas of apparent omission and commission errors, invariably, climatically peripheral points are the first to be removed from the environmentally suitable class. Typically, the periphery of a species distribution is sparsely sampled: the species frequency of occurrence usually decreases near its range boundary, and interest in its presence diminishes. In statistical terms, these range peripheral points also have high leverage. The combination of low abundance and high statistical leverage means that they are of inordinately high value to assessing pest risk. On the one hand they can add greatly to our understanding of potential risk elsewhere, while on the other, any misinterpretation of the meaning of range peripheral records could have a severe detrimental effect on the veracity of the estimated potential range of the species. Examples of the effects of optimizing a model for different statistics are given, and the case is made for using a two-step approach using presence-only data to apply the Exact test or an ANOVA to identify good-fitting pest risk models that are fit for purpose.

Improving the predictive performance of correlative static species distribution models

S.P. Worner[1], T. Ikeda[1], & G. Leday[2]

1-Bioprotection Research Centre, Lincoln University, Canterbury, New Zealand

2-Department of Mathematics, VU University, Amsterdam, the Netherlands

An assessment of environmental suitability for a potential invasive species facilitates better targeting of resources towards preventing unwanted incursions. A wide range of species distribution models can be used to infer habitat suitability from species presence data. A number of these models are static correlative approaches that have been shown to be very accurate but require both presence and absence data. However there are two problems that need to be addressed to ensure their accuracy. First, true absences are almost never recorded, and if they are, it is difficult to confirm that they are real. It may be the search was not able to detect the species or it is able to survive in the absent location but has not yet reached there. Second, species distribution databases are commonly unbalanced with many potential absence records compared with presence records. That imbalance can result in poor model predictive performance where the model cannot generalise to new data. A common solution is to select a random subset of the absence data (called pseudo-absences), but that can also result in poor performance. In several recent studies, profile methods have been used to select representative pseudo-absence data. In this study, we developed a new procedure for choosing representative absence data that is capable of handling high dimension data and complex nonlinear relationships. To obtain representative data that can explain or characterise species absence, a two-step process involving one class support vector machines (OCSVMs) and k-means clustering was used. We tested the performance of nine SDMs over 21 species by selecting pseudo-absences progressively closer to the environmental conditions that characterize the presence locations. We found not only that the predictive performance of all models, as measured by cross-classification and nine performance measures improved, the procedure reduced the problems associated with randomly selected absence locations.

Modelling the potential range of a distributionally-challenged pathogen - *Phytophthora ramorum*

K.B. Ireland[1*], G.E. St J. Hardy[1] & D.J. Kriticos[2]

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Phytophthora ramorum is an invasive plant pathogen causing considerable and widespread damage in nurseries, gardens and natural woodland ecosystems of the USA and Europe, and is classified as a Category 1 emergency plant pest in Australia. Prior to its invasion of the USA and Europe, *P. ramorum* was not on the global pest risk radar, and even to this day its native geographic range remains unknown. Estimating the potential geographic range *of P. ramorum* has been complicated by the lack of geographic data with which to calibrate climatic models. Previous attempts to do so using either invaded range data, or surrogate species approaches have delivered widely varying results. A simulation model was developed using CLIMEX software to estimate the global climate suitability patterns for establishment of *P. ramorum*. Growth requirements and stress response parameters were derived from laboratory ecophysiological observations and site-level phenological factors of transmission and disease persistence associated with climate data from the field. Geographic distribution data from California and Europe were used to validate the model. The model suggests that the invasion of *P. ramorum* in North America is still in its infancy, and it is presently occupying a small fraction of its available range. In Europe, it would appear that most of the climatically suitable countries have already been invaded, though there is still considerable scope for further within country invasion. Results of the model will be presented, and implications for global quarantine and management of the disease discussed.

Integrating CLIMEX, land-use data and economic theory in a weed risk analysis: *Nassella neesiana* in New Zealand as a case study

Graeme Bourdôt[1*], Simon Harris[2] & Shona Lamoureaux[1]

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2-Harris Consulting Resource Economists, PO Box 70 Lyttelton, New Zealand
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The invasive grassland weed, Chilean needle grass *(Nassella neesiana*), was discovered in 2008 growing in pastures and arable crops in a vineyard at a location in the Canterbury region of New Zealand, probably having been dispersed there as seed on sheep or machinery transported from the nearby Marlborough region where the species is well established. In order to justify public expenditure on a containment programme in Canterbury, an estimate of the likely future losses to the pastoral sector in that region is required. To that end, the land area of potential habitat, estimated using GIS procedures in combination with a CLIMEX model, land-use classification data and the species' known distribution in New Zealand, was input into a bio-economic model. The model was further paramaterised using data on the rate of the weed's spread in the nearby region of Marlborough. The model results suggest that under the assumptions used, there is likely to be a positive net benefit to public intervention that ensures containment and local control of Chilean needlegrass in Canterbury.

Modelling the recurrent seasonal risk from a migratory insect pest

Hazel R. Parry[1,2*], Darren J. Kriticos[1] Jean-Philippe Aurambout[3], Wendy Griffiths[2,4], Kyla Finlay[3], Paul De Barro[1,2], & Jo Luck[2,3]

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A spatially-explicit process-based model has been developed using DYMEX to simulate the population dynamics of the aphid *Rhopalosiphum padi* in several agricultural landscapes of Australia. This grid-based model responds to the influence of the environment, including weather, on: (1) the habitat of the species (incorporating a wheat growth model); (2) the species' population dynamics and phenology and (3) the dispersal of the aphid with subsequent Cereal Yellow Dwarf Virus (CYDV) disease spread. The aphid model interacts with the wheat growth model: physiological age and nutrient balance affect aphid survival, fecundity and density. The CYDV infection of the grassland and/or wheat is transmitted to aphids and subsequently spread.

A novel component of the model is the spatially-explicit simulation of aphid dispersal, in particular the initial dispersal of migrant aphids from over-summer grassland habitat into wheat crops in Autumn. The aphid population in grasslands migrates according to local meteorological conditions and wind speed/direction. The wind is simulated using a wind trajectory model (Rochester, 1999).

A case study of Western Australia is used to demonstrate how the process-based simulation of aphid population dynamics incorporates the simulation of wind-driven migration. This enables a spatially-explicit risk assessment for aphid seasonal migration and thus the spread of CYDV from over-summering aphids in grasslands to winter wheat crops.

Rochester, W.A. (1999) PhD Thesis, Dept. Zool. Ento., Univ. Queensland

Risk analysis for *Rhopalosiphum padi*, an aphid species with variable reproductive modes

Sarina Macfadyen* & Darren J. Kriticos

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Many pest aphid species exhibit reproductive mode variations, which may be important to their ability to invade and persist in different areas. For *Rhopalosiphum padi* (Linnaeus), a pest of cereals, reproductive mode variation is influenced by low winter temperatures and the presence of a suitable *Prunus* winter host plant. We used a combination of geographic and published experimental data to fit separate CLIMEX models of the sexual and viviparous reproductive forms of *R. padi*. We used these models to estimate the potential global distribution of *R. padi* under historical climate, and to examine how primary host plant presence and land-use (irrigated or dryland cropping) alter the ability of *R. padi* to persist in particular areas. The CLIMEX results indicate the global climate suitability for persistent and transient populations, which informs the potential range of *R. padi*. Once distributional data for the primary host plant species was incorporated, the greatest risk from establishment of year-round populations experiencing both reproductive modes was in areas with warm temperate climates in North America, Europe and Australia. At the global scale very little difference in risk patterns can be seen between natural rainfall and irrigation scenarios. However, in Australia, the amount of land suitable for persistent viviparous and transient sexual populations increases (by 20%) under irrigation as dry stress was alleviated. Modelling the climate suitability for each *R. padi* reproductive mode separately enabled the type of invasion threat to each area to be identified, and so can inform pest management.

Including climate change in pest risk assessment: The peach fruit fly, *Bactrocera zonata* (Diptera:Tephritidae), in China

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Bactrocera zonata (Saunders) is one of the most harmful species of Tephritidae and causes large amounts of damage in Asia. This species is regulated as one of the quarantine pests in China. The current and future potential geographical distribution of *B. zonata* was modeled using CLIMEX 3.0 and ArcGIS 9.3. The results indicate that under current climatic conditions, its projected potential distribution in China includes most areas between 16.544°N-33.408°N, and the suitable areas account for 27% of the country's total area calculated by ArcGIS. Its projected optimal suitable area accounts for 12% and includes Hainan, Guangdong, most parts of Guangxi and Yunnan, Sichuan basin, southwest of Fujian, south of Jiangxi and Guizhou, parts of Hunan, Taiwan. As a result of climate change, the potential range for *B. zonata* in China is projected to extend further poleward as cold stress boundaries recede and the suitable areas for it are increasing gradually, for 30% in 2020, 32% in 2050 and 35% in 2100. The climatically optimal areas show the similar trend. Based on this study, the likely future significant increases in the potential distribution of *B. zonata* suggests that the biosecurity authorities should routinely consider the effects of climate change when undertaking pest risk assessments under the IPPC framework. In order to prevent the introduction and spread of *B. zonata* in China, the quarantine and monitoring measures should be focused in areas projected to be suitable under current and future climatic conditions.

Grasshopper monitoring and forecasting in western Canada: Past, present and future

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Since first settlement in western Canada, grasshopper outbreaks have been associated with agriculture. Effectiveness of grasshopper control could be enhanced if producers and government agencies were informed of expected levels of infestation in the coming season. Early warning of changes in grasshopper populations is required to determine the potential impact on agricultural crops. Since 1919 large scale grasshopper surveys have been conducted across western Canada. Grasshopper densities are mapped and serve as a forecast of grasshopper levels for the following year. In Saskatchewan grasshopper forecast maps have been produced annually since 1931. Surveys are conducted in August and consist of 1200-2500 survey points. The migratory grasshopper *Melanoplus sanguinipes* (Fabricius) is the species that is often associated with outbreaks resulting in crop loss. In Western Canada, fluctuations in grasshopper density occur over broad geographic regions in response to weather. *Melanoplus sanguinipes* thrives in warm, dry conditions and outbreaks are often associated with a number of seasons with above normal temperatures and below normal precipitation. Prior to the 1980's grasshopper forecast maps were hand drawn. In the last 30 years Geographic Information Systems (GIS) have been used to present survey data and GIS has been used to overlay weather, soil and ecosystem variables. Since 2006 bio-climatic models have been used to analyze the relationship between grasshopper populations and climate. Climate changes caused by human activities is predicted to result in increased temperatures and variable precipitation across western Canada. Recent research has focused on application of bio-climatic models to determine changes in distribution and abundance in future climates.

Projected direct effects of climate change on some invasive forest pathogens

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Invasive alien pathogens have been responsible for fundamental changes in the composition and function of many forests. The consequences of future climate change for the potential distribution of alien invasive species is a critical research area. Output from a number of general circulation models suggests temperatures will continue to warm and precipitation will become more variable in North America. The magnitude of these changes varies regionally. We used the deductive climate-niche model, CLIMEX, to evaluate shifts in the extent and distribution of areas forecasted to be climatically suitable for the establishment of *Phytophthora ramorum* and *Dothistroma septosporum*. Models were run for the baseline climate (1961-1990), through 2020, 2050 and 2080 with downscaled climate data from CGCM1 (Canadian General Circulation Model 1) under emission scenario b2a. For both of these pathogens, the CLIMEX model suggests climate changes by 2080 will cause major reductions in the total areas projected to be climatically suitable for establishment, with suitable areas generally occurring at higher elevations or more northerly latitudes than projected for the baseline climate. Changes are likely to be more dramatic for the eastern half of North America than the western half. Heat stress will play a key role in limiting the distribution of both pathogens.

Uncertain uncertainty: exploring the effect of variation in underlying climate data on species modelling projections

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Correlative and mechanistic species niche models are the mainstay of pest risk assessment. These models invariably include use of direct or derived climatic data as covariates, as this factor is the primary determinant of the potential range of most pests, and hence a useful indicator of the potential for pest threat. As indicated in the recent roadmap for improvement, there is an increasing need for both methodological transparency and an estimate of confidence for projections generated by species models. The effects on the modelled species range of climate data precision, model type, species distribution data, and parameter uncertainty have all been explored previously. For climate change modelling, the effects of emission scenario and global climate model have also been explored. A hitherto unexplored source of modelling uncertainty is the quality of the underlying climatology data. In pest risk modelling, errors in the underlying climate data can affect both the fitting of inferential models, as well as their projection into new continents, or future climate scenarios. We explore the uncertainty in gridded climatologies and their effects on model projections, and develop data products to help modellers to recognize areas with less reliable data. Addressing these issues will result in a significant improvement in our ability to frame model projections with an appropriate level of uncertainty.

Building the Australian Biosecurity Intelligence Network

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The Australian Biosecurity Intelligence Network (ABIN) aims to strengthen Australia's biosecurity research, diagnostic, surveillance and response capability, by enabling researchers, industry and governments to connect with each other, utilise expertise, share data, information, and generate intelligence using leading edge tools and technologies through a secure online workspace. ABIN spans the human, wildlife, aquatic, plant and animal biosecurity sectors and is a federally funded initiative through the National Collaborative Research Infrastructure Strategy. ABIN is building infrastructure to give the Australian biosecurity community access to data and software tools within secure online community spaces. ABIN has engagement across jurisdictions and federally through its Proof of Concept Projects, Tools and Infrastructure Programmes and joint initiatives with the centres for "Remote Connectivity and Surveillance" and the "Biosecurity Intelligence Generation". In this presentation the purpose and initiatives of ABIN will be further expanded including the activities of the ABIN IT Tool Programme its initiatives and objectives.

A framework for modelling and mapping economic impacts

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The estimation of economic impacts is one of the most important components of risk analysis for an exotic plant pest. The estimation of impacts is especially difficult because it requires knowledge of a pest's probability of entry and establishment, rate of spread, host range, possible trade losses, and control options and costs. We propose a framework to calculate economic impacts using four components: i) Risk mapping; ii) Generic ecological model; iii) Commodity economic model; and iv) Incorporation into a web based interface. Risk maps for host density, climate suitability and pathways have been developed by a multi-disciplinary team using the NAPPFAST modeling system and data from National Agricultural Statistics Service, U.S. Forest Inventory, and from the Freight Analysis Framework database. The risk mapping provides a method to spatially estimate components of introduction and establishment which can be used as inputs into the generic ecological model. The generic ecological model developed by Waage et al. is an invasion-spread-control-impact model with parameters designed to allow comparison of a wide range of invasive taxa and economic/ environmental targets. It includes the estimation of uncertainties using a monte-carlo simulation. The generic ecological model also includes a partial equilibrium economic model. To calculate economic impacts more precisely, we propose using a commodity economic model, developed by Paarlberg et al. that assesses effects of supply shocks from the generic ecological model, along with demand and trade shocks, projected over the simulation period. A model has been developed for the small grains industry and one for seed is under development. The final component is to build the generic ecological and commodity economic model into NAPPFAST. NAPPFAST is a role-based access system which allows users including modelers and risk analysts to parameterize and run models and distribute products to end users such as program mangers.

Blue triangles and pink boxes, the modellers' and end-users' dilemma

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The utilisation of modelling and the results it delivers by biosecurity end-users at various levels of decision making, ranging from national strategic policy to on-ground response programs, is often patchy. End-user utilisation is influenced by the context in which it is used including timeframes, amount of information available, sensitivity of the situation being modelled, ability of end-users to understand and relate to the model, and the purpose for which it is meant to help inform a decision. For biosecurity, end users utilisation of modelling tools, and their ability to change the types of tools they use, can often be affected by external factors such as international or domestic trading requirements and impacts.

End-users tend to have an often uncommunicated mental checklist and "reality check" which can tend influence their confidence and use of modelling. Key elements of an end-user check list, as well as the constraints and context which can influence the use of modelling in decision making, need to be better defined by end-users. This needs to be communicated to modellers before and during development of models rather than as a product of a separate parallel activity in the decision making process. Modellers need to understand and be part of the decision making process earlier to identify and address key end-user issues which will limit confidence and utilisation of the modelling results. In this paper, some aspects of both sides will be explored, as well as the potential of developing guidelines for modelling similar to the national guidelines for cost-benefit analysis used in the draft Inter Governmental Agreement on Biosecurity or standards in the International Plant Protection Convention.

Drafting a risk mapping decision support scheme for pest risk analysts

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Risk mapping techniques play a critical role in pest risk analysis (PRA), helping to identify areas at greatest risk, justify appropriate measures and communicate risk. However, there is no existing guide to best practice that (a) helps the risk analyst decide whether it is appropriate to expend the time and resources required to undertake the modelling required to develop a risk map, (b) demonstrates the implications of choosing different climatic modelling and mapping methods for pests with differing ecologies and for which there is varying amounts of information on their climatic responses and distribution, (c) describes how to perform each technique and interpret the results and (d) shows how maps of climatic suitability can be linked with other datasets to map endangered areas. This presentation will outline the progress made in tackling these issues by PRATIQUE, a European funded research project that is addressing the major challenges faced by pest risk analysts.

A measure of climatic suitability, suitable for multispecies comparisons and ease of interpretation

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Most correlative species distribution models generate output that consists of a 'probability of occurrence' for each of the locations being modeled. The probability value cannot be taken literally though if the species in question is a) showing range expansion and/or contraction or b) has been under- or over-recorded; both common situations for invasive pest species. At best, it can be interpreted as an ordered prediction of relative suitability among the sites being modelled for that species. What happens, however, if we wish to compare the relative suitability of one particular site across a range of candidate species? Here, we propose a method for rescaling probabilities of occurrence into an index that can compare site suitability across species with different prevalence's and levels of recording. It expresses the suitability of the focal site, relative to all the sites where the species is known to occur. We illustrate the method with the output of bioclimatic models fitted to a variety of invasive species to determine which is most likely to find a favorable climate in New Zealand. Such a comparison should prove useful to site-level biosecurity managers forced to prioritize effort across a range of potential invasive species. We also discuss how site-level predictions may be used for national-scale prioritization.

A retrospective analysis of the use of ecological theory and pest species assemblages to prioritise pests

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A novel approach to the problem of identifying potential invasive species before they arrive in a new location has been to use a computational intelligence technique called a Self Organising Map (SOM). In previous studies the SOM has been used to organise and visualise a large data set of global pest species distributions so that geographic areas that share similar pest profiles or assemblages are clustered together. From that analysis weights are assigned to individual species based on how important they are to the species profiles in the cluster. The analysis allows those species that are not already present in a regions assemblage but that are high ranked to be identified as potentially high risk. This approach is difficult to validate, but one way is to reverse the presence/absences status of each species in the assemblage in turn, then repeat the SOM analysis and evaluate the change in species ranking. We carried out this retrospective analysis using New Zealand's pest assemblage, as an example. Additionally, the effect of removing whole regions from the analysis in a cross-validation analysis was explored. We found that, had pest risk assessors previously used SOM analyses to filter the large number of global pest species, many potential biosecurity threats would have been identified before they established. We discuss some caveats and identify challenges for SOM use in the area of pest risk assessment.

Analysing Invasive Pest Assemblages (IPA) to rank species' likelihood of establishment

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Biosecurity agencies around the world have the difficult job of trying to determine which species have the highest likelihood of invading their region. The list of potential invasive species can run into the hundreds, which presents formidable challenges to pest prioritisation. Analysing invasive pest assemblages (IPA) with a machine learning technique to look for patterns of assemblage can allow these species to be ranked by likelihood of establishment. I present work showing the resilience of this method to common errors in the data, the reliability of this method as tested in a virtual world and also how to determine a threshold value. All provide compelling evidence for the usefulness of this technique in biosecurity and pest risk modeling.

A multi-criteria risk mapping approach based on the Pareto frontier principle– A simpler alternative to the multi-criteria weighted averaging technique?

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Risk maps for invasive species provide broad policy guidance on where to allocate resources for pest monitoring and regulation, but they often present individual risk aspects (such as introduction potential or climatic suitability) as separate products. Building integrated risk maps usually relies on various multi-criteria analysis techniques and requires prior knowledge of decision makers' preferences (or their perceptions) of the risk components' importance.

This study proposes a multi-criteria aggregation approach for building integrated risk maps that does not require knowledge of the relative importance of individual components. The technique uses the principle of Pareto dominance and analyzes the partial order of elements of a risk map in dimensions of individual risk criteria. Integrated risk rankings are estimated as the subsequent non-dominated Pareto frontiers in dimensions of individual risk criteria.

We demonstrate the approach with the example of the oak splendour beetle, Agrilus biguttatus, a high-risk pest that may threaten North American oak forests. Using US and Canadian data, we compare the performance of the Pareto ranking against aggregation using a weighted-averaging technique. We also explore the performance of both methods in the presence of severe uncertainties using the concept of robustness from information gap decision theory.

The results provide a spatial representation of integrated risks and uncertainties and show major geographic hotspots where the consideration of trade-offs between multiple risk components changes integrated risk rankings. The Pareto-based aggregation can be sought as an alternative to multi-criteria weighted averaging and outranking methods when prior knowledge about the risk criteria is poor. The ordinal nature of the Pareto-based risk rankings also makes integrated maps more reliable tools to

prioritize risks for new or anticipated invasive pests, which usually have an extremely poor prior knowledge base.

Modelling middle age spread: *Buddleja davidii* in New Zealand

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3-Fruition Technologies

Uncertainty about the future dispersal behaviour of pest species presents a major problem for agencies with responsibilities to manage such threats. Spread models have the potential to inform strategic management, but can be limited by an inability to encapsulate the variety of spread mechanisms and by a lack of suitable data for calibration and validation.

We used a recently developed dynamic, stochastic dispersal model (MDiG, or Modular Dispersal in GIS) to simulate the historic spread of *Buddleja davidii* in New Zealand. This invasive species is currently widely distributed, several decades after naturalisation. Using parameters based on more mature European data and starting from several sequential historical New Zealand distributions, we present the model results using the concept of occupancy envelopes (a probabilistic summary of realisations from multiple stochastic simulations). To assess the model's performance, we constructed Receiver Operating Characteristic (ROC) curves to examine the sensitivity (projecting true presences) and specificity (projecting assumed absences) of these occupancy envelopes. We then used a derivative measure, the partial area under these curves (pAUC) calculated through time, to assess overall performance of the spread model.

The model was able to attain a high level of model sensitivity, encompassing all of the known locations within the occupancy envelope through time. However, attempting to simulate the spread of this invasive species for more than approx. two decades after initialisation resulted in very low model specificity. This is mainly attributable to the exponential process of spread, whereby the subject inevitably occupies the entire available habitat. This feature is seen in many reports of spread models without being explicitly acknowledged. Hence we conclude that this type of model has limited application to long-range strategic management at a national scale, but can be helpful for informing regional pest management strategies in the short-term (5-10 years).

Wind trajectory and bioclimatic modelling to provide advance warning of the potential distribution and number of generations of diamondback moth, a serious pest of oilseed crops in western Canada

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Oilseed brassicaceous crops, comprising *Brassica napus* L., *Brassica rapa* L., *Brassica juncea* (L.) Czern, and *Sinapis alba* L., are grown over approximately five to six million ha annually in the western Canadian provinces of Alberta, Saskatchewan, and Manitoba, with minor levels of production also occurring in British Columbia, Ontario, and Québec. Diamondback moth, *Plutella xylostella* L., is an invasive pest of these oilseed crops. In northern regions of the continent, infestations originate primarily from migrant populations associated with sustained air flow in spring from the southern U.S.A. and northern Mexico. Diamondback moth outbreaks have been devastating when large migrant populations arrive early in spring and local environmental conditions are conducive to rapid population build-up. Predicting potential distribution and relative abundance of diamondback moth infestations in the Canadian prairies has important economic and environmental implications, because of the vast geographical areas that are devoted to the production of brassicaceous crops and because application of broad-spectrum chemical insecticide is the most common method of controlling this pest. Three-altitude backward trajectory models (prognostic numerical model GEM [Global Environmental Model]) were used to forecast potential movement of diamondback moth into western Canada. Currently, air parcel trajectories are being constructed from wind fields at discrete intervals and solved numerically to identify potential wind trajectory events that may carry diamondback moth adults from Mexico and the southern U.S.A. into the Canadian prairies. A DYMEX™ model was developed to describe the distribution and potential generation number of diamondback moth. Models were initialized with potential introduction dates based on trajectory model output. Our models indicated that the potential number of generations was dependent on date of arrival and growing season temperatures. Risk to oilseed crops increases with the number of generations that could potentially occur by August (i.e. at about the time that canola is forming pods).

Assessing risk of human-assisted spread of invasive forest pests with firewood transport

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In North America, there has been much recent focus on the potential spread of invasive forest pests with firewood transported by cars, light trucks, and recreational vehicles. Motivated in particular by the ongoing emerald ash borer (*Agrilus planipennis*) invasion, national "don't move firewood" publicity campaigns have been launched in the US and Canada, while an assortment of restrictions have been implemented at various jurisdictional levels. Nevertheless, there has been little quantitative assessment of the risks posed by firewood transport. At the same time, the lack of empirical data regarding human-mediated, long-distance dispersal presents a considerable obstacle to realistic modeling of pest invasions, as well as a significant source of uncertainty in pest risk forecasts.

We present a study that analyzes the risk of forest pest spread with firewood and develops a related dispersal function for application in geographically explicit invasion models. Our primary data source was the US National Recreation Reservation Service database, which records camper reservations at >2500 locations across the country. For >5 million individual reservations, we calculated the distance between camper home address and campground location. We then constructed an empirical density kernel from these distance data, and fitted them with various probability density functions (e.g., exponential, Weibull). We found the data to be strongly leptokurtic and log-normally distributed. Most campers (57%) traveled less than 100 km, but 8% traveled more than 500 km (and some as far as 4500 km). Additionally, we analyzed the impact of geographic region (e.g., eastern vs. western US) and proximity to major parks and urban centers on the shape of the dispersal kernel. In this presentation, we also discuss the potential for these results to serve as a reasonable proxy for other mechanisms of long-distance dispersal, as well as possible pathway modeling applications.

Unveiling human-assisted dispersal mechanisms in invasive insect pests: integration of spatial stochastic simulation and phenology models

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Capturing the spread of biological invasions in heterogeneous landscapes is a complex modelling task where information on both dispersal and population dynamics needs to be integrated. Spatial stochastic simulation and phenology models have been rarely combined to facilitate such integration in order to assist on the study of human-assisted long-distance dispersal events. Here we develop a process-based spatially explicit landscape extent simulation model that considers the spread and detection of invasive insects. Natural and human-assisted dispersal mechanisms are modelled with an individual-based approach using negative exponential and negative power law dispersal kernels and gravity models. The model incorporates a phenology submodel that uses daily temperature grids for the prediction and timing of the population dynamics in each habitat patch. The model was applied to the study of the invasion by the important maize pest Western corn rootworm (WCR) *Diabrotica virgifera* ssp. *virgifera* in Europe. We parameterised and validated the model using maximum likelihood and simulation methods from the historical invasion of WCR in Austria. WCR was found to follow stratified dispersal where international transport networks in the Danube basin played a key role in the occurrence of long-distance dispersal events. Detection measures were found to be effective and altitude had a significant effect on limiting the spread of WCR. Spatial stochastic simulation combined with phenology models, maximum likelihood methods and predicted versus observed regression showed a high degree of flexibility that allowed capturing the salient features of WCR spread in Austria. This modelling approach is useful because allows to fully exploit the limited and heterogeneous information regarding the population dynamics and dispersal of alien invasive insects.

Modelling trade-associated pathways of alien forest insects establishments in Canada

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Recent outbreaks of new pests in North America have demonstrated the importance of considering human activities when assessing the risks and impacts associated with invasive species. Long-distance introductions are often driven by socio-economic factors (e.g., the movement of commodities with global trade), such that traditional "biological" invasion models may not be capable of estimating spread fully and reliably. We present a novel methodology to characterize and predict pathways of human-assisted establishment of alien forest insects. We have developed a stochastic quantitative model of how these species may be moved with commodity flow through a network of international marine ports and major transportation corridors in Canada. The study makes use of a Canadian roadside survey database and statistical data on Canadian marine imports, complemented with geo-referenced information on ports of entry, populated places and empirical observations of historical spread rates for invasive pests. The model is formulated as a Markovian pathway matrix, and allows for quantitative characterization of location-specific likelihoods and vectors of new pest introductions in North America. The model offers the potential to analyze pathways from both existing and anticipated infestations, and is designed to work with a wide range of transportation and commodity movement data.

We applied the pathway model to estimate rates of human-assisted establishment of alien forest insects at urban and rural settlements across Canada, as well as cross-border transport to locations in the U.S. Our results suggest a very low nationwide establishment rate for Canada relative to the U.S. (0.034 new forest insect species per year vs. 1.89). Among Canadian urban areas, Greater Toronto and Greater Vancouver appear to have the highest alien forest insect establishment potential, however the

estimated rates for these areas are nine and 95 times lower, respectively, than the average establishment rates for the five largest U.S. urban areas.

The Web-based Atlas of Living Australia

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The Web-based Atlas of Living Australia will be launched in October 2010. The Atlas will integrate a wide range of biological and environmental data. It will also include an expanding range of tools for spatial analysis. Examples include spatial modeling, sampling environmental surfaces at species locations and environmental domains. There has been wide interest in collaboration on (foss) code/functionality development and use of the developing infrastructure. I'll be using the meeting to demonstrate what has been developed and seeking feedback and interest in collaboration

Posters

1

Invasive alien plants moving north: A Canadian perspective on weeds and climate change

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In the past, Canada's cold winter climate has been considered an effective barrier against most warm-temperate, sub-tropical and tropical pests, including invasive alien plants. However, predictions that climate change will extend the geographic ranges of species northward have led to concerns that new invasive plants will be able to establish and spread into regions of Canada where they were previously unable to survive. Given the irreversibility of most plant invasions, the inclusion of climate change scenarios in weed risk assessments of otherwise borderline-hardy species will be important to capture potential establishment in future time periods within the planning time horizon. Kudzu (*Pueraria montana* (Lour.) Merr.) [Fabaceae] is an invasive alien plant that is already considered to be moving north due to climate change. It was discovered for the first time in Canada in 2009. Collaborators from Canada and Australia are developing a CLIMEX™ model to project the potential current and future distributions of kudzu in Canada. Novel field and laboratory methods will be used to calibrate some parts of the kudzu model, imparting more confidence in the climate-related aspects of the risk assessment.

2

Forecast distribution and severity of clubroot of canola in the Canadian prairies under incremental temperature and precipitation, and potential climate change scenarios

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Clubroot of canola, caused by *Plasmodiophora brassicae* Woronin, was first reported in the St. Albert region of Alberta, Canada in 2003 and has subsequently appeared over a broad area around Edmonton, Alberta, and also in individual fields elsewhere in the province. CLIMEX® was used to model the potential distribution and severity of clubroot of canola in the Canadian prairie region under: 1) incremental temperature and precipitation scenarios using long-term climate normal data (LCND); and 2) using three General Circulation Model (GCM) scenarios (Miroc-H, NCAR-CCSM, CSIRO Mark 3.0), and a baseline scenario (CRU World V2). Initial models of clubroot disease occurrence and severity based on LCND were consistent with observations on cruciferous vegetables in the lower mainland of British Columbia and central Canada, and canola in Alberta. Based on current conditions with either the LCND or CRU World V2 scenarios, the model suggested that clubroot could affect canola over a wide area of the prairie ecosystem, especially the wetter regions of Alberta, Saskatchewan and Manitoba. In the future, the distribution and seasonal development of clubroot in the prairie region is projected to increase, especially for the NCAR-CCSM scenario, compared to the baseline scenario. Incremental temperature increases of 1 to 3 °C resulted in the projected expansion of the area potentially affected by economic levels of clubroot, mainly in the cooler and wetter regions of the prairie ecosystem. Overall, a more northerly expansion and an overall greater economic impact of clubroot may be expected with combined increases in temperature and precipitation.

3

Mycosphaerella leaf disease: impact assessment

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There are presently few tools available for estimating epidemic risks from forest pathogens, and hence informing pro-active disease management. In this study we demonstrated that bioclimatic niche models could be used to examine questions of epidemic risk in temperate eucalypt plantations. The bioclimatic niche model, CLIMEX, was used to identify regional variation in climate suitability for Mycosphaerella leaf disease (MLD), a major cause of foliage damage in temperate eucalypt plantations around the world. Using historical observations of MLD damage, we were able to convert the relative score of climatic suitability generated by CLIMEX into a severity ranking ranging from low to high, providing for the first time a direct link between risk and impact, and allowing us to explore disease severity in a way meaningful to forest managers. We determined that the 'compare years' function in CLIMEX could be used for site-specific risk assessment to identify severity, frequency and seasonality of MLD epidemics. We explored appropriate scales of risk assessment for forest managers. Applying the CLIMEX model of MLD using a 0.25 or 0.5 degree of arc climatology to areas of sharp topographic relief frequently misrepresented the risk posed by MLD, because considerable variation occurred between individual forest sites encapsulated within a single grid cell. This highlighted the need for site-specific risk assessment to address many questions pertinent to managing risk in plantations.

4

An expert-driven rule set to predict the distribution of reed canary-grass (*Phalaris arundinacea*)

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Reed canary grass (*Phalaris arundinacea*) is a circumboreal species that provides forage, erosion control, and potentially biofuels. This grass also outcompetes valued wetland and riparian species and can impede floodplain forest regeneration. We used an expert elicitation approach to develop a rule set to describe environmental factors that might govern the distribution and abundance of reed canary grass in Minnesota. A questionnaire was sent to 29 reed canary-grass experts. Experts were asked whether 67 abiotic factors had a positive, neutral or negative effect on reed canary-grass distribution and abundance. A $\chi 2$ test with a Bonferroni adjustment was used to determine response patterns that deviated from a random distribution. Experts had significant consensus on 14 factors affecting distribution and 17 factors affecting abundance. The experts believed high annual precipitation (32-36 inches) was likely to affect distribution ($p = 4.56 \times 10^{-4}$) but unlikely to affect abundance. They also felt that a flooding depth of 1-3 inches ($p = 6.80 \times 10^{-4}$), shade ($p = 9.12 \times 10^{-4}$), lakeshore cover ($p = 2.75 \times 10^{-3}$), and low nitrogen (<10 ppm) ($p = 3.39 \times 10^{-3}$) were likely to affect abundance but unlikely to affect distribution. The experts agreed that gravel, shade, low soil nitrogen, or <3 inches of soil moisture would have negative effect on reed canary grass. Predictions based on this rule-set were validated with the results from previous weed surveys. Reed canary grass occurred in areas predicted to be suitable more often than would be expected by chance alone ($p<0.05$). The expert elicitation approach is a suitable method to identify consensus among experts/stakeholders regarding the relative importance of factors affecting reed canary-grass distribution. It also helps identify information gaps and may serve as an initial step towards establishing successful partnerships among diverse stakeholders.

5

CLIMEX models for potential distributions of *Onthophagus taurus* and *Digitonthophagus gazella* (Scarabaeidae) in North America

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Dung-fouled pastures are poorly used by cattle, such that rapid dung degradation is desired. As part of a study to establish more efficient species of dung-degrading beetles in Canada, CLIMEX models were developed to predict the potential distributions of *Onthophagus taurus* and *Digitonthophagus gazella* (Scarabaeidae) in North America. *Onthophagus taurus* is predicted to establish across most of southern Canada with greatest potential for establishment in southern Ontario. With an average temperature increase of +3 °C, its distribution is expected to encompass most of the cattle-producing areas of Canada. Even under the latter scenario, *D. gazella* is predicted to remain restricted to the United States.

6

Forecasting the potential distribution and severity of fusarium head blight of wheat in the Canadian prairies under potential climate change scenarios.

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Fusarium graminearum Schwabe is the most important causal agent of fusarium head blight (FHB) of wheat resulting in yield and quality losses, and until recently was mainly a production issue of cereals in the eastern prairie region of Canada. A bioclimatic model using CLIMEX® (Hearne Software, Inc.) was constructed and used to model the potential distribution and severity of FHB in the prairie region under: 1) incremental temperature and moisture scenarios using long-term climate normal data (LCND); and 2) using three General Circulation Model (GCM) scenarios (Miroc-H, NCAR-CCSM, CSIRO Mark 3.0) and a baseline scenario (CRU World V2). Based on current conditions with either the LCND or the baseline scenario, the model indicated that FHB caused by *F. graminearum* could readily develop in the cereal-growing areas of western Canada and present a significant risk to cereal production, especially in moister regions. Under the future climate scenarios projected FHB development in the prairie region tended to be greater, but mainly for the NCAR-CCSM compared to the baseline scenario. Incremental temperature increases of 1 to 3 °C with a 20% increase in seasonal rainfall resulted in the greatest projected increase in the potential range and severity of *F. graminearum* in the prairie cereal growing ecozone. In contrast, a 20% decrease in precipitation resulted in a substantial reduction in the area potentially affected by economic levels of FHB. Moreover, the area was further reduced when the decrease in precipitation was combined with a 1 to 3 °C increase in temperature. Overall, a more northerly and westerly expansion in FHB would be expected under increased summer rainfall or the NCAR-CCSM climate change scenario.

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