iPRRG

International Pest Risk Research Group

Ninth Annual Meeting
Fort Collins, Colorado
25-28 August 2015

Fort Collins Convention & Visitors Bureau

Programme & Abstracts

Programme

Day	Date	Time	Activity
Tuesday	5-Aug	8:30-10:00	Climex workshop
		10:00-10:20	Break
		10:20-12:30	Climex workshop
		12:30-13:30	Lunch
		13:30-14:00	Welcome / opening remarks
		14:00-15:00	**Oral presentations – Risk Factors**
			Helen Sofaer
			Marona Rovira
			Mariona Roige
		15:00-15:20	Break
		15:20-17:00	**Oral presentations – Non-climatic factors**
			Ursula Torres
			Audrey Lustig
			Juha Tuomola
			David Christie
			Gericke Cook
		17:00-17:30	**Poster session (5-minute overviews + Q&A)**
		17:30-17:40	Wrap-up/adjourn
		18:00	Refreshments/Self-organising dinner
Wednesday	26-Aug	8:30-9:50	**Oral presentations – Policy and uncertainty**
			Darren Kriticos
			Dan Borchert
			Frank Koch
			Denys Yemshanov
		9:50-10:20	Break
		10:20-12:30	**Oral presentations – PRA praxis**
			Rob Venette
			Sunil Kumar
			Catherine Jarnevich
			<short bio-break>
			Richard Baker
			Dominic Eyre
			Amy Morey
			Senait Senay
		12:30-13:30	Lunch
		13:30-15:00	Colorado potato beetle - initial discussion
		15:00-15:20	Break
		15:20-17:20	Colorado potato beetle - more
		17:20-17:30	Wrap-up/adjourn
		18:30-19:30	Business meeting (optional – location tbd)

Thursday	27-Aug	8:30-9:00	Election results; constitution + amendments
		9:00-10:00	Planning the next meeting
		10:00-10:20	Break
		10:20-12:20	Colorado potato beetle - more
		12:20-13:00	Lunch
		13:00-17:30	Field trip: brewery, Poudre Canyon, Mishawaka
		17:30 (approx.)	Dinner
Friday	28-Aug	8:00-10:00	Colorado potato beetle - more
		10:00-10:20	Break
		10:20-11:50	Tech transfer: next generation & developing world
		11:50-12:00	Wrap-up
		12:00-13:00	Lunch
		13:00-13:30	Final thoughts

Organising Committee

- Frank Koch
- Darren Kriticos
- Lisa Kennaway

CLIMEX Workshop

CLIMEX Version 4 has just been released. It includes many new features of interest to pest risk modellers:

1. A revised genetic algorithm to improve the fitting of stress parameters to distribution data
2. Automating the exposure of model uncertainty
3. Calculating and reporting the goodness of fit of models
4. Open up new techniques for exploring the dynamic nature of climate suitability using time series models and maps

During this interactive workshop we will explore the use of some of these new features.

Session 1 - Biosecurity Risk Factors

Global sharing of exotic species: the relative importance of trade and climate

Helen Sofaer and Catherine Jarnevich
e: hsofaer@usgs.gov

U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80526 (both authors)

The distribution of exotic species is shaped by processes affecting the probability of introduction, establishment, and spread. Global trade is a major pathway by which species are introduced, while climatic and other conditions are important mediators of the success of exotic species establishment. Yet although trade, climate, human disturbance, and biotic interactions jointly shape global distributions, the relative importance of each of these factors is poorly understood. We analyzed variation in the number of exotic species shared between the United States and other countries worldwide to understand the relative importance of the amount of trade, the similarity in climate, and other factors. We also evaluated whether trade in some types of goods is more closely associated with variation in numbers of shared exotic species, and consider whether the patterns we observed are likely to be maintained at smaller spatial scales. Our results highlight the importance of trade relative to other factors.

What roles do biogeography and climate play in non-native invertebrate invasion?

Marona DM Rovira [1], *Craig B Phillips* [2], *Eckehard G Brockerhoff* [3], *Karen Armstrong* [1] *and Susan P Worner* [1]
e: Marona.RoviraCapdevila@lincolnuni.ac.nz

1 - Bio-Protection Research Center, Lincoln University, Lincoln (Canterbury), New Zealand.
2 - Lincoln Research Center, AgResearch, Lincoln (Canterbury), New Zealand.
3 - New Zealand Forest Research Institute, Scion, Christchurch (Canterbury), New Zealand.

Biological invasions have a number of well-recognized negative ecological and economic impacts. A key part of minimisig such impacts of exotic species is to be able to assess the risk of their establishment and spread in new ecosystems before they arrive. However, invasion success is the result of a combination of several factors and mechanisms, which make accurate predictions difficult. For herbivorous insects, previous studies have indicated that factors such as biogeography, climatic similarity, host phylogenetic affinities and host specificity are important, but not robust analyses of all these factors and their interactions are available. Here we report on the roles of biogeogrphy and climate with respect to invasive beetles within the super families Curculionoidea and Chrysomeloidea that have had impacts either in North America or New Zealand natural ecosystems. Biogeographic matching between each region an the rest of the world was analysed using the Global Biodiversity Information Facility (http://www.gbif.org/), Phylocom (http://phylodiversity.net/phylocom/) and ArcGIS to estimate phylogenetic distances between plant species in different regions. Climatic similarities were tested using the climate matching function of CLIMEX.

Biogeography and climate both have a role in determining the impacts of the species studied on natural ecosystems. Areas with analogous climates and floras with close plant phylogenetic relationships with the target region are more likely to be sources of invasive invertebrates that impact natural ecosystems. In the future, a more comprehensive analysis combining bioeographic factors, host phylogenetic affinities and host specificity should give even more accurate predictions of which non-native herbivorous insect species are likely to invade a particular geographic range.

Using pest assemblages to rank species with potential to invade: The self organising map analysis, validation and recommendations.

Mariona Roige[1], *Susan Worner*[1], *Karen Armstrong*[1], *Craig Phillips*[2], *Matthew Parry*[3] *and Diego Varga*[4]
e: Mariona.Roige@lincolnuni.ac.nz

1 Bio-Protection Research Centre, Lincoln University, Lincoln.
2 AgResearch Institute, Lincoln University, Lincoln.
3 Department of Statistics, Otago University, Dunedin.
4 Universitat de Girona.

The promise of using computational tools to support pest risk analyses (PRA) has become more apparent in recent years. The self-organizing map (SOM) was used in 2006 for the first time to extract valuable information from global datasets recording the distribution of insect pests, by creating ranked lists of species according to their potential for establishment in new regions around the world. Since its first use, the SOM analysis has attracted attention from biosecurity agencies and researchers, as it offers a quantitative way to quickly analyse and make sense of large amounts of global pest distribution data.
While there have been some attempts to validation this approach, this current work aims to provide further validation , as well as add a new metric of cluster validity to highlight the robustness of the interpretation of the resulting ranked lists. The aim is to provide a simple user oriented output of the modelling approach that can be very useful to help decision-makers. Our results provide new recommendations for the use of the SOM approach and species assemblages to assess establishment risk.

Session 2 Non-climatic Risk Factors

Niche dynamics and potential suitable areas of invasive freshwater invertebrates in New Zealand

Ursula Torres [1], *Susan Worner* [1], *Hannah Buckley* [2], *Matthew Parry* [3] *and William Godsoe* [1]
e: ursula.torres.m@gmail.com

1 - Bio-Protection Research Centre, Lincoln University, New Zealand
2 - Faculty of Agriculture and Life Sciences, Lincoln University, New Zealand
3 - Department of Statistics, Otago University, New Zealand

Despite much effort being put into preventing invasions, some species manage to escape surveillance. This failure is partly due to gaps in our understanding of invasion success. In particular, we usually don't consider that some species are able to occupy new environments that are not found in their native range. An analysis was carried out to detect if there are significant similarities between the realized climatic niches in the native and invasive range for invasive freshwater invertebrates. We used the global distribution information of 21 invasive freshwater invertebrates and 35 climatic variables such as temperature, precipitation, solar radiation and soil moisture. Initial results suggest that for many of the species, the overlap of the native and invasive climatic niche is relatively low, suggesting several competing hypotheses influencing invasion success. This information should be carefully considered when modelling potentially suitable areas for invasive species outside of their current range.

Effect of landscape structure on invasive spread: a spatially explicit perspective

Audrey Lustig and Susan P. Worner
e: Audrey.Lustig@lincolnuni.ac.nz

Bio-Protection Research Centre, Lincoln University

Habitat fragmentation and land-use change have been recognized as key drivers of environmental change and biodiversity loss. Both processes result in heterogeneous landscape structures that can influence the invasion process. Landscape structure is particularly important and can act as a barrier to spread or host colonization. However, it is not fully understood why some new populations spread rapidly across the landscape, while others spread slowly or not at all. Whether the variability observed in nature or in experimental ensembles might be accounted for by systematic differences between landscapes or by demographic stochasticity affecting basic vital rates of the organisms involved, remains an open research question.

We present integrative tools that allow hypothesis testing about the relative influence of life history traits, propagule pressure and landscape structure on invasive species spread. We use non-linear multivariate statistics to identify the essential aspects of landscape that interact with dispersal and demographic processes. The results highlight those landscape metrics that are used to established a quantitative relationship between landscape structure and invasive spread. Meeting these challenges promises to give deeper insights into species traits driving spatial patterns of invasion that are key to preventing new incursions and the development of efficient monitoring, surveillance, control and eradication programmes.

An areal pest risk assessment based on spatial and temporal distribution of places of production

Juha Tuomola [1], *Hanna Huitu* [2], *Jaakko Heikkilä* [2] *and Salla Hannunen* [1]
e: juha.tuomola@evira.fi

1 - Finnish Food Safety Authority Evira
2 - Natural Resources Institute Finland

Since the resources for the surveys aiming at early detection of invasive pests are limited, it is necessary to develop methods that enable efficient targeting of the surveys. We use information from the European IACS (LPIS) database on spatial and temporal distribution of places of production to locate areas where the probability of entry, establishment and spread, and the magnitude of impacts of invasive pests are likely to be high.

The probabilities of entry, establishment and spread are described on a 1 x 1 km grid with indices that vary from 0 to 1. The indices do not represent actual probabilities, but they allow comparison of the relative probabilities of entry, establishment and spread in different areas. The index describing the probability of entry is calculated based on the amount of plant propagation material imported to a target area. T he index for the probability of establishment and spread is calculated based on habitat density and persistence. The likely impacts are described by average annual monetary value of the production. The total risk is calculated as the product of the components, i.e. entry, establishment and spread, and impacts.

Using this methodology we estimated the areal risk to strawberry production in Finland, based on nine year cropping history (2006 - 2014). For most of the strawberry production areas (approx. 90%) the index values are very low. Therefore, targeting surveys at the areas with high index values may significantly improve the effectiveness of risk management of invasive pests on strawberry.

Defining port environs in a changing landscape

Kevin Bigsby [1], *Dan Borchert* [2], *David Christie* [1], *Manuel Colunga-Garcia* [3], *Becky Epanchin-Niell* [4] *and Lisa Kennaway* [5]
e: david.christie@aphis.usda.gov

1 - NCSU Center for Integrated Pest Management
2 - USDA APHIS PPQ CPHST PERAL
3 - Michigan State University
4 - Resources for the Future
5 – USDA APHIS PPQ S&T Fort Collins

Increased import volume, transportation methods and new infrastructure is changing and rapidly increasing the size and location of port environs. In these areas, invasive alien species (IAS) transported on or with commodities may be initially exposed to the environment when shipping containers are opened. To date, however, these areas have not been mapped, but doing so would benefit plant health regulatory officials as they try to prevent the introduction of IAS. To address this data deficit, we defined port environs spatially by first identifying point level infrastructural features (e.g., foreign trade zones, intermodal transfer facilities and warehouses) that support imported commodities. We then mapped these locations throughout the U.S. using data from U.S. Customs, Department of Transportation, Hoovers, and other sources. Finally, we applied kernel density analysis to add value to the point level data. This method is analogous to hot spot mapping for crime analysis, and allowed us to map the port environs as a continuous surface from high to low density. In total, port environs comprised 3.1 million km^2, or 32% of the entire US. However, only a small portion of the port environs (5,807 km^2) was medium density or greater, comprising less than one percent of the entire U.S. The port environs are fairly evenly distributed throughout the U.S. and have a strong tendency to be located in and around major metropolitan areas. Identifying the locations of these new port environs has major implications for plant health regulatory officials who can use these maps to survey for pests in these new areas of introduction. Additionally, the density analysis allows hot spots for pest entry to be identified, creating the opportunity for risk-based surveying within the port environ.

Novel anthropogenic activity datasets and predicting long-range introductions of invasive pests

Gericke Cook[1], *Marla Downing*[2], *John Withrow*[3], *Ian Leinwand*[3], *Catherine Jarnevich*[4], *Andrew Liebhold*[5], *Frank Koch*[6] *and Denys Yemshanov*[7]
e: gericke.l.cook@aphis.usda.gov

1 - USDA APHIS PPQ Centre for Plant Health Science and Technology, Fort Collins, CO
2 - US Forest Service, Fort Collins, CO
3 - Cherokee National Technologies, Fort Collins, CO
4 - U.S. Geological Survey, Fort Collins, CO
5 - US Forest Service, Morgantown, WV
6 - US Forest Service, Research Triangle Park, NC
7 - Natural Resources Canada, Sault Ste Marie, ON

Well-defined human movement patterns can be used to characterize some of the mechanisms for accelerating the spread of agricultural pests and diseases in the United States. It is a major challenge to quantitatively characterize these patterns, especially on a national scale. We will be introducing two novel datasets, direction-specific traffic volume modelled onto a road network and household movement data originating from quarantine zones, that have been created specifically for modeling invasive introductions on a national scale. We will discuss their implementation in a statistical model that predicts long range introduction of European gypsy moth.

Session 3 – Policy & Uncertainty

Helicoverpa armigera invading North America: It was just a matter of time

Darren Kriticos [1,2], *Noboru Ota* [1], *William Hutchinson* [2], *Jason Beddow* [2], *Tom Walsh* [1], *Wee Tek Tay* [1], *Silvana V. Paula-Moreas* [4], *Cecília Czepak* [5] *and Myron Zalucki* [2]
e: darren.kriticos@csiro.au

1 - CSIRO
2 - University of Queensland
3 - University of Minnesota
4 - Embrapa
5 - Universidade Federal de Goiás

Helicoverpa armigera has recently invaded South and Central America. It is highly polyphagous, attacking a wide range of important crop species, and is highly mobile, having invaded all major cropping areas except North America. Elsewhere it has developed broad-spectrum resistance to pesticides. We updated a CLIMEX model of the potential distribution of *H. armigera* to assess its global pest risk, with special reference to the threats in the USA. We found that the area of climate suitability for establishment covered most of the major crops in the USA, threatening crop production worth approximately US$78 billion p.a., with US$843 million p.a. worth growing in climates that are optimal for the pest. *Helicoverpa armigera* has been detected frequently at border ports in the USA associated mostly with fresh produce. We reasoned that its invasion of South and Central America meant that it would likely invade the USA, probably through natural dispersal from Mexico or the Caribbean Islands. The logic underpinning a biosecurity response to an incursion depends on the costs and benefits of the response. Pest eradications are expensive operations, and they are usually only conducted in situations where the invasion pathway can be attenuated. In the case of natural dispersal this is not possible. If the presence of three male *H. armigera* moths trapped recently in Florida is thought to have come from natural dispersal, then an eradication may not be the most cost-effective response. Efforts to bolster integrated resistance management strategies would appear to be a no regrets option. The potential for market failure highlights a potential role for both Government and pesticide manufacturers to engage with producers to promote effective and responsible pest management of *H. zea* and other pests ahead of an invasion by *H. armigera*.

Helicoverpa armigera from early assessments and risk products to regulatory decision making

Dan Borchert
e: daniel.m.borchert@aphis.usda.gov

USDA APHIS PPQ CPHST PERAL

Helicoverpa armigera, the old world bollworm, is one of the most widely recognized pests around the world and has recently moved to the western hemisphere and North America. I will discuss past and current risk products and how they are utilized in the recent detections in the United States.

Lessons learned when analyzing the other kind of "weed" risk

Frank H. Koch[1], *Jeffrey P. Prestemon*[2] *and Geoffrey H. Donovan*[3]
e: fhkoch@fs.fed.us

1 - USDA Forest Service, Southern Research Station, Eastern Forest Environmental Threat Assessment Center, Research Triangle Park, NC
2 - USDA Forest Service, Southern Research Station, Forest Economics and Policy Work Unit, Research Triangle Park, NC
3 - USDA Forest Service, Pacific Northwest Research Station, Goods, Services, and Values Program, Portland, OR

Illegal cannabis cultivation on US federal lands is a serious problem, especially on West Coast national forests. These illegal grows cause substantial environmental damage, endanger the safety of forest personnel and visitors, and consume already-strained law enforcement resources. To provide guidance for interdiction efforts, we developed models that reveal how drug markets, policies, and environmental conditions affect grow siting decisions. The models were built on a rational choice theoretical structure, and utilized data describing 2,322 cannabis grow locations (2004-2012) and 9,324 absence locations in the national forests of California, Oregon, and Washington. Explanatory variables included cannabis market prices, law enforcement density, and socioeconomic, demographic, and environmental variables. We also used the models to construct regional maps of grow site likelihood.

Our attempt to model illegal cannabis cultivation activities has many parallels with pest risk modeling and mapping. Consequently, a description of some of the obstacles we encountered, and the ways in which we dealt with them, should be informative for pest risk analysts. For example, one key issue is that the growing locations were not discovered randomly, and thus represent a response-based sample rather than a random sample. This has important implications for the type of model used to identify other likely grow locations, as well as the mechanism used to account for the uncertainty that arises from our imperfect knowledge. Additionally, we were concerned about addressing potential endogeneity between grow location and cannabis price: higher price may encourage more grows, but more grows may reduce price. There was also the more fundamental challenge of determining how to represent and integrate the widely disparate factors (e.g., climate versus regional employment patterns) that may influence grow siting decisions. In this presentation, we strive to translate what we learned about these and other issues into useful guidance.

A hypervolume approach for assessing risk under uncertainy

Denys Yemshanov [1], *Frank Koch* [2], *Bo Lu* [1], *Jean Turgeon* [1], *Ron Fournier* [1] *and Gericke Cook* [3]
e: Denys.Yemshanov@nrcan-rncan.gc.ca

1 - Natural Resources Canada, Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie, ON, Canada
2 - USDA Forest Service, Southern Research Station, Research Triangle Park, NC
3 - USDA Animal and Plant Health Inspection Service, Centre for Plant Health Science and Technology, Plant Protection Quarantine, Fort Collins, CO

Assessing risks of uncertain but potentially damaging events, such as pest invasions, is a key analytical step that supports subsequent decisions about how to respond to these events. We present a continuous risk measure that is influenced by both the expected magnitude of risk and its uncertainty. The approach employs concepts from prospect theory and recent advances in multi-objective optimization. We first represent a set of risk values (e.g., individual cell values in a raster risk map) by their cumulative distribution functions (CDFs) and then find ordered non-dominant subsets of these CDFs, which we use to identify different classes of risk, from high to low. Because each non-dominant subset is estimated with respect to all elements of the full set, the uncertainty in the underlying data is factored into the risk class delineation. Essentially, in portions of the full dataset where variability is high, fewer non-dominant subsets can be defined. We depict each non-dominant subset as a point cloud, where the points represent CDF values of each subset element at defined sampling intervals. For each subset, we define a hypervolume that is bounded by the outermost convex frontier of that point cloud. This results in a collection of nested hypervolumes that act as a continuous measure of risk as opposed to other techniques which can only provide ordinal risk measures.
We demonstrate the approach by assessing risks of human-mediated spread of Asian longhorned beetle (ALB, *Anoplophora glabripennis*) in Greater Toronto, Ontario. ALB is one of the most threatening invasive pests in North America, which could cause catastrophic damage to forests if not controlled. We calculated the hypervolume-based risk metric using stochastic estimates of human-mediated spread of ALB with vehicle traffic in an urban setting, and compared this metric with traditional risk measures based on the probability of the species' spread.

Session 4 – Pest risk assessment praxis

Risks posed by *Agrilus auroguttatus* to the conterminous United States

Robert C. Venette [1], *Tom Coleman* [2] *and Steven J. Seybold* [3]
e: rvenette@fs.fed.us

1 - USDA Forest Service, Northern Research Station, 1561 Lindig Ave., St. Paul, MN 55108.
2 - USDA Forest Service, Forest Health Protection, 602 S. Tippecanoe Avenue, San Bernardino, CA 92408.
3 - USDA Forest Service, Pacific Southwest Research Station, 1731 Research Park Drive, Davis, CA 95616.

Goldspotted oak borer, *Agrilus auroguttatus*, is causing substantial oak mortality southern California. The spread of this insect remains a concern. This research project measured several biological parameters to refine spatial risk assessments for this insect. Cold tolerance testing of prepupae, the primary overwintering stage, indicates that this insect should be unable to survive in U.S. Department of Agriculture (USDA) Plant Hardiness Zones 2b - 5b. Some survivorship might occur in Zone 6a, but this outcome depends on the degree of cold acclimation that larvae may achieve. Host range testing with cut logs confirmed expectations that California black oak, *Quercus kelloggii*, and coast live oak, *Q. agrifolia*, are hosts and that Engelmann oak, *Q. engelmannii*, is not a host for *A. auroguttatus*. Our assays suggest that interior live oak, *Q. wislizeni*, and valley oak, *Q. lobata*, could be hosts, whereas Oregon white oak, *Q. garryana*, is unlikely to be a host. More study is needed to determine conclusively the host status of blue oak, *Q. douglasii*, canyon live oak, *Q. chrysolepis*, and cork oak, *Q. suber*, though field observations suggest canyon live oak can be colonized and killed by this insect. Flight mill studies indicate that adult females might fly up to 4 to 5 km day^{-1} and 9.3 km in their lifetime. Collectively, these results suggest that *A. auroguttatus* poses the greatest risk nationally to California and southern Oregon. If dispersal only occurs through flight, the effects from this insect will likely remain concentrated in southern California for the next 5 to 10 years. Potential movement of *A. auroguttatus* via infested firewood or other human-mediated pathways and the unknown host status of oak species from eastern North America introduce considerable uncertainty into these models.

Assessing the global risk of establishment of Codling Moth (*Cydia pomonella*) using CLIMEX and MaxEnt niche models

Sunil Kumar [1], *Lisa Neven* [2], *Hongyu Zhu* [3] *and Runzhi Zhang* [4]
e: sunil.kumar@colostate.edu

1 - Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado, USA
2 - United States Department of Agriculture Agricultural Research Service, Wapato, WA, USA
3 - Chinese Academy of Sciences, Beijing, China,
4 - Institute of Zoology, Chinese Academy of Sciences, Beijing, China

Accurate assessment of insect pest establishment risk is needed by national plant protection organizations to negotiate international trade of horticultural commodities that can potentially carry the pests and result in inadvertent introductions in the importing countries. We used mechanistic and correlative niche models to quantify and map the global patterns of the potential for establishment of codling moth (*Cydia pomonella* L.), a major pest of apples, peaches, pears and other pome and stone fruits, and a quarantine pest in countries where it currently does not occur. The mechanistic model CLIMEX was calibrated using species specific physiological tolerance thresholds whereas the correlative model MaxEnt used species occurrences and climatic spatial data. Projected potential distribution from both models conformed well to the current known distribution of codling moth. None of the models predicted suitable environmental conditions in countries located between 20°N and 20°S potentially because of shorter photoperiod, and lack of chilling requirement (<60 days at or below 10 °C) in these areas for codling moth to break diapause. Models predicted suitable conditions in South Korea and Japan where codling moth currently does not occur but where its preferred host species (i.e. apple) is present. Average annual temperature and latitude were the main environmental variables associated with codling moth distribution at global level. The predictive models developed in this study present the global risk of establishment of codling moth, and can be used for monitoring potential introductions of codling moth in different countries and by policy makers and trade negotiators in making science based decisions.

Assessing risk with changing climate: what to consider with correlative species distribution models

Catherine Jarnevich [1], *Nick Young* [2] *and others*
e: jarnevichc@usgs.gov

1 - U.S. Geological Survey, Fort Collins Science Center
2 - Colorado State University

Climatic constraints and correlative species distribution models are often used as a component of risk assessment for an invasive species. However, despite high correlations between climate data from overlapping time spans, comparisons of models built using five model algorithms for several species showed sensitivity to choice of climate data. Our results indicate the choice of the time span of climate data is yet another source of uncertainty for model developers which should be evaluated on a case by case basis. Further, while predicting potential distributions of spreading species is not easy, forecasting potential distributions with changing climate is even more difficult. Approaching this question from different perspectives provides a strategy to assess areas of uncertainty. We developed a correlative model and a simple ecophysiological model of coypu distribution, highlighting areas of disagreement from the two approaches. We then examined potential impacts of climate change on the distribution by comparing predictions in modeled climate space. Using a combination of techniques, even with a simplistic ecophysiological based model such as we used, could be useful in modeling potential distributions of invasive species now and in the future. These findings build on the growing literature in species distribution models emphasizing that uncertainty at all stages of the modeling process need to be assessed.

How far north can the Japanese beetle go? Exploring the role of spatial and temporal climatic resolution in pest risk maps

Anastasia Korycinska and Richard Baker
e: richard.baker@defra.gsi.gov.uk

Department for Environment, Food and Rural Affairs, UK

A rapid pest risk analysis (PRA) was undertaken after the highly polyphagous Japanese beetle (*Popillia japonica*) was found in mainland Europe for the first time in 2014. As part of the PRA, we explored the extent to which degree day maps can help predict the potential northerly limits to its distribution. Two factors make this particularly challenging: the pest can complete its life cycle in either one or two years, and most of the life cycle is spent in the soil. We compared results from two gridded climatologies (one global in coverage, the other European), representing different time periods and both low and high temporal and spatial resolutions. The European data set, with high temporal resolution and up to date climate data, also enabled results for recent years to be analysed separately. Various options for summarising the risks and uncertainties for decision makers are provided by these maps and these will be discussed. Degree day accumulations above and below ground were compared and suggest that, for rapid analyses of soil-living insects, the use of readily available air temperature data is an acceptable substitute for less accessible soil data, as long as the limitations of this approach are explicitly noted. The implications of these results for *P. japonica* in particular and risk mapping in general will be presented.

The use of meteorological data to support outbreak modelling and the analysis of natural dispersal

Dominic Eyre [1], *M. Everatt* [1], *R. Baker* [1], *D. Hemming* [2], *P. Boorman* [2], *H. Champion* [2], *S. Millington* [2], *L. Burgin* [2] *and N. Kaye* [2]
e: dominic.eyre@defra.gsi.gov.uk

1 = Defra, Sand Hutton, York, UK
2 = Met Office, Exeter, UK

In the event of outbreaks of non-native pests, decision makers often need rapid answers to questions relating to the potential survival and dispersal of the pest, plus an indication of the times of key life stages such as adult emergence. This presentation will cover how gridded met data, day degree models and recent wind data were used to make such predictions for simulated outbreak of a non-native pest in the UK. The English channel provides a natural barrier to the movement of some pests and pathogens into the UK. The Met Office atmospheric dispersion model NAME has been used to model how non-native pathogens might cross this barrier. The second part of the presentation will cover an examination of possible candidates for further modelling of pest spread using NAME.

Host-mediated shift in the cold tolerance of an invasive insect: What does this mean for pest risk mapping?

Amy Morey [1], *Rob Venette* [2] *and Bill Hutchinson* [1]
e: morey041@umn.edu

1 - Department of Entomology, University of Minnesota, 1980 Folwell Ave, St. Paul, MN
2 - USDA, Forest Service, Northern Research Station, 1561 Lindig Street., St. Paul, MN

Forecasting future distributions of invasive insects is a vital component of many management and regulatory decisions. However, many challenges exist in constructing biologically relevant models that are meaningful over time and space. For much of North America, cold temperature is especially important in defining geographical boundaries of insect survival, and is often used as a key parameter in risk models. An insect's response to cold, though, can be influenced by the type of host it consumes. For highly polyphagous species, host effects could significantly alter distribution projections based on cold.
Here, we used the invasive light brown apple moth (*Epiphyas postvittana* (Walker)) to explore potential effects of host on insect cold tolerance. *Epiphyas postvittana* is a recent invader to the contiguous United States and has been documented to feed on more than 200 plant species, many of which are important to agriculture and forestry. The late instar is the purported overwintering stage and demonstrates partial-freeze tolerance. We reared larvae on five different host plants, and then compared their cold tolerance capacities. We show that *E. postvittana* cold tolerance differs significantly based on larval host plant, and interestingly, the relationship between host suitability and cold tolerance is counter-intuitive; host plants that lowered the fitness of insects under ideal temperatures increased the ability of insects to survive partial freezing. We illustrate the implications of these data for models of future geographic spread and establishment.

A random forest climatic suitability prediction for *Puccinia striiformis* f. sp. *Tritici*

Senait D. Senay
e: ssenay@umn.edu

International Science & Technology Practice & Policy (InSTEPP), Applied Economics Department, University of Minnesota, Minneapolis, USA

Following a number of recent wheat rust disease epidemics, many researchers have focused on the biology and economics of wheat rust diseases. Crop diseases decrease crop yields and increase yield variability, with potentially profound implications for global food security in general and the welfare of subsistence farmers in particular. Wheat stripe rust is one of these diseases that pose risk to wheat crop production around the globe.

The pathogen that causes stripe rust, *Puccinia striiformis* f. sp *tritici*, has long threatened the world's wheat supply. Even though the geographic distribution of this pathogen is mainly limited to its host species range, climatic conditions greatly affect the effectiveness of the pathogen as well as the intensity of potential epidemics.

Here we show the use of random forest model to predict climatic suitability for *P. striiformis* f. sp. *tritici* in sub-Saharan Africa. The goal is to provide a predictive tool that can rapidly provide indicators of climatic suitability for plant pathogens at regional and even global scales. Such models are most useful for preliminary assessment of plant disease hazards until models based on explicit physiological requirements of the species are prepared.

Posters

Integrative risk maps of fruit flies

Kevin Bigsby [1], *Daniel Borchert* [2], *Dave Christie* [1], *Nick Manoukis* [3], *Raul Ruiz* [4] *and Anna Szyniszewska* [5]
e: kevin.bigsby@aphis.usda.gov

1 - NC State University Center for Integrated Pest Management, Raleigh, NC
2 - USDA, APHIS, Center for Plant Health Science Technology, Raleigh, NC
3 - USDA, Agricultural Research Service, Hilo, HI
4 - USDA, APHIS, Center for Plant Health Science Technology, Mission, TX
5 - University of Florida, Gainesville, FL

Fruit flies cause considerable damage on many agricultural commodities and excel at establishing new populations in previously uninfested countries. Consequently, a significant amount of research has been conducted concerning fruit fly biology and the invasion pathway. This research has helped create predictive models for global population dynamics, pest movement on airline pathways, and time to extirpation after a new incursion. However, while these models produce valuable output, they remain independent of one another, thereby limiting the ability to determine likely ports of entry and incursion hot spots across time and space. We propose a framework that integrates these models to holistically model the fruit fly invasion pathway and provide timely information to relevant stakeholders. Specifically, we will expand the analysis of global population dynamics to incorporate additional fruit fly observation data and other relevant covariates, which will increase temporal resolution in output risk maps. Additional information on population dynamics in each country will be joined with the MED-FOES model to predict the duration and efficacy of treatment. The pathway analysis will fuse data on international airline travel, Emergency Action Notifications, and fruit fly detections in passenger baggage to examine and predict spatio-temporal trends. Finally, we will use information on passenger movement post-arrival to predict hot spots for fruit fly incursion. Integration of these models will allow for a system to be developed that generates monthly reports highlighting particular ports of entry and other high-risk locations, allowing stakeholders to effectively allocate resources towards the management of fruit flies.

Areal assessment of pine wood nematode invasion risk based on import statistics, forest inventory data and a grid-based spread model

Hanna Huitu [1], Timo Pukkala [2], Timo Möykkynen [2] and Salla Hannunen [3]
e: hanna.huitu@luke.fi

1 - Natural Resources Institute Finland
2 - University of Eastern Finland
3 - Finnish Food Safety Authority Evira

Potential spread of pine wood nematode (PWN, *Bursaphelenchus xylophilus*) poses a significant threat to forestry in Finland. The need for early detection of possible invasions calls for identification of the key risk areas for entry, establishment and dispersal. We use import statistics, forest inventory data and a grid-based spread model to provide this information.

Areas where the likelihood of PWN entry is elevated are identified and ranked based on 1) data on import events of goods that are likely to be accompanied by wood packaging material originating from countries where PWN is present, and 2) locations of the main logistics centers and storage areas, harbors, and areas with industrial land use, all indicating presence of wood packaging material. The addresses for the final destinations of imports events in 2014 were acquired from the Finnish Customs. The areas with elevated probability of PWN entry will be compared with respect to the outcome of a possible PWN invasion, using grid-based spread model that resembles cellular automaton. In the model vector beetles (*Monochamus galloprovincialis* and *M. sutor*) are expected to be present, and have the capability to spread the infection to new host trees and saprophytic objects. Data on the availability of host trees, pine and spruce is obtained from the multi-source national forest inventory data. The simulation will be carried out at 500 m and 1 km grid resolution. For cells with elevated likelihood of PWN entry, the outcome of an invasion will be presented as the total of contaminated area, and the number and volume of infected trees. The results will support identification of areas with elevated risk of PWN entry, establishment, dispersal, and potential damage.