CONFERENCE/WORKSHOP ORGANISER'S REPORT

"Rapid evolution and the global spread of invasive species"

Brief Description of what the conference/workshop was about

Invasive non-native species and emerging pathogens are a major and growing threat to agriculture, forestry, biodiversity and human well-being. Current approaches to predict their potential spread and impacts for risk assessment generally ignore the potential for rapid evolutionary change occurring during invasion. This is despite knowledge that many species undergo evolutionary changes as they colonise novel environments, which can potentially increase the invasion rate, geographic range, trophic interactions and impacts of invasive non-native species. However, whether evolution also exacerbates global invasion risk by increasing the probability of long distance transport into uninvaded regions remains an open question. Furthermore, if the evolutionary potential of invading populations is changing the very nature of invasions at global scales, then can we predict and manage the consequences?

This workshop brought together leading experts from the disciplines of invasion ecology and evolutionary biology alongside stakeholders with interest in invasive species, plant and animal health from the policy sector. Participants discussed current understanding of how multiple evolutionary forces may interact to influence risk across different stages of invasion (transport, establishment, spread and impact) and considered the implications for predicting invasion, risk assessment and management of biosecurity risks.

Participation – details of total number of participants, countries they came from, backgrounds (academia, industry, etc.)

The workshop included 12 participants from seven countries (UK, Ireland, Switzerland, France, Italy, USA and New Zealand). The participants mostly came from academia (universities and public sector research institutes) but two participants were from the plant and animal health policy sector.

Major highlights from the presentations

Prof Yvonne Buckley (Trinity College Dublin, Ireland) presented on life history variation across non-native species ranges, often signaling evolutionary changes to individual demography. She showed how population growth and spread rates emerge from demographic performance, providing the link between selection on individuals and invasiveness, and presented results from a global network quantifying demography in *Plantago lanceolata* across its native and invaded ranges.

Dr Nicky Lustenhouwer (University of California, USA) presented on the mechanisms of evolutionary change in spreading populations. She explained how life history trade-offs mean evolution of increased spread rates can impact tolerance of stressful environments, and yet provided examples where invading species have adapted, for example developing latitudinal clines in flowering phenology. She concluded that evolutionary processes may differ between native and non-native range expansions and rapid evolution adds complexity to our understanding of invasion dynamics.

Dr Daniel Chapman (University of Stirling, UK) presented on the role of global trade networks in spreading non-native species around the world. He demonstrated correlations between invasion risk trade network connectivity and discussed how this may interact with traits of the invading species, creating the potential for evolutionary selection to occur. Discussions concluded that evidence for this remains largely lacking, but promising initial results suggest certain traits of plant pathogens, such as cold tolerance and low virulence, may promote spread through human transport networks.

Prof Max Suckling (University of Auckland, New Zealand) presented on rapid evolution of pesticide resistance in insect pests and how this has enabled them to spread globally. The presentation focused on selected high impact species – fruit

flies, coffee berry borer, light brown apple moth and brown marmorated stink bug. These case studies suggest that human pest management induces selection in a range of invasive pest species, driving evolution of increased invasive potential through pesticide resistance.

Dr Cléo Bertelsmeier (University of Lausanne, Switzerland) presented on whether there is evidence that evolution in invasive populations accelerate global spread. She discussed data for ants showing that the majority of new arrivals come from non-native populations in other parts of the world (so-called bridgehead or secondary invasions). This means that traits evolved in invading populations are potentially able to spread globally. However, she concluded that there is currently a lack of specific evidence of adaptive evolution in bridgehead populations, favouring secondary spread.

Dr Rob Tanner (European and Mediterranean Plant Protection Organisation, EPPO, France) presented on Pest risk analysis for invasive non-native plants in the European and Mediterranean region. He explained the role of EPPO including a recent project to provide risk assessments for invasive plant species for the European Union Regulation (EU) no. 1143/2014. This included EPPO's approach to species prioritization, expert-led risk analysis and climate matching through species distribution modelling. Participants discussed whether and how evolutionary changes could be incorporated into risk analysis.

Major outcomes/conclusions in terms of policy relevance
Participants agreed that evolutionary changes within non-native populations could favour increased global spread and impacts of invasive species. Workshop discussions identified numerous ways in which selection could act on non-native populations during all stages of invasion, such as transport, establishment and spread. Although it is plausible that such selection leads to increased global spread and impacts, participants considered that clear evidence that this is the case remains to be demonstrated.

The participants considered that evolutionary change in invasive species increases uncertainty for risk assessment, where biological understanding from the native range is often used to predict risk in the region at risk. Participants recommended consideration of evolutionary potential and evidence of evolutionary adaptation during invasion when scoring levels of uncertainty in risk assessment.

Participants considered that management and biosecurity practices should be mindful of the potential to select for invasiveness. For example, use of pesticides to control invasive populations or heat treatment of exported wooden pallets selects for resistance or tolerance of those stressors. Strategies to mitigate these selective pressures, while still providing effective management of risk, should be developed.

Participants decided to collaborate together to produce a review and opinion manuscript focusing on the roles of humans in driving and mediating evolutionary change in invading species. The idea for this focus came out of discussions into the main knowledge gaps about evolution during invasion. Participants agreed that humans are intricately linked to the dynamics of invasive non-native species and yet missing from most theoretical and conceptual studies of their evolutionary dynamics. A plan for the manuscript was developed at the workshop and participants have since been working on the draft text. Once submitted, a short policy brief will be published, linking to summary papers from the presentations.

Relevance to CRP theme(s)
The workshop contributes to the CRP research theme 'Managing Risks in a Connected World' by improving understanding of global invasion dynamics and considering how risk assessment and policy should account for evolution during invasions.

Website for further details – please also indicate if the presentations are/will be available on the website
Summary papers from the OECD-funded presentations will be published on the website of the Centre for Ecology & Hydrology (https://www.ceh.ac.uk/).