Interdisciplinary Analysis of Plant Health Threats to Arable and Horticultural Crops in Scotland

Policy Summary

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1 Policy Summary

1.1 Background

Emerging plant pests and diseases (PPD) present a growing threat to global agriculture, horticulture, forestry and natural ecosystems. The re-emergence of wheat stem rust in the UK and Ireland, and emergency eradication of a small population of Colorado Potato Beetle found in Kent, England in the summer of 2023 illustrate the continued exposure of our plant resources to biological threats. Open land borders, similar climate and shared cropping systems mean that England, Wales and Scotland face many of the same plant protection issues. Indeed, the DEFRA Plant Health Risk Register (PHRR), which assesses PPD for potential invasion risk and impact, considers the UK as a whole. Risks for Scotland in particular are not explicitly analysed. This report uses an interdisciplinary approach to evaluate those risks.

1.2 Key Research Questions

We conducted an interdisciplinary risk analysis for PPD of arable and horticultural crops not yet present in Scotland, to identify those that have high risk of arrival and establishment. We then selected three example PPDs representing potential threats to the economically important cereal, potato and soft fruit industries for qualitative appraisal through expert knowledge elicitation to understand how key stakeholders view the risk from PPDs in the context of potential future scenarios for Scotland's agricultural sector. We then applied a state-of-the-art invasion model to a particular case study to illustrate how such models can be used to understand the risk to Scotland under future climate change. Finally, we assessed knowledge gaps that should be addressed to improve the precision of Pest Risk Assessments for Scotland.

1.3 Research Undertaken

We employed the CABI Distribution Database for PPDs to analyse 171,481 distribution records of 9472 PPDs across 480 geographical units. We first conducted an ecological assemblage analysis to identify which geographical regions shared the most PPD with Scotland, then applied a machine learning algorithm known as a Self-Organizing Map (SOM) to estimate probabilities of invasion by PPDs currently absent from Scotland and the UK. We then used global climate matching and crop distributions to estimate biophysical risk ratings for absent PPD, focussing on the most important arable and horticultural crops for Scotland in terms of area grown and economic contribution (barley, wheat, oats, oilseed rape and potato, plus soft fruit). We used international imports of crop products and live plants into the UK to estimate the risk of arrival by trade, and international tourism data to estimate the risk of PPD arrival through travel. We worked with a diverse range of agricultural stakeholders (farmers, agronomists, crop breeders, scientists, policy advisors, regulatory bodies, and value chain actors) to develop plausible future scenarios for Scotland's agriculture sector and consider how risks from PPD would differ among scenarios. Finally, we employed the Pest or Pathogen Spread (PoPS) model to investigate how a PPD of particular interest, Colorado Potato Beetle, might invade the UK under a range of different climate scenarios, focussing on the risk of establishment in Scotland following an initial invasion into southern England.

1.4 Main Findings

Other than immediate UK neighbours, Scotland is most likely to share PPD with Central Europe, though some regions of North America are also relatively similar. The PPD probability of presence in Scotland derived by the SOM model was greater for PPD listed in the DEFRA PHRR, providing validation for the SOM approach. SOM and biophysical risk models identified a number of PPDs of greatest risk to Scotland. PPDs which emerged as being of particular concern included wheat thrip (*Haplothrips tritici*), cotton bollworm moth

(*Helicoverpa armigera*), common bunt (*Tilletia laevis*) and Colorado Potato Beetle (CPB, *Leptinotarsa decemlineata*). Some of those identified had high unmitigated risk ratings in the PHRR, including CPB, the disease vector *Hyalesthes obsoletus*, pea leafminer (*Liriomyza huidobrensis*), tarnished plant bug (*Lygus lineolaris*) and potato virus S. The potato flea beetle (*Epitrix papa*) was identified as a risk through travel and has a high PHRR unmitigated risk rating. Additionally, we considered wheat stem rust (*Puccinia graminis* f.sp. *tritici*) as a substantial threat to Scotland due to its recent re-emergence in the UK and Ireland. Several species are known migrants to southern UK and could become problematic in Scotland under climate change. Our PoPS dynamic model showed that a successful invasion of CPB into southern UK is likely to spread to Scotland within decades, assisted by climate warming which accelerates development time and promotes adult dispersal. CPB could establish in Scotland under current climate conditions if directly introduced.

The PPD noted as concerns by stakeholders did not align with those prioritised by multimodel analysis, perhaps reflecting that they are more concerned with PPD established already, rather than future projected risks. This highlights a KE requirement to share information on the priority PPD predicted.

Summary of PPDs identified as of greatest risk from multi-model and interdisciplinary analyses. Alphabetical order:

Organism	Common name	Comments
Epitrix papa	Potato flea beetle	High travel introduction risk and Defra risk rating.
Eurygaster integriceps	Senn pest (shield bug)	Climate change increases risk.
Haplothrips tritici	Wheat thrip	Distributed across Eurasia.
Helicoverpa armigera	Cotton bollworm moth	Wide host range and global distribution.
Hyalesthes obsoletus	Hemipteran bug	Disease vector with high Defra risk rating
Leptinotarsa decemlineata	Colorado Potato Beetle	Recently intercepted in southern England.
Liriomyza huidobrensis	Pea leafminer fly	High Defra risk rating
Lygus lineolaris	Tarnished plant bug	High Defra risk rating
Meloidogyne javanica	Javanese root-knot nematode	Wide host range and high risk to glasshouse crops.
Potato virus S		High trade import and Defra risk rating.
Puccinia graminis f.sp. *tritici*	Wheat stem rust	Re-emerging throughout the UK.
Spodoptera frugiperda	Fall armyworm	Climate change increases risk.
Tilletia laevis	Common bunt of wheat	Global distribution, high trade import risk.

Our stakeholder engagement exercise elicited two potential future scenarios for Scotland's agriculture sector, one where Scotland has a greater degree of autonomy for strengthening agri-food trade, investment and policy (termed "Scotland's own vision") and the other where there is less autonomy and Scotland's agri-food system is weakened by external competition (termed "Agriculture elsewhere"). PPD were considered to pose a greater threat to Scotland's agricultural production under the "Agriculture elsewhere" scenario.

1.5 Recommendations

Project recommendations are summarised in terms of the target audience, and take into account the recommendations from stakeholder analysis of future scenarios for Scottish arable and horticultal production.

For policy advice and regulation, these include:

1. Maintain and publish an active list of present and emerging PPD in Scotland, or work with e.g. CABI to do so.
2. Maintain and publish data on PPD interceptions at Scottish ports.

3. Consider emerging PPD as governmental agricultural support programmes are developed, including support for PPD monitoring and government insurance and assurance schemes.
4. The PPD listed as of concern by stakeholders did not align with those identified by risk modelling, highlighting a need for knowledge exchange to raise awareness and continued dialogue.

For farmers, agronomists and other agricultural practitioners:

1. PPDs flagged as being of high risk by multiple methods in the present analysis should be prioritized for early detection and management, using existing solutions in good time to mitigate PPD impacts.
2. Consider diversifying crop production systems to increase resilience, including use of resistant crop varieties, intercropping, mixtures of landraces, diverse uncropped vegetation, and modifying or adapting crop rotations.

For research and development:

1. Conduct a biophysical and socioeconomic modelling to understand potential future changes in Scotland's crop production in coming decades, particularly to identify where and when novel crops may be cultivated.
2. Detailed life history and ecophysiological information for PPDs of interest should be collated from the literature or obtained via experiment to enable invasion modelling.
3. Improve decision support to enable targeted control measures, including research into the implications of changing PPD management methods (e.g. switching from chemical to biological control or novel chemical control)
4. Conduct co-creation of knowledge for PPD management (research with stakeholders which translate into actions).

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