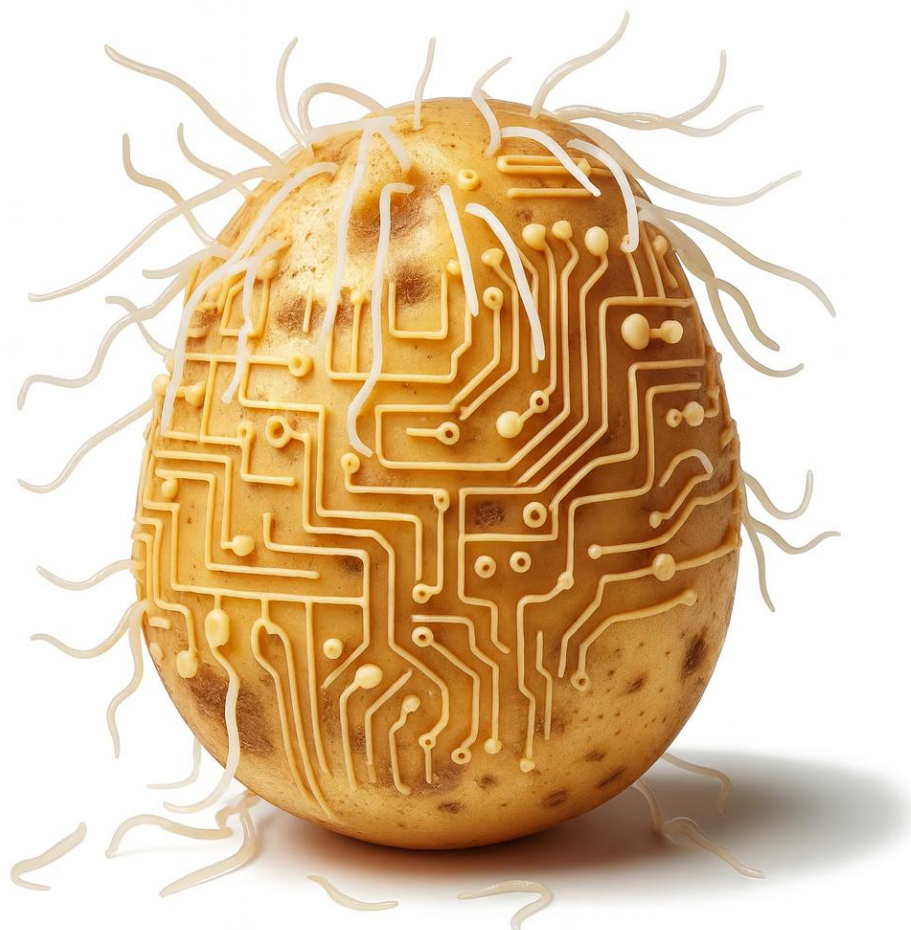


PCN-ML: Developing new models to predict PCN species presence / absence in Scottish soils

Policy Summary



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This work was commissioned by Scotland's Centre of Expertise for Plant Health Funded by Scottish Government through the Rural & Environment Science and Analytical Services (RESAS) Division under grant agreement No [PHC2024/05](#)

Full report is available [online](#)

Please cite this report as follows: P. Skelsey (2026). PCN-ML: Developing new models to predict PCN species presence / absence in Scottish soils. Policy Summary. PHC2024/05. Scotland's Centre of Expertise for Plant Health (PHC). DOI: <https://doi.org/10.5281/zenodo.21222963>

Dissemination status: Unrestricted

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1 Policy Summary

1.1 Background

Potato cyst nematodes (PCN) are among the most economically damaging soilborne pests of potato. Two species occur in Scotland, *Globodera rostochiensis* and *G. pallida*, and they exhibit significant differences in their biology and response to management. Knowledge of the distribution of each species is therefore crucial because it provides context for statutory test results, facilitates clear communication of risks, and supports tailored management advice. By transforming statutory testing data into accessible spatial information, growers, advisors, and policy teams can identify regional patterns, track emerging trends, and take informed measures to protect PCN-free land and safeguard Scotland's seed potato industry.

1.2 Key Research Objectives

This project aimed to develop an interactive PCN mapping and prediction application that brings together PCN testing data, spatial analysis, and machine learning. The app visualises the distribution and relative intensity of *G. pallida* and *G. rostochiensis* across Scotland, highlighting where infestations are most concentrated and where current risk is greatest. By combining observed data with model-based estimates, it also provides estimates of infestation likelihood in unsampled areas. These insights are intended to support evidence-based policy and deliver species-specific risk and management advice to growers and decision-makers across Scotland.

1.3 Research Undertaken

The project was structured under the following objectives:

- Collate, clean, and standardise statutory PCN testing data from multiple years and regions of Scotland, integrating these records with spatial reference data for analysis at multiple spatial scales.
- Apply geostatistical methods to map the observed distribution of *G. pallida* and *G. rostochiensis*, identify areas of high infestation intensity, and derive spatial risk indicators.
- Develop and train machine learning models to generate species-specific nowcasts of current PCN distribution and risk across Scotland. These provide probabilistic estimates of present infestation likelihood derived from spatial and temporal patterns in the statutory testing dataset, including the probability of species presence in unsampled areas and locations where infestations exist at low densities that routine soil testing may miss.
- Integrate these analytical outputs into an interactive desktop application that enables SASA to visualise distributions, explore species-specific risks, and support targeted management advice and policy decisions.

1.4 Main Findings

- Statutory PCN testing data from 2010–2024 were provided by SASA and combined with postcode area, district, and sector identifiers to enable computation of regional summary statistics.
- Statistical mapping methods were developed and implemented to visualise the distribution and intensity of *G. pallida* and *G. rostochiensis* across Scotland.
- Machine learning models performed well when evaluated on independent test data, accurately distinguishing between *G. pallida*, *G. rostochiensis*, and negative samples.
- The analytical outputs were integrated into an interactive mapping application, PCN-Mapper, allowing users to explore species distributions and risk patterns at multiple

spatial scales across Scotland. The tool combines observed sample results with model-based nowcasts to generate intuitive visualisations and summary statistics. This integration transforms complex testing data into accessible, decision-ready intelligence, supporting SASA in assessing species-specific risk, prioritising surveillance, and communicating trends in PCN distributions more effectively.

1.5 Recommendations and next steps

- Following training of relevant SASA staff and an initial testing phase, the PCN-Mapper app could be updated at the end of each growing season as new PCN testing data become available, ensuring that maps, models, and risk indicators remain representative of current PCN populations.
- The following recommendations, while subject to SASA's resource availability and careful consideration of grower confidentiality, have the potential to enhance the delivery of actionable plant health information and thereby increase the overall impact of PCN-Mapper:
 - It is recommended that PCN-Mapper outputs are incorporated into SASA communications and advisory material accompanying positive PCN test notifications, providing tailored advice on species-specific risk and management.
 - Growers receiving negative test results could also be provided with contextual information on local PCN risk, drawn from PCN-Mapper, to encourage preventative management in high-risk areas.
 - PCN-Mapper could be used as a communication tool in grower and stakeholder meetings to illustrate regional and species-specific risk patterns, support discussion of management options, and raise awareness of emerging trends.
 - The app produces a wide range of high-level regional summary statistics, and these could be provided to agronomists, major seed houses, and policy teams to inform strategic decisions and long-term management policy.
 - Consider, in consultation with SASA policy teams, whether aggregated regional summaries derived from PCN-Mapper could be shared with stakeholders in a way that protects grower confidentiality and avoids misuse of sensitive data.
- PCN-Mapper could be promoted alongside the PCN Scenario Planner developed under the PCN Action Scotland project, with each tool serving distinct but connected purposes: PCN-Mapper for visualising and communicating risk at landscape scale, and the Scenario Planner for guiding management decisions on infested land.
- PCN-Mapper can support prioritisation of soil testing in higher-risk areas, improving the efficiency of surveillance resources.
- Key priorities for future research include:
 - Integration of field and sub-field management data (e.g., crop varieties, resistance deployment, and evolving field boundaries) to better capture within-field variation in PCN risk where such data can be integrated.
 - Develop and retain records at the sub-field (sampling-unit) scale, as this level of detail would provide valuable predictor variables for machine learning. Information on crop varieties and management practices would improve model performance and understanding of factors influencing PCN spread and persistence.
- Investigate opportunities for real-time data sharing and automated updates between PCN-Mapper and SASA's PCN testing database to streamline future reporting and ensure timely model updates.

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