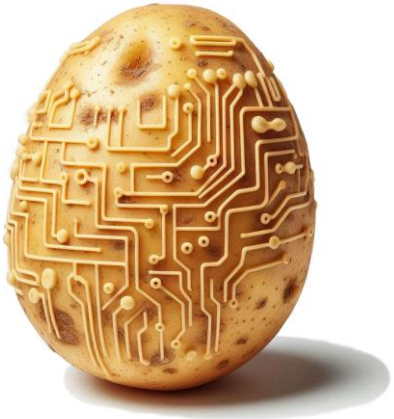
Analysing and predicting potato pests & diseases

Using data science and AI to strengthen the resilience of our potato industry

Peter Skelsey



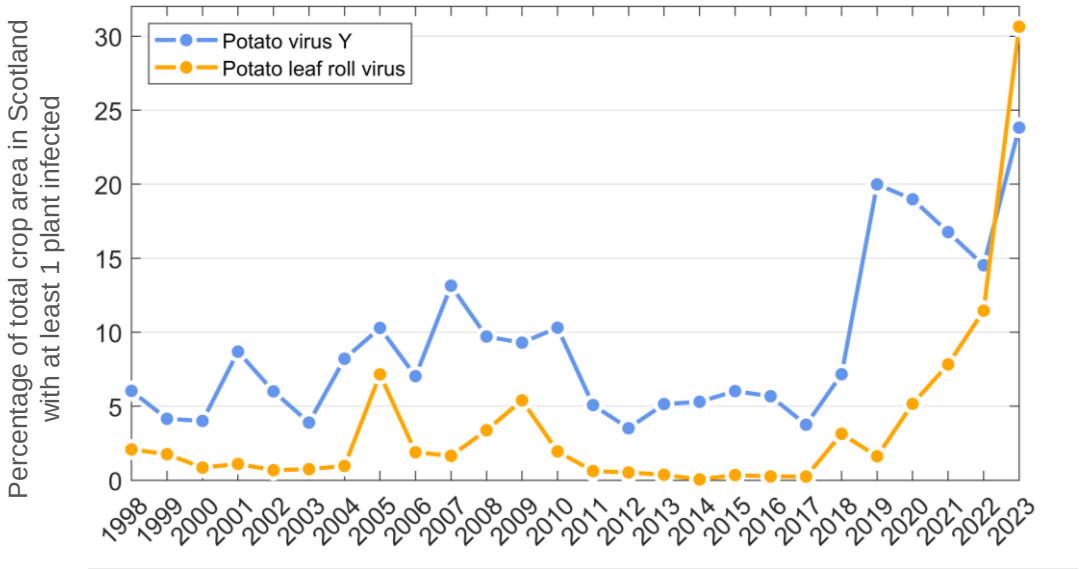
The James Hutton Institute

Potato pests and diseases - the problem

- Scottish potato sector is worth approx. £2bn per annum
  - ⚠ Potato viruses: a threat to our global reputation as a producer of high-quality seed
  - ⚠ Potato cyst nematodes: a soil pest that could collapse the seed industry by 2050
  - ⚠ Late blight: fungicide resistant / aggressive strains in Europe threaten our crops
- **We are using data science and AI to guide management and inform policy**

The potato virus problem

- Incidence of potato viruses has been increasing over the last 5 years
- The industry has expressed a need for a national evidence-based IPM strategy
  - This includes data analyses & models to inform decision-making

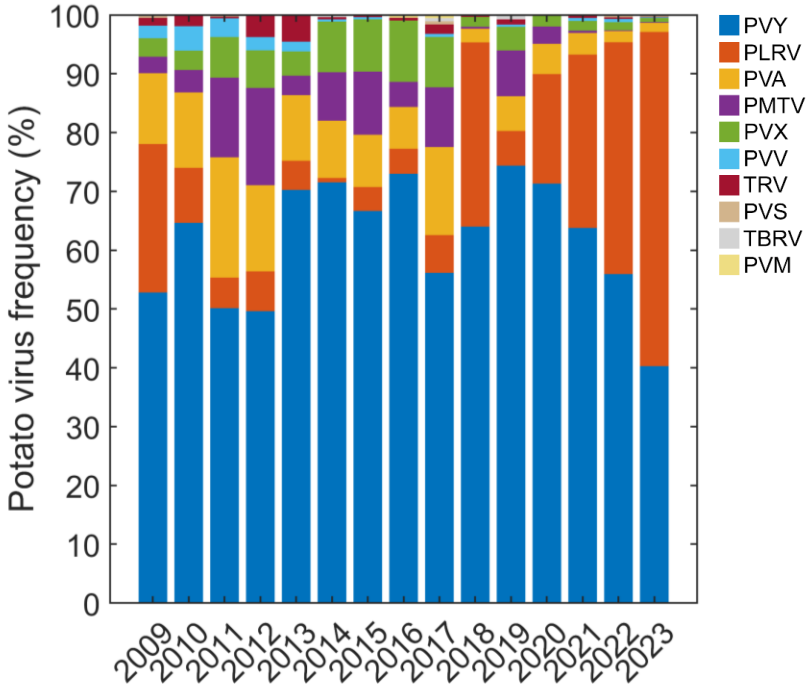


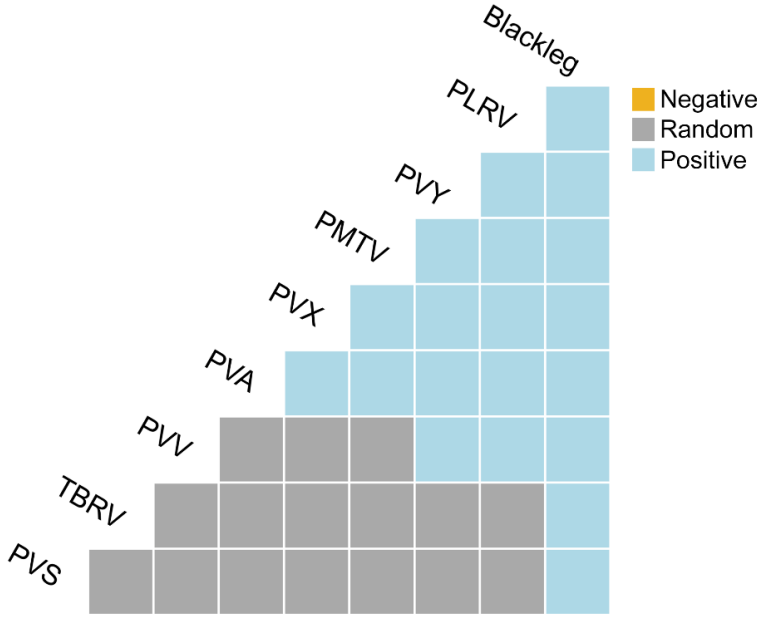
Potato virus data

- Scottish Seed Potato Classification Scheme, SASA
- Every growing seed crop inspected 2-3 times a season
- Data on 10 different potato viruses from over 100,000 crops (1998-2023)
  - *Never been analysed before!*

Describing and analysing potato virus data

- RESAS SRP 2022-2027, project JHI-A1-1: Epidemiology of key pests & diseases

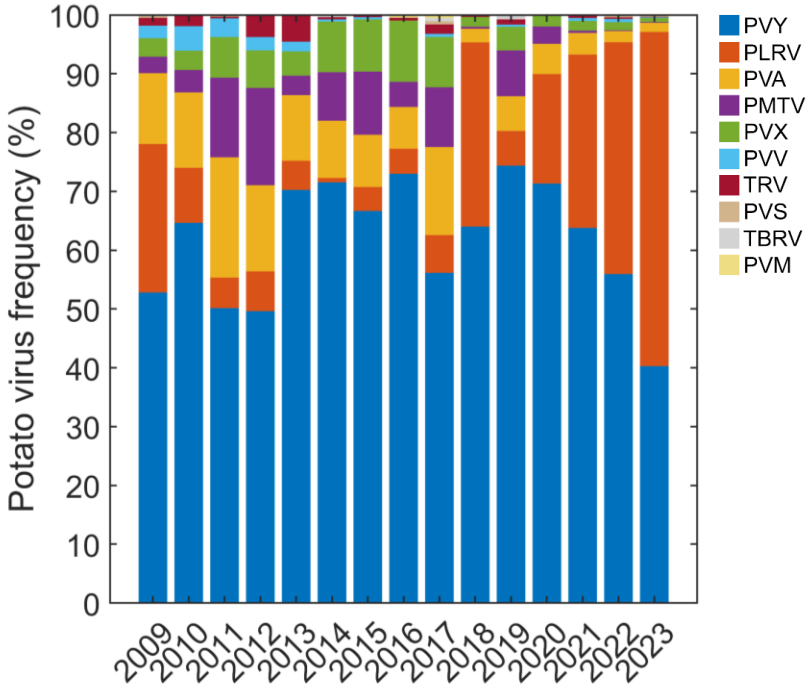




Co-occurrence analysis
(showing +/- species pair associations)

Describing and analysing potato virus data

- RESAS SRP 2022-2027, project JHI-A1-1: Epidemiology of key pests & diseases



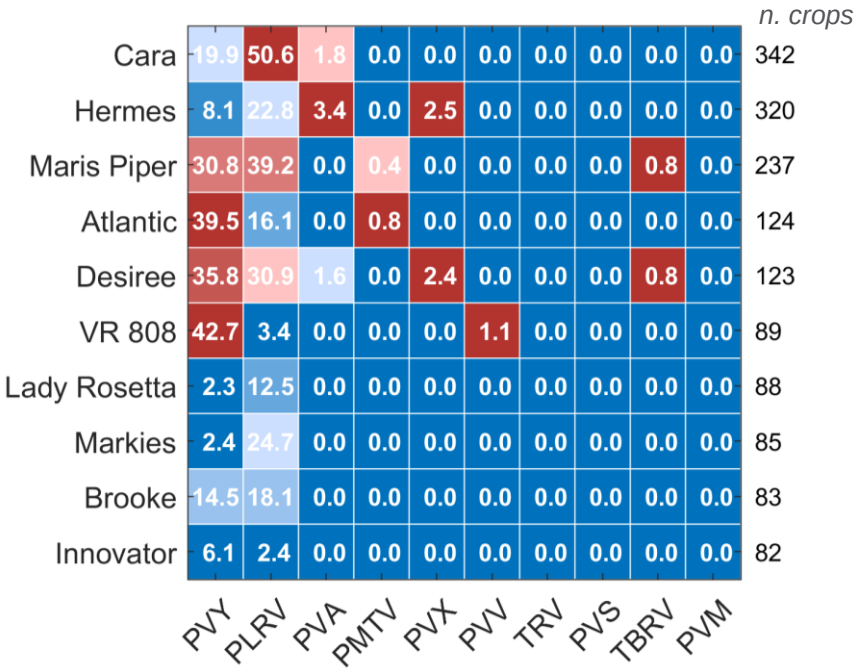
Number of infected seed lots (and %) of all infections

Single infection		Double infection		Triple infection		Quadruple infection	
PVY	3549 (61.97)	PVY–PLRV	285 (4.98)	PVY–PVA–PMTV	7 (0.12)	PVY–PVA–PLRV–PVV	2 (0.03)
PLRV	767 (13.39)	PVY–PVA	89 (1.55)	PVY–PVA–PVV	7 (0.12)	PVY–PVA–PVX–PVV	1 (0.02)
PVA	331 (5.78)	PVY–PMTV	62 (1.08)	PVY–PLRV–PVX	5 (0.09)		
PMTV	202 (3.53)	PVY–PVX	37 (0.65)	PVY–PLRV–PMTV	3 (0.05)		
PVX	155 (2.71)	PVA–PVX	32 (0.56)	PVY–PVA–PLRV	3 (0.05)		
TRV	51 (0.89)	PVA–PVV	17 (0.30)	PVY–PLRV–TBRV	2 (0.03)		
PVV	31	PLRV–	11	PVY–	2		

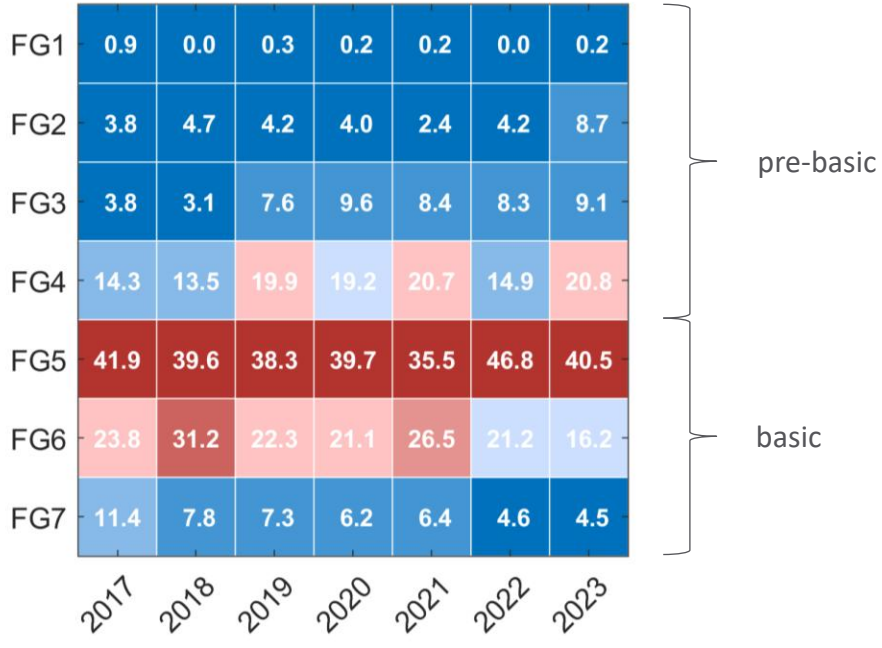
Describing and analysing potato virus data

The James Hutton Institute

Variety-specific incidence rate 2023
(percentage of crops with at least 1 infected plant)



PVY incidence by field generation
(percentage of total faults attributed to FG)

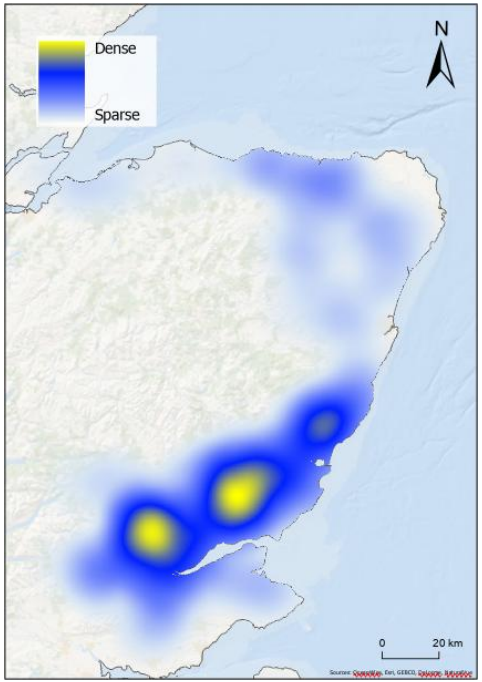


** colour-coded by column (virus)*

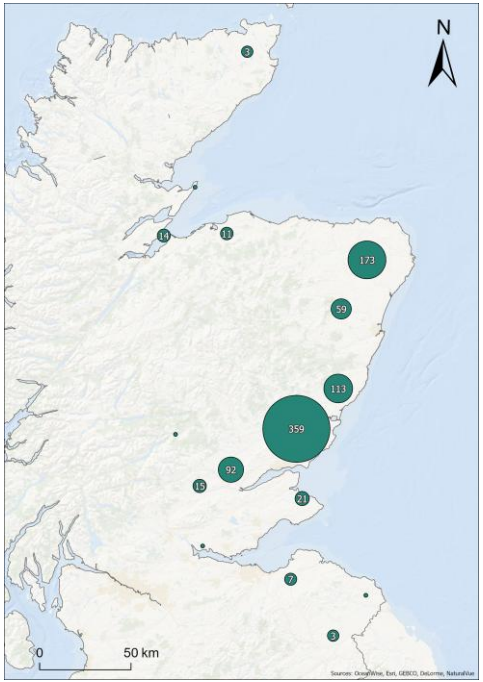
Mapping potato virus data – getting an overview of the situation

The James Hutton Institute

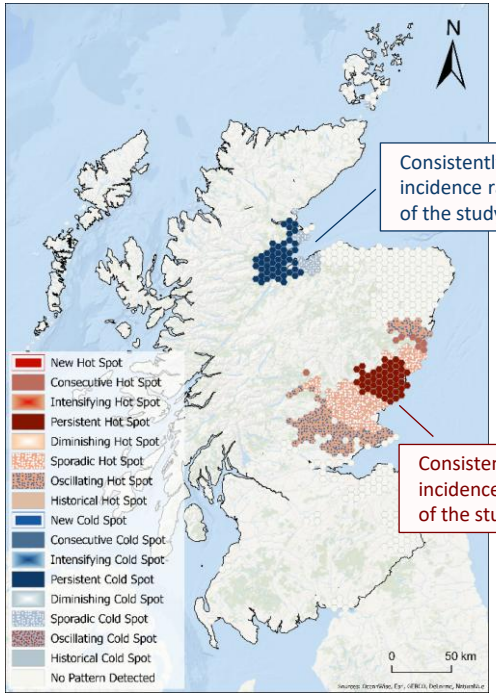
Density of PVY 2023



PLRV incidence 2023



Spacetime patterns of PVY in seed crops, 2009-2023



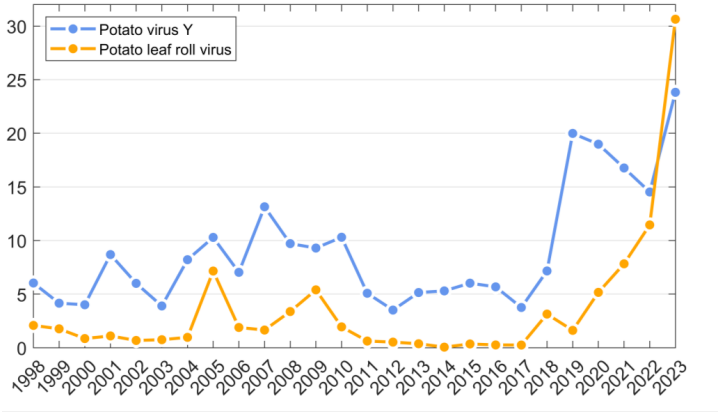
Consistently low incidence rates over 90% of the study period

Consistently high incidence rates over 90% of the study period

** 17 different types of spatiotemporal patterns*

Implications for policy and the Seed Potato Classification Scheme

- Ware crops - compulsory use of certified seed & increased crop separation distances
- Field generations - revisit the virus tolerances set in the SSPCS
- Seedborne infection - improved post-harvest tuber-testing to flush virus out
- Varieties - restrictions on poorly-performing varieties
- Region-specific rules – e.g., an extra inspection or incentives in hot-spot areas



Forecasting potato virus risk – new AI-based national warning systems

The James Hutton Institute

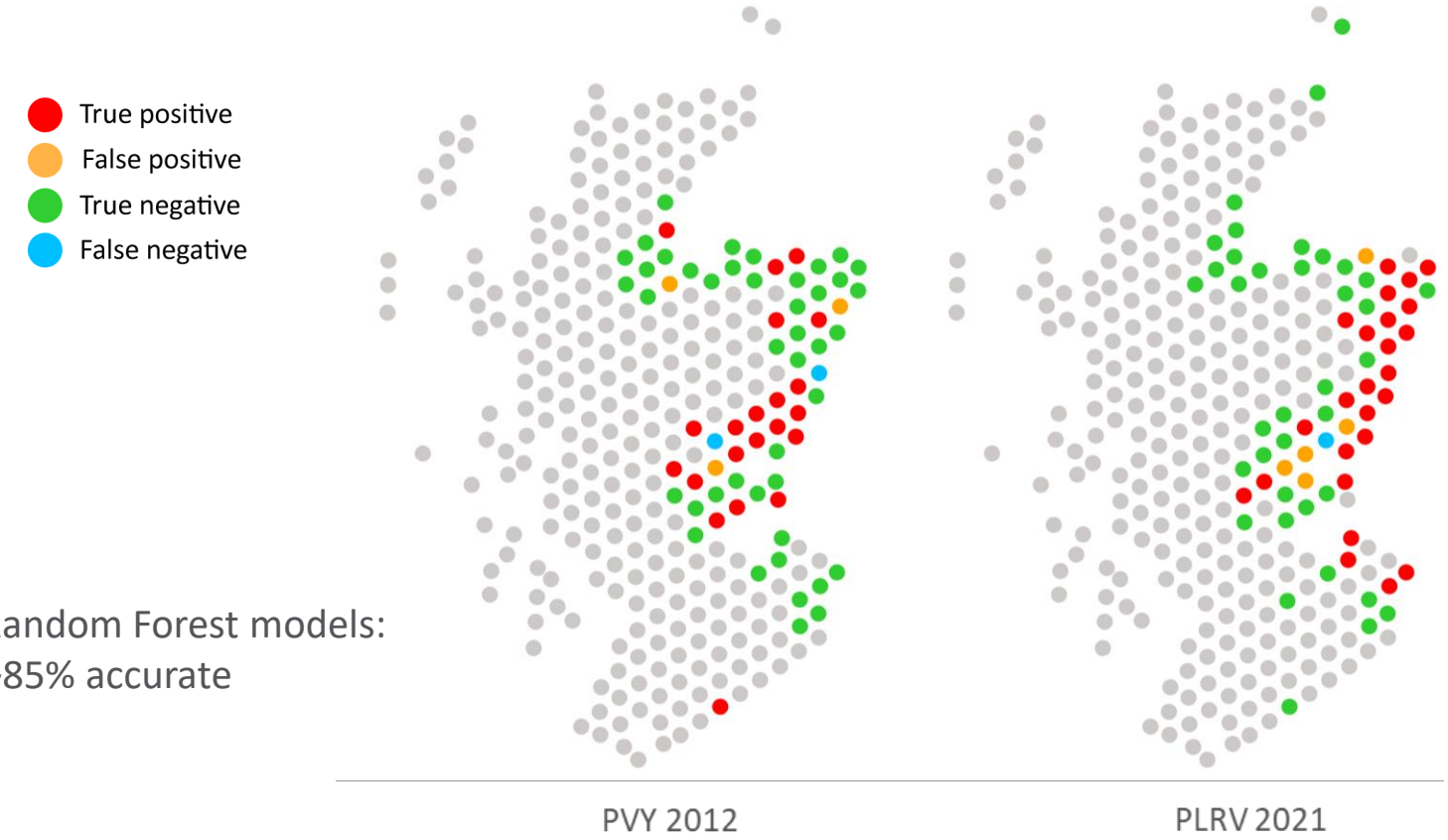
- Leveraged funding, PHC Project, 2024 – "*Potato virus forecasts: developing new models to guide sustainable management of potato crops in Scotland*"
- Stakeholder focus group – wanted a 'green alert' / 'red alert' system
- Data – 25 years of national virus levels, 25 years of national aphid vector counts
- Modelling task - *will virus levels next year be lower or higher than the average season?*
- Tested > 25 different AI algorithms:

Performance of AI models for predicting virus risk

Virus & Algorithm	True negative rate	False negative rate	True positive rate	False positive rate	Accuracy
PVY: Support Vector Machine	98%	4%	96%	2%	97%
PLRV: Decision Tree	97%	5%	95%	3%	96%

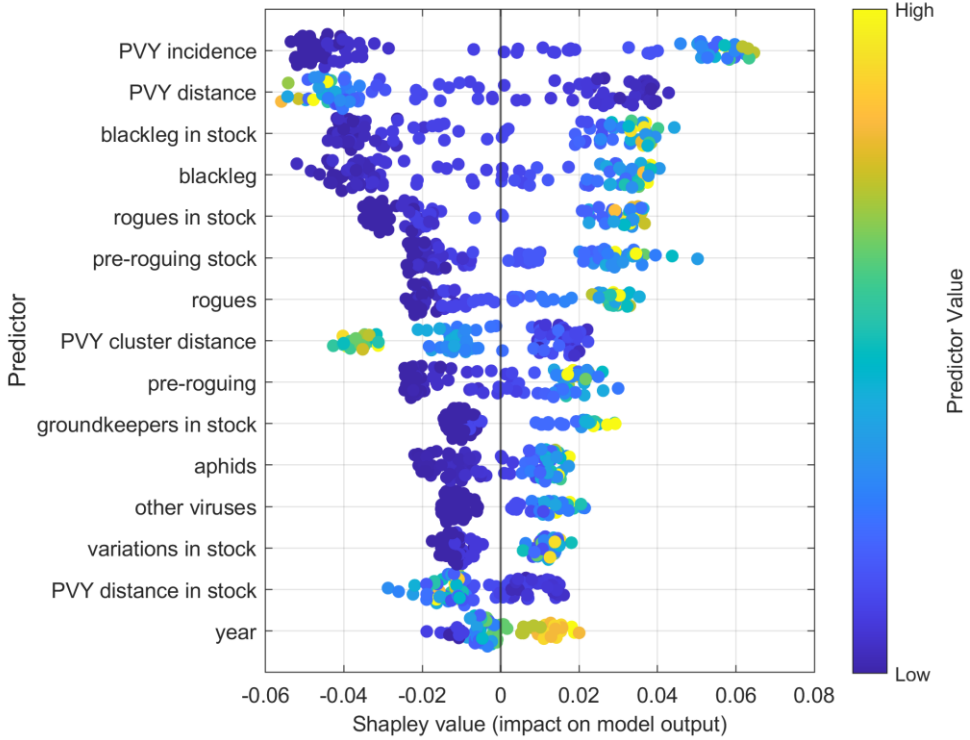
Forecasting potato virus risk – new AI-based local warning systems

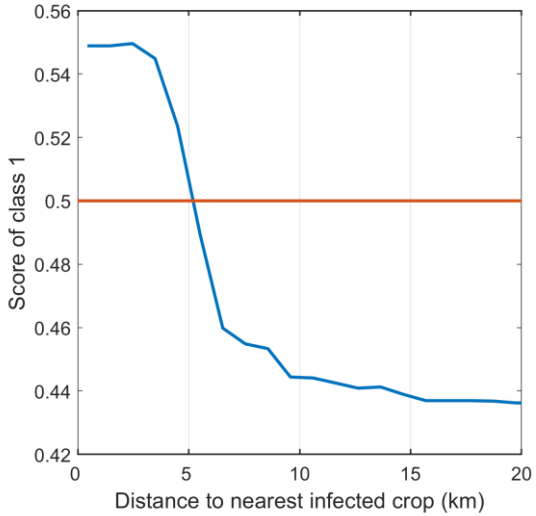
The James Hutton Institute



Random Forest models:
~85% accurate

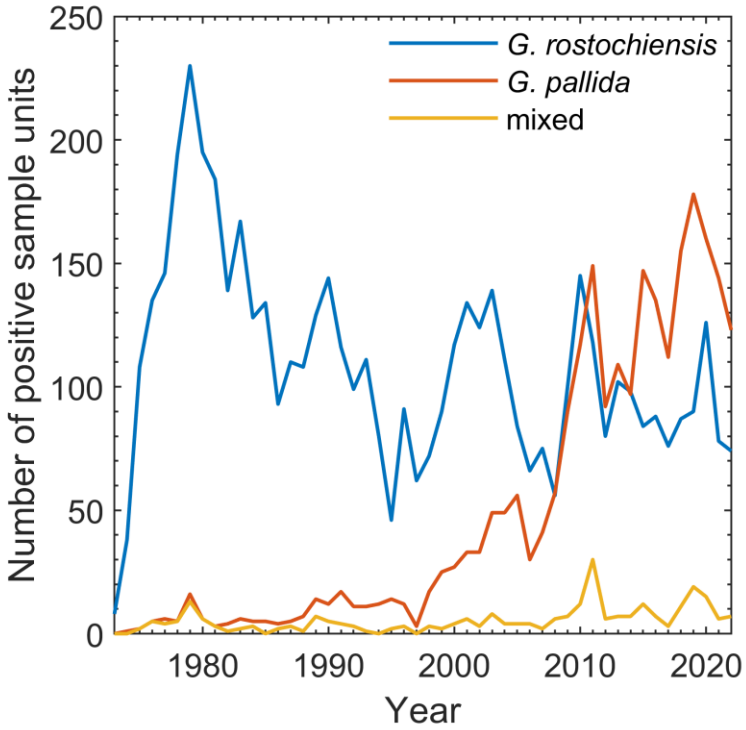
Forecasting potato virus risk – PVY local model interpretation





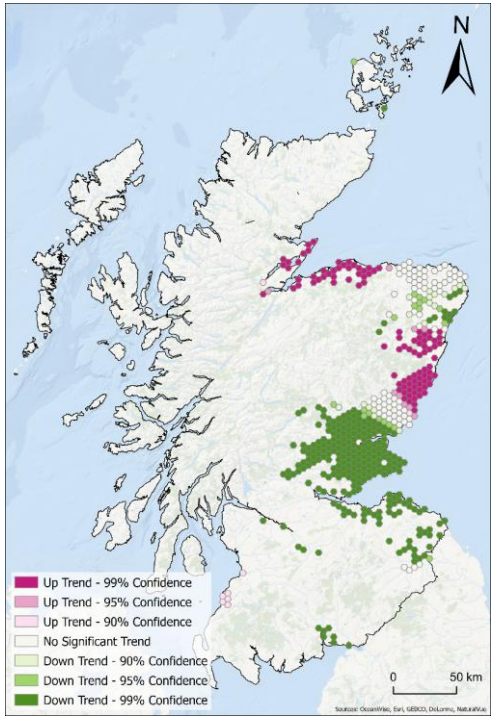
Potato cyst nematodes - statutory PCN testing data

- Seed potatoes can only be grown on land that is PCN-free
- PCN is already present in ~25k ha of Scottish soils
- The cysts can survive for many years, and the amount of infested land is doubling every 6-7 years
- Recent predictions suggest PCN will cause the end of the seed industry by 2050
- Analysing the statutory soil testing data 1973-2022 (~100k sample units)



Potato cyst nematodes – mapping and modelling

Spacetime patterns of *G. rostochiensis*



Moving north due to climate change

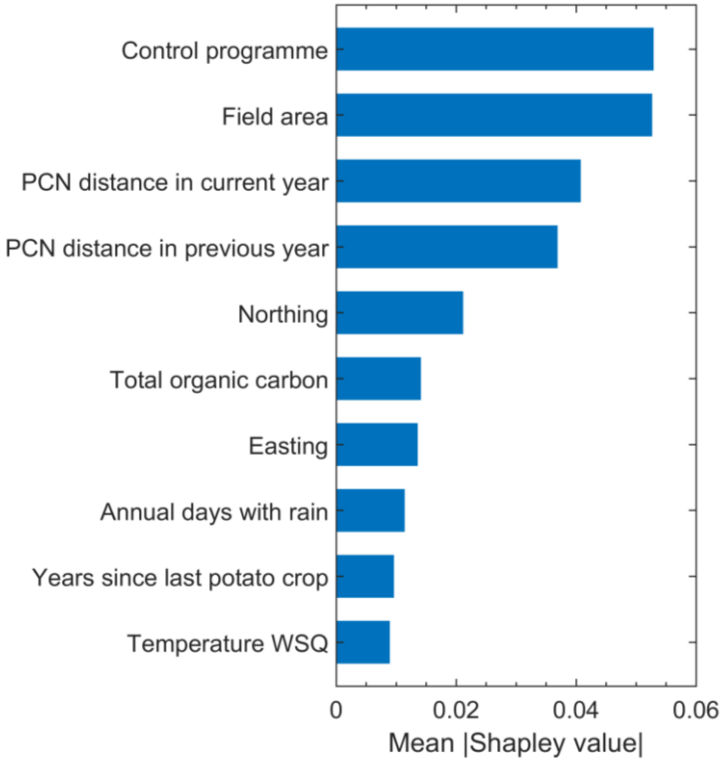
= identify problematic areas & new insights

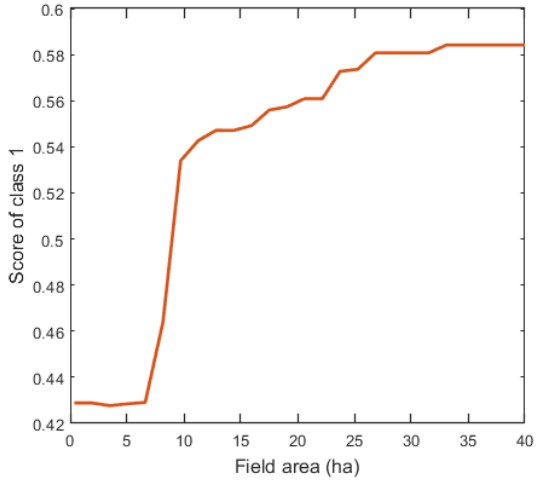
Performance of an AI model to predict whether a soil sample will be positive or negative for PCN

Random forest model	Balanced accuracy
Training results	93% (2%)
Test results	91% (5%)
Final model	**97%**

= a new tool for industry

Potato cyst nematodes – model interpretation





Potato cyst nematodes – new funding for an AI model

The James Hutton Institute

Leveraged SG / PHC call-down funding 2024

- Project title: "*Developing new AI models to predict PCN species presence / absence in Scottish soils*"

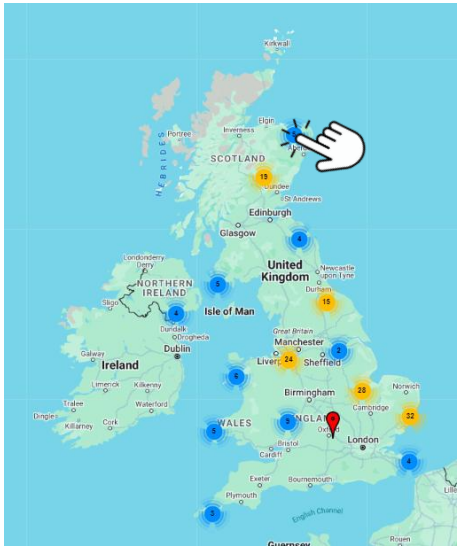
Implications for industry / policy

- Develop spatial, species-specific management strategies
- Model could help reduce costs of testing
- Make predictions for ware areas
- Increase sustainability of our potato industry

Potato late blight – Fight Against Blight campaign

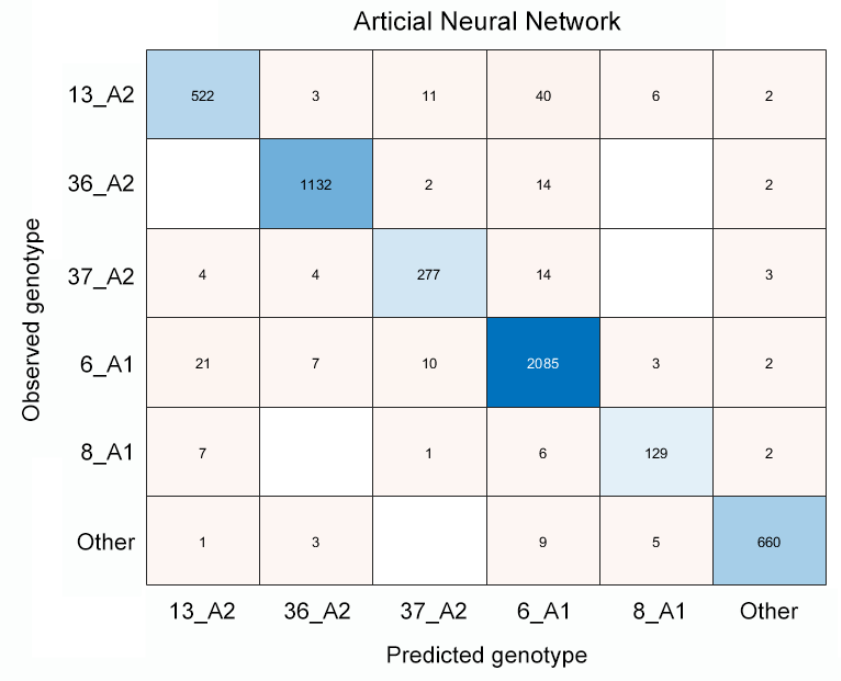
- Running since 2004 (PCL / AHDB Potatoes), now operated by Hutton
- Blight scouts submit samples of suspected outbreaks:
  - Monitoring pathogen populations (genotyping)
  - Virulence to new blight resistant cultivars
  - Sensitivity to key fungicides
  - Sensitivity to environmental conditions
  - Comparing to European populations (EuroBlight database)
- Results are fed back to the industry to keep them informed
- **Can we predict late blight genotypes?**

Blight services at JHI



Potato late blight – predicting the genotype of outbreaks

- Developed an AI model to predict the genotype of potato late blight outbreaks = 98% accurate



Implications for industry / policy

- Faster than sampling
- Provide predictions for crops that weren't sampled
- Inform growers which fungicides to use & when to use their premium products
- Inform growers of their chances of resistance failing

Thank you for listening …

The James Hutton Institute

RESAS
Rural & Environmental Science and Analytical Services

Scottish Government
Riaghaltas na h-Alba

Plant Health Centre
Scotland's Centre of Expertise

SASA
Helping Scotland Grow

ROTHAMSTED RESEARCH
Insect Survey

fera