# Moths, Maths, and Modelling Tree Pests

J.P. McKeown[1], L.E. Wadkin[1], N.G. Parker[1], A. Golightly[2], A. W. Baggaley[1,3]

[1] Newcastle University, [2] Durham University, [3] Lancaster University

## MOTIVATION

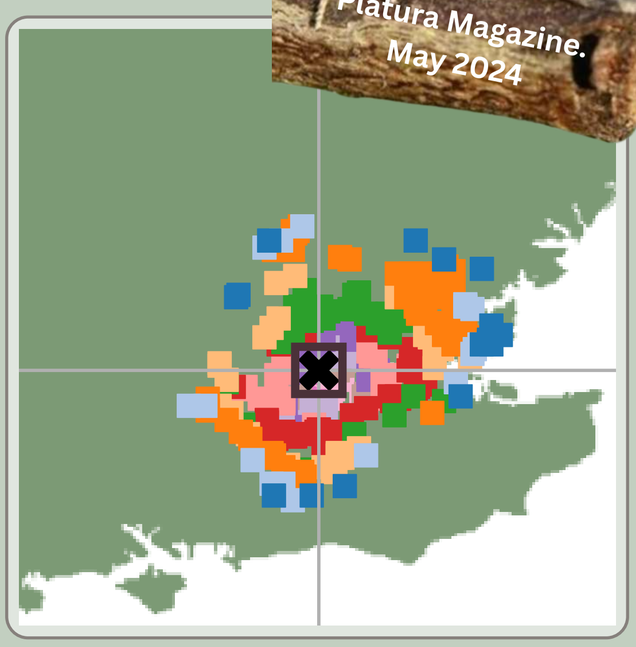
Invasive pests ***threaten UK forests*** and cost UK taxpayers ***£1 billion/year***.

***Observational studies*** alone are ***infeasible due to limited resources***.

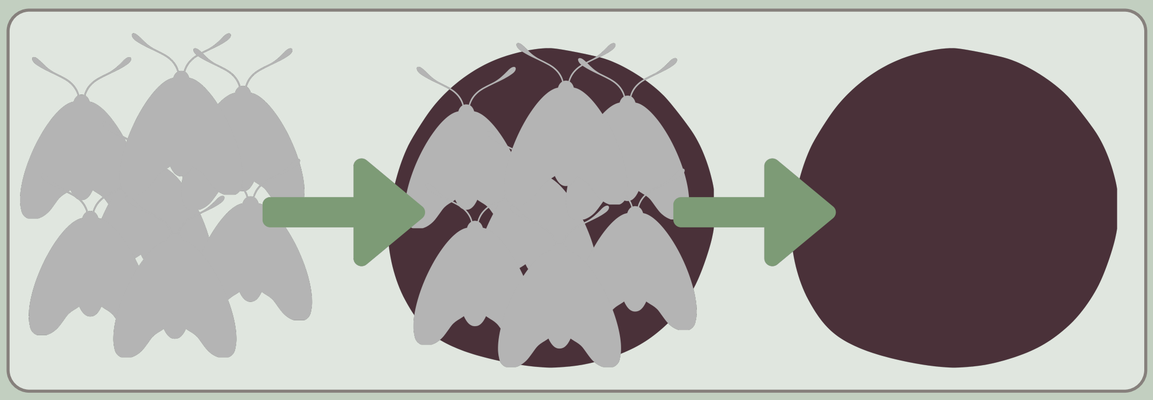
***Mathematical models*** can ***effectively quantify invasive pest spread***.

## CASE STUDY

- ***The oak processionary moth (OPM)*** is an invasive pest in the UK.
- Caterpillars ***defoliate oak trees*** and their ***toxin covered hairs*** pose a significant ***public and animal health risk***.
- Currently ***no model of their spatiotemporal evolution***.

## FRAMEWORK



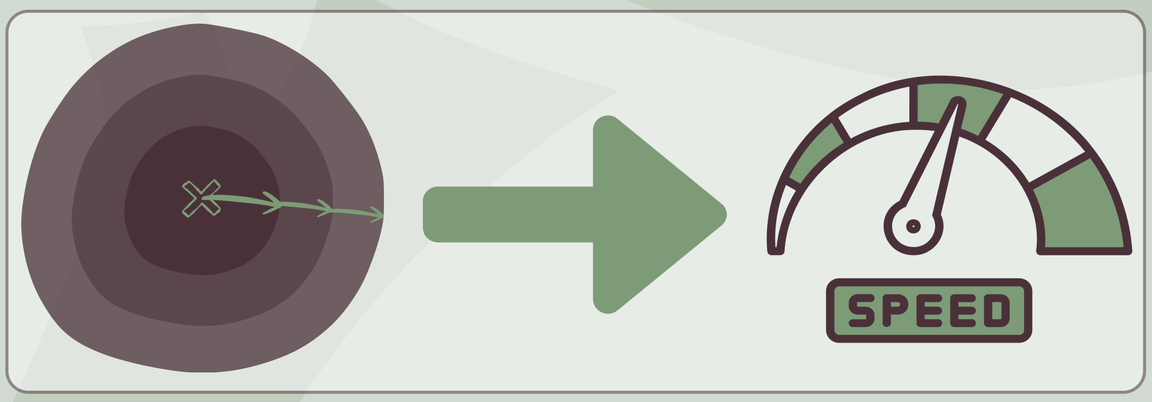
- We model the ***collective behaviour of the pest***, quantifying its ***range expansion***.
- The pest's spatial distribution is described by a ***population density field***, which evolves according to a ***reaction-diffusion*** equation:

$$\frac{\partial N}{\partial t} = D\nabla^2 N + rN\left(1 - NK^{-1}\right).$$

- The ***expansion rate*** is given by

$$v = 2\sqrt{Dr}.$$

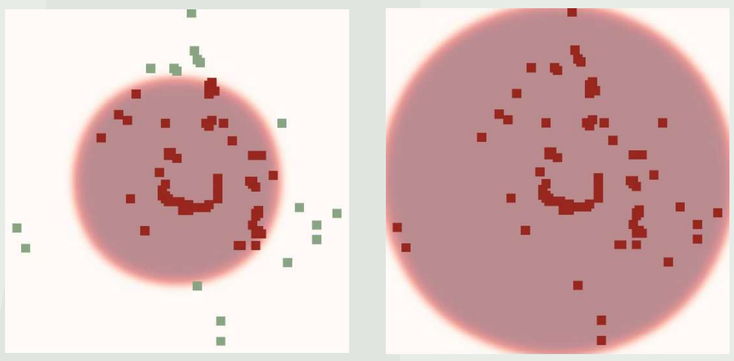
- When we look at how the density field changes over time, it shows ***range expansion*** with a ***clear, outward travelling invasion front.***
- We use ***Bayesian inference*** to ***identify most likely parameters for the model***.
- We use the ***expansion rate formula*** to convert the most likely parameters into a ***most likely expansion rate***.




## IMPLEMENTATION

### REAL DATA

Collected by the Forestry Commission



- Predicts ***arrival time*** of OPM in areas of the UK.
- Determines ***expansion rate*** of OPM in the UK.

## OUTCOMES

- ***OPM spreads at a non-constant rate***.
- ***Slower expansion*** from ***2006 to 2014***.
- ***Faster expansion*** from ***2014 to 2023***.
- ***Expansion rate*** has ***increased since 2019***.

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