# How Forest Roads Impact the Propagation of Invasive Plant Species

**Bradly Deeley (bfd913@bham.ac.uk)  Supervisor: Natalia Petrovskaya**

## The Problem

Biological invasion of plant and tree species poses a major threat to the ecosystem and economy [1].

It is, therefore, important to understands how invasive plant species spread through a landscape.

Several studies have shown that forest roads act as corridors, increasing the rate of invasion [2,3,4]. However, little is known about the underlying mechanisms at play.

In order to investigate the impact that roads have, we have built a mathematical and computational model to investigate the impact of roads on the invasive species [5].

Our study shows that the answer is more complex than forest roads act as corridors. Forest roads can but do not always act as corridors to invasion.

## The Model

The population density is denoted by $N$

We will be using a stage structured dispersal kernel based model

$$N_{t+1}(\mathbf{r}^*) = \int_\Omega F(N_t(\mathbf{r}))k(\mathbf{r}^*, \mathbf{r})d\mathbf{r}$$

$\mathbf{r}^* = (x^*, y^*)$ - position where we detect the invasive species

$N_{t+1}(\mathbf{r}^*)$ - the population density at $r^*$ at time $t+1$ (to be computed from the model)

$N_t(\mathbf{r}^*)$ - the given population density at time $t$

The population is stage-structured:

The growth stage the population grows but there is no dispersal.

$F(N_t(\mathbf{r}))$ - the growth function

The dispersal stage - the population disperses across the domain but does not grow.

$k(\mathbf{r}^*, \mathbf{r})$ - the dispersal kernel

## Corridor Case

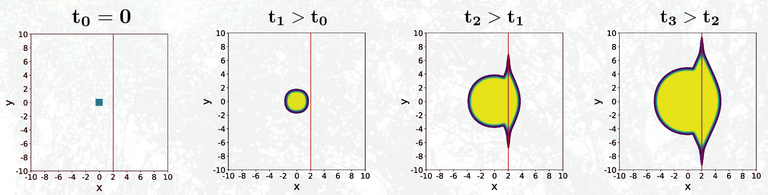


**Figure 1:** Population density solutions for the corridor case, the road is given by the solid red line.

## Barrier Case

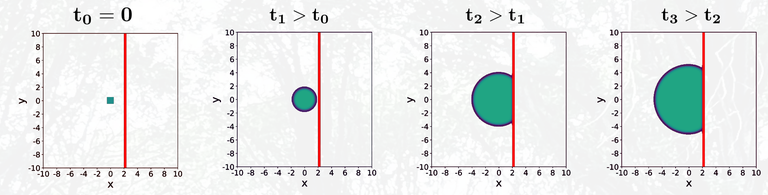


**Figure 2:** Population density solutions for the barrier case, the road is given by the solid red line.

## Beachhead Case

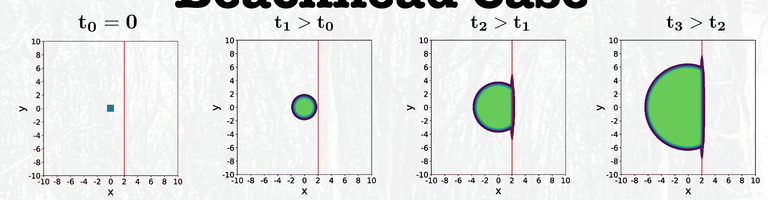


**Figure 3:** Population density solutions for the beachhead case, the road is given by the solid red line.

## Population Density


## Road Width Vs Growth Parameter

The $(A, \delta)$- plane, where:

- the road width is given by $\delta$
- the growth function is given by $F(N) = \dfrac{\rho N^2}{A + N^2}$

with strong Allee effects.

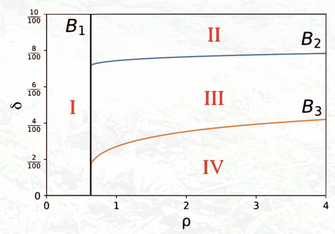


**Figure 4:** Region I the extinction regime, region II the barrier regime, region III the beachhead regime, region IV the corridor regime [6].

## The Results

The population density solution falls into one of three cases.

The first case is the corridor case; this is where the rate of invasion is increased. The population density has invaded further into the domain and has invaded more of the domain than without the road.

The second case is the barrier case. The underlying dynamics of the invasive species are not sufficient to cross the road and invade the domain in front of the road. The overall area the population density has invaded is decreased, and control measures only need to be applied to the domain behind the road.

The third case is the beachhead. This is where the population density has spread to the domain in front of the road but remains constant, forming a standing wave.

The beachhead case is particularly interesting. As it stands, to control the invasive species, we only need to focus on the domain behind the road. However, if any conditions change in favour of the invasive species, for example, climate change, this could turn into a corridor case, leading to the population density invading the domain in front of the road.

## Current and Future Work

- Road Edge Effects
- Long Distance Dispersal
- Seed Banks
- Complex Road Geometry

**About the Author**

My background is in applied mathematics. I am interested in the intersection of mathematics, computer science and nature.

**@BradlyDeeley**


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[2] W. Lonsdale and A. Lane, "Tourist vehicles as vectors of weed seeds in kakadu national park, northern australia," Biological Conservation, vol. 69, no. 3, pp. 277– 283, 1994.
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