# Dendritis – Technical Manual

## Mathematical models to explore the spread of tree diseases

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**The programs**

This module aims to educate young people (14-19) about the importance of trees, the significance of tree diseases worldwide, and their rates of infection. It introduces the concept of mathematical modelling, and attempts to demonstrate how an increasingly accurate mathematical model can be created through the addition and modification of algorithms. The activity sheets allow students to access source code and through making alterations create a more realistic model.

**Other files**

We also have uploaded a set of materials which help students aged 14-19 explore the models:

- An activity pack
- A file containing images of the board game we constructed and a set of instructions on how to play the game

**How the program works**

The program charts the spread of the disease from one selected tree (coloured red on the map). A random number is generated (from 1-6 to emulate the roll of a die). Depending on the outcome, a radius of infection is chosen, for instance, if a '1' is generated, then the radius of infection is 1.9m, a '2' creates a radius of 2.4m and a '3' creates a 1.5m radius.

The program iterates through the list of infected trees and tests whether a healthy tree is in the infection radius using the following equation:

$$d = \sqrt{(x_p - x_c)^2 + (y_p - y_c)^2}$$

Where 'd' is diameter of the circle, x and y (p) are the coordinates of the healthy tree and x and y (c) are the coordinates of the infected tree.

Now take 'r' to be the radius of the circle. If d <= (smaller than or equal to) r, then d is within the radius of the circle, or on the edge of the circle, and therefore the healthy tree can be infected and changes from green to red.

If a '4', '5' or '6' are rolled then another random number (from 1 to 6) is generated. If this second number is equal to 2 then a random healthy tree, anywhere on the map, is infected. This is to model the arrival of additional insects from elsewhere.

The second model has been altered to make 10% of healthy trees immune. Or rather, upon start-up, each healthy tree has a 10% chance of becoming immune. We achieved this by iterating through the list of healthy trees, and generating a random number between 1 and 10 for each tree. If this number is a 3, then that healthy tree then becomes immune and is ignored by the disease.

The third program utilises a file, which plots the line of the path through the map. To infect healthy trees, the program iterates through the list of the path's points and checks whether a healthy tree can be infected by one of these points, using the same equation as used before with the infected trees, but within a set circle radius of 2m. If a path point can infect healthy trees, it does so, infecting all healthy trees within its circle of infection. Then the infection can spread from these infected trees, in the usual way.

The fourth program is an amalgamation of the two previous programs and shows the effects of natural immunity and human footfall working in combination.

**Requirements for running the models**

The program has been created in Python so that the source code is fully accessible to the general public. The program downloads each contain a mini-version of Python so that those without Python installed on their computers can run the models. The program can be run from the .exe file on Windows and from the source code on Linux and Mac.

**Requirements for making changes to the code**

However, to access and make changes to the code, users must have installed Python 3 on their computer and made Python part of their PATH.

They must also have installed:

- Matplotlib
- Numpy

using pip in Python e.g. by typing 'pip install matplotlib' in terminal/cmd/command line.

**Installation for windows**

Click on the download button on the 'Imaginary' website and extract the files from their zip.

Locate the file called 'main.exe' (which is in the 'dist\main' folder) and run this file.


**Accessing the source code and path coordinates**

The source code (for use with the activity pack) is found in 'main.py' (in the folder 'src')

The path coordinates (for use with the activity pack) is found in 'path.txt' (in the folder 'src')


**Future development**

We hope that users of this software will develop and refine our model. The Mathematics of Planet Earth department of the CDT at Imperial have kindly agreed to fund a refined visualisation of our software – since we do not have the technical ability to do this ourselves at the moment. We would also like all four versions of the program to be available in one download, but at the moment this file is too large to upload to the 'Imaginary' website.