# How to run the urban tree model

Paper:

Webb CR, Avramidis E, Castle MD, Stutt ROH, Gilligan CA. 2023. Modelling the spread of tree pests and pathogens in urban forests.

Contents

[How to run the urban tree model 1](#_Toc137811380)

[Disclaimer 2](#_Toc137811381)

[Software requirements 2](#_Toc137811382)

[Background 2](#_Toc137811383)

[Converting tree data for use in model (using QGIS) 3](#_Toc137811384)

[Creating landscapes (simplified from paper as assumes only NTM® data available) 4](#_Toc137811385)

[Step 1: Selecting trees from all trees recorded with unknown species to assign as some species X 4](#_Toc137811386)

[Step 2: Extract the road data that covers area of tree map and convert shape file to text file 4](#_Toc137811387)

[Step 3: Rasterise host landscape for use in model 5](#_Toc137811388)

[Plotting the synthetic landscapes (optional step) 5](#_Toc137811389)

[Running the disease spread model 5](#_Toc137811390)

[Optional: Choose a start location for infestation 5](#_Toc137811391)

[Plots 6](#_Toc137811392)

## Disclaimer

The code is made available for readers of the above paper to enable experienced users of Matlab to run the model code. The instructions and code may not be compatible with future version of QGIS or MATLAB® or cloud versions of the products. There may be some formatting differences between operating systems resulting in some path errors for non-Windows users. The instructions are not intended to be a complete walk through of all aspects of the code merely to provide an example run from which you can explore the code further.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR

IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,

FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE

AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER

LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM,

OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE

SOFTWARE.

## Software requirements

* QGIS (for data processing). These instructions are written for QGIS version 3.30.3-'s-Hertogenbosch.
* MATLAB® core installation + STATISTICS AND MACHINE LEARNING TOOLBOX
* Mapping toolbox for MATLAB® found at <https://www.eoas.ubc.ca/~rich/mapug.html>
* For plotting results: MATLAB® File Exchange colormap toolbox: <https://github.com/DrosteEffect/BrewerMap>
* For plotting results: MATLAB® File Exchange toolbox [.xyz file functions - File Exchange - MATLAB Central (mathworks.com)](https://uk.mathworks.com/matlabcentral/fileexchange/56414-xyz-file-functions?s_tid=ta_fx_results)

## Background

A detailed description of the model and example output is provided in Webb et al 2023. The model code is written in MATLAB®. The National Tree MapTM data used in the paper were supplied under licence by Bluesky International Ltd. However, a sample dataset is available from National Tree MapTM: <https://bluesky-world.com/downloads/samples/#national> which we use here to illustrate the process of converting raw data into a raster for use in the model. We also provide two example synthetic datasets for exploration of pest and pathogen dynamics which allow the user to compare random and clustered dynamics. These instructions assume some basic knowledge of coding in MATLAB® and interactive use of QGIS.

## Converting tree data for use in model (using QGIS)

Note: there are many ways you could do this but here we take you through the process we used.

1. Download sample dataset from the National Tree Map website: <https://bluesky-world.com/downloads/samples/#national>
2. Download open roads data from <https://beta.ordnancesurvey.co.uk/products/os-open-roads#get> as an ESRI® shapefile
3. You only need the open road shape files for the National Grid Square SK for the sample tree data.
4. Open QGIS
5. Start a blank project: go to the menu ‘Project’ and choose ‘New’
6. In the QGIS Browser navigate to location you have stored the ntm downloaded sample dataset (if this is slow on your machine you can also drag files across from Explorer).
7. Drag SK5639\_NTM\_Points.shp to the New Empty Project window
8. Right click on SK5639\_NTM\_Points in the **Layers browser window** and select Layer CRS>Set Layer CRS
   1. In the pop-up **filter** for **3857** and select “WGS 84/Pseudo-Mercator EPSG: 3857” then press **OK**
   2. Right click on layer again and select zoom to layer
9. Right click on SK5639\_NTM\_Points in Layers browser and select Layer CRS> Set Project From CRS Layer
10. Drag SK\_RoadLink.shp to the same project, accept default transformation and ignore any warnings
11. Right click on SK\_RoadLink in the **Layers browser window** and select Layer CRS>Set to ESPG: 3857
12. From main tool bar select Vector > Geoprocessing Tools > Buffer ..
    1. Set **Input layer** to SK\_Roadlink (it should default to this without you needing to do anything)
    2. Set **Distance** to desired buffer distance from road centre to count a tree as a road tree e.g. 20
    3. Press **Run** and when complete **Close** Buffer tool window
13. In layers panel drag **Buffered** layer to bottom of list and you should be able to see which trees are in road buffer zone
14. To assign trees as park or road select the difference tool: **Vector>Geoprocessing Tools > Difference ..**
15. In popup menu
    1. set **Input layer:** SK5639\_NTM\_Points []
    2. set **Overlay layer:** Buffered
    3. Press **Run** then **Close**
16. In the **Layers Browser Window** rename **Difference** as **NTM\_ParkTrees**
    1. Right click on the NTM\_ParkTrees layer and select Export>SaveFeaturesAs>
    2. Select ESRI shape file from the Format pull down menu and save to UrbanEpidemicModel2023>dataPrepare>shapeFiles>ntm>NTM\_ParkTrees.shp
17. Next we split the two tree data sets using **Vector>Geoprocessing Tools > Difference ..**
    1. **Input layer:** SK5639\_NTM\_Points
    2. **OverlayLayer:** NTM\_ParkTrees
    3. Press **Run**
18. In the **Layers Browser Window** rename **Difference** as **NTM\_RoadTrees**
    1. Right click on the NTM\_RoadTrees layer and select Export>SaveFeaturesAs>
    2. Select ESRI shape file and save to UrbanEpidemicModel2023>dataPrepare>shapeFiles>ntm>NTM\_RoadTrees.shp

## Creating landscapes (simplified from paper as assumes only NTM® data available)

This part of the instructions require MATLAB ([MATLAB - MathWorks](https://uk.mathworks.com/products/matlab.html)) with the **Statistics and Machine Learning Toolbox**.

Before you proceed YOU WILL ALSO NEED TO DOWNLOAD THE FREE MAPPING TOOL BOX FROM [M\_Map Users Guide (ubc.ca)](https://www.eoas.ubc.ca/~rich/mapug.html) – follow their instructions to install and make sure to add a link to where you have stored it on your computer to the file path using the inbuilt **addpath** function in each file as instructed below.

### Step 1: Selecting trees from all trees recorded with unknown species to assign as some species X

1. Open YourFilePath/UrbanEpidemicModel2023/dataPrepare/**callGenerateSyntheticDatasets2023.m** in MATLAB®
2. Edit **callGenerateSyntheticDatasets2023.m**
   1. Update string on right hand side of the assignment **TopPath** to YourFilePath e.g. TopPath = 'C:/Me/UrbanEpidemicModel2023 '
   2. Update string on right hand side of the assignment **MyFileExchangeFiles\_m\_Map** to the location you have downloaded m\_map.
   3. In this file you can edit the proportion of roadside and park trees that are estimated to be of the species of interest
   4. You can also edit the number of datasets generated.
3. Run **callGenerateSyntheticDatasets2023.m** you will see plots of the generated tree locations and six new text files and a .mat file should be generated for each run of the model in dataPrepare>SyntheticDatasets>UnknownRandom> and dataPrepare>SyntheticDatasets>UnknownMaternPoisson>

*Note: if you want to change the parameters used for the Matern poisson you can edit the assignUnknownMaternPoisson file: open the file and find the section “Assign trees as host species: EDIT MATERN POISSON PARAMETERS HERE”*

### Step 2: Extract the road data that covers area of tree map and convert shape file to text file

1. Open YourFilePath/UrbanEpidemicModel2023/dataPrepare/src\_mat/**genRoadFromShp2023.m** in MATLAB®
2. Edit **genRoadFromShp2023.m**
   1. Edit string on right hand side of the assignment **TopPath** to YourFilePath e.g. TopPath = 'C:/Me/UrbanEpidemicModel2023 '
   2. Edit string on right hand side of the assignment **PathToShapeFiles** to YourFilePath e.g. PathToShapeFiles = 'C:/Me/UrbanEpidemicModel2023/MyShapeFiles '
   3. Edit string on right hand side of the assignment **MyFileExchangeFiles\_m\_Map** to the location you have downloaded m\_map.
3. Run the code: this should generate a plot showing roads and synthetic landscape and create a file NTMsample\_OpenRoads.txt

*NOTE: If you have another source of tree data in which you have already filtered out by species of interest you can follow the same process above in QGIS to set road and park trees then use speciesAssigmentType.All to set all trees in shape file to species of interest. You will also need to change the names of the shape files called on lines 11 and 19.*

### Step 3: Rasterise host landscape for use in model

1. Open YourFilePath/UrbanEpidemicModel2023/dataPrepare/**urbanLandscapeGeneration2023.m** in MATLAB®
2. Edit Local path and path to location of **m\_map** so they can be found on your local machine (see previous sections)
3. Optionally edit parameters to control maximum road segment length, cell size (meters) and maximum dispersal distance along roads (note making this too large can slow the code down significantly).
4. Optionally change NumLandscapes and names (depending on whether you generated fewer or more landscapes in previous steps and whether you changed the naming structure)
5. You should now have \*.mat files for each of the Synthetic datasets you generated in the previous steps in the SyntheticLandscape folder.

You now have the landscapes formatted for use in the model.

## Plotting the synthetic landscapes (optional step)

1. Open …/UrbanEpidemicModel2023/dataPrepare/**plotHostLandscapes.mlx**
   1. Edit string on right hand side of the assignment **TopPath** to YourFilePath e.g. TopPath = 'C:/Me/UrbanEpidemicModel2023 '
   2. You may also need to uncomment the mkdir command the first time you run this code to create a folder for the output figures.
   3. Edit line 31 – LandscapeType; line 26: which landscapes reps to call
   4. Grey squares show grid squares in which there are park trees of species X and black dots show the street trees.

# Running the disease spread model

1. Before following this step you need to generate a landscape on which to model disease spread as described in the first part of this document.
2. Open the master file: …/UrbanEpidemicModel/exampleModelCall2023
   1. Edit string on right hand side of the assignment **TopPath** to YourFilePath e.g. TopPath = 'C:/Me/UrbanEpidemicModel2023 '
3. Try running the code – hopefully if you have created the landscapes successfully and not changed the names of input files, the code should run.
4. Extension: read the code to see where you can change parameter values, landscape choice and number of replicates of the model.

# Optional: Choose a start location for infestation

1. Open …/UrbanEpidemicModel2023/**code\_functions/chooseStartLocation2023.m**
2. Edit TopLevel and Local Path lines as previously
3. Run code: a plot should appear with a cross wire that you can move. Select a location near a tree. The output will output information to the command window including the index of the road and garden patches nearest to where you placed your cross which you can then feed into exampleModelCall2023.m

# Plots

Output files are labelled simOut\_#.mat where the number is the simulation number for repeated simulations with same parameters, initial conditions and landscape. Loading a simOut\_N.mat file into MATLAB® opens a structure always called simout containing 18 fields giving time course data and containing a structure opts which has all the input values.

To analyse any specific output file you will need the urbanLandscape.mat file and the simout.mat file. simout.opts.LandscapeName gives the name of the landscape used to generate the output.

To plot the results of a single simulation you can use …/UrbanEpidemicModel2023/plotting/PlotSpatialTimeCourse.mlx

You will need to change the file paths and download [.xyz file functions - File Exchange - MATLAB Central (mathworks.com)](https://uk.mathworks.com/matlabcentral/fileexchange/56414-xyz-file-functions?s_tid=ta_fx_results) from Matlab file exchange.

Again, you need to change the file path which tells Matlab where to find your files. To plot a specific output, edit the line “SimulationOutputToPlot”.

This example run of the model is on a 1km square. This means that the impact of clustered versus random method to assign trees is less obvious in the output.