

Using a GIS to Identify and Analyze Dutch Elm Disease Hotspots within the City of Portland

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Overview

- Problem Statement
- Dutch Elm Disease
- Part 1: Hotspot Analysis
- Part 2: Proximity Analysis
- Part 3: Environmental Factor Analysis
- Results
- Conclusions

Are there hotspots of Dutch Elm Disease (DED) in the City of Portland and what spatial factors may contribute to this pattern?

What is Dutch Elm Disease?

- Discovered in the U.S. in 1930
- Fungus
 - *Ophiostoma ulmi* (syn. *Ceratocystis ulmi*)



www.apsnet.org/online/archive/1-9.htm

Scolytus multistriatus (Marsham) Elm Bark Beetle



<http://entomology.lsu.edu/lsam/scolytinae/New%20Folder/key/Scolytinae%20of%20Louisiana/Media/Html/Scolytusmultistriatus.html>

- Two Vectors of DED
 - Elm Bark Beetle
 - Root Grafting

Symptoms

Dutch Elm Disease



http://www.tulsamastergardeners.org/plant_pathology/images/dutchelm.jpg

Elms Close to Home



■ <http://web.pdx.edu/~nac/pdxdirtycheap/images/swparkmain.jpg>



http://content.answers.com/main/content/wp/en/thumb/0/0c/250px-IMG_2653vi.jpg



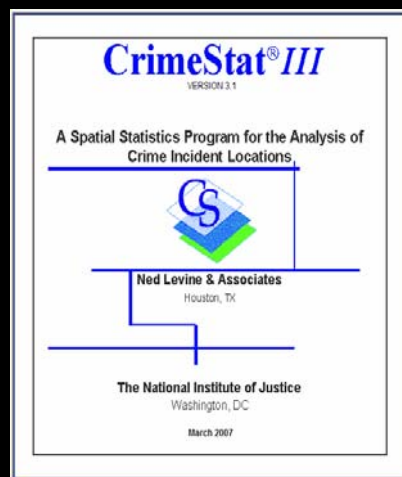
Data Sources

- Elms in the City of Portland (Urban Forestry)
 - American Elms
 - American Elms Removed due to DED
 - Siberian Elms
- Other Data Layers
 - 10 m DEM (USGS)
 - Stream Lines (RLIS)
 - Parks (RLIS)
 - Major Arterials (RLIS)
 - Neighborhoods (RLIS)

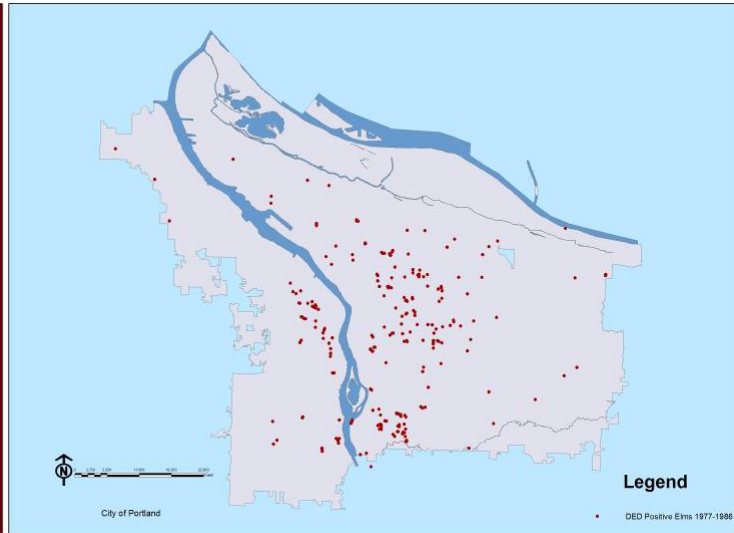
Part 1: Hot Spot Analysis

Hot Spot Analysis

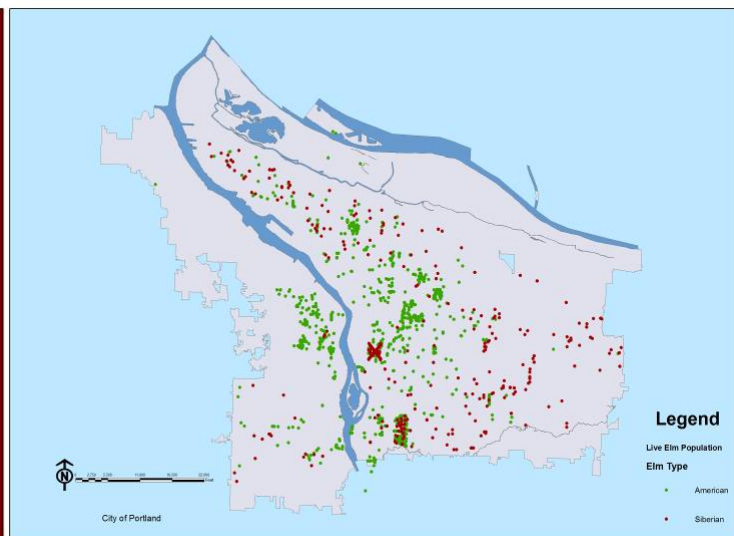
- Crime Stat
- Detecting hot spots of DED within the City of Portland



DED Occurrences



Live Elm Population



Data Setup

- Primary File
 - Input data
 - Coordinates
 - Data units
 - Time units

CrimeStat III

Data setup | Spatial description | Spatial modeling | Crime travel demand | Options

Primary File | Secondary File | Reference File | Measurement Parameters

Primary File: <None> [Select Files] [Edit] [Remove]

Variables:

Name	File	Column	Missing values
X	Z:\Zoe\ElmTree_DEDfinal.dbf	POINT_X	<Blank>
Y	Z:\Zoe\ElmTree_DEDfinal.dbf	POINT_Y	<Blank>
Z (Intensity)	<None>	<None>	<Blank>
Weight	<None>	<None>	<Blank>
Time	Z:\Zoe\ElmTree_DEDfinal.dbf	Yr_Prim	<Blank>
Directional	<None>	<None>	<Blank>
Distance	<None>	<None>	<Blank>

Type of coordinate system:

☐ Longitude, latitude (spherical)

☒ Projected (Euclidean)

☐ Directions (angles)

Data units:

☐ Decimal Degrees

☒ Feet

☐ Meters

☐ Miles

☐ Kilometers

☐ Nautical miles

Time Unit:

☐ Hours

☐ Days

☐ Weeks

☐ Months

☐ Years

[Compute] [Quit] [Help]

Data Setup

- Reference File
 - Create Grid

CrimeStat III

Data setup | Spatial description | Spatial modeling | Crime travel demand | Options

Primary File | Secondary File | Reference File | Measurement Parameters

External File: [Select File] Grid cells: 0

Create Grid:

Grid area:

	X	Y
Lower Left	6747.014246	8523.332118
Upper Right	10781.320975	2243.691348

Cell specification:

☐ By cell spacing (in same units as data units)

☒ By number of columns: 100

Reference origin:

Use a reference origin to convert X/Y data into angular data

☒ Use lower-left corner as origin

☐ Use upper-right corner as origin

☐ Use a different point as origin

X: 0

Y: 0

[Compute] [Quit] [Help]

Data Setup

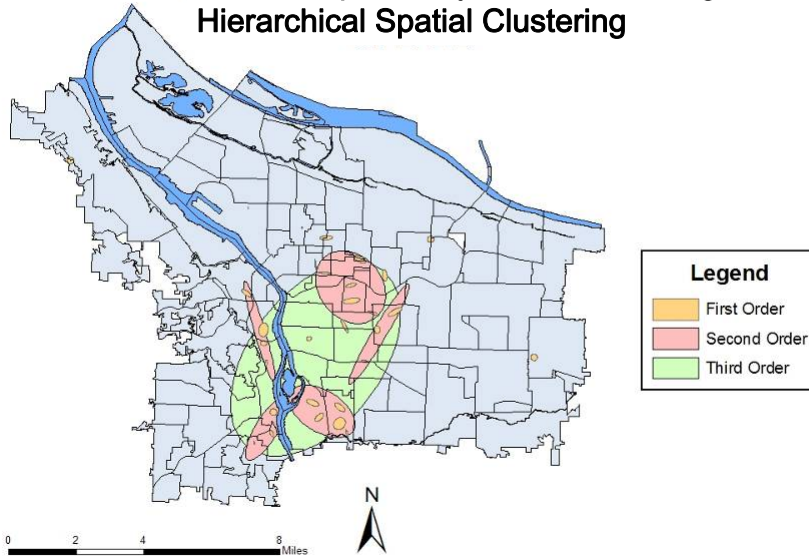
- Measurement Parameters
 - Define Coverage

The screenshot shows the 'Data setup' tab of the CrimeStat III software. The 'Coverage' section includes a text box for 'Area' containing '140920767.1001' and a dropdown menu set to 'Square feet'. Below it, 'Length of street network' is set to '0' with a dropdown menu set to 'Miles'. The 'Type of distance measurement' section has three radio buttons: 'Direct' (selected), 'Indirect (Manhattan)', and 'Network Distance'. A 'Network Parameters' button is next to the 'Network Distance' option. At the bottom are 'Compute', 'Quit', and 'Help' buttons.

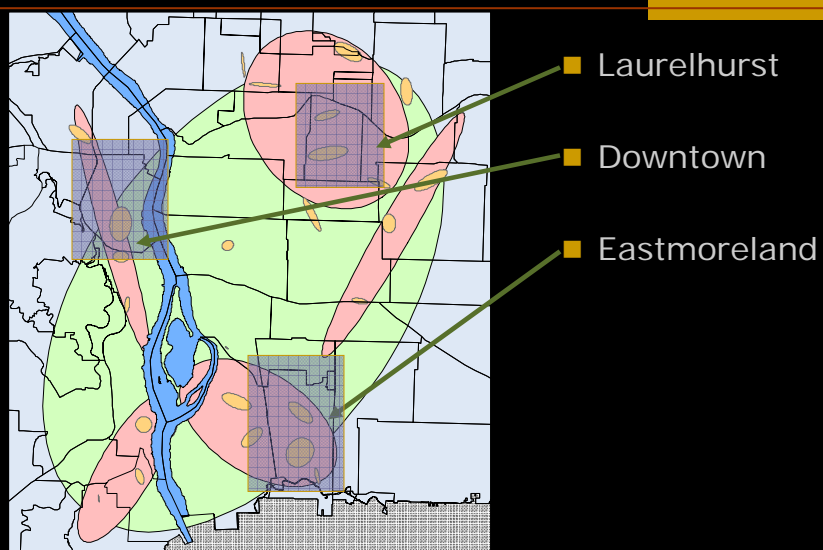
Spatial Description

The screenshot shows the 'Spatial description' tab of the CrimeStat III software. It features several sub-tabs: 'Spatial Distribution', 'Distance Analysis I', 'Distance Analysis II', 'Hot Spot Analysis I', and 'Hot Spot Analysis II'. The 'Mode' section has checkboxes for 'Mode' and 'Fuzzy Mode (F-Mode)'. The 'Radius' is set to '0' with a 'Miles' dropdown. The 'Nearest Neighbor Hierarchical Spatial Clustering (Nnh)' checkbox is checked. Below it, 'Risk-adjusted (Rnnh)' is unchecked, with a 'Risk Parameters' button. The 'Type of search radius' section has radio buttons for 'Random NN distance' (selected, with a note 'must be consistent with area on measurement parameters tab') and 'Fixed distance'. A 'Search radius' slider is shown with 'Smaller' and 'Larger' labels. The 'Minimum points per cluster' is set to '5' and the 'Output unit' is 'Feet'. The 'Number of standard deviations for the ellipses' has a slider with '1X', '1.5X', and '2X' markers. The 'Simulation runs' is set to '1'. On the right, there are buttons for 'Save result to...', 'Save result to...', 'Save result to...', 'Save ellipses to...', and 'Save convex hulls to...'. At the bottom are 'Compute', 'Quit', and 'Help' buttons.

DED Hotspot Analysis: Nearest Neighbor Hierarchical Spatial Clustering

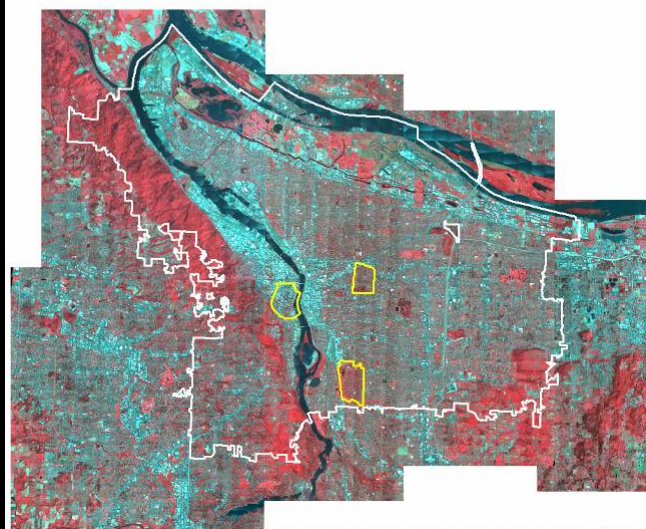


High Risk Neighborhoods



Part 2: Proximity Analysis

Neighborhood Analysis of Hot Spots



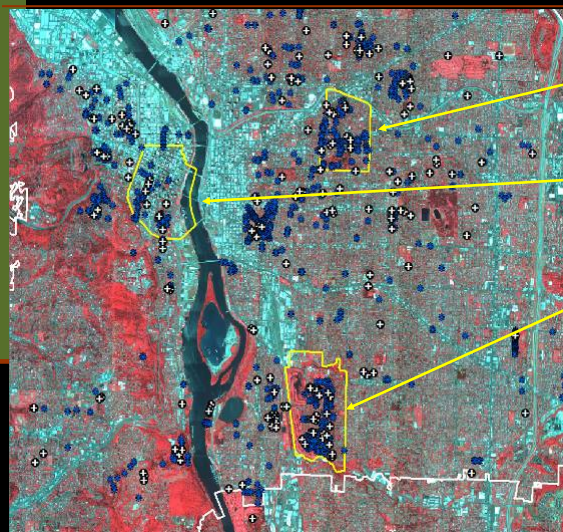
Vectors for Disseminating DED Fungus



- Root Grafting
- Siberian Elms
- Elm Bark Beetle



DED/American Elm Spatial Relationships throughout Portland



- Laurelhurst
- Downtown
- Eastmorland

DED in the Downtown Neighborhood



- Elms within 50 ft of one another tend to root graft
- Root grafting is a vector for transmitting the DED Virus
- Null Hypothesis: Am Elms within 50 ft of a DED tree should also contract DED

50 foot American Elm Buffer



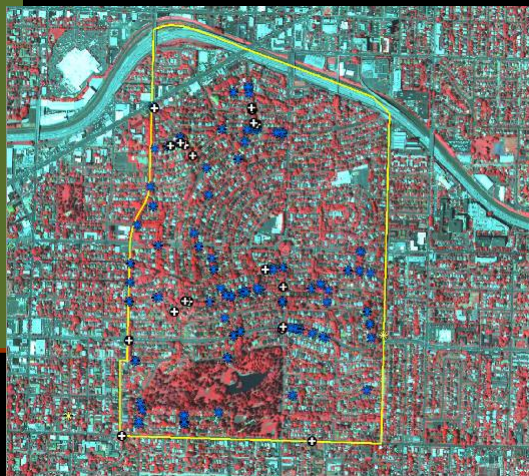
- American Elms clipped to Downtown boundary (blue)
- Am Elms buffered at 50 ft
- Only those buffers that overlap are selected (yellow)

DED within 50 ft of another American Elm



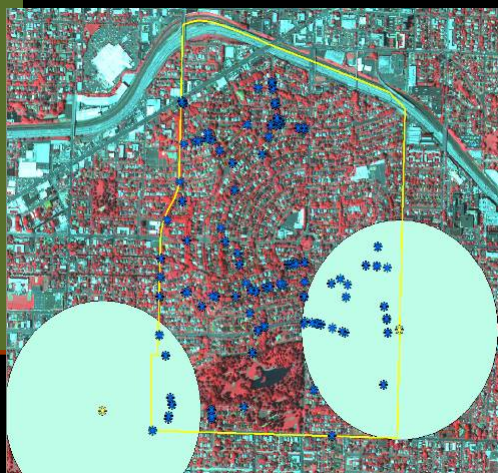
- 364 Am Elms in Downtown
- Only 64 are recorded with DED (18%)
- Out of 64 buffered Am Elms, only 3 showed DED (5%)

DED in the Laurelhurst Neighborhood



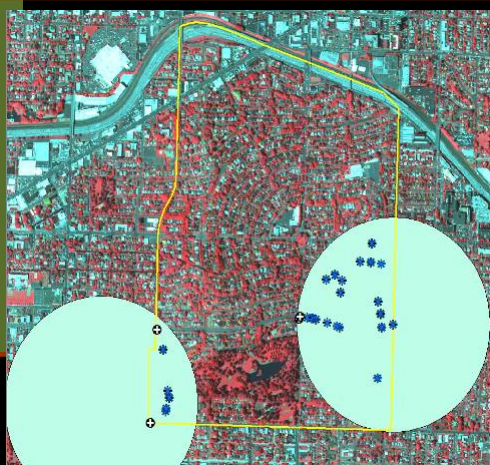
- Siberian Elm is resistant to DED, but may be a host
- Elm Beetle can effectively travel 1500 ft
- Null Hypothesis: Am Elms within 1500 ft of a Siberian Elm should have DED

1500 ft Siberian Elm Buffer



- Am and Sib Elms clipped to Laurelhurst
- Siberian Elms (yellow) buffered at 1500 ft
- American elms clipped to 1500 ft buffer

DED within 1500 ft of Siberian Elms (host)



- 267 Am elms in Laurelhurst
- 77 Am elms within 1500 ft of a Siberian elm (29%)
- 7 of those Am elms have DED (9%)

Possible Relationships

- Is there a relationship between tree proximity (density) and the prevalence of DED?
- Do Siberian Elms serve as a host for the DED beetle and therefore propagate the disease?
- Does root grafting influence the spread of DED?

T-test

T-test is used to determine whether two samples are likely to have come from the same two underlying populations that have the same mean.

1500 ft Buffer Test	AmElms	DED			
Laurelhurst	77	7	267	28	
Eastmorland	368	40	368	40	
Downtown	209	5	364	14	
Laurelhurst	0.288389513	0.25			
Eastmorland	1	1			
Downtown	0.574175824	0.357142857			
T-test (percentage)					
0.798696189					

50 ft Buffer Test	AmElms	DED			
Laurelhurst	61	18	267	28	
Eastmorland	258	26	368	40	
Downtown	64	3	364	14	
Laurelhurst	0.228464419	0.642857143			
Eastmorland	0.720570391	0.65			
Downtown	0.175824176	0.214285714			
T-test (percentage)					
0.602322403					

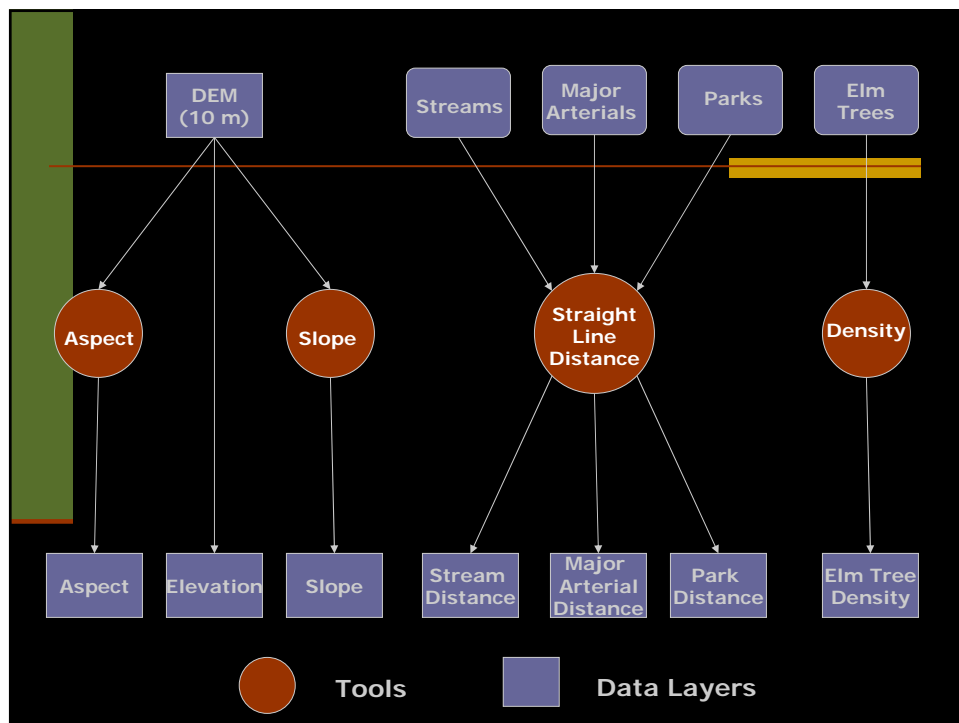
Part 3: Landscape Factors

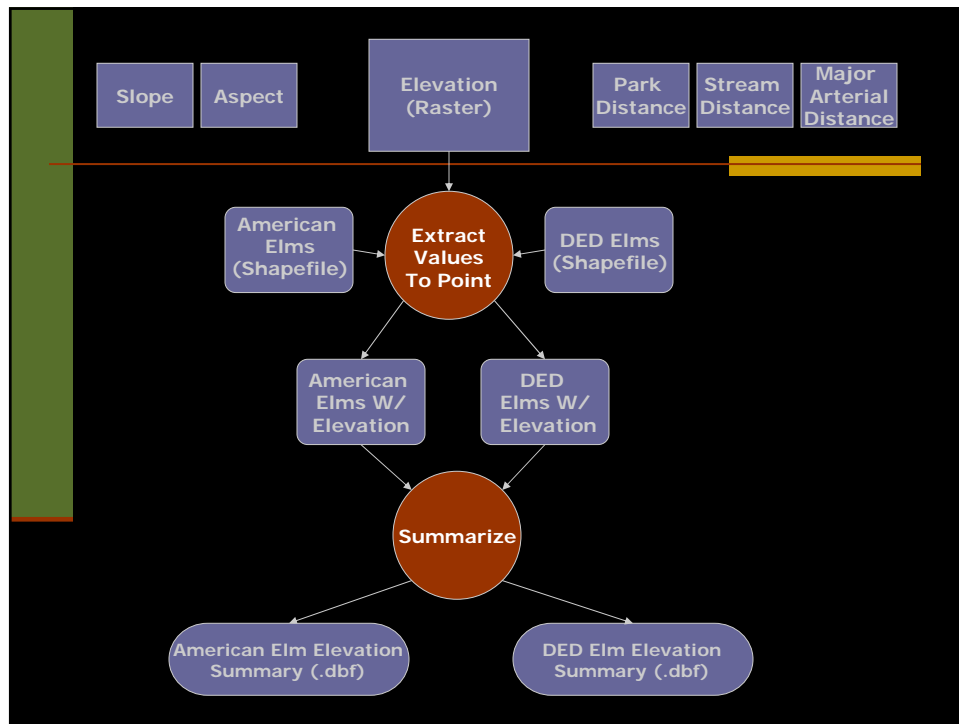
Landscape Influences

- The spread of pathogens and the expression of disease are influenced by landscape features
 - Susceptibility of trees (i.e. multiple stressors)
 - Vector distribution and abundance
 - Pathogen virulence
 - Management
- Landscape features can have a synergistic (+/-) influence on the spread and expression of a disease
- A GIS can be used to map the relative risk of infection for different locations based on an array of landscape features

DED: Landscape Factors

- We examine the influence of:
 - Elevation
 - Slope
 - Aspect
 - Distance to streams
 - Distance to parks
 - Distance to major arterials
- To map the relative risk of DED infection of American Elms in the City of Portland
- If the map of risk of DED infection can predict existing “hotspots” of DED infection, it could be useful to pinpoint other susceptible areas



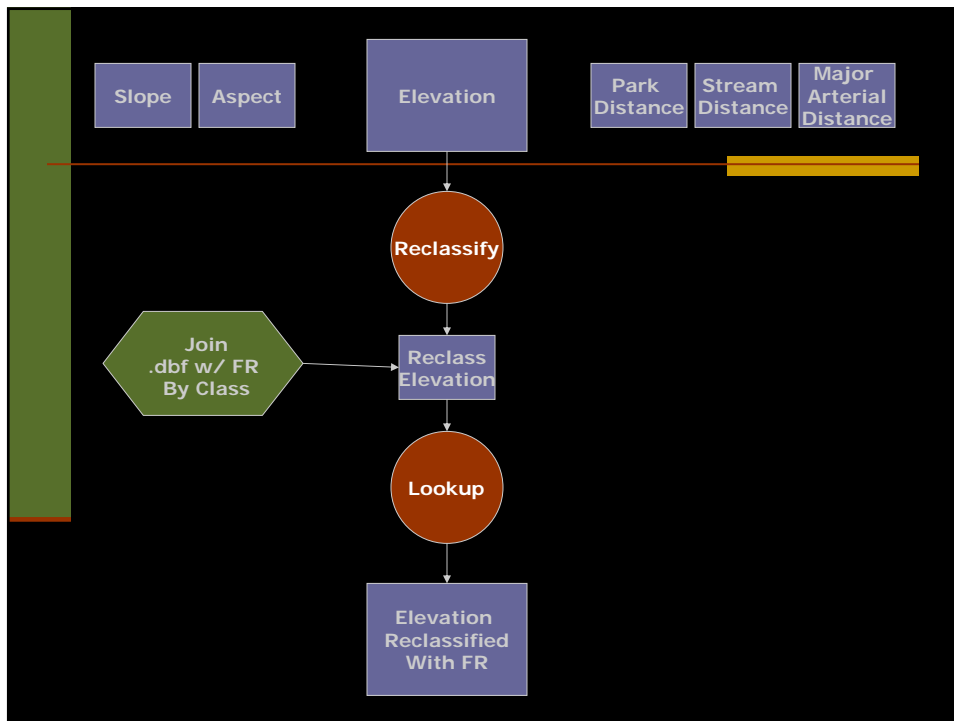
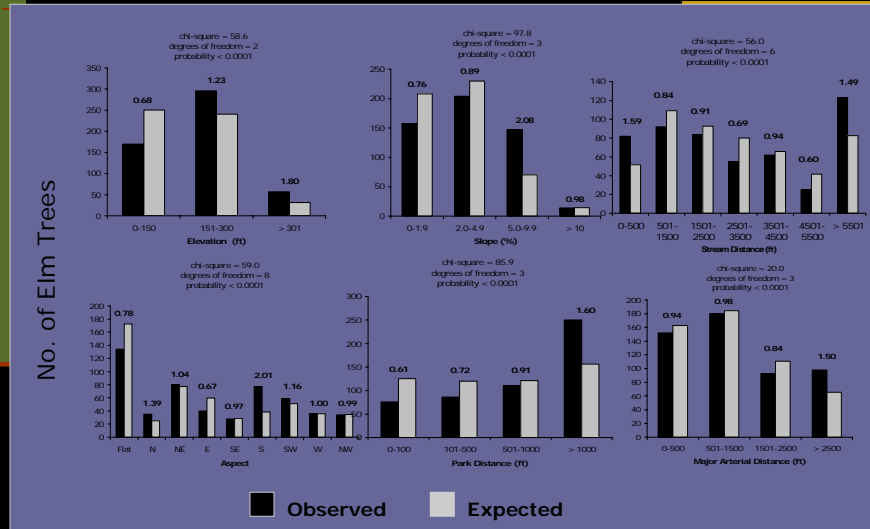


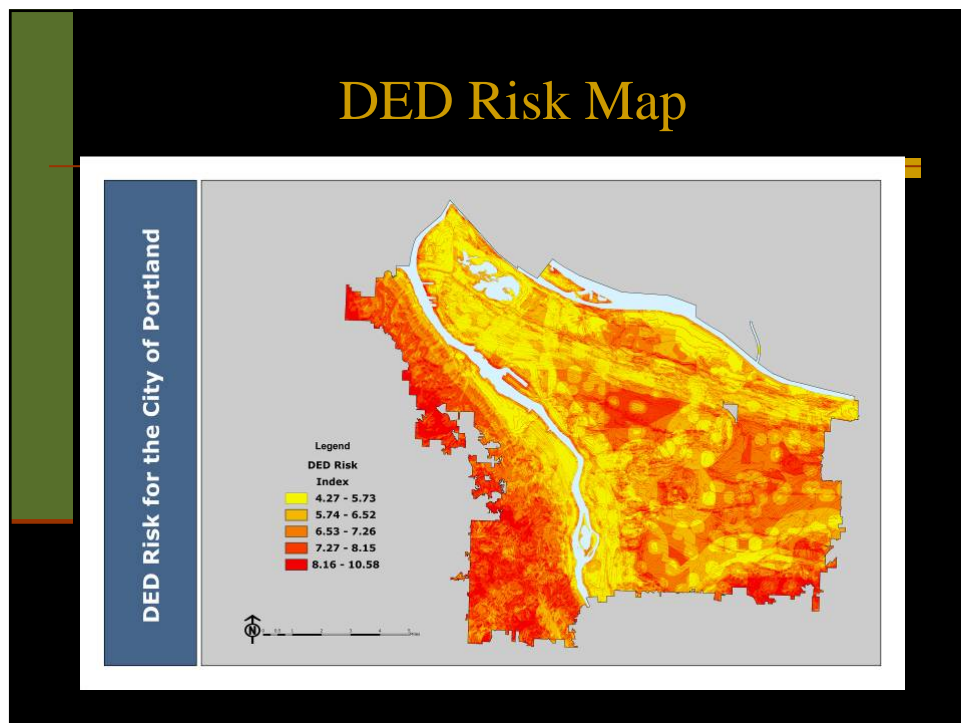
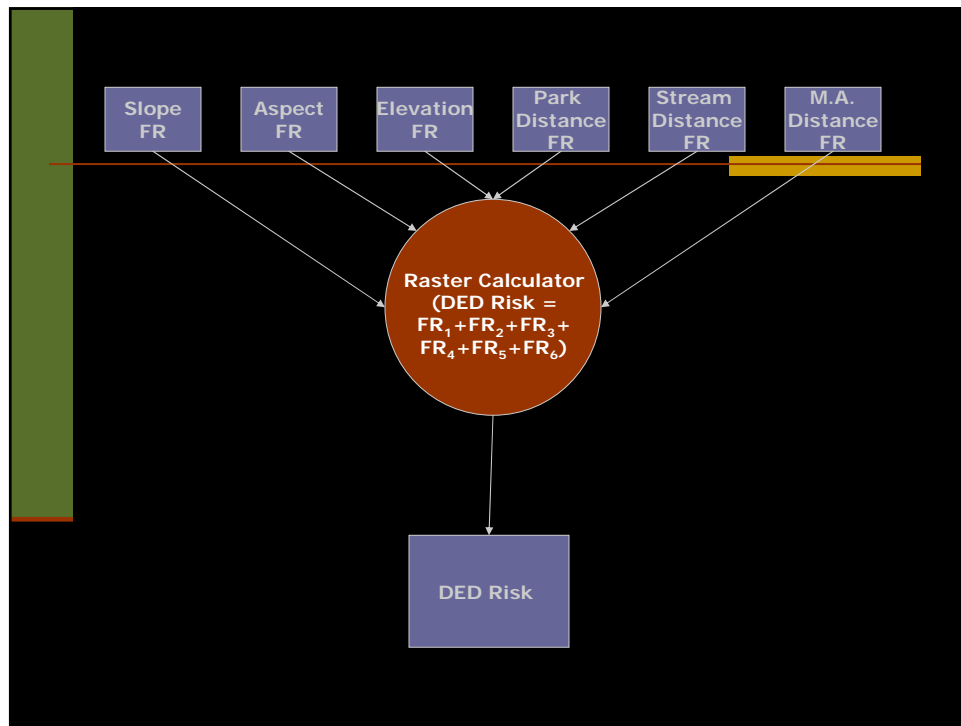
Frequency Ratio

- Landslide hazard mapping (Lee and Pradhan 2007)
- Compare distribution of observed to expected assuming random process (Chi-Square Test)
- Frequency ratios (FR) can be summed to calculate relative risk of DED infection
- Method has weaknesses but has the advantage of being simple

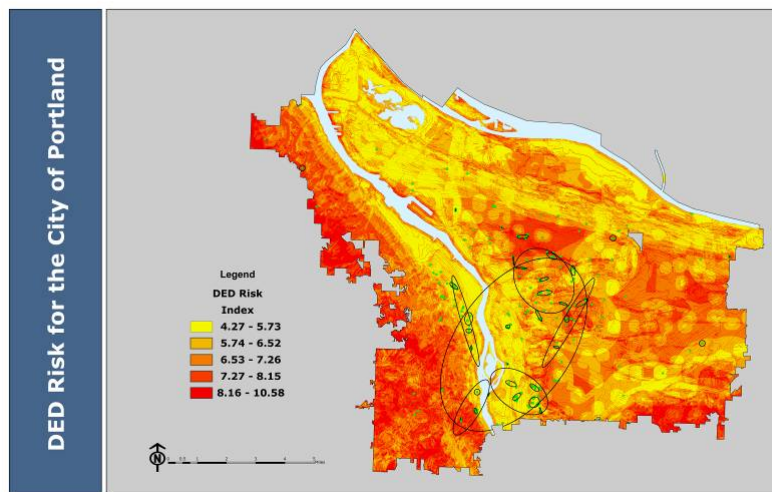
Elevation	# of Am. Elm Trees	% of Am. Elm Trees	Expected * Sum (Obs DED) [%]	Observed	FR Obs/Exp
0-150	1580	0.48	250.56	170	0.68
151-300	1518	0.46	240.73	296	1.23
> 301	200	0.06	31.72	57	1.80

DED: Landscape Factor Distribution





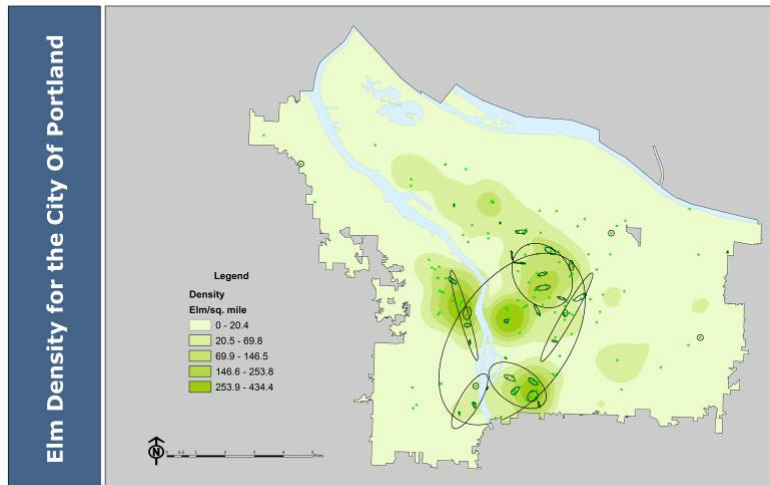
DED Risk Map



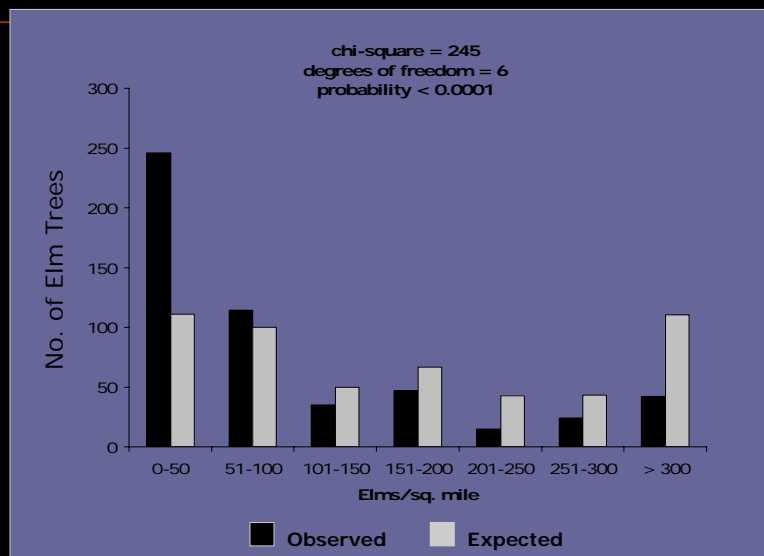
Results

- Hotspots of DED are found in the City of Portland
- Spatial proximity of Elms does not appear to effect the incidence of DED (reject null hypotheses)
 - Root Grafting of American Elms
 - Siberian Elms as hosts
- Analyzed Landscape factors are not an accurate predictor of DED hotspots
- But....

Elm Tree Density



DED Incidence and Density



Conclusions

- Ornamental population versus natural population
- High DED risk areas appear to be in areas with lower density of elm trees
 - Susceptibility of trees (i.e. multiple stressors)
 - Vector distribution and abundance
 - Pathogen virulence
 - Management
- Management can impact spread of disease which might explain some of the observed patterns

Recommendations

References

- http://en.wikipedia.org/wiki/Dutch_elm_disease
- <http://www.oznet.ksu.edu/path-ext/factSheets/Trees/Dutch%20Elm%20Disease.asp>
- Jennifer Karps and Urban Forest Division of the City of Portland
- Lee, S. and Pradhan, P. 2007. Landslide hazard mapping at Selangor, Malaysia using frequency ratio and logistic regression models. *Landslides*, 4: 33–41.
- Meentemeyer, R., Rizzo, D., Walter M., Lotz, E. 2004 Mapping the Risk of Establishment and Spread of Sudden Oak Death in California. *Forest Ecology and Management*, 195-214.

Questions?



Special Thanks: Jennifer Karps and Steph Gaspers