A comparative study of street trees in two neighborhoods of Portland

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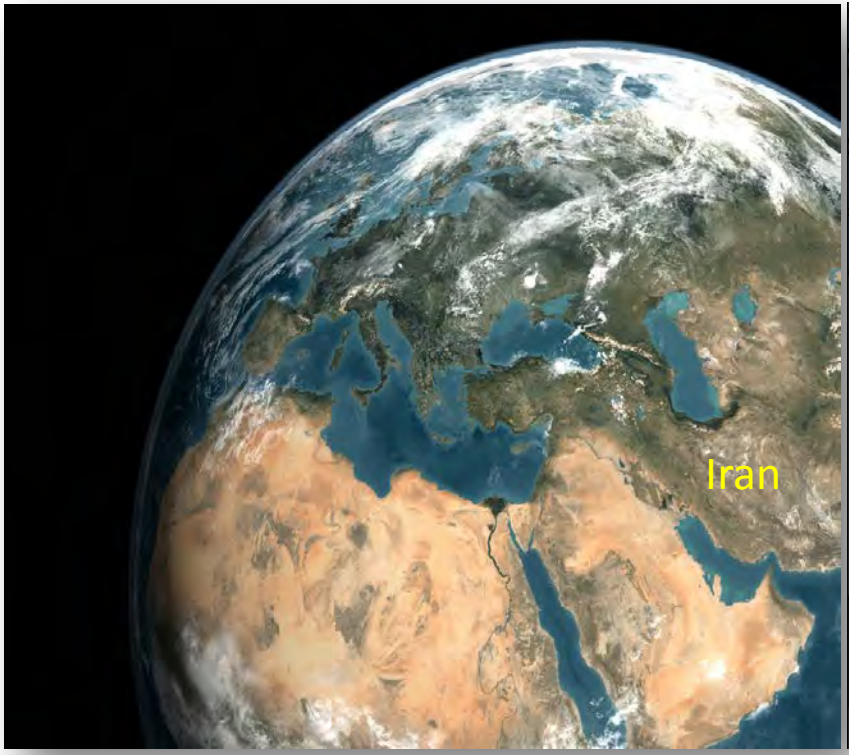
WORLD FORESTRY CENTER

World Forest Institute

	USA	Iran
Population (million)	315	78
Area (Km²)	9,830,000	1,648,000
Forestlands (hectares)	305,000,000	12,000,000
Forest area (% of land area)	33.3	6.8

Middle east



(NASA)

Iran (*Persia*)

Location : South-western Asia (Middle East)
24˚ - 40˚ North Latitude
44˚ - 64˚ East Longitude

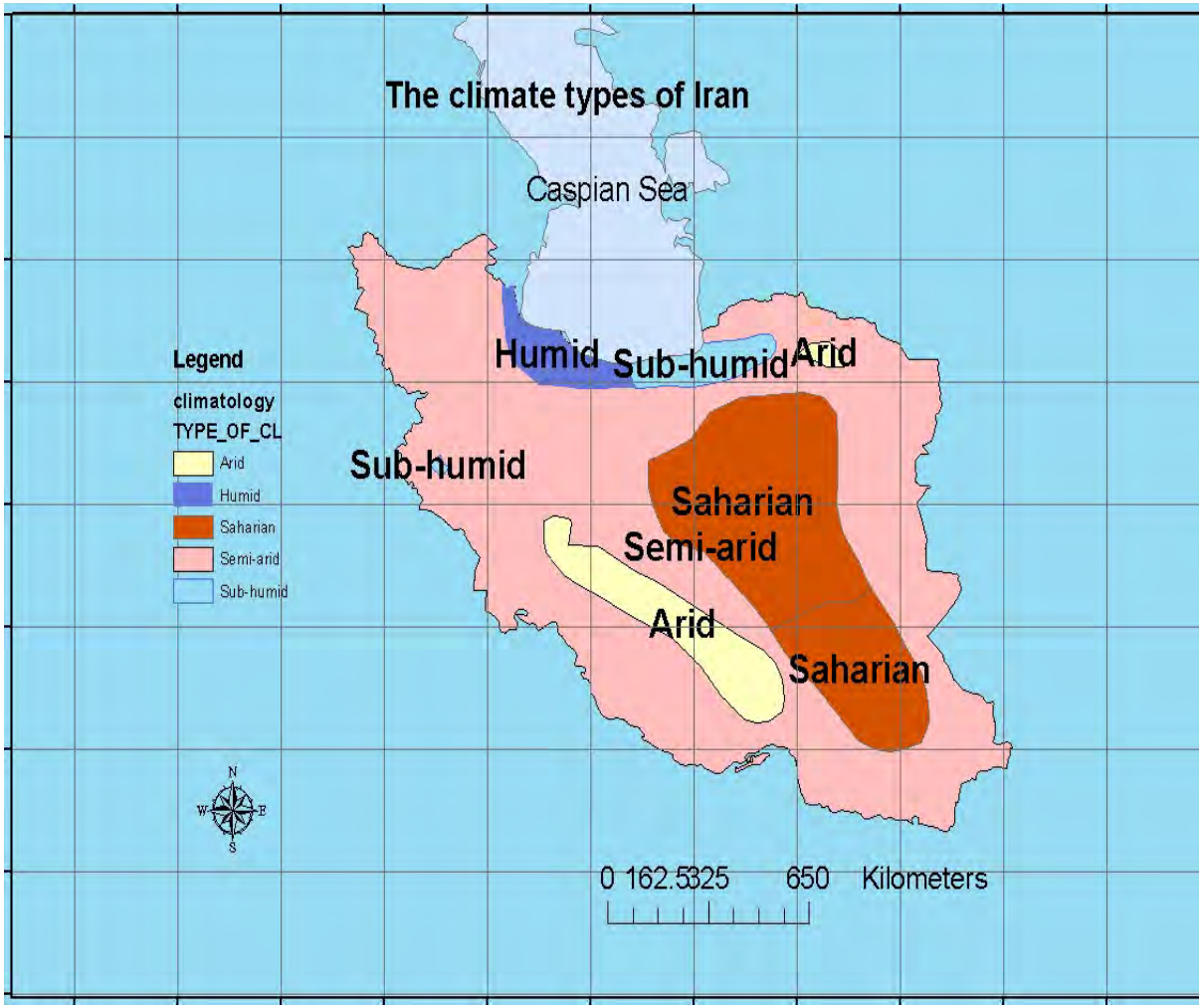
Area : 18th largest country in the world
(1,648,195 km² or 636,372 mi²)
= UK + France +Spain+ Germany or larger than state of Alaska

Population : 78 million
(70% under age of 30- literacy rate is over 85%)

Neighbors: Russia , Turkey , Iraq , afghanistan and pakistan.

Energy : 2nd in the world in natural gas reserves
3rd in the world in oil reserves

Climate



Annual mean precipitation

Humid : 1400 mm (55 inch)

Sub humid : 1000 mm (40 inch)

Semi arid : 400 mm (16 inch)

Saharian : 150 mm (6 inch)

Arid < 100 mm (4 inch)

Annual mean temperature

Humid : 17 ° C (63˚ F)

Sub humid : 20 ° C (68˚ F)

Semi arid : 23° C (73˚ F)

Saharian : 27° C (81˚ F)

Arid > 35° C (95˚ F)

Facts

Total forest area : 12.4 million ha
(30,642,000 acres)
(7.4 % of the total land area)

Total desert area : 34 million ha
(84,016,000 acres)
(20.6 % of the total land area)

Total rangeland area: 90 million ha
(222,395,000 acres)
(54.6 % of the total land area)

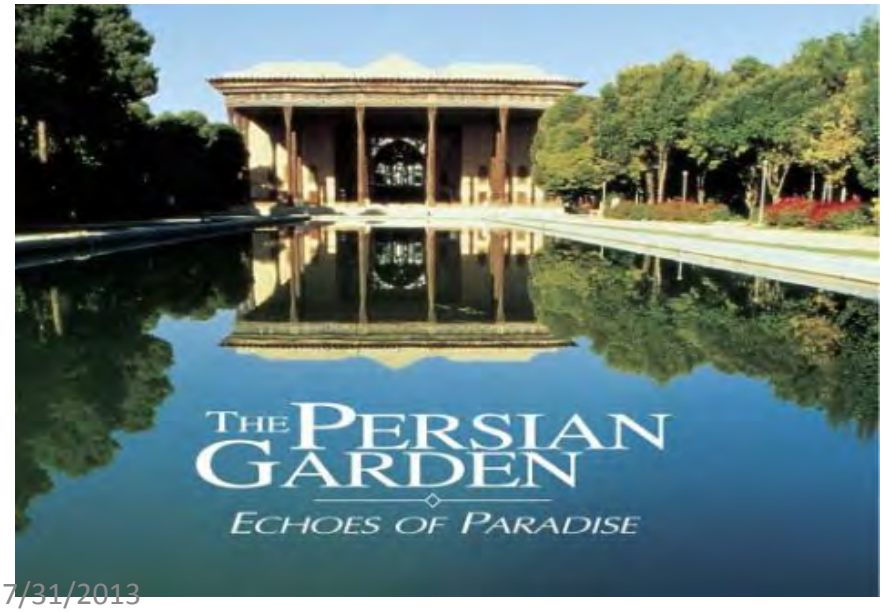
Low Forest Cover Country (LFCC)

Per capita forest area = 0.2 ha (0.5 acre)
(1/3 world average)

Rich biodiversity : 8000 plant species

History of Urban Forestry in ancient Persia

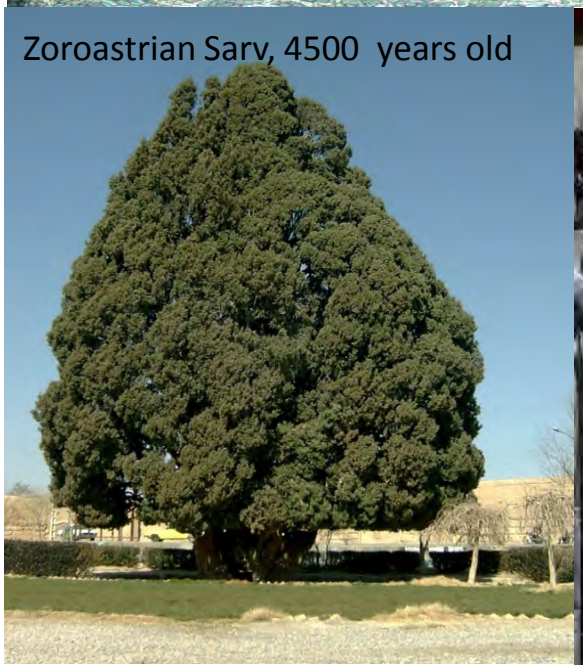
- The concept of phrase “urban forestry” was common among ancient Persians.
- As early as 4000 BC the idea of *earthly paradise* spread through Persian literature.
- Paradise(Persian language: *Pardis*) means urban garden or urban parks (forests).
- Pardis is a place in which existence is positive, harmonious, and timeless.



- Sunlight and water have been the main factors in designing urban parks (Pardis).

- Cypress was a sacred tree in Persia planted and well protected since 6000 years ago.

- The second oldest tree and the oldest cypress tree in the world_ *cypress of Abar-Kuh* or Zoroastrian Sarv is over 4000 years old and it is the oldest living thing in Asia. www.wikipedia.org/wiki/Sarv-e_Abarkuh



History of Urban Forestry in Europe and America

- Urban green spaces (botanical gardens) were cultivated during Middle Ages.
- The term “arborist” was first recorded in 1578.
- In the 1800s, landscape design received more attention with street tree plantation in Avenue des Champs-Elysees.
- In 1700s, New England town squares were converted from pasture to park.


Avenue des Champs-Elysees, Paris


Paris

Urban forest's benefits

- Urban forests in the U.S. contain about 3.8 billion trees with an structural asset value of $2.4 trillion (Nowak *et al., 2002).*
- Climate change- urban trees store 770 million tons of carbon (Nowak, 2002).
- Water flow and quality- urban trees can reduce runoff by 7 percent (Sanders, 1986).
- Noise abatement- planting of tall trees can reduce loudness by 50 % (Cook ,1978).
- Local climate and energy use- urban trees in the US save about $2 billion annually in reduced energy costs (Akbari *et al*. 1988,1992; Donovan, 2009).

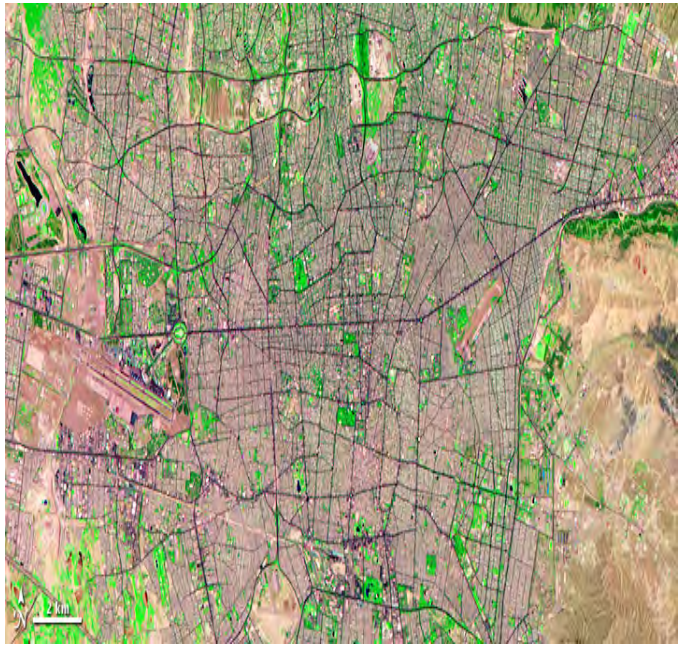
- Air quality-urban trees in the US remove 784,000 tons of air pollution annually , with a value of $3.8 billion (Nowak *et al*., 2006).
- Real state and business- prices for goods purchased in Seattle were 11% higher in landscaped areas (Wolf, 1998).
- Individual well-being and public health- tree shade reduces UV radiation
- Life and death (Donovan, 2011).
- The healing effects of urban forests- strengthen our immune system by increasing natural killer cells that destroy cancer cells (Karjalainen, 2010).

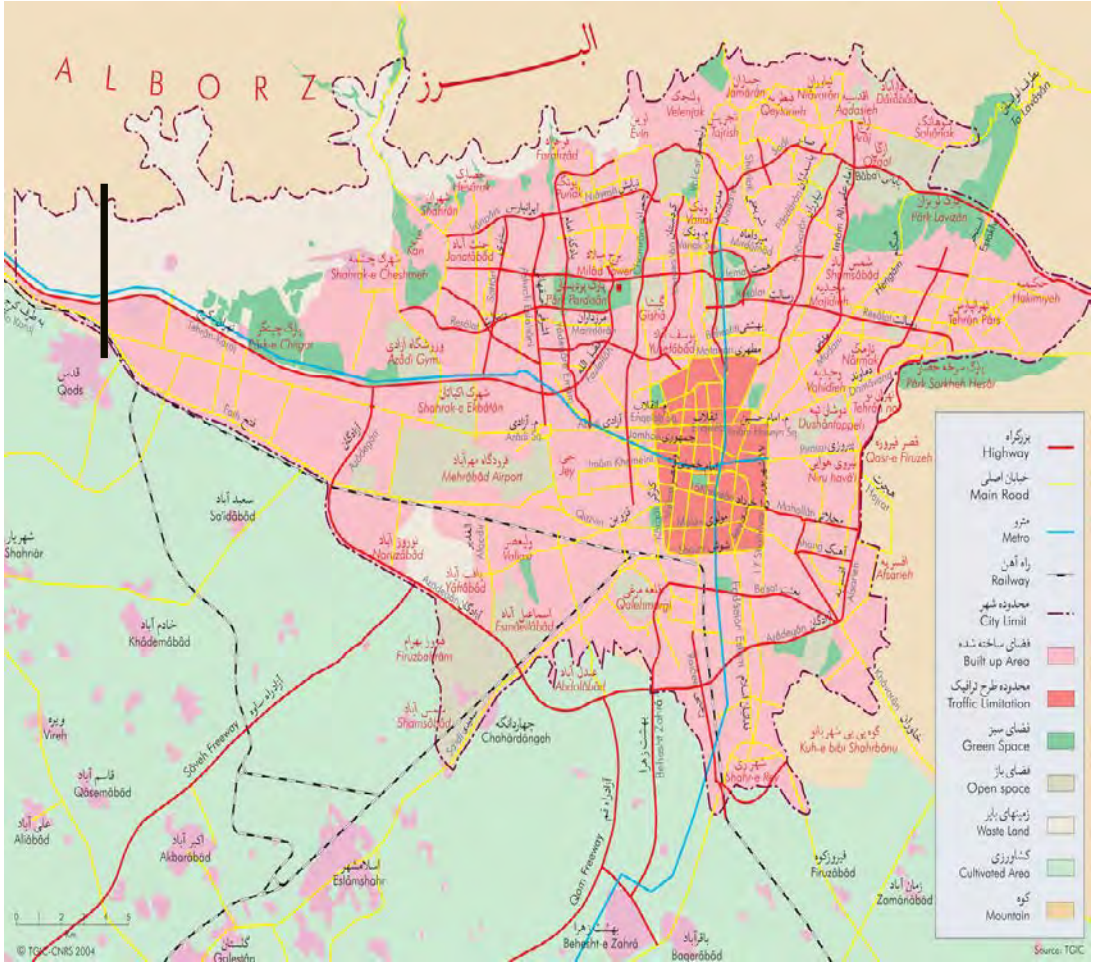
Downtown, Seattle


Seattle

satellite image of Tehran's urban green spaces

- Capital city of Iran
- Area: 686.3 Km²
- Population (2012): 12 million
- Green space: 70 Km² (4.11 %)
- Climate: Semi-arid





Tehran, the city of *Plane trees*

- Tehran is famous for its pomegranate orchards and plane trees (*Platanus orientalis*).
- Urban trees have been a part of Tehranians' life for at least 200 years.
- The modern concept of urban forestry goes back to 45 years ago.
- Tehran municipality have achieved numerous international honors in terms of:

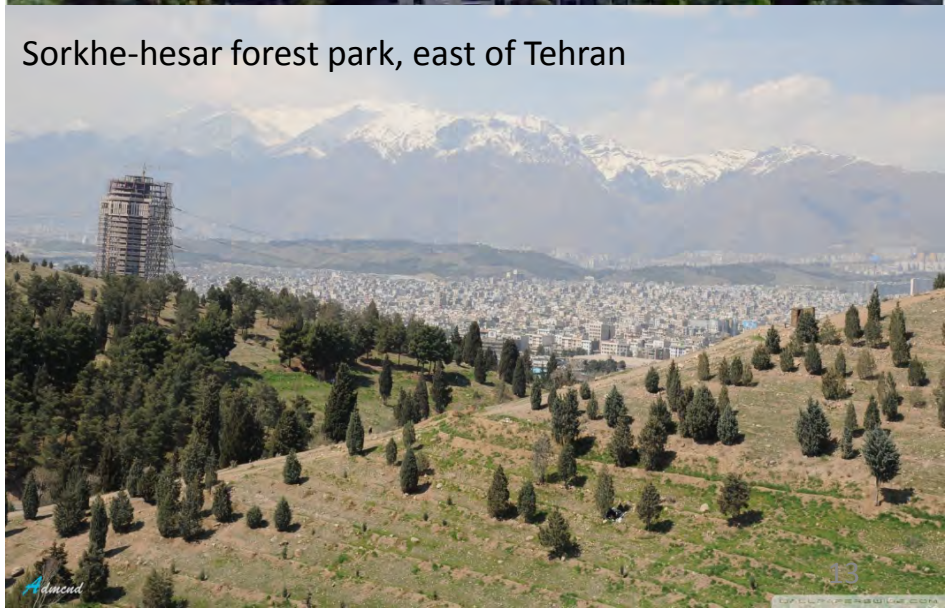
-Monitoring urban forest health.

-Increasing urban canopy cover.

-Developing afforestation with native and exotic species.

-Mitigating Urban Heat Island(UHI) effect.

- Establishing green belts around city.



Main tree species in forest parks

Eldar pine *(Pinus eldarica)*

Arizona cypress *(Cupressus arizonica)*

Locust tree *(Robinia pseudoacacia)*

Judas tree *(Cercis griffithii)*

Arbor vitae *(Thuja orientalis)*

Pomegranate *(Punica granatum)*

Mountain almond *(Amygdalus scoparia)*

Main street tree species

Oriental plane (*Platanus orientalis*)

Urban forests' management plan in Tehran

- Increasing canopy cover
- Selecting suitable sites for tree plantation
- Establishing green belts
- Afforestation and reforestation with native species
- Mitigating CO2 emissions
- Mitigating Urban Heated Island (UHI) effect
- Decreasing air pollution
- Decreasing sound pollution
- Decreasing Volatile Organic Compounds (VOCs) level
- Forest therapy

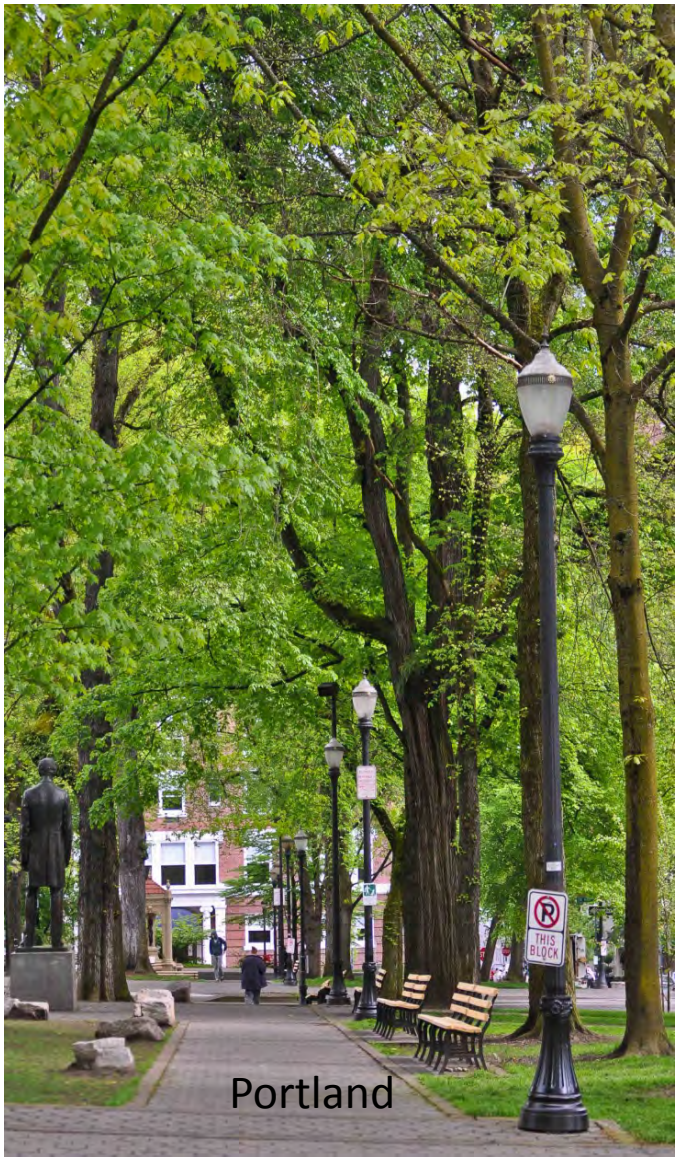
Oregon's urban forests' facts

- Average tree canopy cover: 28.5%
- Urban tree canopy cover: 15%
- Total number of trees in urban areas: 27.6 million.

Urban trees:

- Store 5.3 million metric tons of carbon($120.8 million) annually.
- Remove 173,000 metric tons of carbon($3.9 million) annually.
- Remove 4,090 metric tons of air pollution($31.4 million) annually.

- Reference: Nowak and Greenfield, 2010. Urban and community forests of the Pacific region: California, Oregon, Washington. Gen. Tech. Rep. NRS-65.



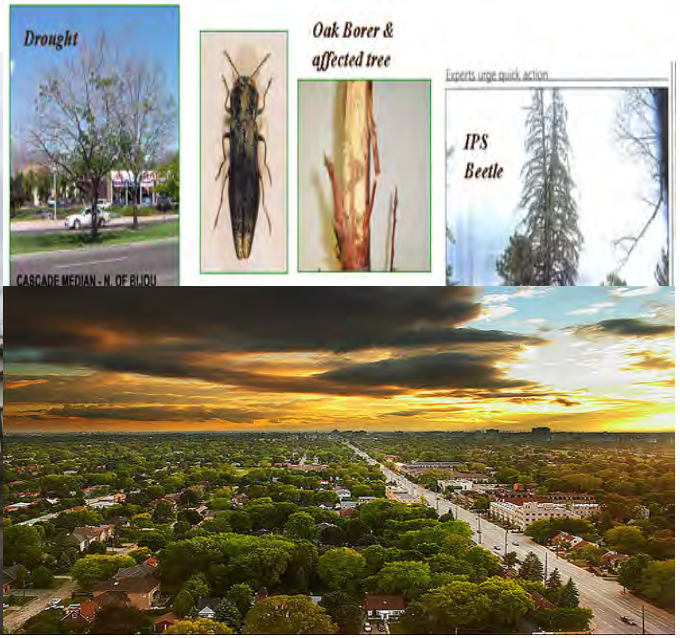
Portland

Portland's urban forests facts

- Street tree population: 236,000 of 171 different types
- Park tree population: 1.2 million of 41 different types
- Broadleaf deciduous trees are dominant, 85% of street trees and 77% of park trees
- 90% of street and park trees are in fair condition
- Maples are dominant tree species
- Norway maple is the most important street tree
- The majority (60%) of street trees are native to Asia and Europe
- The majority (86%) of park trees are native to the Portland area
- Current canopy cover: 29.9 %
- Canopy cover goal in 30 years: 47 %

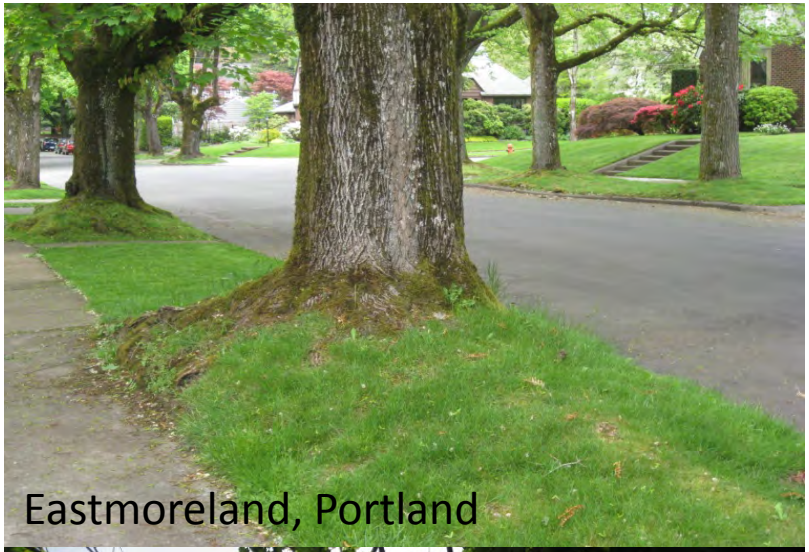
Urban forest's challenges

- Insect and diseases
- Wildfire
- Natural catastrophic events
- Invasive plants
- Air pollution
- Additional development
- Planting strip size
- Overhead utility



Research questions

- Do site factors such as “strip size” and “overhead utility” have any effects on the health of street trees?
- Do street trees in different urbanized regions of the world follow similar structural patterns?
- What is the best index to study the relationship between street trees and people in different communities?



Objectives

- Finding the statistical relationship of tree dimensions, health, and site factors in different neighborhoods.
- Comparing the structural pattern of street trees in Portland and Tehran.
- Comparing different neighborhoods using basal area and canopy cover attributes.

Eastmoreland, Portland

Why did I do this research?

Because:

- Tree measurements such as dbh, total height, crown diameter and crown area can provide vital information on their own, as well as providing crucial data for other calculations such as leaf area and leaf biomass (Nowak 1996; Peper *et al.* 2001a; Peper *et al.* 2001b).

- Most of the environmental benefits associated with urban trees , such as CO2 sequestration (McPherson, 1998; McPherson and Simpson, 2000; Nowak and Crane, 2000), air pollution removal (Beckett *et al.,* 1998; Nowak, 1994,2006; Nowak *et al.,* 2002; Donovan *et* al.2005; Yang *et al .,* 2005; Escobedo and Nowak, 2009), reduction of storm water runoff (Sanders, 1986; Xiao *et al.,* 1998, 2000a,b), microclimate modification and reduction of the Urban Heat Island (UHI) through shading and evaporative cooling (Rosenfeld *et al.,* 1998; Simpson, 1998; Akbari *et al.,* 1998; Akbari, 2002; Donovan and Butry, 2009) are related to their size, and particularly to the size of their crowns.

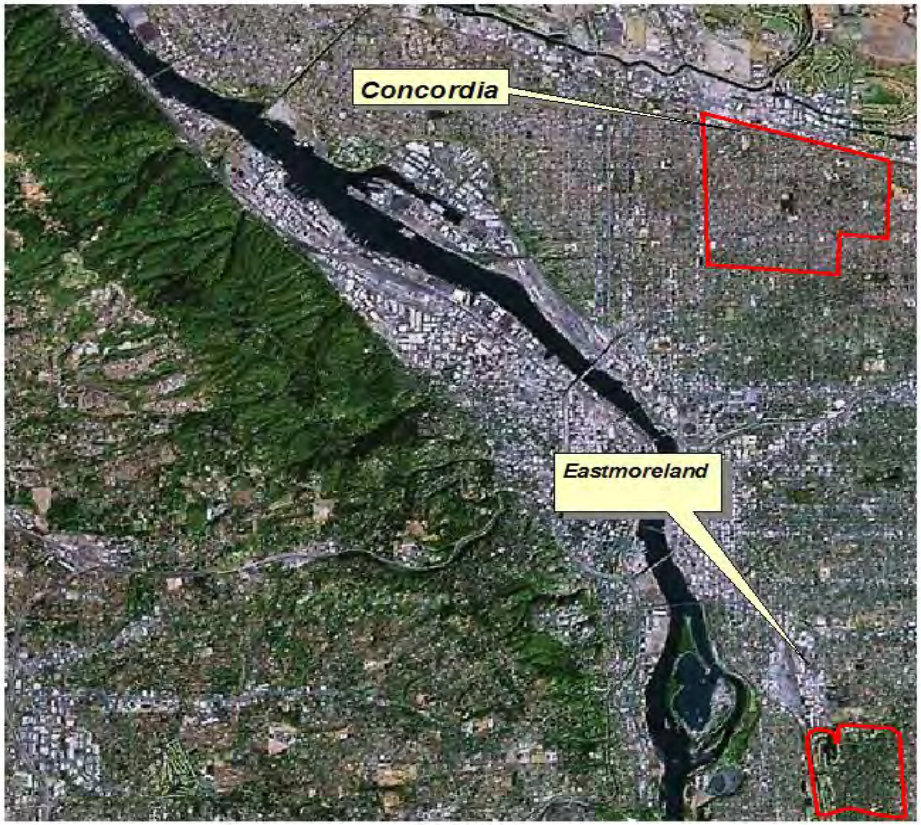
- Models *(predictive equations*) have been developed to assess costs and benefits of the existing urban forests and determine the best management practices to maximize the environmental benefits of urban trees (Nowak and Crane, 2000 ; Nowak and Dwyer, 2000 ; Nowak *et al.*, 2008 ; McPherson *et al.* 1999, 2000).

- Tree canopy cover is a critical measure of the urban and community forest resource (Nowak, 2009).

- Studying urban forest attributes such as tree canopy cover per capita, total green space, canopy green space , and available green space is the most important goal of urban forest's biometrics in any metropolitan city (Nowak, 2009).

Materials & methods

Study area- Portland's satellite imagery



Neighborhoods' facts

Neighborhood	Eastmoreland	Concordia
Location	SE Portland	NE Portland
Area	285 ha	345 ha
population	5007	9550
Population density	17.5 persons/ha	27.7 persons/ha
Median income	$ 63,364	$ 25,694
Below poverty level (%)	7 %	19 %
Total households	1543	3835
Crime density (Street robberies, 1995-2010) http://www.pdx.edu/cjpri/hot-spot-map	Below average	Above average

Data collection

1- Quantitative and qualitative data(tree species, health condition , strip size and dbh) of 3316 and 4636 street trees in Eastmoreland and Concordia respectively.

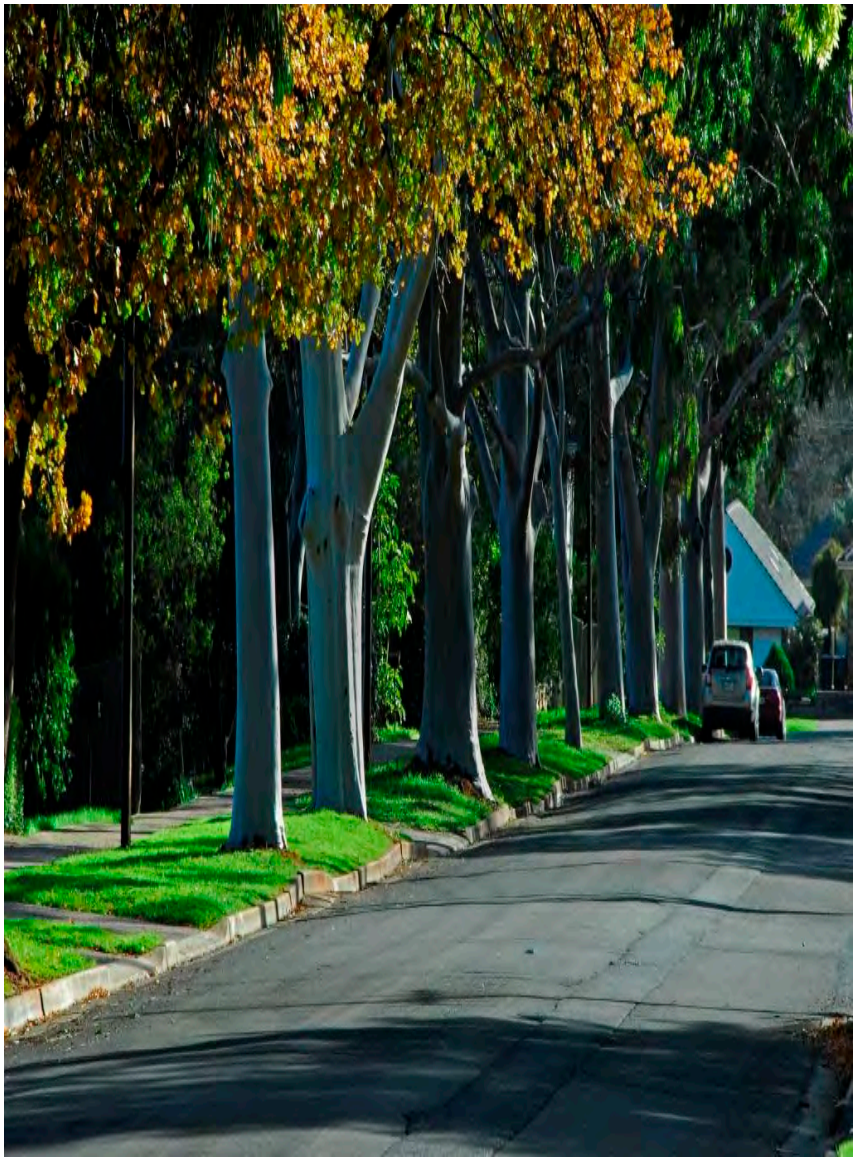
2- Quantitative and qualitative data(dbh, crown diameter, tree height and health condition) of 60 Lindens *(Tilia americana)* in Eastmoreland.

3- GIS – based vegetation map of Portland in 2007.

4- Census data, and robbery maps of Portland in 2010.

Methods

- Statistical analyses of street trees' attributes in Eastmoreland and Concordia.
- Modeling Lindens' attributes using predictive equations in Eastmoreland.
- Comparison of canopy cover attributes in Eastmoreland and Concordia.



Statistical analyses of street trees' attributes in Eastmoreland and Concordia

- Number of samples: 7952 trees (3316 trees in Eastmoreland and 4636 trees in Concordia).
- Tree factors: Dbh, strip size, tree location, health condition, and presence or absence of overhead utility.
- Type of analysis: (GLM) *Generalized Linear Model*

Modeling Linden's attributes using predictive equations in Eastmoreland

- Tree measurement

Number of trees: 60 (in both sides of Reed college Blvd.)

Measured factors: Dbh, mean crown diameter, tree height, health condition.

- Regression analysis

a. Linear model
b. Non - linear exponential model
c. Logarithmic regression model

Comparison of urban forests' attributes in Eastmoreland and Concordia

- Classifying two neighborhoods into four classes_ Tree cover, water, pervious, and impervious surfaces_ using *Feature Analyst extension* in ArcGIS 10.

- Calculating urban canopy attributes
  - Canopy cover per capita
  - Canopy green space

- Calculating urban forest's indexes
  - Trees per hectare
  - Total basal area
  - Basal area per hectare
  - Basal area per capita

Results

Statistical analyses of street trees' quantitative factors in Eastmoreland and Concordia

Eastmoreland

Paired factors	Omnibus test	Wald chi-square statistics
Dbh-tree health	P<0.05	800.850
Overhead utility -tree health	P<0.05	56.191
Strip size-tree health	P<0.05	28.586

Concordia

Paired factors	Omnibus test	Wald chi-square statistics
Dbh-tree health	P<0.05	223.515
Overhead utility – tree health	P>0.05	----------
Strip size-tree health	p<0.05	183.499

Modeling Linden's attributes using predictive equations in Eastmoreland

Quantitative paired factors	Linear model	Nonlinear exponential model	Logarithmic regression model
	R^2	R^2	R^2
Dbh vs. tree height	0.47	0.47	0.48
Dbh vs. mean crown diameter	0.08	0.18	0.06
Dbh vs. crown area	0.03	0.18	0.02
Dbh vs. tree health	0.02	0.00	0.02
Basal area vs. crown area	0.04	0.45	0.42

The Omnibus test for predicting tree health from dbh is not significant ($p>0.05$)

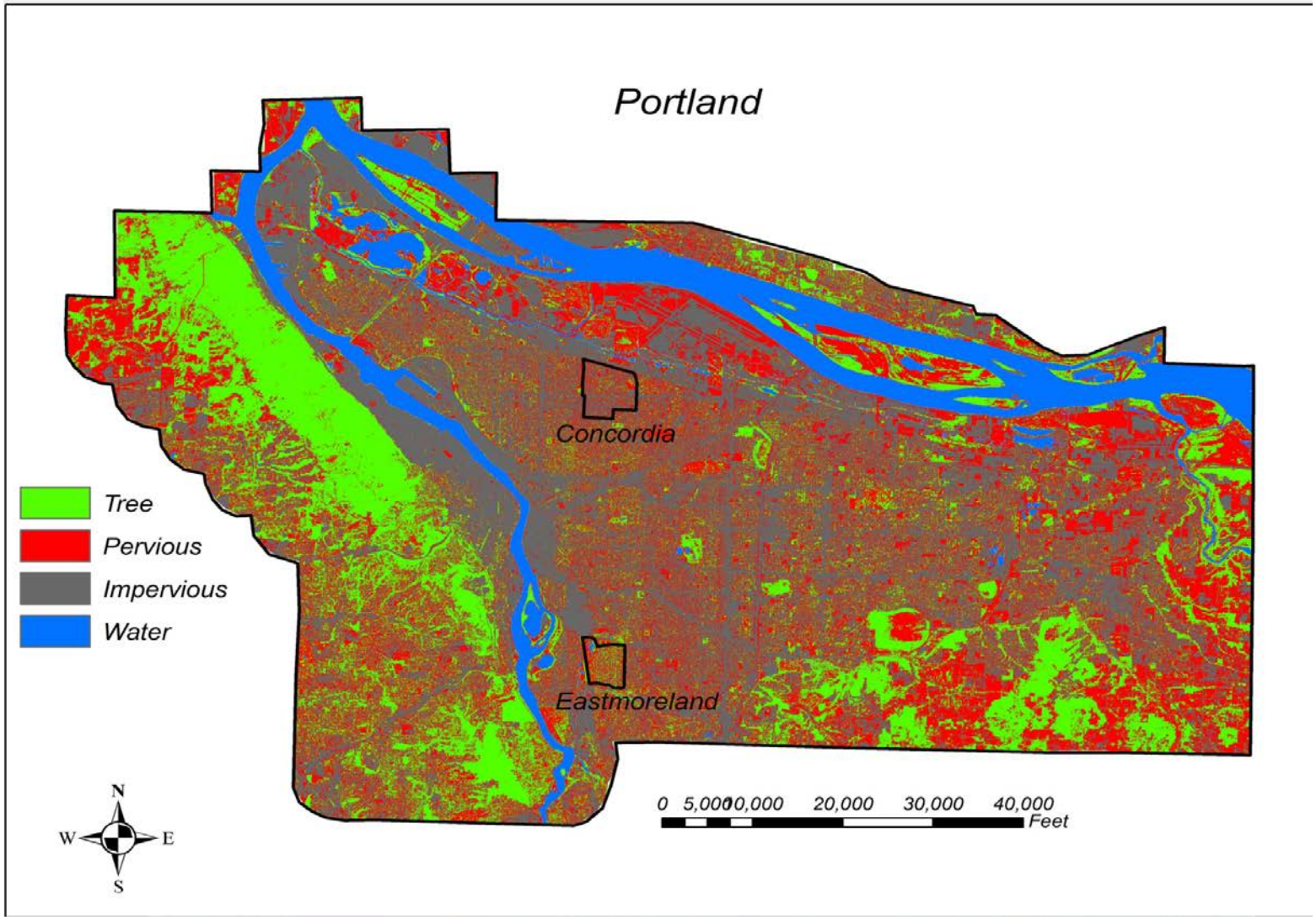
Modeling oriental plane's attributes using predictive equations in district 6 of Tehran

Quantitative paired factors	Linear model	Nonlinear exponential model	Logarithmic regression model
	R^2	R^2	R^2
Dbh vs. tree height	0.49	0.50	0.46
Dbh vs. mean crown diameter	0.06	0.22	0.07
Dbh vs. crown area	0.23	0.25	0.21
Dbh vs. tree health	0.05	0.00	0.04
Basal area vs. crown area	0.03	0.48	0.44

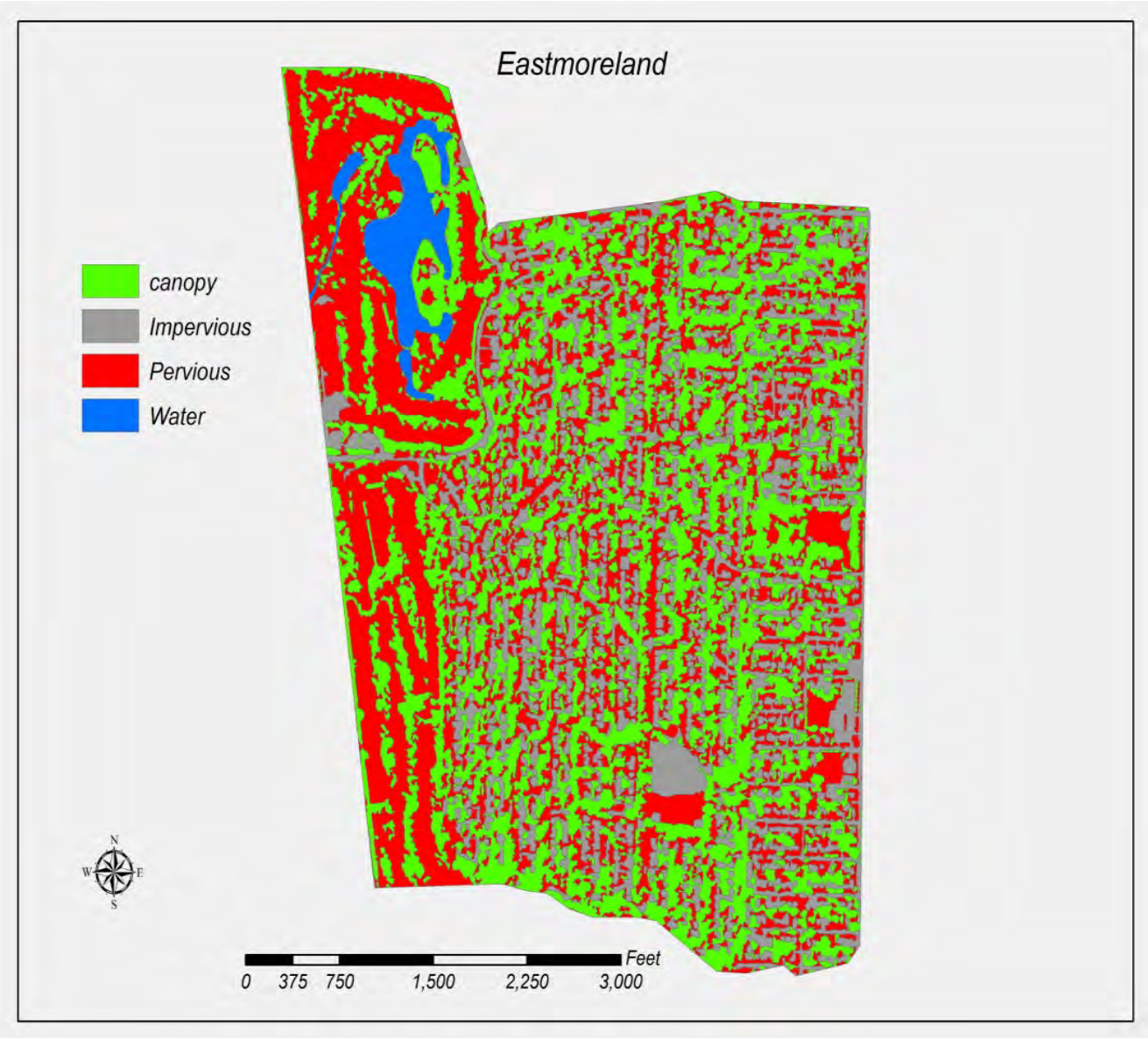
The Omnibus test for predicting tree health from dbh is not significant ($p>0.05$)

Comparison of canopy cover attributes in Eastmoreland and Concordia

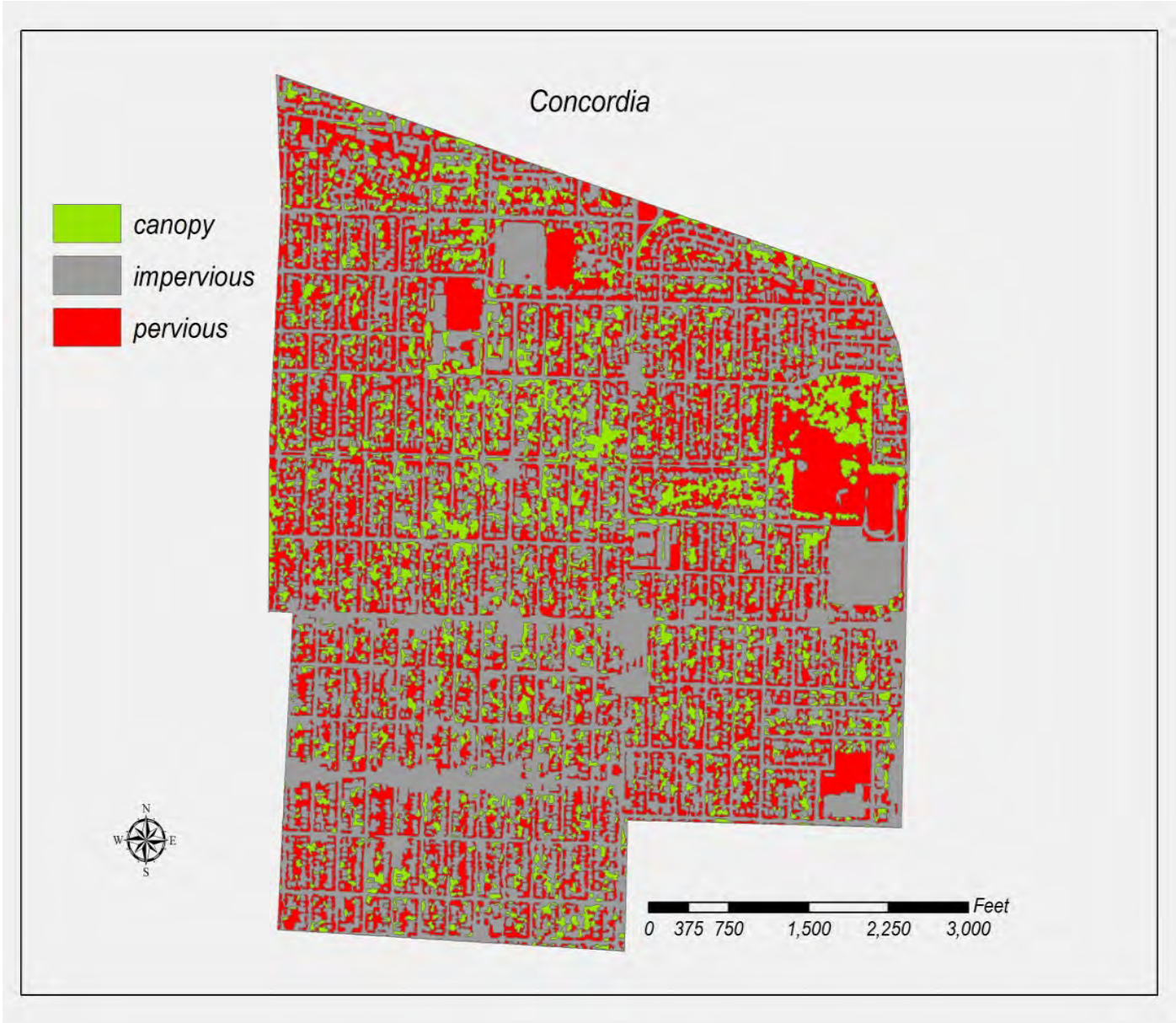
GIS-based classified map of Portland



GIS – based classified map of Eastmoreland



GIS-based classified map of Concordia



Urban forests' attributes and indexes	Eastmoreland	Concordia
Total canopy cover (ha)	80.52	51.82
Impervious surfaces (ha)	44.34	149.87
Pervious surfaces (ha)	73.67	117.79
Water (ha)	5.28	----------
Tree canopy cover per capita (m^2/person)	160.81	54.26
Canopy green space (%)	1.09	0.43
Trees per hectare	11.61	13.34
Basal area per hectare (m^2)	3.15	0.77
Basal area per capita (m^2/person)	0.17	0.02
Total basal area (m^2)	899.5	267.24

Discussion

- In both neighborhoods, trees' health is mainly affected by increase in dbh size which is a factor of aging.
- Crown trimming and ongoing removal of interfering branches with overhead wires have significantly deteriorated the health condition of tress in Eastmoreland.
- Overhead utility does not have any effect on the health of street trees in Concordia.
- Strip size is the major health-induced factor for street trees in Concordia.
- In Eastmoreland, strip size does not have any effect on trees' health.

- In Lindens, the relationship between dbh and tree height is the strongest but, between dbh and tree health the weakest.
- The relationship between dbh and health condition of Lindens is not significant.
- In Lindens, the relationship between dbh and crown area is very weak.
- Pervious and impervious surfaces in Concordia are 1.6 and 3.4 times more than Eastmoreland respectively.
- Basal area and canopy cover per capita in Eastmoreland are 8.5 and 3 times more than Concordia respectively.
- Basal area per capita is the most reliable index for studying the relationship between street trees and people.
- Street trees in different regions of the world have similar structural pattern.


Thank you