2002 URBAN FOREST CANOPY & LAND USE IN

PORTLAND'S HOLLYWOOD DISTRICT

Final Report

by

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Abstract

This project explored the extent of forest canopy cover and the potential for increased tree planting possibilities of Portland's Hollywood District, using 1-meter-resolution digital aerial photography. First, an unsupervised classification with four different bands (green, red, infrared, and a ratio of red and infrared) was performed to identify the categories "tree," "grass," and "impervious surface." In a second step, the canopy classification maps were related to land-use data. As anticipated, commercial and industrial areas had less canopy cover than residential and institutional areas; the commercial/industrial area showed a canopy cover of 6.4% of its total, whereas the residential and institutional/vacant areas had more canopy cover with 19.2% and 28.6%, respectively. In the third part of the project, the little-explored factors of tree shape (columnar versus spreading) and spacing between trees were investigated to calculate estimates of how many trees need to be planted to cover potential planting sites in various land-use categories. Several scenarios with different tree-spreads in all land-use categories were examined. For instance, it would take approximately 1,000 mature spreading trees that each cover about 200 square-feet (such as *Acer platanoides*) to fill the grassy areas of the commercial/industrial category with tree canopy, while it would take more than 7,000 mature columnar trees (such as *Calocedrus decurrens*) to cover the same area. City planners can use the study results as an aid to locate areas that are suitable for tree-plantings and can calculate the costs of eventual plantings with different tree types and spacing between trees.

Introduction

The urban forest is a vital part of a city. Its values and benefits including reduction of runoff and air pollutants, heating and cooling effects, provision of wildlife habitat, as well as increased aesthetic and psychological values are well-documented in literature (Miller 1997 45-77, Harris 1992 4-14). Portland, Oregon, is recognized as one of the greenest and most well-treed cities in the United States. In 1995, the City of Portland implemented its *Urban Forest Management Plan*, which as one of its major goals has to "maximize and expand the urban tree canopy where feasible and appropriate" (2). This study aids this effort by examining a way to quantify urban forest canopy extent. The study also explores how different land-use categories relate to tree canopy extent and identifies areas where trees can be planted in order to reach specific tree-canopy target values for each land-use category.

Study Area & Data

Portland's Hollywood District was chosen as a study site for several reasons. First, it provided a good example of a diverse urban landscape with different land uses. Second, 2002 digital aerial photography with a spatial resolution of one meter for the same area was available and used to perform the canopy extent classification. These data consisted of a natural color image and green, red, and infrared bands. Third, the area is small enough to be handled in the computationally intensive algorithms that were used for the classification. Fourth, a recent Portland Planning Bureau study of the area provided reliable and up-to-date land-use data.

The study area extends roughly from NE 12th Avenue to NE 61st Avenue, with NE Sandy Boulevard going diagonally across from the southwestern to the northeastern corner of the study area. The whole area covers a little more than 700 acres. Sandy Boulevard is surrounded by mostly commercial and industrial areas on either side. Further away from its major arterial, residential areas dominate. I-84 crosses Sandy Boulevard, thereby dividing the study area in an Eastern and Western half. Notable features include Benson High School, Grant High School, and Oregon Park. Image 1 illustrates the study area with its main features labeled, and image 2 provides a detailed look at land use. In order to perform the analysis, the digital aerial photography used was reduced to the extent of the land use data. The land use data, available in vector format, was rasterized to 1-meter pixels and then georeferenced to match the feature boundaries of the aerial-photography layers.

Tree Canopy Classification

An unsupervised classification was performed with IDRISI software and resulted in three classes—grass, canopy, and impervious surface. The green, red, infrared, and a red-infrared ratio of the 1-meter resolution digital imagery were used as input layers to produce 30 clusters that were then collapsed into the three different land-cover classes. In an article on urban mapping methods with high-resolution imagery, Thomas et al. write that although digital 1-meter imagery works well for distinguishing features in mixed urban areas, the high-resolution data has the disadvantage of great within-class spectral variation (963). Such variation within the canopy class caused confusion between the grass and canopy at several spots. Areas that should have been canopy were falsely combined with areas of grass, despite the fact that the classification algorithm produced 30 clusters. Splitting of the clusters that caused the confusion into sub-clusters solved the problem and most of the confused pixels were classified correctly. The final classification (Image 3) yielded an overall accuracy of approximately 78%, with an accuracy of about 90% for the impervious-surface class and accuracies of 74% and 77% for the canopy and grass classes, respectively.

Current Tree Canopy & Land Use

After the land cover classification was completed, it was combined with the land use data by using a cross-tabulation process that related each pixel of the land cover map to each pixel of the land use map. It needs to be noted that the land use data do not include the areas that are covered by streets. Therefore all square-meter pixels that fall on a street are excluded for this part of the study. Table 1 shows how much area in each land-cover class is covered by canopy, grass, and impervious surface. For example, Hollywood's single-family residential area has 203,646 pixels (~50.3 acres) of tree canopy, which is 30.8% of the whole single-family residential class in the study area. On the other hand, the industrial area has only 1,983 pixels (~0.5 acres) of tree canopy or 1.9% of the whole industrial area. At the bottom of table 1, some land-use categories are collapsed into the more general classes of residential, commercial/industrial, and institutional/vacant. The numbers show that an expected pattern emerges, where the commercial and industrial areas have much less tree canopy cover than any of the other land use classes. Images 4, 5, and 6 illustrate how canopy cover, grass, and impervious surface are distributed spatially within the three generalized land use categories.

A recent study on Portland's tree canopy cover suggests a recommended tree-canopy target value of 47% for residential areas and 12% for commercial/industrial areas (Poracsky & Lackner 2004). Table 1 shows that Portland's Hollywood district does not meet these suggested values, although it needs to be mentioned that the street trees that are located in the various land-use classes are excluded. Even if the street trees were included, the residential and commercial/industrial areas would still be below the recommended target values for canopy cover. However, if all grass areas of the residential area would be trees, the tree canopy percentage would increase to 43.1%. Likewise, the commercial / industrial area's canopy percentage would go up to 10.1% if all of its grass area would be covered by trees. These values would almost reach the recommendations.

Maximizing and Expanding Tree Canopy

According to Reynolds and Dimon, between 150 and 175 tree species grow well in the Willamette Valley, and 22 of the 48 species native to Oregon, 22 are native to the Greater Portland area (1993 15). In the study area there are approximately 79 acres, excluding ball fields, of grassy area that could provide tree-planting space. Maybe not all of the grass area is suitable or desirable for additional trees, but there appear to be adequate opportunities to increase the tree canopy in the study area. It is essential to choose the right tree for the right location by considering planting constraints, such as utility poles, buildings, or narrow planting strips. Tree characteristics, including height, leaf density, spread, among others must be chosen carefully to fit the planting location. While this study did not explore all these characteristics, it examined the little-explored factors of tree shape (spreading vs. columnar), the spacing between trees, and their implications for the number of trees needed to cover potential planting areas.

The spread of a tree is closely related to the area that the tree crown will cover when the tree matures. Two trees that are native to the area will be used in the following example. The spreading tree *Acer platanoides* (Crimson King Norway Maple) can cover an area of approximately 113 to 177 square feet after a ten years and about 177 to 314 square feet another decade later. The square footage for the columnar tree *Calocedrus decurrens* (Incense Cedar) is about 7 to 20 and 13 to 28 over the same time periods. Allowing a period of twenty years of tree growth, it would take 334 of the above mentioned maples and 4,008 of the cedars to cover the 4.6 acres of grass zone in the commercial/industrial area. The step-by-step description of how this calculation was performed is described below:

1. Planting space → 4.6 acres = 200,376 square feet
2. Divide planting space by 2 for planting the 2 different species → 2 areas of each 100,188 square feet
3. Divide the potential planting area for each species (100,188 square feet) by the square footage of each species → Maple: 300 square feet (after 20 years), Cedar: 45 square feet (after 20 years) →
   Maple: 100,188 / 300 = 333.9 (**334 trees**)
   Cedar: 100,188 / 45 = 4,007.52 (**4,008 trees**)

This is of course only a very simplified calculation, but it can be refined to include different tree species, spacing between trees, and specified tree planting areas instead of the whole commercial/industrial area as used in the example just described. Table 2 illustrates how many trees would be necessary to cover the grass areas of the different land use classes, providing four different tree spreads. Examples for trees **[maybe include one more exmpl→ deciduous columnar]** with these spreads can be found in Arboriculture literature. However, increased distance between trees decreases the amount of available planting space. Graph 1 illustrates how increased spacing between trees limits the possible tree-planting space of the study area. Given the spread of a tree and possible planting areas, city planners can calculate a number of scenarios in the same way as the example just described.

Further Study & Conclusion

This study only considered grass areas as possible tree planting sites because they were fairly easy to detect with the used classification method; these sites are also cost-efficient because no concrete cuts need to be made, as is the case with possible planting sites on sidewalks or parking lots. Further research could examine these additional planting sites as well as areas of bare soil, gravel, and shrub, along with the associated costs of all possible planting sites. In order to determine the feasibility of a planting space, additional geospatial data, such as building outlines and power-line locations could be used to categorize the areas under consideration. This would help in narrowing down possible planting sites, thereby limiting the number of field checks in order to determine the final sites. These additional data could also aid in the choice of the tree types that can be planted at a certain location.

While this study does not attempt to provide a comprehensive method of managing the urban forest, it offers a fairly inexpensive way for estimating urban forest canopy extent and possibilities for increasing it. The described methodology of this study can be applied to other urban areas of similar size, giving city planners tools they can use to accomplish their goal to maximize the city’s tree canopy.

References

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Appendix

Image 1: Study area with main features and locator map.

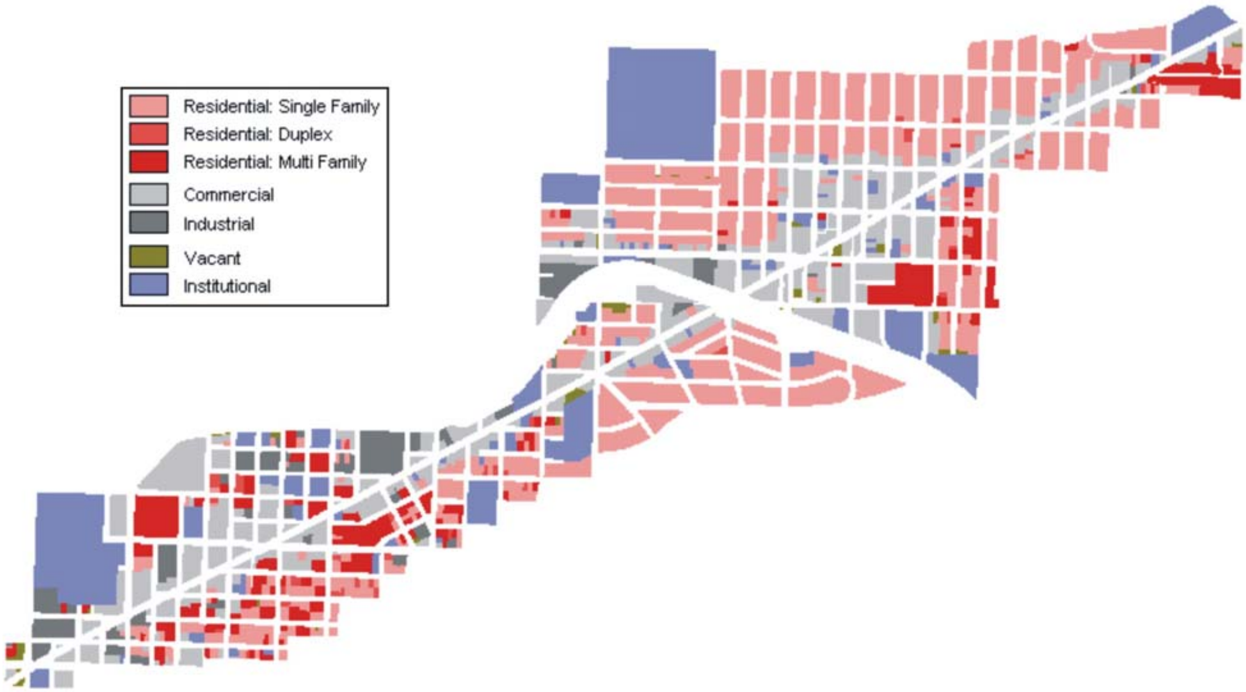


Image 2: Detailed land use classes for the study area.

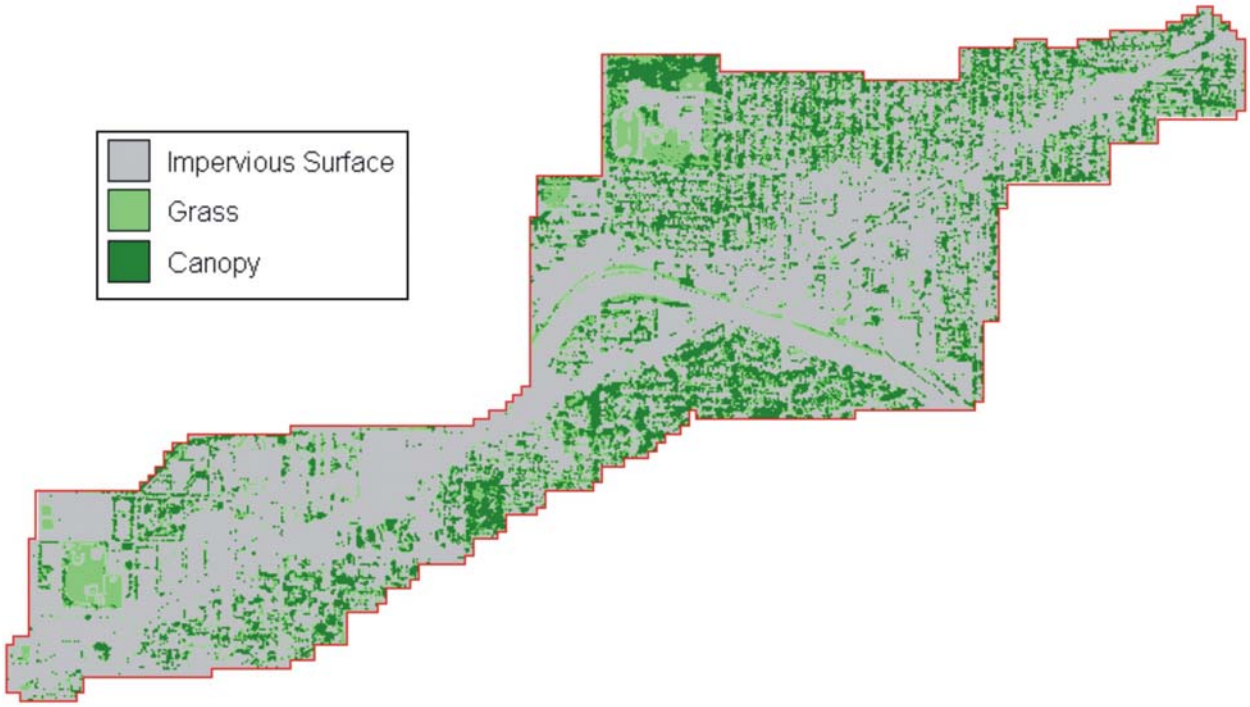
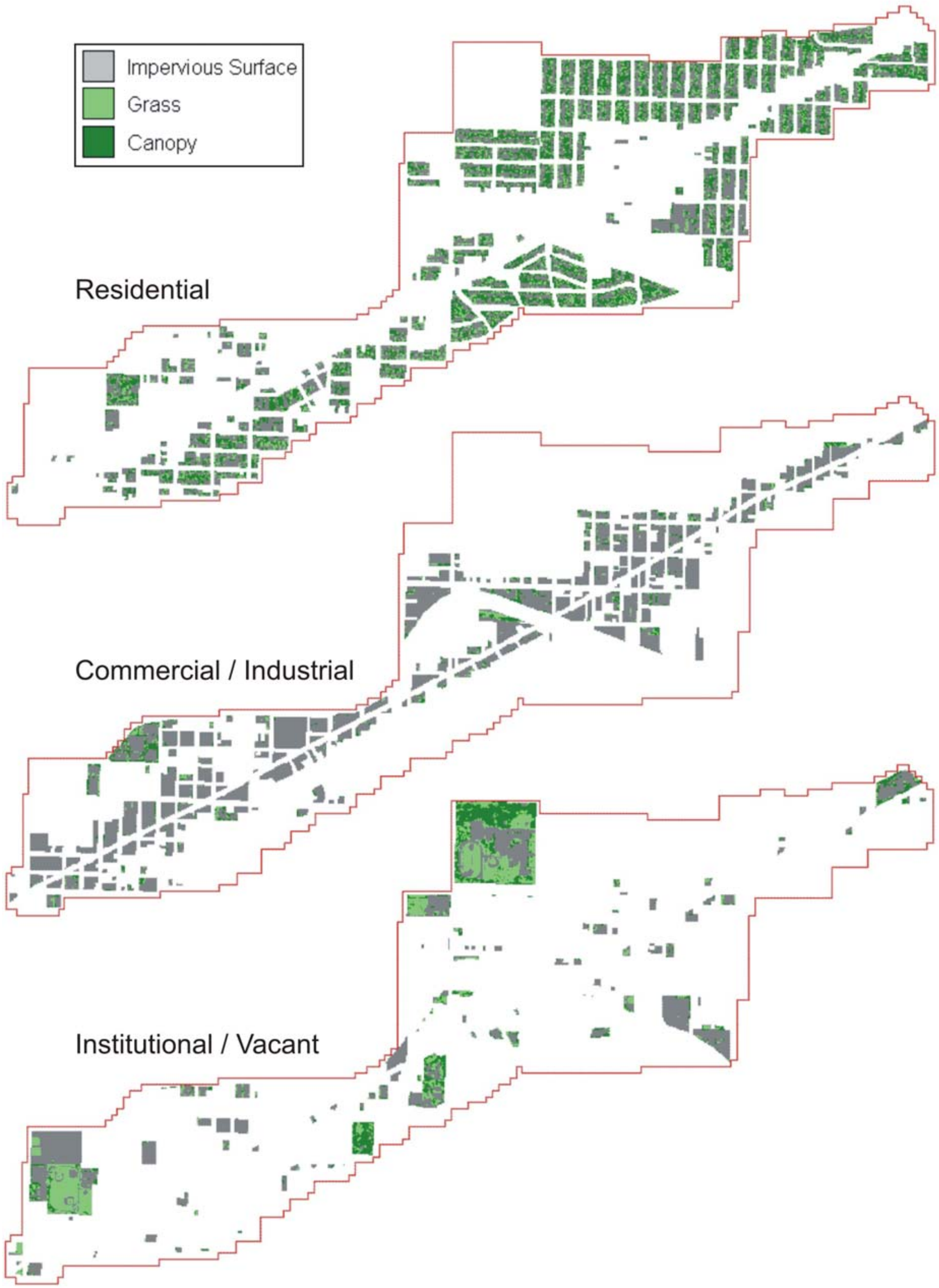


Image 3: Final classification.

Landuse	Land Cover:	Impervious	Grass	Trees	Total
Residential: Single Family		353250	103419	203646	**660315**
%		53.5	15.7	30.8	**46.5**
Residential: Duplex		12513	3313	4984	**20810**
%		60.1	15.9	24.0	**39.9**
Residential: Multi Family		114267	15546	32718	**162531**
%		70.3	9.6	20.1	**29.7**
Commercial		363772	17316	30800	**411888**
%		88.3	4.2	7.5	**11.7**
Industrial		96778	1479	1938	**100195**
%		96.6	1.5	1.9	**3.4**
Vacant		6532	4940	3641	**15113**
%		43.2	32.7	24.1	**56.8**
Institutional		216219	90854	72252	**379325**
%		57.0	24.0	19.0	**43.0**
Total		1163331	236867	349979	**1750177**
%		66.5	13.5	20.0	**100.0**

Residential		480030	122278	241348	**843656**
%		56.9	14.5	28.6	**43.1**
Commercial / Industrial		460550	18795	32738	**512083**
%		89.9	3.7	6.4	**10.1**
Institutional / Vacant		222751	95794	75893	**394438**
%		56.5	24.3	19.2	**43.5**

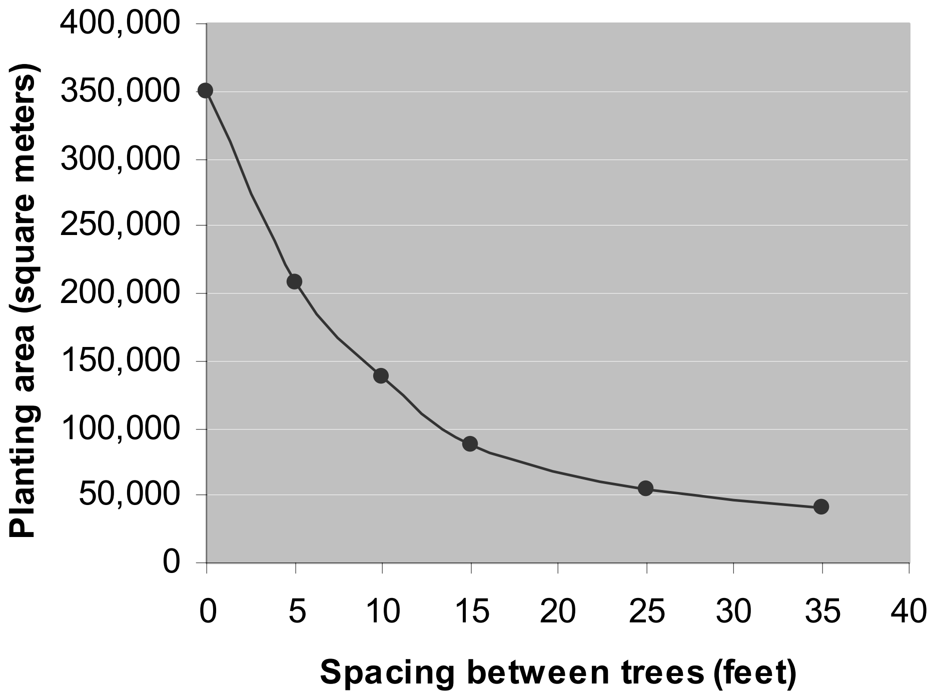
Table1: Land cover classes are related to land use classes.



Images 4, 5, 6: Land cover compared to land use.

Land Use	Grass Area (in Acres)	Spread 1 (55 sq.f)	Spread 2 (97 sq.f)	Spread 3 (194 sq.f)	Spread 4 (300 sq.f)
Commercial/Industrial	4.6	3,759	2,088	1,044	671
Institutional/Vacant	23.7	19,159	10,644	5,322	3,421
Residential	30.2	24,456	13,586	6,793	4,367

Table 2: Number of trees with various spreads that are needed to cover the grass area of a certain land-use class



Graph 1: As the spacing between trees increases, the available tree planting area decreases.