THE USE OF COMPUTER GENERATED MAPS IN INTERPRETING URBAN FORESTRY DATA

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I. Introduction

The need to observe and to catalog urban tree resources for use in planning urban resources is being realized by planning agencies throughout the United States. To date, the only urban tree inventories have been on a level prohibited for large scale urban use. These surveys have been efforts to catalog specific species of flora by visiting the specific areas of the municipality included in the survey.[1] The need for small scale tree inventories can best be accomplished by extracting the data from air photos or other forms of remotely sensed data collected by a stratified random sampling technique. In this form the data can usually be converted into a computer generated statistical surface that will aid the planner, and/or agency, in developing an urban forestry resources program.

To fill this need, a method for small scale (approx. 1:32,000) tree inventories was developed at the Association of Bay Area Governments, using NASA's U2 color infrared photography of the San Francisco Bay Area. At this scale, specific species of trees could not be reliably discerned from one another, so a new classification system had to be used. Three classes of urban trees were used. These classifications were based on geographical locations rather than taxonomical considerations. The three classifications of urban trees are: street, private, and park and watershed.

1. Street trees are defined as any tree facing or situated next to a street or thoroughfare.
2. Private trees are defined as trees that are not adjacent to a street or thoroughfare.
3. Park and watershed trees are defined as any tree situated in an open area within the urban limits, but not situated in urbanized sectors of the city.

For use in this study, trees can be defined as any free standing, woody-perennial over three feet in height.

II. Methodology of Data Collection

The data was obtained by placing an inch-square grid network over a 1:32,000 scale infrared photo transparency. Each one-inch square is divided into 16 ¼" by ¼" grid cells. The area covered by each grid cell is approximately .475 of an acre, or 20,691 square feet. Each one-inch grid of the network contained approximately 7.6 acres, or 331,056 square feet. Each grid cell in every one-inch grid is numbered from 1 to 16; using a random number table, various numbers of cells out of each grid were chosen to be inventoried. The number of cells chosen depended on the area of the city that was being inventoried. A fifty percent random sample was used in areas of residential housing and large urban parks. A twenty-five percent sample was used in areas of industrial development and a fifteen percent sample was used for central business districts. These sampling densities were calculated from sample surveys which used different densities to calculate the optimal density for urban forestry resources in specific municipal land use zones.

A base map of the locations of each of the grid networks with the centroid for each of the sample cells was recorded as part of the inventory technique. The type of trees, their locations, and the number of trees for each of the sample cells were recorded on coding sheets.

Three cities were chosen as target municipalities for this study. The target municipalities were chosen on the criteria of: (1) fit the population sample derived for the study (i.e., one city of population under 5,000, one city whose population is between 10,000 and 100,000, and an urban center with a population of

100,000 plus); (2) be located in the San Francisco Bay Area.

Alameda, Brisbane, and San Francisco were the target cities chosen for the study (No. 1). The city of Alameda is situated on two man-made islands near the eastern shore of San Francisco Bay. The Alameda Naval Air Station occupies the northern end of Alameda Island. The Alameda Public Works Department has a program of urban tree planting in the newer areas of the city. In the early 1970s a ground study, similar to Schmid and Durrenbacker, was completed for Alameda's street trees. The results of this survey showed approximately 15,000[2] street trees. Alameda has continued an active policy of street tree planting.

Brisbane is a small municipality south of San Francisco with a population of 3,600. Brisbane has a concentrated urban center in the southern portion of its boundaries. The northern portion of Brisbane is predominantly industrial. The largest land user in this northern zone is Southern Pacific railroad which maintains a large rail yard. To date, no reliable ground study has been produced for Brisbane.[3]

San Francisco is the largest city in population in the San Francisco Bay Area. It is 49 miles square and has a population of 714,000. The San Francisco Urban Street Tree Department is in charge of issuing permits for street trees. Only about a quarter of the 66,000 street trees are maintained by the city. The other 44,000 have been planted by the city, but by a permit process, are maintained and owned by the residents and the businesses that the trees front. Approximately 2,500 trees a year are planted along San Francisco's streets by federally funded projects and the city's tree planting program.[4]

III. Calculations and Results

The calculations and results are divided into two parts. The first part is to estimate the numbers of trees in the various classifications from the data collected. The second part of the study was the computation of computer generated surfaces. This is accomplished by various stratified sampling techniques. In comparing the final estimations to known ground data, it is found that a twelve percent discrepancy exists between the calculated data and the ground truth data. This discrepancy does not constitute a statistically significant error in the data, at the confidence interval selected for the study. The discrepancy can be accounted for by the inclusion of multi-zonal grid cells.

The need for graphic representation of the distributional qualities of the data is assessed as the accuracy of the data becomes known. The use of computer cartographic techniques became necessary as there were a large number of data points in the study. In order to facilitate graphic representation, the centroid location and the data are smoothed, using a nearest neighbor averaging algorithm. The revised centroid location and the accompanying data are recorded on punch cards and transferred to magnetic tape. After the data has been stored, simple contour and trend surface maps, first to the sixth order, were computed using the SYMAP algorithm.

The results of the computer generated surfaces were interpreted, and likewise the correlation coefficients of the trend surfaces were calculated. The fifth order for each of the three cities were used for the interpretation. The correlation coefficients for the three cities are: Alameda, .912; Brisbane, .971; and San Fransisco, .821.

IV. Interpretations of Trend Surface

The fifth order trend surface for Alameda shows the heaviest concentration of street trees in the southern residential zones. The area of the city which shows any variations in regard to street trees is the northwestern tip of the island where the Alameda Naval Air Station and industrial zones are located.

The distribution for private trees in Brisbane demonstrates the zonation of the city. The heaviest concentration of trees are in the southern residential zone; the lightest area of concentration and the one with the most variation is the northern industrial zone and the Southern Pacific railroad yards. The central business district has a very stable number of trees. This is due to the distribution of several large parks in the downtown area.

The surface calculated for San Francisco shows the greatest amount of variability in private trees. This is due to the distribution of various civic parks and military reservations in the city. The central business district and the wharf area of the city shows a dramatic lack of vegetation. Areas of moderate income (the west central area and the southeastern area) show a slightly heavier concentration of trees. The wealthier districts show the heaviest concentration of trees. The military reserves and the civic and national parks in the northern part of the city caused the greatest amount of variation from the known data and the calculated surface.

V. Conclusions

The cartographic representations of trend surfaces produced for this study are valuable as a tool for use by the urban planner trying to cope with the problem of limited resources. These surfaces, if interpreted correctly, will aid the planner in setting specific target areas for concentration of resources in urban tree planting programs. This also will allow for a decrease in time and expenditure for overhead and planned development.

This paper proposes only one method that works for older and well established communities that have experienced maximum growth potential. The methodology needs further development if it is to meet general purpose requirements for use in rapidly developing communities or communities that have not met their maximum growth potential.

[1]William E. Darrenbacher, "Plants and Landscape: An Analysis of Ornamental Planting in Four Berkeley Neighborhoods." Unpublished Master's thesis, Univ. of California, Berkeley, 1969; James A. Schmid, "Urban Vegetation," Univ. of Chicago, Dept. of Geography Research Paper No. 161, 1975.

[2]From a conversation with Mr. Durant, City Public Works Dept., Alameda, Calif.

[3]From a conversation with Janet Kirby, Park Dept., Brisbane, Calif.

[4]From a conversation with Robert Leet of the San Francisco Street Planting Dept.

References: Dougenik, J.A. and Sheehan, D.E. SYMAP Users Reference Manual. Cambridge, Mass.: Harvard Univ. Press, 1972.

Mendenhall, William; Ott, Lyman; Scheaffer, Richard; Elementary Survey Sampling. Belmont, Calif.: Duxbury Press, 1971. pp. 31-52.