



## i-Tree Canopy Technical Notes

---

This tool is designed to allow users to easily and accurately estimate tree and other cover classes (e.g., grass, building, roads, etc.) within their city or any area they like. This tool randomly lays points (number determined by the user) onto Google Earth imagery and the user then classifies what cover class each point falls upon. The user can define any cover classes that they like and the program will show estimation results throughout the interpretation process. Point data and results can be exported for use in other programs if desired.

There are three steps to this analysis:

- 1) Import a file that delimits the boundary of your area of analysis (e.g., city boundary). Some standard boundary files for the US can be located on the US Census website. Data from these sites will require some minor processing in GIS software to select and export a specific boundary area polygon.
- 2) Name the cover classes you want to classify (e.g., tree, grass, building). Tree and Non-Tree are the default classes given, but can be easily changed.
- 3) Start classifying each point: points will be located randomly within your boundary file. For each point, the user selects from a dropdown list the class from step 2 that the point falls upon.

*The more points that are interpreted, the more accurate the estimate.*

### Credits

The concept and prototype of this program were developed by David J. Nowak, Jeffrey T. Walton and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company).

### Limitations

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. Thus the classes that are chosen for analysis must be able to be interpreted from an aerial image. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate. Information on calculating standard errors can be found below. Another limitation of this process is that the Google imagery may be difficult to interpret in all areas due to relatively poor image resolution (e.g., image pixel size), environmental factors, or poor image quality.

### Calculating Standard Error and Confidence Intervals from Photo-Interpreted Estimates of Tree Cover

In photo-interpretation, randomly selected points are laid over aerial imagery and an interpreter classifies each point into a cover class (e.g., tree, building, water).

From this classification of points, a statistical estimate of the amount or percent cover in each cover class can be calculated along with an estimate of uncertainty of the estimate (standard error (SE)). To illustrate how this is done, let us assume 1,000 points have been interpreted and classified within a city as either “tree” or “non-tree” as a means to ascertain the tree cover within that city, and 330 points were classified as “tree”.

To calculate the percent tree cover and SE, let:

$N$  = total number of sampled points (i.e., 1,000)  
 $n$  = total number of points classified as tree (i.e., 330), and  
 $p = n/N$  (i.e.,  $330/1,000 = 0.33$ )  
 $q = 1 - p$  (i.e.,  $1 - 0.33 = 0.67$ )  
 $SE = \sqrt{pq/N}$  (i.e.,  $\sqrt{0.33 \times 0.67 / 1,000} = 0.0149$ )

Thus in this example, tree cover in the city is estimated at 33% with a SE of 1.5%. Based on the SE formula, SE is greatest when  $p=0.5$  and least when  $p$  is very small or very large (Table 1).

**Table 1.** Estimate of SE (N = 1000) with varying p.

p	SE
0.01	0.0031
0.1	0.0095
0.3	0.0145
0.5	0.0158
0.7	0.0145
0.9	0.0095
0.99	0.0031

### Confidence Interval

In the case above, a 95% confidence interval can be calculated. “Under simple random sampling, a 95% confidence interval procedure has the interpretation that for 95% of the possible samples of size  $n$ , the interval covers the true value of the population mean” (Thompson 2002). The 95% confidence interval for the above example is between 30.1% and 35.9%. To calculate a 95% confidence interval (if  $N \geq 30$ ) the  $SE \times 1.96$  (i.e.,  $0.0149 \times 1.96 = 0.029$ ) is added to and subtracted from the estimate (i.e., 0.33) to obtain the confidence interval.

### SE if $n < 10$

If the number of points classified in a category ( $n$ ) is less than 10, a different SE formula (Poisson) should be used as the normal approximation cannot be relied upon with a small sample size ( $< 10$ ) (Hodges and Lehmann, 1964). In this case:

$$SE = (\sqrt{n}) / N$$

For example, if  $n = 5$  and  $N = 1000$ ,  $p = n/N$  (i.e.,  $5/1,000 = 0.005$ ) and  $SE = \sqrt{5} / 1000 = 0.0022$ . Thus the tree cover estimate would be 0.5% with a SE of 0.22%.

### References

- Lindgren, BW and GW McElrath. 1969. Introduction to Probability and Statistics. Macmillan Co. London  
 Hodges, JL and EL Lehmann. 1964. Basic Concepts of Probability and Statistics. Holden-Day, Inc. San Francisco.  
 Thompson, S. K. 2002. Sampling, second edition. John Wiley and Sons, Inc., New York, New York.