Using i-Tree Software to Estimate and Value Ecosystem Services

Case of study: Air pollutants removal in Portugal Park

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Abstract— *Over the years, ecosystem services valuation has being used more frequently in order to include the environmental variable among the environmental management process. This paper estimates the potential for atmospheric pollutants removal and their equivalent monetary value at Portugal Park. In order to achieve this objective, the i-Tree Canopy tool, from i-Tree toolkit, was used. The procedure verified that these benefits are equivalent to more than UD$ 400,000, removing an average of 10 kt of atmospheric pollutants. However, the use of this software presents some limitations, such as results depending on the user's ability to classify points and satellite images quality. Also, some degree of generalization was verified by the software's methodology; resulting in the need for a specific database when the desired result requires a more technical and less statistical precision. Therefore, despite these limitations, the use of i-Tree software has shown promising to estimate and value the benefits generated by ecosystem services.*

Keywords— ecosystem services.; ecosystem services valuation; i-Tree; i-Tree Canopy; Portugal Park.

INTRODUCTION

Various environmental experts associate the exclusion of environmental costs from market prices and unsustainable resource use along with population growth and poverty as essential causes of the environmental problems we currently face [3]. According to 225º article from Constitution of the Federative Republic of Brazil, 1988, ensuring that everyone, including future generations, has the right to an ecologically balanced environment is a responsibility of public authority [1].

Therefore, instruments that allow the inclusion of the environmental variable in the activities of the public sphere are needed [5]. This task can be complicated when environmental services are not analysed with a well-defined value, also being often faced as costs rather than investments. For this reason, the valuation of ecosystem services can be seen as an instrument for supporting decision-making in the public management process [6].

Estimating and valuing ecosystem services are valuable tools for evaluating the function of green areas inserted in the urban context. In the case of green areas inserted in the urban context, the data resulting from this quantification can base awareness initiatives on the importance of these areas for human well-being and helps the processes involved in environmental management [6]. Valuation, although less widespread, supports payment programs for environmental services and bases decision-making on public policies [5].

Tree canopies have an important role in urban environments. They bring an array of benefits including psychological and aesthetic effects on humans and climate, and mitigation of air pollution. These benefits increase health, well-being and quality of life to the urban residents [2]. The public domain software i-Tree can examine the potential for these benefits in urban areas. Moreover, the data provided by i-Tree can be used to have a better understanding of the cities surface area, its environmental aspect, improvements and benefits [7].

In this work, the potential for atmospheric pollutants removal and their equivalent value in Portugal Park (Taquaral Park or Lake) were estimated using i-Tree Canopy tool, from i-Tree toolkit.

A. Aims and Objectives

- Undertake a land cover classification of the Portugal Park area using the i-Tree Canopy program;
- Quantify the potential for atmospheric pollutants removal, sequestration and storage of carbon provided by the vegetation inserted in the study area;
- Estimate the monetary value of vegetation benefits.

B. I-Tree Software Overview

i-Tree is public domain and are freely accessible software suite from the USDA Forest Service that provides urban and rural forestry analysis and benefits assessment tools. The tools available in i-Tree help community, private companies and government organizations by quantifying the structure of trees and forests, and the ecosystem services those healthy environments provide [9].

The specific tool i-Tree Canopy uses a simple methodology to quickly produce a statistically valid estimate of land cover use through aerial images available in Google Maps. i-Tree Canopy provides two outputs: the quantity of pollutants removal and their equivalent monetary value [7].

Fig. 1. I-Tree logo [9]

C. Methods

The software was used to examine land cover types with respect to five cover classes (see Table 1) for the Portugal Park, located in Campinas, São Paulo (see Figure 2). This five cover classes were suggested by Reference [4].

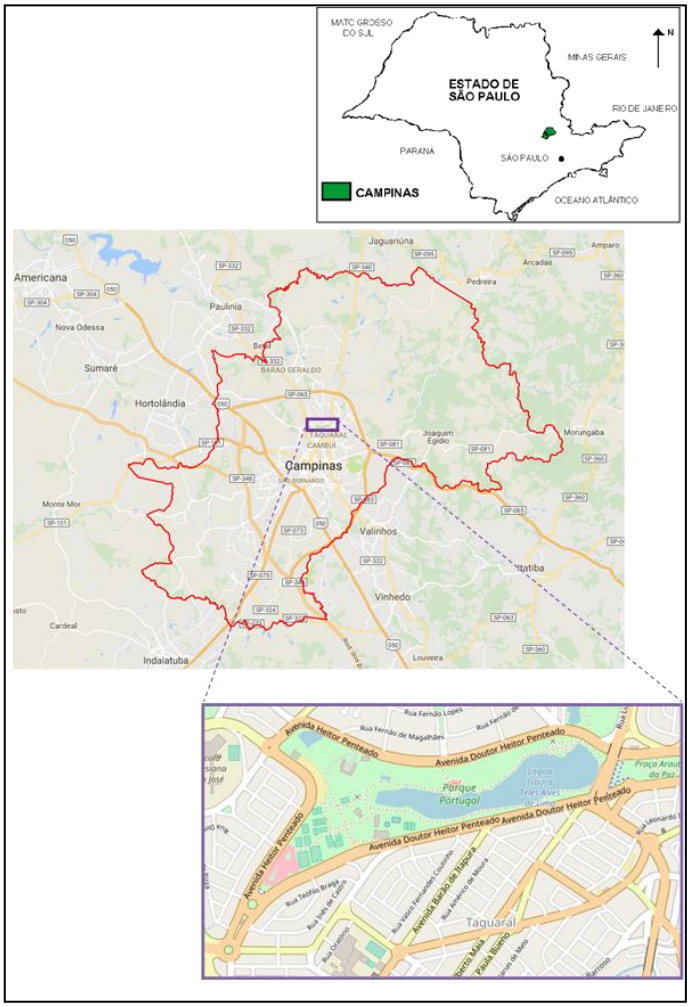


Fig. 2. Portugal Park location

TABLE I. SURFACE COVER CLASSIFICATION

Cover Class	Description
Hard surface (H)	Non-plantable
Aquatic surface (W)	Water bodies
Bare soil (B)	Potentially plantable
Grass and shrub (G)	Developing canopy cover, understory
Tree (T)	Canopy cover

The benefits were estimated based on two scenarios. The first one, considering only tree benefits and the second one considering tree, grass and shrubs benefits. Figure 3 summarizes the procedures conducted:

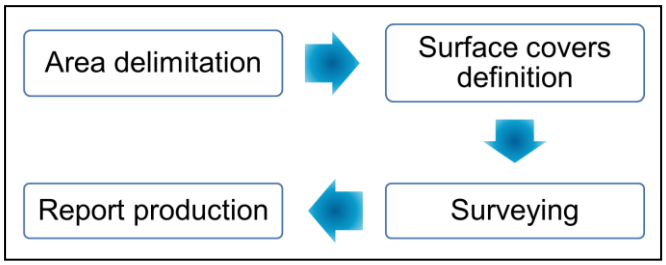
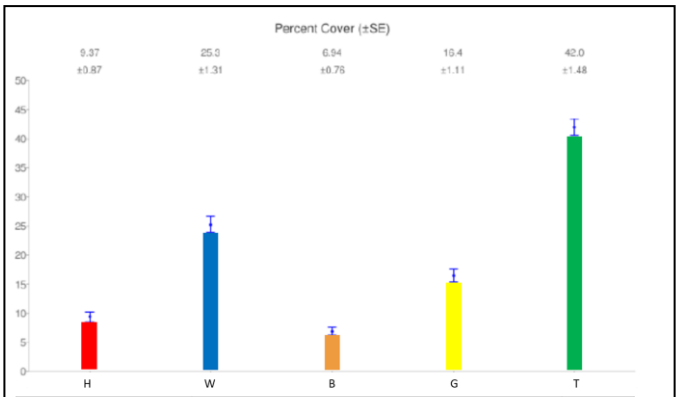


Fig. 3. Methodology Flow-chart

i-Tree Canopy is able to export a report which estimates cover percentages and tree benefits (amount and monetary value). The results refer to annual values, except by carbon dioxide stored in trees [8].

D. Results

The land area of Portugal Park assessed in i-Tree is approximately 800,000 square meters. Overall, tree canopy was the predominant land cover, followed by aquatic surface, grass/shrubs, hard surface and bare soil respectively (see Figure 4).



Cover Class	Description	Abbr.
Hard surface	Non-plantable	H
Aquatic surface	Water bodies	W
Bare soil	Potentially plantable	B
Grass and shrub	Developing canopy cover, understory	G
Tree	Canopy cover	T

Fig. 4. Land use in Portugal Park

Table 2 (scenario 1) and Table 3 (scenario 2) shows the i-Tree assessment results (ecosystem services regarding to pollutants removal amount and monetary value).

Carbon dioxide stock is quantitatively the most significant ecosystem services considered by the i-Tree Canopy. In the first scenario (table 2), the contribution is 7.97kt, which in monetary value represents US$ 308,299.84. In scenario 2 (table 3), the contribution is 10.99kt, equivalent to about $ 428,708.80.

In general, the ecosystem services in atmospheric pollutants removal and their monetary value are 8.28 kt and US$ 321.440.01 for scenario 1; and 11.43 Kt and US$ 446,980.96 for scenario 2.

TABLE II. I-TREE ACCESSMENT RESULTS (TREE)

Pollutants (symbol)	Amount removed (annually)	Value (US$/year)
CO	28,35 Kg	2,66
NO2	154,61 Kg	4,58
O3	1,54 t	238,42
MP 2.5	74,82 Kg	492,86
SO2	97,43 Kg	0,80
MP 10	515,78 Kg	173,09
CO2 (annual)	313,53 t	12.227,76
CO2 (storage) [a.]	7,97 Kt [a.]	308.299,84 [a.]
TOTAL ANNUAL	315,95 t	13.140,17
TOTAL	8,28 kt	321.440,01

[a.] This benefit is not an annual rate.

TABLE III. I-TREE ACCESSMENT RESULTS (TREE + GRASS/SHRUB)

Pollutants (symbol)	Amount removed (annually)	Value (US$/year)
CO	39,43 Kg	3,70
NO2	214,99 Kg	6,37
O3	2,14 t	331,54
MP 2.5	104,04 Kg	685,35
SO2	135,48 Kg	1,11
MP 10	717,22 Kg	240,69
CO2 (annual)	435,98 t	17.003,40
CO2 (storage) [a.]	10,99 Kt [a.]	428.708,80 [a.]
TOTAL ANNUAL	439,33 t	18.272,16
TOTAL	11,43 kt	446.980,96

[a.] This benefit is not an annual rate.

FINAL CONSIDERATIONS

Overall, i-Tree Canopy was a very efficient tool to quantify and value ecosystem services related to air quality. However, the tool has some limitations that, depending on the purpose, may be relevant.

The main limitation is a degree of generalization resulting from the software methodology. For calculation purposes, types of vegetation and their growing phase are not considered. For example, although the user classifies grass/shrub and tree separately, the software assigns the same benefit values to both classes. In fact, more detailed studies indicate that grass, shrubs and trees remove different proportions of atmospheric pollutants [8].

Regarding to the quality of the results, the accuracy of the analysis performed was dependent on three main factors. Firstly, the human ability to correctly classify a point into its correct class. Secondly, the quality of Google Earth imagery (e.g., resolution, shadows). Finally, the number of points classified. As more points are categorized, the precision increases and, consequently, the standard error decreases. In addition, if the number of classes is considerably high, more points will be required to achieve a suitable standard error.

The methodology used in this work concluded that the ecosystem service for pollutants removal in Portugal Park reaches the monetary value of more than US$ 400.000,00. Although very significant, ecosystem services are wider than only maintenance of air quality. Unfortunately, i-Tree Canopy tool, the only one in i-Tree suite that can already be used in Brazil, calculates only air quality benefits. This limitation lies on a lacking Brazilian database. Therefore, the development of this database is crucial for the use of other tools from i-Tree suite and, consequently, for others benefits calculation and valuation.

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