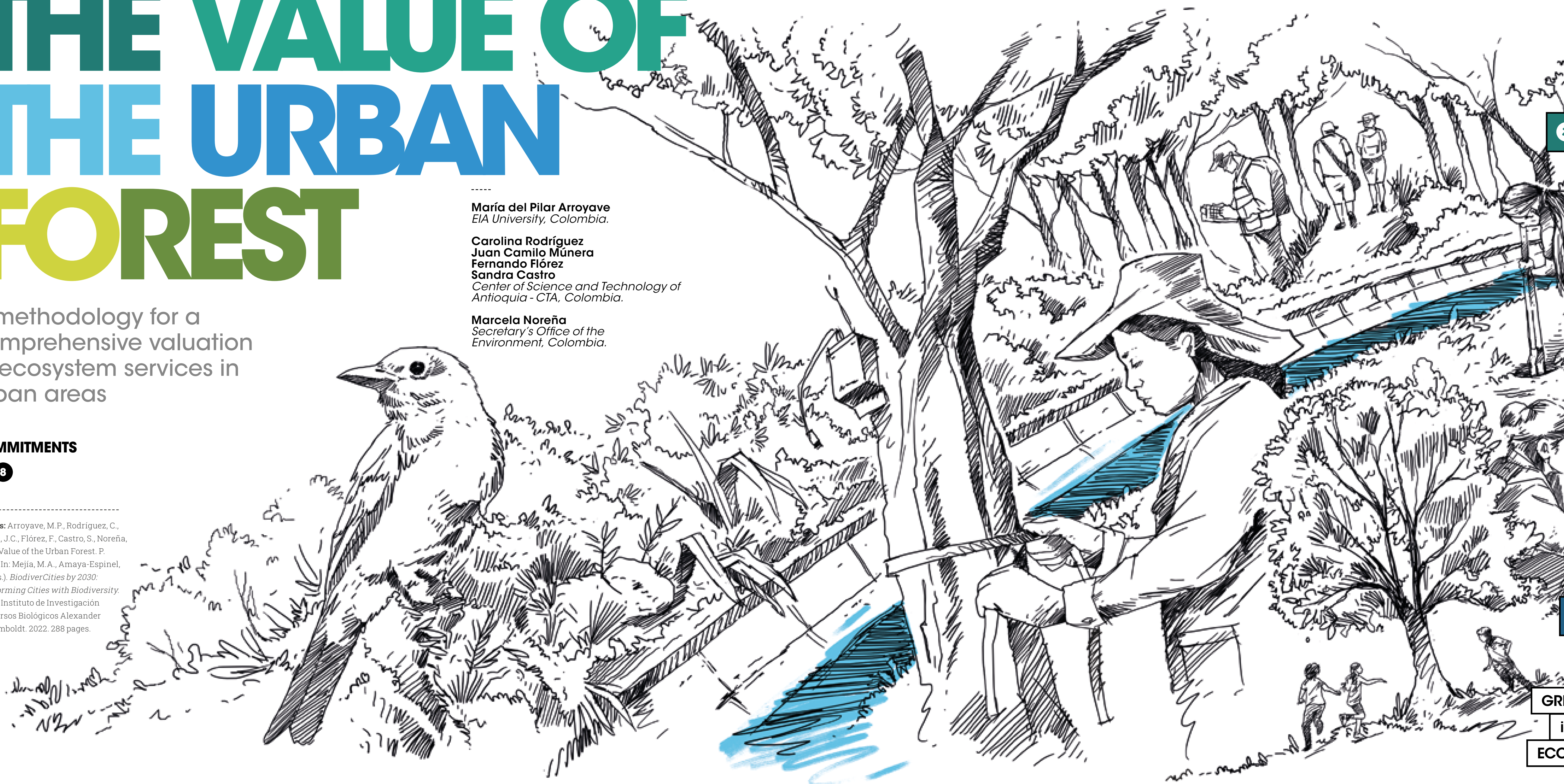
THE VALUE OF THE URBAN FOREST

A methodology for a comprehensive valuation of ecosystem services in urban areas

María del Pilar Arroyave
EIA University, Colombia.

Carolina Rodríguez
Juan Camilo Múnera
Fernando Flórez
Sandra Castro
Center of Science and Technology of Antioquia - CTA, Colombia.

Marcela Noreña
Secretary's Office of the Environment, Colombia.



MEDELLÍN, COLOMBIA

Pop. **2,427,129**

382 km²

1,479 m.a.s.l.

COMMITMENTS

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KEY CONCEPTS

- AIR POLLUTION
- HEAT ISLAND
- GREEN INFRASTRUCTURE
- i-TREE ECO SOFTWARE
- ECOSYSTEM DISSERVICES

A part of La Hueso stream in Medellín, Colombia, was the pilot site for an innovative methodological approach to valuing ecosystem services. By combining ecological, social, and economic components, urban planning institutions and citizens now have a complete picture of the contributions of this stream's biodiversity to human well-being and a tool that can be replicated in other areas.

When forests are not valued, they are increasingly susceptible to development and conversion pressures. Lacking a formal market, these natural assets are traditionally absent from society's balance sheet, and their critical contributions are often overlooked in public, corporate and individual decision-making (U.S. Forest Service, 2007).

The urban forest, in particular, helps mitigate **air pollution**, captures and stores carbon, regulates the water cycle and microclimate, provides habitat and food for wildlife, and represents a significant landscape contribution (Arroyave et al.). For example, the net cooling effect of a single healthy young tree is equivalent to running ten air conditioners in a room for 20 hours a day (McDermott, 2012), thus helping to combat the **heat island** effect. Therefore, it is necessary to make the value of these benefits explicit at a multi-scale level so that decisions made around public and private spaces are informed and contribute to the implementation of climate change mitigation and adaptation mechanisms.

Intending to strengthen **green infrastructure** management, specifically by assessing its benefits, the environmental authority of Medellín developed a methodology that had its first pilot application in La Hueso stream, located in the Atanasio Girardot soccer stadium area. The experience can be replicated in different municipality regions, establishing payment schemes for environmental services based on information that allows companies and citizens to compensate for their carbon footprint. In addition, through this methodology, it has been possible to identify measures to address problems that afflict the city, such as heat islands and air quality.

ECOLOGICAL VALUATION

Three methodologies were employed:

1 I-Tree Eco model

Estimates of carbon storage and sequestration, air pollutant removal, and water regulation.

2 Direct estimations in an experimental plot in a short period

Experimental plot to measure a rainy month.

Measurement of external and internal precipitation in the ground cover to identify canopy interception.

Measurement of soil moisture retention.

3 Establishment of four 10-meter transects to determine microclimate regulation

Installation of devices equipped with sensors for temperature and relative humidity measurement.

Estimation of temperature variation range and specific humidity of the air in each transect, from the green zone to the urbanized areas.

SOCIAL VALUATION

Conduction of 700 perception surveys in the 16 *comunas* of the city and focus groups on the *comunas* of the project's pilot area. These reflected:

Socio-cultural characterization.

Local perception of urban green spaces.

Knowledge about the ecosystem services provided by urban green areas.

Perception of the ecosystem disservices of urban green areas.

Assignment of socio-cultural values of urban green areas identified as providers of ecosystem services.

Needs for the management and social appropriation of knowledge by interested groups.

ECONOMIC VALUATION

Part of the analysis of the ecological assessment results.

Estimation of costs that would have to be incurred if the ecosystem service were unavailable.

Association of ecosystem services that are subject to commercialization with their market price.

Identification of unit values of ecosystem services that can be extrapolated to different areas of Medellín.

PILOT AREA IN LA HUESO STREAM

Sampling polygon
Urban green areas
Trees
Sampling plots
Sampling transects

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Source: Secretariat of Environment of Medellín

BETWEEN THEORY AND PRACTICE

The Secretariat of Environment of Medellín, the CTA, and EIA University developed a two-phase process. First, a state-of-the-art on urban ecosystem services was prepared, and case studies were referenced. Four ecosystem services were prioritized -carbon capture and storage, water regulation, microclimate regulation, and pollutant removal- and variables with the most significant impact were characterized. Finally, a methodology for their assessment was proposed. Then, in the second stage, La Hueso stream was chosen as a pilot site, and the proposal was applied, which contemplates three assessments: ecological, social, and economical.

ECOSYSTEM SERVICE	ECOLOGICAL ASSESSMENT IN THE PILOT AREA (What is the ecosystem supply?)	SOCIAL ASSESSMENT (Percentage of the population that identifies the ecosystem service)	ECONOMIC ASSESSMENT: UNIT VALUE ($/TON)	ECONOMIC ASSESSMENT: VALUE FOR THE PILOT ZONE ($)
CARBON STORAGE	4,195 tons of stored carbon, equivalent to 15,384 tons of carbon dioxide.	**35 %**	COP 128,272 per ton in storage	COP 1.971.795.023
CARBON SEQUESTRATION	231 tons of carbon captured per year, equivalent to 847 tons of carbon dioxide.	**35 %**	COP 128,272 per ton captured	COP 108,495,674/year
REMOVAL OF AIR POLLUTANTS	3671 kilograms of pollutants removed per year: 1419 kg/year of nitrogen dioxide (NO_2), 1448 kg/year of ozone (O_3), and 803 kg/year of PM2.5	**80 %**	Not available	COP 9,972,304/year for deaths averted and COP 898,391/year for cases of disease averted.
WATER REGULATION	The experimental results suggest that surface runoff can be close to 50% of total precipitation, in contrast to impermeable urbanized areas where it is 100%.	**11 %**	COP 16,100 per m^2 of green infrastructure	COP 5,966,086,907 per year
MICROCLIMATE CONTROL	Differences of up to 8 °C between the sensors closest to the green zone and those farthest from it.	**53 %**	COP 12,439 per m^2 of tree cover	COP 6,141,637,500 per year

THREE METHODS IN ONE MODEL

For *ecological assessment*, carbon storage and sequestration, air pollutant removal, and water regulation were estimated using the **i-Tree Eco software.** (USDA Forest Service, 2017). This model requires a secondary and field data collection phase, followed by data processing and results analysis.

An experimental plot was established to complement the quantification of water regulation in a green zone of the pilot area, where measurements were taken on a rainy month. This way, it was possible to recognize the importance of the combined effects of water interception in the trees and its storage in the soil to reduce overflow.

Subsequently, four different parameters representing urban green areas of varying shapes and sizes were established to estimate microclimate regulation. The range of temperature variation and specific air humidity was assessed, determining how they changed from green areas as they approached urbanized areas.

The *social assessment* mainly used two tools. The first consisted of a perception survey, with a sample of 700 surveys in the 16 *comuna* of the city. This allowed the socio-cultural characterization of the surveyed population and the local perception of urban green areas, identifying their uses and knowledge about the existing supply of ecosystem services. Perceptions about possible **ecosystem disservices** were also collected.

The second was creating a focus group in the pilot area with various stakeholders (public, institutional, community), who, based on their experience and knowledge, carried out a socio-cultural assessment of the ecosystem services associated with the study area.

Unit values were compiled for the *economic assessment* based on the results obtained in the pilot zone. Then, based on these, unit values were obtained that can be extrapolated to other areas of Medellín. Different benefits were considered for each service: health benefits for pollutant removal, reduction in pressure on the public sewer in the case of water regulation, and thermal comfort for microclimate regulation. For these services, the assessment method was the avoided cost method, which estimates the value of the costs that would have to be incurred if the ecosystem service were not available. Meanwhile, carbon storage and sequestration were valued by associating them with the market price at which they are traded.

A NECESSARY STANDARD

It is essential to comprehensively assess the benefits that green areas provide to the population to inform urban planning processes. This assessment makes it possible to create schemes that encourage a balance between green, blue, and gray infrastructures and provide a sustainable territorial offer. Having a standardized methodology based on scientific concepts such as the one developed and validated in the case of the municipality of Medellin will make it possible to establish a baseline on the ecosystem supply and analyze how it changes over time. This represents a valuable tool for decision-making by local and environmental authorities.

KEY LESSONS

- The i-Tree software is an effective tool for the ecological assessment of urban ecosystem services. It yields valuable results in a short period of time for the management of urban green spaces.
- This assessment exercise can be an input for creating new carbon footprint offsetting schemes to be applied in urban areas. It can also be used to manage green infrastructure, for example, when issuing a building permit and establishing its cost.
- The structural analysis of trees, green areas, and their ecosystem services can be the source of information for an urban forest observatory that measures the quality of this resource. The project could then lead to an indicator monitoring exercise that measures the supply of ecosystem services over time and the perception that citizens have of these benefits.
- In the planning stage of an urban development project, the information obtained through the ecosystem service assessment would make it possible to evaluate the opportunity cost of the ecosystem service that will be affected.
- This analysis of different dimensions contributes to meeting the standards outlined in international programs such as Tree Cities of the World, which seeks to recognize those cities committed to properly managing and assessing their trees.
- The project sheds light on possible changes that can be implemented in the flow of resources. For example, the design of payment programs for urban ecosystem services could be based on economic value rather than opportunity cost through this information.
- These inputs feed into the monitoring and follow-up system to implement nature-based solutions for renaturalization and biodiversity enhancement.