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Trees and Crime in Bogota, Colombia: Is the link an ecosystem disservice or service?

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ABSTRACT

There is a perception that increased forest cover and density in urban contexts is associated with increased criminality. But, this complex relationship between urban vegetation, crime, ecosystem services (ES) and disservices (ED), has been little studied in low and middle income countries. This study's aim was to statistically determine if specific structural and socioeconomic characteristics of urban treescapes were related to crime occurrence, considered an ED, in a major Latin American city. We used spatial and statistical analyses of a public tree inventory, homicide occurrence, and available geospatial data to analyze if urban treescape, demographic, and socioeconomic variables were related to the incidence of homicides in Neotropical Bogota, Colombia. First, a generalized linear model indicated that fewer homicides occurred in public treescapes with taller trees and higher tree density. In contrast, the amount of overall green space and average tree basal area were not significant predictors of homicide occurrence. Second, a geographically weighted regression model indicated that the inclusion of tree basal area rendered tree height insignificant, and that higher basal areas were associated with fewer homicides. Thus, both models indicated that increased tree density and size were actually associated with lower homicide occurrences. The amount of public green areas was however, not significantly related to homicide occurrence. Results indicate that in general, Bogota´s treescapes provided overall net ES as opposed to ED in terms of crime. Findings could be used to develop land use policies and management practices that increase the overall provision and demand for ES from urban forests.

1. Introduction

The presence and characteristics of urban vegetation have been tied to both socio-environmental benefits but also costs, such as levels of criminality (Lafortezza et al., 2009; Sander and Zhao, 2015; Scopelliti et al., 2016; Troy et al., 2012). Studies report that dense vegetation can be actively used by criminals to hide or identify crime victims (Forsyth et al., 2005; Michael et al., 2001). On the contrary, several other studies show an inverse relationship between crime levels and presence of vegetation across different land uses (Kuo and Sullivan, 2001; Salazar, 2014; Troy et al., 2012). For example, trees in public rights of way have been associated with lower crime rates in the United States (US; Donovan and Prestemon, 2012). Similarly, incidences of theft in Colombia were lower in public areas with increased tree planting activity (Carriazo and Tovar, 2016). A review of ten studies of green spaces and their relationship with incidents of crime and violence in the US, also found that green spaces reduce rates of violence and crime, leading to the conclusion that green spaces can promote healthy environments (Bogar and Beyer, 2015). However, such studies relating urban trees and crime are mostly from high-income countries, especially in North America and Europe, while very few publications are from low and middle income countries (Carriazo and Tovar 2016; Maruthaveeran and Konijnendijk, 2015).

According to the relevant body of literature, the relationship between the incidences of, and propensity to commit, crime in urban green spaces is mixed (Donovan and Prestemon, 2012; Kuo and Sullivan

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2001; Maruthraveeran and Konijnindijk, 2014, 2015; Troy et al., 2012). But, the relationships between urban ecosystem structure (i.e., amount, cover, density and distribution of an ecosystem´s biotic attributes) and the provision of different socio-cultural ecosystem services (CES) and their benefits has been well established (Deng, 2015; Jorgensen et al., 2002; Donovan and Prestemon, 2012). For instance, relaxation and stress reduction are well documented CES provided by urban parks and gardens (Konijnendijk et al., 2013; Lafortezza et al., 2009; Ward Thompson et al., 2012). Urban green areas are also reported to increase the perception of self-reported health of those living nearby (Maas et al., 2006; Ordóñez and Duinker, 2014; Scopelliti et al., 2016). Strengthening of social interactions through passive recreation and sport activities has also been described as a benefit (Coombies et al., 2010; Ordóñez and Duinker, 2014; Maas et al., 2009). As in the case of urban trees and crime, studies of urban CES from high income countries in Europe, the United States (US) and Canada are common, while there are far fewer studies linking urban trees and CES in low-middle income countries (Ordóñez and Duinker, 2014).

These benefits, or ecosystem services (ES; Costanza et al., 2017), are provided by natural and semi-natural areas in cities and accordingly there have been several studies on these (Lafortezza et al., 2009; Sander and Zhao, 2015; Scopelliti et al., 2016; Troy et al., 2012). More recently the related concept of ecosystem disservices (ED) is increasingly being mentioned and cited in the ES literature as it refers to the overall adverse effects that result from nature and as such, these EDs are the net costs - monetary and non-monetary - to human well-being that result from ecological structures and their functions (Escobedo et al., 2011; Lyytimäki, 2015; von Döhren and Haase, 2015). That is, just as ecosystem structures and their functions provide services and subsequent monetary and non-monetary benefits to humans, so to can ecosystem structure and functions result in EDs and subsequent financial and non-financial costs (Escobedo et al., 2011).

However, most of this literature is in the form of reviews, so hypothesis-driven research studies modelling the ecosystem structure-ED nexus are lacking (Lyytimäki, 2015; von Döhren and Haase, 2015). Escobedo et al., (2011) groups these ED into 3 classes: financial, environmental, and social nuisances. Thus, accounting for ED in these types of ES assessments is important as the above literature on urban ES and ecosystem function in human-dominated ecosystems has consistently indicated that humans do perceive detrimental ecosystem functions and subsequent costs to green spaces. As a result they do indeed “pay” for and “suffer” from these costs related to trees in cities, in the form of maintenance, allergies, debris, litter, nuisance wildlife attraction, damage to buildings/roads, and perceived costs such as fear, nuisances, and also crime (Dobbs et al., 2014; Shackleton et al., 2016).

This link between vegetation attributes (i.e., ecosystem structural characteristics) and crime has been well studied as previously explained. Jorgensen et al. (2002) found the spatial arrangement of woodlands to be the most important factor in perceived safety. Troy et al. (2012) and Donovan and Prestemon (2012) attribute such relationships to the increased attraction and increased use of public vegetated spaces, as criminal activities are made more difficult in crowded environments. Reduced crime may also be an indirect effect of green spaces, as stress and mental fatigue can be mitigated by vegetation, attenuating the inclination for violent behavior (Kuo and Sullivan, 2001). This was supported by Gilstad-Hayden et al (2015), who found that greater tree canopy cover was associated with lower violent and property crime rates in New Haven, US, and Wolfe and Mennis (2012), who found that violent crime incidence was lower with greater presence of vegetation. Similarly, greening of vacant lots has also been reported to reduce violent crimes in cities (Garvin et al., 2013; Kondo et al., 2016). Kondo et al., (2017) also found that after adjusting for six socioeconomic factors, including income and racial demographics as well as alcohol-related access and crime, gunshot assault was inversely related to tree cover in low-income areas of Philadelphia, USA. In one of the few studies in developing countries, increased tree planting activity was associated with decreased incidences of thefts in Bogota, Colombia (Carriazo and Tovar 2016). Indeed, all these studies together depict the presence of complex relationships between the presence and characteristics of urban vegetation and crime.

However, crime in urban contexts has not been frequently studied using the ES or ED framework (Escobedo et al., 2011; Shackleton et al., 2016; von Döhren and Haase, 2015). Although authors have not directly analyzed for crime as an ED, studies have analyzed the role of the spatial characteristics of woodlands on perceived safety and preferences (Jorgensen et al., 2002), and tree characteristics on their relationship with crime (Deng, 2015). Crime in the form of urban violence has been traditionally studied with an epidemiological approach, to identify neighborhood-level environmental and social factors associated with increased levels of violence (Morenoff et al., 2001). For instance, the United Nations Human Settlements Programme (Habitat) reported that crime levels result from the interaction of three types of variables: institutional, social, and physical (CNUAU, Habitat, 2009). Although multiple methods and approaches have been used to address the topic, the fundamental question in most of the urban-crime literature is: what neighborhood, land use, and inherent social phenomena facilitate or reduce crime in comparison to other nearby locations (Morenoff et al., 2001)?

For example, Morenoff et al. (2001) introduced the idea that spatial autocorrelation must be taken into account since political borders often do not describe the spatial distributions of social phenomena. More recently, spatial analyses of urban crime have studied the effect of land use and alcohol sale density on violence in Cincinnati, US (Pridemore and Grubesic, 2012). Similarly, nationwide studies in the US have explored the spatial relationships between socio-demographic variables and crime rates across spatial-administrative scales (Messner and Anselin, 2004). Morenoff et al. (2001) approach shows the difference in perspectives and methodologies used to study violence: from initial studies that conceived violence as an emergent property of structural characteristic and sociodemographic variables, to others that use spatial analyses and are heavily influenced by an epidemiologic approach to inquire about the associations between events and the influence of structural sociodemographic variables.

Many of these studies from high-income countries have been based on publically available spatial, green space, site, demographic, socioeconomic and crime statistics data (Deng, 2015). However, such data is rarely available in low and middle-income countries. Most of this research also relies on remotely sensed imagery without information on individual tree and site characteristics (Donovan and Prestemon, 2012; Wolfe and Mennis, 2012). As such, studies from developing countries that use actual tree structural measurements, demographic and geospatial data, and appropriate statistical modelling approaches are rare and could fill a void in the understanding of the dynamics of documented ES/ED from treescapes and urban and peri-urban forests in rapidly growing and highly populated cities. Also, if we understand how the ES and ED from treescapes affect overall well-being, such research provides decision makers the information and measurable indicators necessary to minimize ED. This has relevance in places such as Bogota as trees are a local government’s responsibility and, accordingly, there are several policies directing their establishment, maintenance and removal in both public and private lands.

To these ends, this study’s aim is to better understand if and how specific tree, palm and shrub structural characteristics (i.e. crown cover, densities, heights) are related to crime occurrence, an ED, in a major Latin American city. Specifically, our objectives are two-fold. First, we statistically and spatially identify specific urban tree structural and site predictor variables that can be used to better understand the effect of treescapes on homicide occurrences. Second, we use the ES-ED framework to link such structural characteristics to crime incidence and determine if treescapes are an ED when it comes to crime and thus contribute to a marginal decrease in overall well-being (i.e., cost; Shackleton et al., 2016). We hypothesize that treescapes dominated by