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# Role of Plant Canopy in Reducing Carbon Footprint of an Institutional Area

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**ABSTRACT:** Plant canopy offer significant benefits in reducing building air-conditioning demand and improving urban air quality by reducing smog. The savings associated with these benefits vary by climate region and can be up to \$200 per tree. The cost of planting trees and maintaining them can vary from \$10 to \$500 per tree. Tree-planting programs can be designed to have lower costs so that they offer potential savings to communities that plant trees. Our calculations suggest that plant canopy play a major role in sequestering CO<sub>2</sub> and thereby delay global warming. We estimate that a tree planted avoids the combustion of 18 kg of carbon annually, even though it sequesters only 4.5-11 kg (as it would if growing in a forest). In this sense, one shade tree canopy is equivalent to three to five forest trees. In a recent analysis we estimated that planting an average of four canopy trees per house (each with a top view cross section of 50 m<sup>2</sup>) would lead to an annual reduction in carbon emissions from power plants of 16,000, 41,000, and 9000 t, respectively (the per-tree reduction in carbon emissions is about 10-11 kg per year). These reductions only account for the direct reduction in the net cooling- and heating-energy use of buildings. Once the impact of the community cooling is included, these savings are increased by at least 25%.

Climate change influences on pests and pathogens are mainly plant-mediated. Rising carbon dioxide and temperature and altered precipitation modifies plant growth and development with concomitant changes in canopy architecture, size, density, microclimate and the quantity of susceptible tissue. The modified host physiology and canopy microclimate at elevated carbon dioxide influences production, dispersal and survival of pathogen inoculum and feeding behaviour of insect pests. Elevated temperature accelerates plant growth and developmental rates to modify canopy architecture and pest and pathogen development. Altered precipitation affects canopy architecture through either drought or flooding stress with corresponding effects on pests and pathogens. But canopy-level interactions are largely ignored in epidemiology models used to project climate change impacts. Nevertheless, models based on rules of plant morphogenesis have been used to explore pest and pathogen dynamics and their trophic interactions under elevated carbon dioxide. The prospect of modifying canopy architecture for pest and disease management has also been raised. We offer a conceptual framework incorporating canopy characteristics in the traditional disease triangle concept to advance understanding of host-pathogen-environment interactions and explore how climate change may influence these interactions. From a review of recent literature we summarize interrelationships between canopy architecture of cultivated crops, pest and pathogen biology and climate change under four areas of research: (a) relationships between canopy architecture, microclimate and host-pathogen interaction; (b) effect of climate change related variables on canopy architecture; (c) development of pests and pathogens in modified canopy under climate change; and (d) pests and pathogen management under climate change.

**KEYWORDS:** Plant canopy, reducing, carbon, footprint, institutional, area, architecture, climate, management

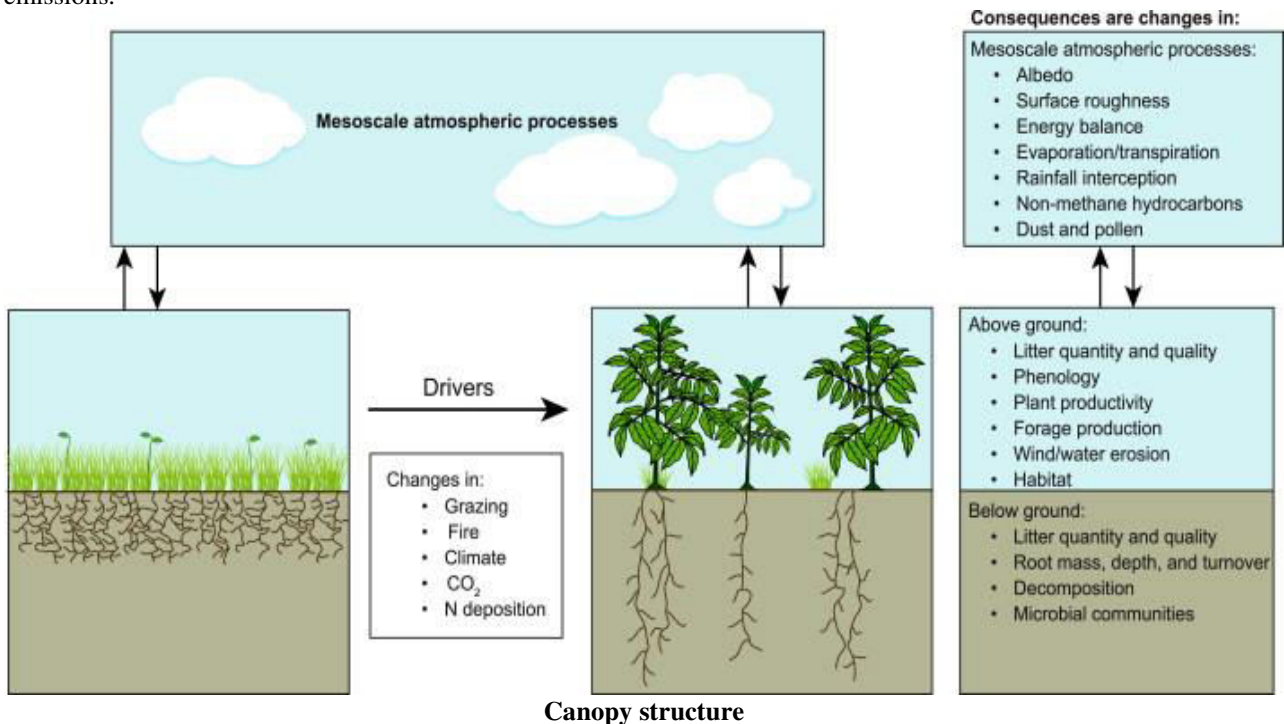


I. INTRODUCTION

We are at the beginning of the urban century. One of the preeminent tasks of cities will be making themselves vibrant, healthy, attractive places to live. This report has focused on just one small part of this task: the quest to make urban air healthier. Cities continue to strive to reduce concentrations of particulate matter and other atmospheric pollutants. And they are beginning to plan for the increased frequency and intensity of heat waves that climate change will likely bring. Succeeding against these twin challenges—air pollution and excess heat— will require an array of approaches. In this report, The Nature Conservancy – in coordination with C40 Cities Climate Leadership Group – has tried to understand whether nature can play a role in helping to solve these twin challenges. The answer appears to be a qualified “yes.” Institutional trees can be a part of a cost-effective portfolio of interventions aimed at controlling particulate matter pollution and mitigating high temperatures in cities. While trees cannot and should not replace other strategies to make air healthier, trees can be used in conjunction with these other strategies to help clean and cool the air. Moreover, trees provide a multitude of other benefits beyond healthier air. In the right spot, trees can both help make our air healthier and our cities more verdant and livable[1,2]

The present work is a sustainability initiative to inventory the trees of institutional campus and compute their carbon storage capacity. AGB and BGB were also estimated using the non-destructive method. A total of 1997 trees belonging to 45 different species have been recorded on the institutional campus, with the carbon sequestration potential of 139.9 tons. The ratio of native to non-native species on the campus is approximately 1:1. The results of the study illuminate the value of urban trees, not only as ornamental and aesthetic plantations but also in mitigating the impacts of climate change at a local level. Higher education institutes have an important role in expanding their green cover so as to act as local carbon sinks. It is also imperative that more native species should be planted as compared to the exotic species. The results of the study can be used for future on-campus greening plans, and act as a baseline for future assessments of the campus carbon sink. Such education institutes can model themselves as agents of change and influence student behavior by undertaking such sustainable green practices on campus.

With a lack to address climate change, cities, the private sector, and institutions have shouldered much of the work to reduce carbon dioxide (CO<sub>2</sub>) and other greenhouse gas emissions. This study aims to determine how landcover characteristics influence the amount of carbon (C) sequestered and respired via biological processes, evaluating the role of land management on the overall C budget of an urban university. In this study, we digitized and discretized each Indian University’s three urban campuses into landcover types, with C sequestration and respiration rates measured and scaled to provide a University-wide estimate of biogenic C fluxes within the broader context of total University emissions.



## II. DISCUSSION

Our study quantifies the role of urban landcover in local C budgets, offering insights on how landscaping management strategies—such as decreasing mulch application rates and expanding tree canopy extent—can assist universities in minimizing biogenic C emissions and even potentially creating a small biogenic C sink. Although biogenic C fluxes represent a small fraction of overall anthropogenic emissions on urban Indian institute and university campuses, these biogenic fluxes are under active management by the university and should be included in climate action plans.

Ecosystem C exchange includes uptake of C through photosynthesis and losses through respiration, with the difference between these two processes resulting in either a biological sink (uptake) or source (release) of atmospheric CO<sub>2</sub>. Soil respiration contributes about 70% of respiratory losses in CO<sub>2</sub> in temperate forests while CO<sub>2</sub> fluxes from soil respiration in lawn and landscaped landcover in urban areas can be the same order of magnitude as fossil fuel emissions, especially in intensively landscaped environments such as suburbs. Management choices to amend the soil (e.g. addition of compost and mulch) can more than double CO<sub>2</sub> respiration rates relative to nearby rural forests. Increased rates of soil respiration due to mulch application, for example, mean that landscaping “beautification” efforts can have significant effects on the rate and magnitude of C emitted from soils. Landscaping maintenance activities also have direct fossil fuel emissions associated with activities such as crew and product transportation, lawn mowing, leaf blowing, canopy structure and fertilizer application, as well as the operation of bucket trucks, chainsaws, and wood chippers during tree maintenance. Landcover management decisions in institutional areas therefore have the potential to greatly influence the direction and magnitude of biogenic C cycling in urban ecosystems.[3,4]



### The carbon balancing act

High rainfall intensity causing high erosion rates. Land cover conditions greatly determine water degradation in the hydrological cycle. The shape and type of plants canopy have significant effect on soil structure and water absorption. The role of plant canopy on the value of rainwater canopy escape as a supporter of hydrological cycle. Tree species were determined based on the level of dominance at study site using transect method. The dominant trees are Sea Sengon Tree (*Paraserianthes falcataria*), Teak Tree (*Tectona grandis*), Suren Tree (*Toona sinensis*) and Durian Tree (*Durio zibethinus*). The results showed that high rainfall intensity with a long rain period affected the amount of canopy escape. Durian Tree has highest canopy density with value of 0.301, and Sengon Laut is the lowest with value of 0.240. The value of passing the canopy of the Suren Tree is lower than the other tree species. The shape of canopy of Suren tree, which is round and oval, also affects the lower pass value of canopy compared to other tree species. The higher the value of canopy density can reduce the value of canopy escape to support the hydrological cycle even in institutional areas.[5,6]



*Tectona grandis*

Canopy structure is the organization or spatial arrangement (three-dimensional geometry) of a plant canopy. Leaf area index (LAI), leaf area per unit ground area, is a key measure used to understand and compare plant canopies.

The canopy is taller than the understory layer. The canopy holds 90% of the animals in the rainforest. They cover vast distances and appear to be unbroken when observed from an airplane. However, despite overlapping tree branches, rainforest canopy trees rarely touch each other. Rather, they are usually separated by a few feet.

Dominant and co-dominant canopy trees form the uneven canopy layer. Canopy trees are able to photosynthesize relatively rapidly due to abundant light, so it supports the majority of primary productivity in forests. The canopy layer provides protection from strong winds and storms, while also intercepting sunlight and precipitation, leading to a relatively sparsely vegetated understory layer.[7,8]

Institutional canopies are home to unique flora and fauna. Some biodiversity resides in the canopy of institutions. The canopy is below the emergent layer, a sparse layer of very tall trees, typically one or two per hectare. With an abundance of water and a near ideal temperature in rainforests, light and nutrients are two factors that limit tree growth from the understory to the canopy.

In the institutional community, the canopy is the highest of seven layers.

### III. RESULTS

Institutional Canopy soils, also known as arboreal soils, exist in areas of the canopy in any institution where branches, crevices, or some other physical feature on a tree can accumulate organic matter, such as leaves or fine branches. Eventually, this organic matter weathers into some semblance of a soil, and can reach depths of 30 cm in some temperate rainforests. Epiphytes can take root in this thin soil, which accelerates the development of the soil by adding organic material and physically breaking up material with their root system. Common epiphytes in the canopy soils in temperate rainforests include mosses, ferns, and lichens. Epiphytes on trees in the temperate zone are often ubiquitous and can cover entire trees. Some host trees house up to 6.5 tons dry weight of epiphytic biomass, which can equate to more than 4x of its own foliar mass. This massive presence means their dynamics need to be better understood in order to fully understand institutional dynamics. The nutrients that become stored within canopy soils can then be utilized by the epiphytes that grow in them, and even the tree that the canopy soil is accumulating in through the growth of canopy roots. This storage allows nutrients to be more closely cycled through an ecosystem, and prevents nutrients from being washed out of the system.

Numerous factors are involved in evaluating the characteristics of a developing canopy soil. The types of plant material that accumulate on canopy soils can strongly influence the conditions that develop, including pH, moisture content, nutrient content, and nutrient availability for the soil. The age of the canopy is also important to its development. Older canopies can accumulate more material and create a deeper soil. Within the soil, the organic material will further decompose in an older canopy soil, and will have less fibrous material than a younger canopy soil. Perhaps more intuitively, the height at which organic material begins to accumulate can also significantly impact the development of canopy soils. Canopy soils higher in a forest's canopy will be more exposed to the elements, resulting in a higher exposure to sunlight and wind, which could result in extreme shifts in available soil moisture.[9,10]

Most epiphytes have very shallow root systems, mainly used to attach them to their host tree. Thus moisture-dependent epiphytes in shallow root systems are more sensitive to changes in moisture content, and at risk of desiccation. In contrast, canopy soils that form lower in the canopy are more likely to be sheltered from more extreme swings in light exposure and moisture content. Additionally, lower canopy soils also have a greater chance of accumulating organic



matter that falls from higher neighboring trees, or from the higher regions of the tree housing the canopy soil. This allows these lower canopy soils to accumulate more organic matter and nutrients, which allows them to be more productive.

The organisms that inhabit a soil significantly influence the development and the turnover time of nutrients, and the same is true for canopy soils. Macro-organisms such as mites and maggots can consume organic material and break it down in their digestive tracts, aiding in the mixing and formation of soil. Microorganisms such as bacteria and fungi essentially serve the same purpose, but use different degradation pathways. The presence of these organisms is critical in maintaining the nutrient cycles within the soil, and make available the necessary nutrients for the growth of epiphytes and the micro-ecosystem. The microorganism community found in canopy soils has been found to be distinct, but similar to the communities found in the soil of the forest floor. Generally, bacterial communities from fallen epiphytic material are quickly replaced by forest floor bacterial communities, although not completely. Also, when limbs of a host tree containing canopy soils have been severed from the host, a shift in the bacterial community within the soil can be measured. This indicates that the communities contained in the canopy have some reliance on the host tree.[11]

#### IV. CONCLUSION

Canopy research is a relatively new scientific field which was hampered for a long time by lack of means of access to the tree canopies and lack of appropriate means of housing researchers.

Climbing gear, tree houses, canopy walkways, cranes, airships, institutional canopies and inflatable platforms resting on the treetops have lately overcome these barriers.

- Cranes have proven to offer the best three-dimensional access. The effort to set them up is worthwhile, as most research projects are long term.
- Airships (or dirigibles, or blimps) offer the best means of accessing large areas of canopy.
- Tree houses are best for housing because they offer dry, light and secure accommodation without cutting down an area of forest.

Canopy architecture in institutional areas can be viewed as a visible but momentary expression of plant form . When used to describe plants, architecture refers to the spatial configuration of the aboveground plant organs and implies that this configuration has functional significance . The concept of plant canopy architecture is, in many ways, an abstraction that relates plant form to an orderly, genetically determined “growth plan.” The relationship between genetic encoded information and the resulting canopy architecture is analogous to that between a blueprint and the building it represents. Unlike buildings, plant canopies are dynamic and constantly changing with time and space in response to their environment. A primary function of plant canopies is to intercept radiation to drive photosynthesis and other metabolic processes. This interception occurs with varying degrees of efficiency, which is determined chiefly by leaf area, configuration relative to the sun, and to a lesser extent the spatial arrangement of leaves in any institution. Other important morphological canopy characteristics include plant height, tillering, branching patterns, and sizes and shapes of individual leaves. At least 90 percent of the biomass of higher plants is derived from CO<sub>2</sub> assimilated through photosynthesis . Because crop growth and yield are determined largely by photosynthesis, they are also highly dependent upon the amount of light intercepted by the canopy. Therefore, in environments in which light is the most limiting factor to crop growth and production, canopy properties that lead to greater interception of sunlight generally increase photosynthesis, and consequently grain or dry matter yield. Conversely, those that lead to poor light interception result in lower growth and yield in institutional canopies. [12]

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