Chapter 17
"Canopy-Less" Monitoring of Biodiversity and Climate Change: Signs of a Leaky Roof

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Bullet Points

1. Monitoring of biodiversity has gained importance in recent decades due to global climate change. Although we have a sizeable percentage of biota locked up in the forest canopies, most monitoring programs have neglected this realm.
2. Remote sensing and Lidar techniques allow for some landscape-level monitoring of canopies. For finer stand-level data, canopy biologists include passive ways of monitoring by collaborating with systems and instrumentation experts enabling dataflow to the ground.

Summary

Forest canopies are considered the last biotic frontier, and studies of canopy biota and related processes are just beginning to emerge in some parts of the world. Monitoring changes in biodiversity and related processes have gained much significance in the few last decades, particularly due to climate change. In addition, changes in biodiversity have been addressed by incorporating monitoring at various spatial and temporal scales that range from landscape-level changes, ecosystem dynamics, to population and species-level processes over extended time scales.

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Most efforts on forest monitoring remain "canopy less" and hence can give an eclipsed view. The main impediment is access for repeated sampling. It is now critical for canopy ecologists to set up a flagship monitoring effort in canopies to incorporate passive monitoring protocols through collaboration with system engineers and instrumentation experts and integrate into ground-level efforts.

1 Introduction

Several anthropogenic factors such as selective logging, agriculture, and fire have led to severe deforestation globally; these are considered as major forces of ecological change throughout tropical regions (Asne et al. 2006; Hansen et al. 2010). A number of studies show that such changes alter species distributions and abundance (Hansen and Defries 2004; Laurance and Peres 2006) and in the future may even lead to the extinction of a large fraction of the species on earth (e.g., Thomas et al. 2004; Raxworthy et al. 2008).

With increasing rise in global CO_2, large-scale changes in the functional aspects of the forests are also getting affected in terms of forest compositional change (Melillo et al. 1996; Houghton et al. 2001) and the dynamics of forest ecosystems (Phillips et al. 1994). Forest canopies are considered the last unexplored biotic frontier in many parts of the world but with potential of having unique biota. Studies of canopy biota and related processes are just beginning to emerge in some parts of the world (Devy and Ganesh 2003; Devy et al. 2012). Forest degradation and climate change are happening at a rapid rate that can affect species uniquely adapted to forest canopies (making them prone to local extinction). For instance, canopy discontinuity affects non-volant canopy mammals like primates, and the disappearance of fog and mist might affect the lichens, orchids, and other bryophytes in the canopy (Lowman and Rinker 2004).

Many of the canopy species provide important ecosystem services such as pollination and pest control and often travel long distances across the mountain landscapes tracking the food resources. For instance, bees in tropics forage on several canopy trees and help in pollination (Devy and Davidar 2003) but are rarely monitored; the emphasis has always been either trees (e.g., Center Tropical Forest Science, USA) or large charismatic mammals (Center for wildlife studies, India). Monitoring is also carried out at ground level, omitting the canopy biota (Devy et al. 2009).

2 "The Third Dimension"

Monitoring landscapes, ecosystems, populations, and species is a complex process (Singh et al. 2010; Müller et al. 2010). Despite these challenges, monitoring has gained much significance in the last decade, with recent emphasis by Hansen et al. (2010) using remotely sensed data. In addition, changes in biodiversity have been addressed by incorporating monitoring at various spatial and temporal scales that range from landscape-level changes, ecosystem dynamics, and population- and species-level processes over extended time scales (Lindenmayer and Likens 2010; Hobbie et al. 2003; Dearing et al. 2006). This "third dimension" comprising the vertical structure of a forest, especially in structurally complex rainforest ecosystems, is an important habitat where most species reside between ground and canopy (Ozanne et al. 2003; Lowman and Nadkarni 1996; Lowman and Rinker 2004; Lowman et al. 2012). The modification of this niche space can strongly affect species as seen in a study on avian assemblages in the rainforests of India where species loss was documented in insectivorous birds of mid-storey following forest disturbance (Vivek and Ganesh 2012). In most of the old world tropics, canopies are poorly explored even from a biodiversity point of view. Therefore, we must initiate short but focused collaborative studies (e.g., IBISCA, Investigating the Biodiversity of Soil and Canopy Arthropods) to collect base line inventory from selected sites before monitoring protocols can be set up.

3 Climate Change and Canopy Monitoring

Large-scale monitoring of tree canopies has been revolutionized by the use of high-resolution satellite imageries and LIDAR (Asner et al. 2007). Studies on carbon sinks in relation to forest canopies and climate change have determined how rapidly newly assimilated carbon(C) is invested into recalcitrant structures of the forests (Free-Air CO_2 Enrichment, FACE, Körner et al. 2005). Recently the Carnegie Institution and its collaborators have started developing new scientific approaches that integrate taxonomic, chemical, and spectral remote sensing perspectives—collectively called spectranomics—to map canopy function and diversity among species throughout tropical forests of the world (Asner and Martin 2009; see chapter by Asner in this volume). The necessity of ground truthing such expansive aerial monitoring is now almost entirely eliminated, given the extraordinary capability of airborne surveys.

Those long-term monitoring sites that currently exist or are planned in the future should involve monitoring components from "soil to canopy" as proposed by Global Canopy Programme (Fig. 17.1). Though some efforts have been done to establish these "Whole Forest Observatories" in parts of America, Australia, Europe, and Malaysia, many forest types in Asia, Africa, and South America have none (Mitchell et al. 2002; Ganesh et al. 2006). Such infrastructure could facilitate long-term data collection synchronously from the ground to canopy and would encourage a diverse range of researchers to participate and contribute to understand forest change.

4 Passive Techniques for Biodiversity Monitoring

Accessibility has been an obvious impediment for major global monitoring programs to have excluded the canopy in their sampling. But with the advent of many data loggers, camera traps, and sound recorders, passive canopy monitoring is

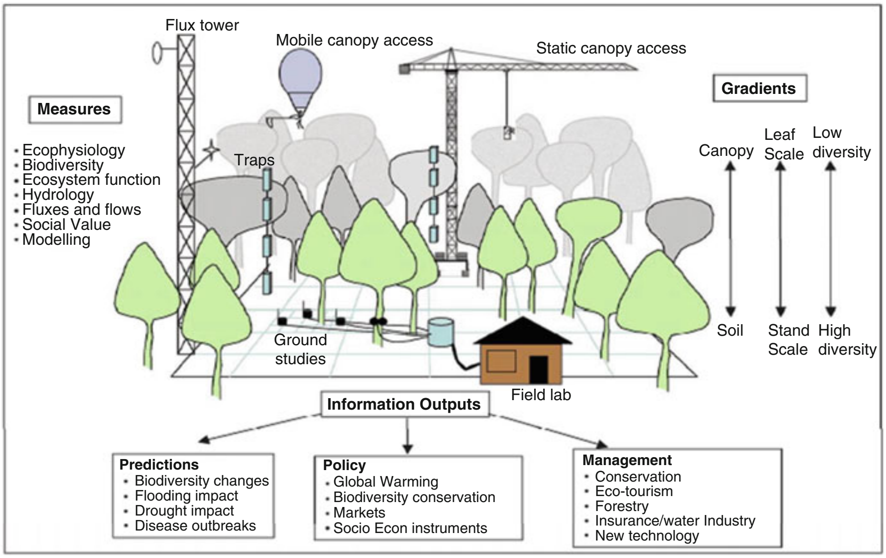

Fig. 17.1 Whole forest observatory for monitoring biodiversity and related processes from soil to canopy as visualized by Global Canopy Programme

simple and reliable (e.g., Lobo et al. 2005; Ganesh and Devy 2012). Even cryptic nocturnal taxa (e.g., frogs and crickets; see chapters in this volume by Seshadri & Ganesh and Jain & Balakrishnan) can be studied using these techniques. Our pilot study in collaboration with Sun Microsystems demonstrated that passive monitoring is feasible by downloading data from data loggers in the canopy from the ground. But there are still major drawbacks to accurately monitoring "the third dimension" with adequate statistics and models (see Nychka and Nadkarni 1990). Perhaps a flagship canopy project, which demonstrates passive monitoring with methodological rigor, could expand global monitoring efforts.

5 Conclusions

Although the above-mentioned efforts may seem an expensive venture, it is only a small percentage of what is invested on polar or space exploration. We strongly advocate for integrated forest canopy monitoring at multiple sites with diverse methods to address challenges including biodiversity loss, environmental change, and ecosystem services.

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