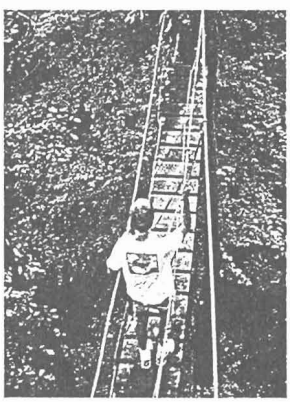
FOREST CANOPIES



Edited by
Margaret D. Lowman & Nalini M. Nadkarni

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Canopy Science: A Summary of Its Role in Research and Education

Nalini M. Nadkarni and Margaret D. Lowman

The time has come when scientific truth must cease to be the property of the few, when it must be woven into the common life of the world.
—Louis Agassiz (1863)

So, what next, we wonder? These chapters attest to the enormous accomplishments gained in the frontiers of canopy biology—most in the last five years. We see many new directions of research to respond to the unanswered questions that arise. Perhaps more significant, we face the challenges of translating the complexities of canopy biology to applied situations and to the people living in or near forest ecosystems. Education on the scientific processes of the canopy is a critical priority, especially because it can be used as an effective tool for forest conservation.

One goal of assembling this book was to allow readers to evaluate the "state of the art" of canopy science. Research accomplishments, gaps in our knowledge of the canopy, and avenues for future investigations are now evident. These authors have documented that the forest canopy is a region of great ecological importance. Forest canopies contain a major portion of the diversity of organisms on Earth and constitute the bulk of photosynthetically active foliage and biomass in forest ecosystems. Members of canopy communities contribute substantially to the dynamics of the forest ecosystems they inhabit.

Studies of canopy phenomena have shifted from earlier, primarily descriptive work. Historically, canopy studies were dominated by people seek-

ing the thrill of climbing and the excitement of discovering a new arboreal species. Early quantitative estimates of the complex nature of the canopy were restricted to ground-based surveys or to short-statured trees. More recently, however, the innovation of high-strength, low-cost climbing equipment has made more detailed canopy study a viable option for scientific research. With the improvement of effective technological climbing methods, the canopy raft, the canopy crane, and ground-based methods such as fogging, researchers can now spend less time figuring out how to work in the treetops and more time recording, analyzing, and interpreting meaningful data and results.

Within the past decade, the amount of information on canopy biology has burgeoned. The number of scientific publications on canopies has grown at a disproportionately rapid pace relative to the general field of biology (Fig. 1). Other evidence for the growing interest in the canopy are recent symposia on canopy biota, books, popular articles, and documentaries. This attention is a consequence both of new techniques for canopy access and of growing concern for conservation issues such as biodiversity, global atmospheric change, and conservation of tropical rain forests.

The research summarized here documents that both the types and amounts of canopy data are changing rapidly. In the last decade, the simplicity of rope climbing generated studies by scientists who worked solo or in small groups and produced fairly small data sets. The more recent development of access techniques that permit teams of scientists to work within

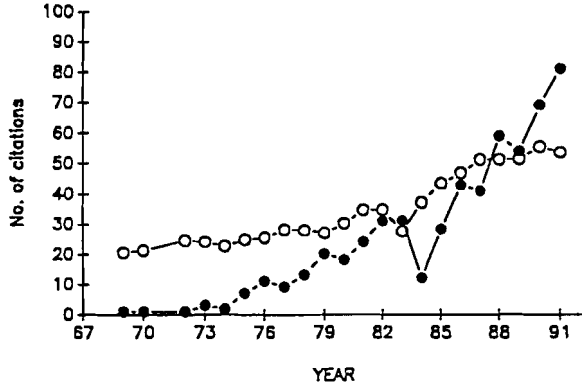

Figure 1 Indication of the rate of scientific literature published on canopy structure compared to the rate of literature published in the general biological literature. Data points are the number of citations with keywords related to canopy structure tallied in a bibliographic search of the data base BIOSIS (solid circles) and the total number of all citations indexed in BIOSIS for that year (×10,000) (open circles). Note that the rate of publications concerning "canopy structure" greatly exceeds the rate of "call citations" after 1984, indicating the explosion of interest and study of forest canopy structure in recent years.

the same volume of the canopy has led to complex data sets whose collecting expense warrants collaborative use.

Scientists are notorious for their independent (at times idiosyncratic) ways of taking, storing, and analyzing data. Because the data from access tools such as construction cranes are expensive and difficult to obtain, canopy researchers will need to deal with (1) new types of data, (2) much more data, and (3) the necessity of sharing data among scientists who have different research questions. We need to plan for developing the means to collect, process, store, analyze, portray visually, interpret, and distribute these types of data. In many ways, the current situation is analogous to what planetary scientists faced when anticipating data from the *Voyager* space probe: large quantities of new types of data that must be shared by a variety of scientists asking different questions.

The field of canopy science is ready for research that will (1) quantify the distribution and abundance of the major canopy components and the processes that link them; (2) formulate protocols that will allow other researchers to gather comparable data on canopy processes, thereby building the available data on canopies for all scientists; and (3) lead to the generation of specific hypotheses that can be rigorously tested.

One approach to integrate canopy research is the Canopy Research Network (CRN), which has received funding from the National Science Foundation (Database Activities Program). It brings together forest canopy researchers, quantitative scientists, and computer scientists to establish methods to collect, store, analyze, and interpret three-dimensional spatial data relating to tree crowns and forest canopies. The CRN mandate is to (1) compile an array of research questions and needs from the canopy research community, (2) examine potentially applicable information models and software tools that are in use in allied fields, and (3) develop conceptual models and recommendations for the types and format of information and analyses necessary to answer research questions posed by forest canopy researchers.

A second approach is to integrate the results of canopy research into the same publications rather than have disciplines appear in an array of disjointed journals as has historically been the case. This volume is a first attempt to unify canopy research results for the scientific audience. Similarly, the journal *Selbyana* has taken the lead in publication of canopy research via the proceedings of the epiphyte and canopy symposia held at The Marie Selby Botanical Gardens in the 1980s and 1990s.

A third approach is to facilitate the communication of research ideas and inspirations, access techniques, and results within and outside of the multifaceted canopy research, education, recreation, and conservation communities. Although much of this communication has occurred among the few canopy scientists through informal "networking" and word-of-mouth ex-

changes, the growing size and diverse interests of current and future canopy workers demand a more formal structure for information transfer. In 1993, the CRN initiated an electronic mail bulletin board for those interested in the canopy, with a first-year subscribership of 250 scientists. A newsletter to summarize and disseminate information to non-computer-linked canopy scientists will be initiated in 1994.

Another conspicuous feature of canopy science highlighted in this book is that few comparative data exist at the ecosystem level. One goal of many canopy researchers is to develop standardized protocols to measure canopy organisms and processes and to compare them directly between ecosystems. In the longer term, canopy scientists envision the incorporation of canopy measurements into many forest studies in a variety of locations: parks, field stations, forest plantations, and university campuses. Ultimately, canopy scientists will be able to generate testable hypotheses based on comparable data that will contribute to our understanding of forest structure and function.

The image of canopy science is generally poor among traditional scientists. Because early canopy biology focused on techniques of getting to the canopy and documenting its poorly known biota, canopy science was viewed by many academics as "Tarzan stuff" or a throwback to nineteenth-century descriptive biology. There is a clear need to continue to explore canopy access methods and to document unknown species. However, work described in this book demonstrates that experimental approaches and theoretical issues are well integrated into canopy science.

How might we improve research and communication in canopy science? First, we must increase communication among canopy scientists. One scenario would be to formalize the existing informal network by establishing an international canopy network, which could publish a regular newsletter and/or journal, stage annual meetings, and produce a directory. Regular international meetings would help to keep colleagues abreast of progress and facilitate personal interactions that lead to collaborative studies.

Second, canopy scientists should be made aware that a wealth of canopy workers exists outside the realm of scientific journals, symposia, and granting agencies. These are the arborists, who are currently more closely allied to horticultural rather than academic worlds. They have their own organizations, publications, and meetings. Major strides may be made if we cross-pollinate ideas and techniques with professional tree climbers, tree surgeons, and tree pathologists.

Third, there are few direct outlets by which scientifically sound information can be shared with the general public. Most research results are presented and discussed at closed scientific meetings. We need to increase the flow of canopy information to the general public. The few outlets of this information to nonscientists have been extremely well received. For

example, Ben Shedd's OMNIMAX film *Tropical Rainforest,* which featured segments on biologists working in the canopy, has received a great deal of positive critical acclaim. In 1994, the Jason Project (an international science education program that broadcasts live from field sites) featured a canopy biologist studying the ecology of rain forest tree crowns in Belize. The success of these popular media treatments of the canopy attests to the inherent interest of the general public in canopy biology.

In the same breath that we advocate greater interest of the general public in forest canopies and encourage the "person on the street" to vicariously take to the treetops, we recognize the need to develop and enforce wise methods of canopy access. There is still no overarching moral ethos for climbing. Anyone can buy a rope and sling it over any tree in any manner. Safety considerations are up to the individual. As with rock climbing and caving, there is a general sense that ethical climbing must be espoused by canopy visitors. This is currently being discussed among arborists, canopy scientists, and science educators.

In this volume, canopy research has been shown to be relevant to both basic biology and applied ecology. One example of how canopy research relates to a major environmental issue is the potential use of epiphytes as indicator species of global atmospheric changes. Human-influenced changes to the atmosphere include the increasing concentration of particular nutrients. Because many epiphytes are partially or entirely dependent on atmospheric sources for their nutrients and water, some species may be highly sensitive to changes in atmospheric chemistry, which in turn would affect those organisms directly or indirectly associated with them. "Vulnerable" epiphytes and their associated biota could serve as biological indicators in the canopy for particular attributes of atmospheric conditions, the proverbial "canaries in the coal mine." The documentation of canopy ecology in "healthy" forests provides a benchmark foundation for future investigations on the effects of atmospheric changes on canopy communities.

Relating basic ecological processes to solving environmental problems is an important, albeit underutilized, application for current biological research. The "Sustainable Biosphere Initiative," generated by the Ecological Society of America in 1991, emphasizes that the exploitation of natural ecosystems may have an irreversible and detrimental effect on the ability of ecosystems to regulate themselves naturally. Ecological understanding of the canopy lags far behind the current knowledge of most other components of terrestrial ecosystems. Understanding the canopy as part of whole-ecosystem processes is an obvious priority if we are to responsibly manage and conserve forests in the future.