

Margaret Lowman · Soubadra Devy
T. Ganesh *Editors*

Treetops at Risk

Challenges of Global Canopy Ecology
and Conservation

 Springer

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Editors

Margaret Lowman
North Carolina Museum
of Natural Sciences
North Carolina State University
Raleigh, NC, USA

Soubadra Devy
Ashoka Trust for Research in Ecology
and the Environment (ATREE)
Bangalore, KA, India

T. Ganesh
Ashoka Trust for Research in Ecology
and the Environment (ATREE)
Bangalore, KA, India

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Foreword

E.O. Wilson has said that we are letting “nature slip through our fingers.” Depleting Earth’s fabric of life means we could slip through hers. In a few decades, I have personally witnessed the loss or serious decline of about half of the coral reefs, kelp forests, seagrass meadows and mangroves, elimination of 90 % of many kinds of fish and other ocean wildlife, creation of hundreds of coastal dead zones, a sharp reduction in oxygen-generating carbon dioxide-absorbing phytoplankton, acidification of the ocean, acceleration of global warming, a swift reduction of polar ice, and introduction of tons of toxins and plastic into the blue heart of the planet.

The good news is that we have arrived at the “sweet spot” in our history. Never before could we so clearly grasp our dependence on – and loss of – intact, living systems that underpin everything we care about. Never again will there be a chance as good as the present time to restore and protect the natural systems that keep us alive. Now we know what no one knew when I was a child. Making peace with nature is the best hope for having an enduring future for humankind.

In this volume, international forest scientists describe the challenges, methods, and their hope for conservation of these terrestrial systems. Like the oceans, forests are critical hot spots for biodiversity, and their future health is intertwined with that of humans.

Raleigh, NC, USA

Sylvia Earle (aka “Her Deepness”)

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Contributors

L.A. Ashton Environmental Futures Centre, Griffith School of the Environment, Griffith University, Nathan, QLD, Australia

Gregory P. Asner Department of Global Ecology, Carnegie Institution for Science, Stanford, CA, USA

M. Baimas-George Department of Biology, Colgate University, Hamilton, NY, USA

Rohini Balakrishnan Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India

N. Barbier IRD, UMR AMAP, Montpellier, France

James Barsimantov Department of Environmental Studies, University of California Santa Cruz, Santa Cruz, CA, USA

Kamaljit S. Bawa Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, KA, India

S.L. Boulter Environmental Futures Centre, Griffith School of the Environment, Griffith University, Nathan, QLD, Australia

T. Bourguignon Department of Biological Sciences, National University of Singapore, Singapore

Anna E. Burns Department of Zoology, La Trobe University, Bundoora, VIC, Australia

C.J. Burwell Environmental Futures Centre, Griffith School of the Environment, Griffith University, Nathan, QLD, Australia

Biodiversity Program, Queensland Museum, South Brisbane, QLD, Australia

Catherine L. Cardelús Department of Biology, Colgate University, Hamilton, NY, USA

Rose Caspa Agronomic and Development Research Institute, Yaoundé, Cameroon

Lynne Cherry Young Voices on Climate Change, Lynne Cherry, Washington, DC, USA

Tiffany Clark Department of Biology, Baker University, Baldwin City, KS, USA
North Carolina Museum of Natural Sciences, Raleigh, NC, USA

P. Couteron IRD, UMR AMAP, Montpellier, France

Mohan P. Devkota Department of Botany, Tribhuvan University, Amrit Campus, Kathmandu, Nepal

Soubadra Devy Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, KA, India

Daniela Dutra Elliott Botany Department, University of Hawaii at Manoa, Honolulu, HI, USA

Alexandra Fischer-Pardow Department of Plant Ecology and Systematics, University of Kaiserslautern, Kaiserslautern, Germany

Evariste Fongzossie Fedoung University of Douala, Douala, Cameroon

Logan Gallardo Department of Biology, Baker University, Baldwin City, KS, USA

North Carolina Museum of Natural Sciences, Raleigh, NC, USA

T. Ganesh Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, KA, India

Frances Gatz Frances Gatz, Environmental Expeditions, Silver Spring, MD, USA

David B. Greenberg Environmental Change Institute, Oxford University Centre for the Environment, School of Geography and the Environment, University of Oxford, Oxford, United Kingdom

School of Geography, University of Leeds, Leeds, United Kingdom

Penelope Greenslade Centre for Environmental Management, School of Science and Engineering, Mt Helen, University of Ballarat, Ballarat, VA, Australia
Australian National University, ACT, Australia

Nimal Gunatilleke University of Peradeniya, Peradeniya, Sri Lanka

Savitri Gunatilleke University of Peradeniya, Peradeniya, Sri Lanka

Andrew J. Hamilton Department of Agriculture and Food Systems, The University of Melbourne, Dookie Campus, Dookie College, VIC, Australia

Harold Heatwole Department of Zoology, North Carolina State University, Raleigh, NC, USA

Rebecca C.-C. Hsu Taiwan Forestry Research Institute, Taipei, Taiwan
Universiteit van Amsterdam, Institute for Biodiversity and Ecosystem Dynamics (IBED), Amsterdam, GE, The Netherlands

Manjari Jain Institute of Evolutionary Biology and Environmental Studies, University of Zurich, Zurich, Switzerland
Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India

Leon Kaganovskiy Touro College, New York, NY, USA

Roland Kays North Carolina Museum of Natural Sciences, Raleigh, NC, USA
Smithsonian Tropical Research Institute, Panama, República de Panamá
North Carolina State University, Raleigh, NC, USA

R.L. Kitching Environmental Futures Centre, Griffith School of the Environment, Griffith University, Nathan, QLD, Australia

Ch. Körner Institute of Botany, University of Basel, Basel, Switzerland

Bhaskar Krishnamurthy TREE Foundation, Sarasota, FL, USA

Jagdish Krishnaswamy Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, KA, India

M.J. Laidlaw Queensland Department of Science, Information Technology, Innovation and the Arts, Queensland Herbarium, Toowong, QLD, Australia

Michael Lakatos Department of Plant Ecology and Systematics, University of Kaiserslautern, Kaiserslautern, Germany

C.L. Lambkin Biodiversity Program, Queensland Museum, South Brisbane, QLD, Australia

William F. Laurance Centre for Tropical Environmental and Sustainability Science (TESS) and School of Marine and Tropical Biology, James Cook University, Cairns, QLD, Australia

Maurice Leponce Biological Assessment Section, Royal Belgian Institute of Natural Sciences, Brussels, Belgium

Simon L. Lewis School of Geography, University of Leeds, United Kingdom
Department of Geography, University College London, London, WC1E, United Kingdom

Zoë Lindo Department of Biology, University of Western Ontario, London, ON, Canada

Wen-Yao Liu Key Laboratory of Tropical Forest Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Yunnan, China

Thomas Lovejoy George Mason University, VA, USA

The Heinz Center for Science, Economics and the Environment, Washington, DC, USA

Margaret Lowman North Carolina Museum of Natural Sciences, North Carolina State University, Raleigh, NC, USA

S.C. Maunsell Environmental Futures Centre, Griffith School of the Environment, Griffith University, Nathan, QLD, Australia

E. McCord Department of Biology and Environmental Studies, New College of Florida, Sarasota, FL, USA

William R. Miller Department of Biology, Baker University, Baldwin City, KS, USA

North Carolina Museum of Natural Sciences, Raleigh, NC, USA

Andrew W. Mitchell Global Canopy Programme (GCP), Oxford, UK

Mark W. Moffett National Museum of Natural History, Smithsonian Institution, Washington, DC, USA

Demetria Mondragón Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional (CIIDIR) unidad Oaxaca, Santa Cruz Xoxocotlán, Oaxaca Mexico

Nalini M. Nadkarni Center for Science and Mathematics Education, University of Utah, Salt Lake City, UT, USA

A. Nakamura Environmental Futures Centre, Griffith School of the Environment, Griffith University, Nathan, QLD, Australia

Bernard-Aloys Nkongmeneck University of Yaoundé I, Yaoundé, Cameroon

F. Ødegaard Norwegian Institute for Nature Research, Trondheim, Norway

Claire M.P. Ozanne Department of Life Sciences, Centre for Research in Ecology, University of Roehampton, Holybourne Avenue, London, UK

Raphaël Pélissier Ecology Department, French Institute of Pondicherry, Pondicherry, India

IRD, UMR AMAP, Montpellier, France

Pierre Ploton Ecology Department, French Institute of Pondicherry, Pondicherry, India

IRD, UMR AMAP, University of Yaoundé I, Yaoundé, Cameroon

Christophe Proisy IRD, UMR AMAP, Montpellier, France

Alex Racelis Department of Environmental Studies, University of California Santa Cruz, Santa Cruz, CA, USA

Department of Biology, University of Texas Pan American, Edinburg, TX, USA

Nitin D. Rai Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, KA, India

B.R. Ramesh Ecology Department, French Institute of Pondicherry, Pondicherry, India

D.C. Randle St. Francis High School, St. Francis, MN, USA

Yves Roisin Evolutionary Biology and Ecology, Université Libre de Bruxelles, Brussels, Belgium

Stefan A. Schnitzer Department of Biological Sciences, University of Wisconsin – Milwaukee, WI, USA

Markus Seibel Geographisches Institut der Humboldt-Universität zu Berlin, Berlin, Germany

Reinmar Seidler University of Massachusetts, Boston, MA, USA

K.S. Seshadri Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, KA, India

Siddappa Setty Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, KA, India

S.P. Singh Centre for Ecology, Development and Research (CEDAR), Dehradun, Uttarakhand, India

Liang Song Key Laboratory of Tropical Forest Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Yunnan, China

Nigel E. Stork Environmental Futures Centre, Griffith School of Environment, Griffith University, Nathan, QLD, Australia

Rajesh Thadani Centre for Ecology, Development and Research (CEDAR), Dehradun, Uttarakhand, India

Tamara Ticktin Botany Department, University of Hawaii at Manoa, Honolulu, HI, USA

Stephen M. Turton Centre for Tropical Environmental & Sustainability Sciences, School of Earth and Environmental Sciences, James Cook University, Cairns, QLD, Australia

Sybille Unsicker Institute of Ecology, University of Jena, Jena, Germany

Vivek Ramachandran Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, KA, India

Manipal University, Manipal.edu, Madhav Nagar, Manipal, India

Bryson Voirin Max Plank Institute for Ornithology, Radolfzell, Germany
Smithsonian Tropical Research Institute, Panamá, República de Panamá

Carl W. Wardhaugh School of Marine and Tropical Biology, James Cook University, Cairns, QLD, Australia

Alemayu Wassie Eshete Department of Forestry, Bahir Dar University, Bahir Dar, Ethiopia

David M. Watson School of Environmental Sciences, and Institute for Land, Water and Society, Charles Sturt University, NSW, Australia

Martin Wikelski Max Planck Institute for Ornithology, Radolfzell, Germany
North Carolina Museum of Natural Sciences, Raleigh, NC, USA

Neville N. Winchester Department of Geography, University of Victoria, British Columbia, VIC, Canada

Jan H.D. Wolf Universiteit van Amsterdam, Institute for Biodiversity and Ecosystem Dynamics (IBED), Amsterdam, GE, The Netherlands

Stephen P. Yanoviak Department of Biology, University of Louisville, Louisville, KY, USA



Part I

Emerging Issues

Introduction

The notion of “treetops at risk” is an understatement. According to Laurance (this section), over half of the world’s original forests have been destroyed. Although tree-planting remedies often occur, many countries restore nonnative forests or plantations, both of which have significantly different impacts on planetary health. In this first section, called “Emerging Issues,” authors comment on challenges facing our global forests—from logging to climate change to insidious shrinkage of forest boundaries, the human race is intent upon reducing the world’s forest resources. Canopies are part of this critical package—forest canopies provide unique ecosystem services to all life on Earth, and so the notion of “treetops at risk” indicates our current plight. The authors in this section represent synthesizers, leaders, and consensus builders in the world of canopy biology. They all spoke at the 5th International Canopy Conference in Bangalore, India, during 2010. From that collaborative conference, this book had its inspiration. In this introductory section, authors provide commentary about solutions, threats, and the future of global forests and their canopies.

Chapter 1

The Role of Scientific Conferences to Foster Conservation Solutions for Global Forests

Margaret Lowman, Soubadra Devy, and T. Ganesh

Keywords Canopy conference • Science education • India • Forest conservation

The professional group of biologists who prioritize studies of the forest canopy hosted their first international conference in Sarasota, Florida, in 1994, and the field's first textbook was published the same year. Subsequently, canopy scientists have convened a dedicated conference every 4 years, with a mission of advancing the scientific field through collaborative exchange of ideas. For its first time ever, the fifth International Canopy Conference (ICC) convened in an emerging country, hosted by Ashoka Trust for Research in Ecology and the Environment (ATREE) in Bangalore, India. Also, for the first time ever, education outreach was added as a new session to the conference agenda, including a highly popular canopy education workshop that drew Indian students, teachers, scientists, and stakeholders from all regions of the country. This session was advertised as an open forum where laypersons and teachers could interface with canopy scientists, who enthusiastically shared their experiences, thereby taking science outside the conventional walls of academia. In a country like India, this was groundbreaking. In subsequent feedback, we were inspired by the reports of burgeoning education outreach activities in India spawned by this conference session.

Like many developing countries, India needs success in advancing its forest conservation. The Western Ghats forest region in southern India is one of India's

M. Lowman (✉)

North Carolina Museum of Natural Sciences, North Carolina State University,
121 W. Jones Street, Raleigh, NC 27603, USA
e-mail: canopymeg@gmail.com

S. Devy • T. Ganesh

Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave,
Srirampura, Jakkur Post, Bangalore, KA 560064, India
e-mail: soubadra@atree.org; tganesh@atree.org



Fig. 1.1 Teaching Indian students about canopy access

four designated biodiversity hotspots, and the other three also contain critical forest habitat. India is losing 2 % of its forests annually (see Seidler et al.'s chapter), and charismatic megafauna such as tigers, leopards, and Indian elephants remain poster children for India's forest conservation, as well as the potential economy of ecotourism for future generations. The promotion of education outreach at the ICC fostered new enthusiasm in forest canopy conservation using canopies as a "hook" to inspire rapid action. New outreach programs promoted by canopy scientists throughout India after this conference included (1) tree planting programs in schoolyards, (2) citizen surveys of butterflies, (3) Fulbright funding for canopy education outreach, (4) participation by canopy scientists in Earthwatch field courses for HSBC Bank employees, (5) graduate training programs in canopy access (Fig. 1.1), (6) publication of a canopy science book for the public, and (7) a certificate course in conservation for young professionals. All these activities illustrate the genesis of a new



Fig. 1.2 Future women scientists of Assam, India

culture among Indian canopy scientists to engage in education outreach. One year later, hundreds of Indian students and thousands of citizens benefited directly from this one session at the canopy conference.

The notion of including science education and outreach as part of a technical scientific conference agenda was not part of the first ICC, nor of many other scientific meetings several decades ago. Almost 100 years old, the Ecological Society of America (ESA) has witnessed an exponential increase in education sessions at its annual meetings, from less than five in 1990 to over 25 in 2010. The emerging priorities of communicating science and fostering education of diverse stakeholders is an increasingly important platform for scientific conferences, especially given the urgent priorities for STEM (science, technology, engineering, and mathematics) education initiatives in many countries. In India, the priority of education outreach at the canopy conference provided a new model for scientific meetings. This session fostered discussion of a critical question: Will canopy scientists pursue business-as-usual in the face of significant forest degradation, or challenge themselves to do things differently, such as prioritizing education of youth, policy makers, and citizens? Keynote speaker Dr. Thomas Lovejoy (former President, Heinz Center for Economics and Environment, Washington, DC) remarked to the international attendees, “By any measure, tropical forests are in big trouble.” But to date, none of the four prior forest canopy conferences celebrated clear links between conventional scientific data collection and forest conservation. The Bangalore, India, conference, for the first time ever, inspired conversation about the role of women in science (especially for developing countries) (Fig. 1.2) and the notion of actions to educate



Fig. 1.3 Environmental education in rural India – bird spotting

many diverse stakeholders about the importance of their environment. Will innovative approaches for both research and education aimed at engaging citizens and policy makers to achieve better metrics of success for forest canopy conservation?

In India, the notion of “treetops at risk” is a clear threat to human quality of life and also to ecosystem health. Over one hundred teachers of India’s southern states representing diverse cultures, ages, gender, and religions eagerly attended the conference and listened to important take-home messages: (1) develop short courses in canopy science for teachers, citizens, and K-12 (Fig. 1.3); (2) create climate change awareness in schools and for regional government; (3) share resources; and (4) plant trees to “green India” as a strategy to offset climate change and sustainable services.

The ICC fostered a dialogue where a combination of economics and environment, via more effective science communication and education outreach, may hold the key to producing a scientifically literate generation of citizens and policy makers. If every practicing scientist were to give 10 % of his or her professional time to education outreach, not exclusively limited to technical publications, then perhaps the notion of a scientifically literate public could be attained. Currently in India and elsewhere, many science professionals still think that education outreach does not fall into their purview. The expanding footprint of education integrated with science at technical conferences provides one metric of hope for improving science literacy among diverse stakeholders, not just scientists.

This volume was inspired by the 5th International Canopy Conference held in Bangalore, India, but the authors and issues have subsequently burgeoned, as has the mission of this book. By sharing the story of Bangalore, we hope to set the stage

for this book as a “wake-up call” for scientists in many fields of expertise – we must not only uncover the secrets of how ecosystems operate, but we must also disseminate our findings in a manner that inspires conservation and solutions by the diverse stakeholders that comprise the seven billion people of planet Earth. The stakes for conservation have never been higher. And the ultimate height of the forest canopies represents an epicenter for many global solutions – carbon storage to offset global warming, biodiversity of millions of species, productivity of billions of leaves, shade for humans, freshwater cycling, and essential spiritual sanctuaries.

Chapter 2

Greening the Planet?

Thomas Lovejoy

Keywords Climate change • Carbon sequestration • Ecosystem restoration

In 1896 Swedish scientist Svante Arrhenius addressed a very important question: Why is the Earth a habitable temperature for humans and other forms of life? Why isn't it too cold? The answer (building on the work of the British scientist Tyndall earlier in the century) was the greenhouse effect. He even did a quite accurate projection of what double preindustrial levels of CO₂ would do to planetary temperature. What he would not have known was the detailed history of planetary temperature for the previous hundreds of thousands of years – in particular that the last 10,000 years were an unusually stable period of global climate and temperature. During those ten millennia, much of modern civilization (agriculture, human settlements) developed, and all ecosystems adjusted to a stable climate.

That of course is changing because of human activity and rising levels of carbon dioxide in particular. Global temperature is currently approaching 0.9° increase over preindustrial levels. CO₂ concentrations are approaching 400 parts per million (ppm) versus 280 ppm in preindustrial time. The lag between reaching a concentration level and the accumulation of heat means that the planet will reach another 1.0° increase even if CO₂ concentrations rise no further. Most of the response to climate change to date is relatively minor. Nonetheless, there is substantial reduction in glaciers in the tropics and sea ice in the Arctic Ocean. Sea level is rising in part because of thermal expansion of water but increasingly because of glacial melting. While the sea level end point is fairly clear from understanding past climates, the rate at which it will be reached is not.

T. Lovejoy (✉)
George Mason University, VA, USA

The Heinz Center for Science, Economics and the Environment, Washington, DC, USA
e-mail: lovejoy@heinzcenter.org

There is definite increase in the frequency of wildfires from warmer summers, earlier snowmelt, and in certain instances drought associated with climate change. In Costa Rica's Monteverde Cloud Forest, an increasing number of dry days are recorded, since clouds tend to form at higher altitudes more frequently than in the past. This could lead to major change if the trend continues because those forests depend primarily on condensation from clouds as a source of moisture.

Already we are seeing responses in nature. Species are changing their annual cycles: flowering species blooming earlier, birds nesting earlier, and the like. Species are already changing where they occur, e.g., the Edith's Checkerspot Butterfly is clearly moving northward and upward in altitude in western North America. With double preindustrial levels, it has been projected that sugar maple will occur in Canada but not New England. Mostly seen so far in temperate and boreal habitats are decoupling events in which two coincident features of nature begin to disassociate because one uses temperature as a cue and the other day length. These are all relatively minor changes, essentially ripples in nature. Nonetheless, this kind of change is being detected in almost every place that scientists look. So this is now statistically robust.

More serious abrupt change is also beginning to be detected. Tropical coral reefs are particularly sensitive to short periods of elevated water temperature and undergo bleaching events. These are happening with increasing frequency every year with grim implications for the one-twelfth of humanity that depends on the reefs for well-being. Similar abrupt change is occurring in the coniferous forests of western North America. There warmer summers and milder winters have tipped the balance in favor of native bark beetles leading to massive defoliation and subsequent tree mortality (up to 70 % of stands in some instances). Even larger-scale change is being detected in terms of ocean chemistry where elevated CO₂ absorbed by the oceans also produces carbonic acid. Ocean pH is already 0.1 pH unit more acidic than in preindustrial times. This carries enormous implications for animal species that build shells or skeletons of calcium carbonate.

In the Amazon the hydrological cycle that produces much of the rainfall and works synergistically with the rain forest (in addition to providing rain further south in agricultural regions) may be approaching a tipping point. A World Bank model of the combined effects of fire, deforestation, and climate change suggests a possible tipping point leading to Amazon dieback in the southern and eastern Amazon at around 20 % deforestation. It is currently at about 19 %. This has significant implications to the health of forest canopies. Looking ahead, we can anticipate that additional climate change would disproportionately affect island species and species at high altitudes. And from past climate change, we know that ecosystems do not move but rather that individual species move individually: almost an ecosystem disassembly with surviving species forming novel ecosystems that are hard to manage in advance.

All of that argues strongly that the 2° of increase that is the target of negotiations is really too much for most ecosystems. Yes, one can make species less vulnerable by restoring natural connections in landscapes. In the end, however, it becomes imperative to seek ways to reduce the amount of climate change that would

otherwise take place. Geo-engineering schemes which purport to do so mostly do not because they address temperature (the symptom) rather than the cause (greenhouse gas concentrations). The biology of the living planet can be particularly helpful. A substantial amount of the excess CO₂ in the atmosphere actually comes from three centuries of destruction and degradation of ecosystems. Ecosystem restoration at a planetary scale could easily draw down 50 ppm from the atmosphere by converting it into thriving forests, grasslands, and agroecosystems. It is not enough, so we need to find economic ways to do so non-biologically.

It is time to recognize that this planet works as a linked biological and physical system and we should manage it as such. Re-greening the Emerald Planet will make Earth more habitable for ourselves and other forms of life. Efforts to plant trees and restore forest canopy cover represent an important stewardship action.

Chapter 3

Comparative Canopy Biology and the Structure of Ecosystems

Mark W. Moffett

Keywords Architecture • Biofilm • Biodiversity • Biomechanics • Coral reef
• Epiphyte • Kelp • Periphyton • Rhizosphere • Stratification

1 Summary

- The way ecologists think about canopy biology as a scientific discipline could lead them to overlook different communities of spatially fixed organisms that may have properties usefully compared to or contrasted with forest canopies. This chapter represents a series of discussions and reviews on the possible nature and limits of canopy biology and introduces the prospect of a general comparative science of biological canopies.
- Rather than restricting canopy biology to plants in terrestrial systems, I argue that *canopy* can be defined in terms of the parts of any community of sessile organisms that emerge from a substratum, the structural products derived from them included. This opens the field to diverse communities that could share many properties with forest (or plant) canopies. I overview the canopy literature on kelp forests, algal turfs, periphyton, bacterial films, and coral reefs. The word *canopy* has already been applied to each of these ecosystems. Periphyton and biofilms in particular have great potential as model systems for studying assembly rules for the physical structure and dynamics of canopies.
- Among the similarities and differences between these types of canopy are the distribution of resources, such as light and nutrient gradients; factors affecting these distributions, such as the flow of air or water; and the resulting disposition of

M.W. Moffett (✉)
National Museum of Natural History, Smithsonian Institution, 10th Street and Constitution
Avenue, Washington, DC 20013-7012, USA
e-mail: naturalist@erols.com