

WHAT'S UP?

THE NEWSLETTER OF THE INTERNATIONAL CANOPY NETWORK

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CANOPIES IN CANADA: INTEGRATED CANOPY RESEARCH AT HALIBURTON FOREST, ONTARIO

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The upsurge of research interest in forest canopies over the last decade has displayed a characteristic geographic signature – namely a migration from tropical latitudes to more northerly locales. Consistent with this pattern, the vast forest canopies of Canada, some 10% of the world's total, remain largely unexplored. It is true that there have been a few intensive research campaigns with a strong canopy component (notably the carbon-cycle focused BOREAS project), and some noble efforts by widely-dispersed researchers exploring aspects of canopy biodiversity (notably among entomologists). However, there is a general lack of integrated projects on forest canopies in Canada of the sort now found in the US, Europe, and sites in the tropics.

Such an integrated forest canopy program has recently coalesced at Haliburton Forest (HF), Ontario. Formally designated the Haliburton Forest and Wildlife Reserve, Ltd., HF is a large (~25,000 ha), privately owned “working” forest located in the Haliburton Highlands immediately southwest of Algonquin Provincial Park (45°15'N, 78°35'W) in south-central Ontario <www.haliburtonforest.com>. The site is situated on the Canadian Shield: Precambrian granite scoured by glacial ac-

tion into a landscape of small hills interspersed with lakes and wetlands. The dominant trees are sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), eastern hemlock (*Tsuga canadensis*), and yellow birch (*Betula alleghaniensis*). More than 30 tree species and 6 distinctive forest types occur. The forested landscape is managed mainly

by selection system logging in which at least 2/3 of canopy trees are left intact. Residual areas of untouched primary forest also occur. From above the canopy one has the view of a vast rolling sea of forest interspersed with small lakes. Beneath it is a forest replete with both charismatic Canadiana (wolves, moose, black bear, loons), and organisms of particular interest to canopy aficionados (flying squirrels, migrant warblers, cyanolichens, leaf-rolling caterpillars and



Fig. 1. An insect flight interception trap in old growth white pine at the canopy walkway at Haliburton Forest (Photo: S. Smith).

their un-described parasitoid wasps).

HF is an unusual and exciting place to work for additional reasons. The first working forest in Canada to be certified by the Forest Stewardship Council, sustainable forestry is the raison d'être of HF. This emphasis has coex-

isted with the development of the property as a major regional site for eco-tourism, with attractions ranging from a 300 km network of mountain-biking trails to winter sled-dog rides to submarine excursions exploring the lake environments. Close collaboration with HF management facilitates the establishment of large-scale manipulative experiments, and the eco-tourism presence provides an immediate means of communicating canopy science to a general public.

CANOPY ACCESS

HF is home to North America's longest canopy walkway system – over 500 m of tree-suspended walkway up to 20 m in height, situated in a ~130 year-old stand of eastern white pine. Although it is mainly used by eco-tourists, the walkway has also been the basis for studies on canopy ecophysiology and insect communities. It provides an immediate basis for public outreach, with more than 2000 visitors yearly.

In 2003, a grant from the Canadian Foundation for Innovation provided funds for a dedicated aerial lift platform at HF (Fig. 2). The Finnish-built Scanlift SL 240 has a 24 m platform working height, providing access to the upper canopies of all trees in the system, with the exception of



Fig. 2. The dedicated aerial lift for canopy access at HF. The lift design is especially suited for off-road use (Photo: T. Gradowski).

the tallest emergent white pines. This lift is also unique in its capacity for off-road use, being self-propelled with 4WD, high ground clearance, independent steering of wheels, and hydraulic arms that lift the entire chassis off the ground for canopy access. This last feature is critical in that it enables the lift to weigh in at less than 10,000 lbs, while retaining rock-solid stability. The maintained road network at HF, in conjunction with skid trails in harvested stands, makes it possible to gain access to

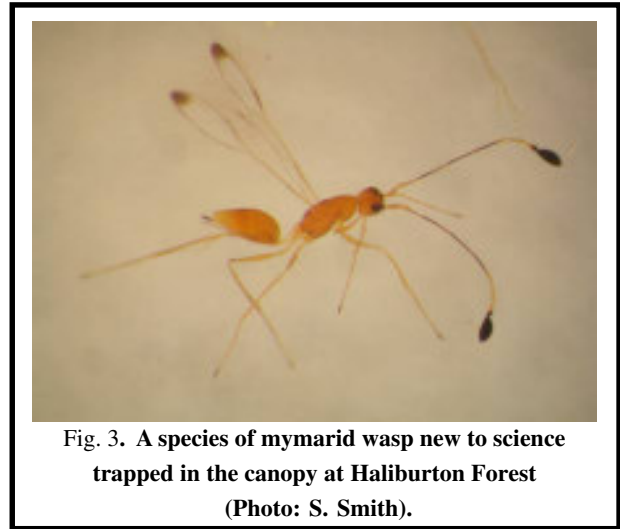


Fig. 3. A species of mymarid wasp new to science trapped in the canopy at Haliburton Forest (Photo: S. Smith).

large parts of the 25,000 ha property. We have accessed areas up to 1 km from maintained roads. This mobility is critical in allowing fully replicated experimental studies involving direct canopy access.

CANOPY INSECTS

Although well-described by tropical standards, alpha taxonomy is completed for only about 1/2 of Canada's insects, and a large number of the undescribed taxa appear to be inhabitants of forest canopies. Even less is known of their ecological roles or responses to logging and other anthropogenic factors. Studies at HF to date have focused on differences in insect communities between pine- and sugar maple-dominated stands, and effects of selection-system logging on insects in the latter. An initial study on longhorned beetles (Coleoptera: Cerambycidae) has documented large differences in the canopy vs. understory communities, with 11 of 28 species collected only from canopy traps. Canadian canopy insects with many taxa new to science are exemplified by mymarid wasps (Fig. 3).

CANOPY VERTEBRATES

Trapping surveys in 2003-2004 surprisingly revealed the presence of both southern and northern flying squirrels at HF. The former appear to be strongly dependent on tree reproductive output in the form of "mast" and catkins as a food resource. We are now examining the relationships between climate variation, tree reproduction, and population dynamics of both flying squirrel species.

CANOPY STRUCTURE AND DYNAMICS

Research underway makes use of canopy and ground access techniques to examine crown extension dynamics

following logging, and differences in canopy structure among tree age classes. We have noted crown thinning in older trees, which may have implications in forest community dynamics.

CANOPY PHYSIOLOGY

Mobile canopy access in a “working” forest is providing a basis for experimental studies at the whole-tree and stand level. Projects focus on the physiological responses of canopy sugar maple trees to removal of neighbors during logging operations, and to additions of limiting mineral nutrients. Results point to the importance of slow (multi-year) acclimation responses of canopy trees to environmental changes, and to the importance of phosphorus limitation of growth and physiological processes – likely due to high levels of nitrogen deposition.

REMOTE SENSING

Given the vast scale of Canada’s forest, there is intense interest in developing remote sensing techniques for forest inventory and assessment. Current projects link within-canopy measurements of leaf structure and chemistry with high resolution hyperspectral data obtained through the CASI (Compact Airborne Spectrographic Imager) instrument.

INTEGRATED STUDIES

An important challenge is the integration of the canopy research areas outlined above: i.e., putting together studies of tree structure and physiology, canopy-dependant organisms and remote sensing. Such studies at HF have the general theme of understanding how the age of individual trees determines forest canopy processes. Leaf morphology and chemistry change in characteristic ways through tree ontogeny, and these changes appear to have pronounced effects on canopy structure, canopy plant assemblages and animals. Age-related changes in leaf properties and tree canopy structure may also potentially be detected via remote sensing. Such changes have received some attention in other systems, but remain essentially unstudied in the forests of eastern North America.

INVESTIGATORS AND FUNDERS

Scientists currently involved in canopy research at HF are mainly based at the University of Toronto and affiliated institutions. Principle investigators include T.J. Carleton, J.P. Caspersen, J.M. Chen, J.R. Malcolm, S.M. Smith, S.C. Thomas; more than 15 graduate and undergraduate students have been involved in canopy work at

HF to date. Canopy studies at HF have been supported by P. Schleifenbaum, owner of HF, and funded by the Canadian National Engineering and Research Council, the Canadian Foundation for Innovation, the Richard Ivey Foundation, and the Brown Research Fund at Haliburton Forest.

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For more information or questions, contact the ICAN office: (360) 867-6788; <canopy@evergreen.edu>.

THE 4TH INTERNATIONAL CANOPY CONFERENCE: A RETROSPECTIVE VIEW

Martin Unterseher

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The 4th International Canopy Conference took place from 10 to 16 July 2005 in Leipzig, Germany, under the topic 'Canopy ecology - tropical versus temperate forests'. This conference guideline seemed appropriate as permanent canopy access facilities are now located across the globe in both tropical and temperate forests in equal numbers, with the newest canopy creane in Leipzig <www.uni-leipzig.de/leipzigcanopycrane>. Nearly one third of all speakers presented results from temperate forests and most symposia were organized in such a way that a direct comparison between tropical and temperate forest canopies was possible.

On behalf of Prof. Wilfried Morawetz, the organizers from the Department of Systematic Botany, University of Leipzig, were privileged to host about 150 guests from 30 countries from all continents, representing more than 300 scientists, who shared and spread new research results and ideas, strenghtened existing collaborations, and established new projects.

Eleven symposia and one workshop on important topics of canopy research such as canopy structure, diversity of arthropods, effects of climate change, fungal organisms, plant physiology, biomechanics, floral ecology, pollination, seed dispersal and bioinformatics demonstrated the importance of forest canopies for global biodiversity and ecosystem functioning . We also discussed the need for a broad interdisciplinary approach in canopy science. In the course of six days 90 scientific talks elucidated the most recent advances in canopy research. One highlight was the session '*Influence of Global Change to Forest Canopies*'. Under the chair of Andrew Mitchell, Director of the Global Canopy Programme, specialists in botany, plant physiology, entomology and climatology presented fascinating and partly alarming news. The complex effects of elevated CO₂ on a temperate forest canopy in Switzerland were also highlighted, e.g., the loss of biodiversity and ecosystem functioning, if forests become hotter, drier and more fragmented. Environ-

mental concern was the topic of a press conference that resulted in many radio and television broadcasts, and local, national and international newspaper articles.

Contributions on insects dominated the contents of the conference program. Within the first of three symposia of arthropods in temperate and tropical forest canopies, a session chaired by Andreas Floren (University of Würzburg, Germany) focused on arthropods from Poland's primeval temperate forests to the evergreen subtropical forests of the Azorean islands. A session guided by Yves Basset (Smithsonian Tropical Research Institute, Panama) concentrated on IBISCA, a project to study the vertical stratification and beta diversity of arthropods in a rainforest in Panama. The symposium on canopy arthropods, hosted by Prof. Eduard Linsenmair, covered topics from both temperate and tropical investigation sites. David Shaw, former manager of the Wind River Canopy Crane Research Facility chaired a session on the influences of herbivores on canopy ecosystems that was illustrated with nine contributions from study sites all over the world.

For the first time in the series of Canopy Conferences, a small but informative session on canopy fungi and fungal organisms was held. A talk about plant parasitic microfungi in epiphytic orchids clearly demonstrated that almost nothing is known about the hidden diversity of rusts and smuts and their influence for vascular epiphytes in forest canopies.

In the forefield, the GCP Steering Committee, hosted by Andrew Mitchell, took place on Sunday, 10 July in Leipzig. Though it was a non-public event, it influenced discussions and conversations among scientists during the week. Mitchell announced a several million US \$ project that will help to expand the network of canopy science across the globe. According to Mitchell, the United Nations Environment Program (UNEP) and the Global Environment Facility (GEF)

have given their backing to a proposal to add five more canopy crane research facilities in Brazil, Ghana, Madagascar, India and Malaysia. As one consequence of GCP's efforts, representatives from India proposed to organize the 5th International Canopy Conference in Bangalore, India.

On behalf of the organizers of the 4th International Canopy Conference we hope that all had a successful conference, a pleasant stay in Leipzig and Germany. We thank all participants who made this year's event a great success, especially the chairmen of the symposia and workshops who brought some of the most recommended scientists to Leipzig.

We look forward to the next Canopy Conference. More informations of the past meeting are still available on the conference website
<www.uni-leipzig.de/leipzigcanopycrane/conference>.

ECOINFORMATICS WORKSHOP

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The Ecoinformatics Workshop presented by Anne Fiala of the Canopy Database Project <www.canopy.evergreen.edu> on the final day of the 4th International Canopy Conference in Leipzig, Germany was a success. After a six-day meeting, there were still attentive participants from around the world. Capturing the international flavor of the meeting, attendees came from diverse locations that included Columbia, Germany, Holland, India, Singapore, Tasmania, UK and USA. The workshop covered topics that included: the pros and cons of using databases instead of spreadsheets, an overview of *DataBank*, our database generator program, and an introduction to *CanopyView*, our software for visualizing canopy datasets. Many of the participants left the workshop with tools that they are now using to work with their own datasets. If you were unable to participate in the workshop but would like more information, visit the workshop's website: <<http://scidb.evergreen.edu/leipzig-workshop/>>. Alternatively we would be happy to send you information. We would also like to hear from you if you are interested in attending a future workshop. If you have questions or comments contact Anne Fiala <fialaa@evergreen.edu>.

ISCAN IS BORN

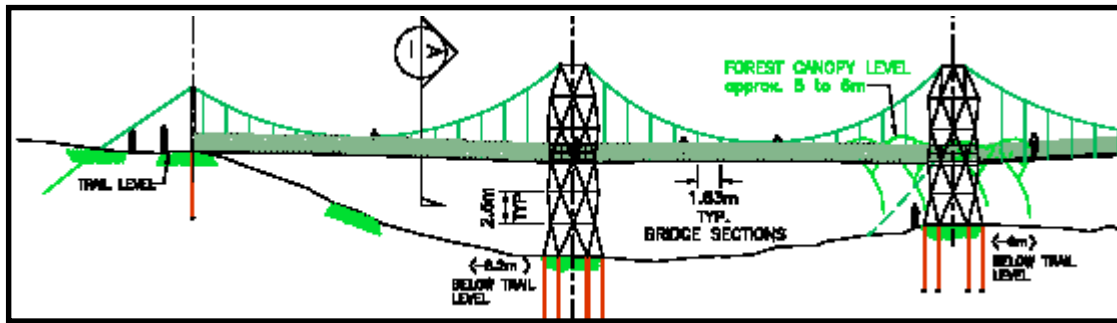
John Switzer Haagensen
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A student canopy network has been established as a result of an exceptional good conference in Leipzig, **The International Student Canopy Network (ISCAN)**. The network will be developed in collaboration with ICAN and connects students interested in canopy science. Canopy students are just like established canopy scientists, registered on the red list over threatened species, which emphasize the importance of such a network's existence. A degree programme in canopy science still does not exist, so students interested in the science are widely spread. This network will ease communication and can be used for discussions, project ideas and questions among students and PhD's. It also opens a great opportunity for the established scientists to reach the younger generation more efficiently.

A homepage will be created with the content aimed at undergraduate/graduate students. In that context it is my personal goal to establish a project database for the students. We are all eager to get more students involved in the science which requires more transparency in how to get there. This is essential at least until a proper degree programme is developed. The development of the network is still in its juvenile stage so any inputs would be greatly appreciated. Updates on the further development will be announced on ICAN. We hope for your support and would therefore like to ask you all to contact your students interested in canopies and let them know about the new network. Send an email to <canopy.students@googlemail.com> they will then be on the emailing list just like on ICAN. An article about the network will also be published in IFSA's news magazine (International Forestry Students Association), so the number of members should soon be substantial.

Have you recently moved or changed your e-mail address? If so, please let us know so we can keep your records current. E-mail your new information to <canopy@evergreen.edu>.

CLOUD FOREST CANOPY WALKWAY SYSTEM IN THE PERUVIAN ANDES UNDER DEVELOPMENT



The ACEER Foundation and the Amazon Conservation Association (ACA) have partnered with the National Geographic Society, the Moore Foundation, the Windhover Foundation, West Chester University of PA, and Greenheart Conservation to construct and operate the world's largest canopy walkway system, and the only one of its kind in a cloud forest ecosystem. The system will be located at Wayqecha in the Kosñipata valley adjacent to the Manu Biosphere Reserve on a private tract of land owned by ACA. The Walkway will consist of a series of nine, 20 meter tall aluminum towers connected by 31 meter suspended walkways. One tower will be equipped with a classroom/laboratory module for education and research. Entrance will be via a visitor's center with nature interpretation exhibits. The total cost of the system will be approximately \$1.5 million USD.

Greenheart Conservation of Vancouver, Canada, is the engineering firm that designed the system. Fabrication in Canada will begin this fall with shipping and installation on-site shortly thereafter. The Walkway is scheduled to be in operation in 2006.

The Wayqecha site is unique in South America with 99% of the forest still intact. It is in the strategic buffer zone protecting Manu Biosphere Reserve. The site is the only recorded habitat for the Andean kinkajou and home to the endangered spectacled bear. Over 1000 bird species including the endangered solitary eagle have been recorded at Wayqecha. In addition, the site supports some of the highest species diversity of orchids on the planet.

This cloud forest ecosystem is critical to overall Amazon conservation efforts and is currently being impacted in two fundamental ways 1) by the burning of grasslands above the

tree line, that in turn is impeding natural forest succession and by 2) extensive deforestation in the lowlands. Both organizations are committed to dedicating all revenue generated by the Walkway to their respective conservation education and research programs in Peru. Information on how to visit the Wayqecha Cloud Forest Walkway, conduct research there, or participate in educational workshops scheduled for the site, will be available early in 2006 from both ACEER and ACA.

ICAN members may follow the progress of the Walkway on both ACEER's and ACA's websites: www.aceer.org and www.amazonconservation.org.



ICAN will resume its regular coverage of The Global Canopy Programme in the next issue of What's Up?

Please check back to learn of the most recent GCP activities and updates.

For more information visit www.globalcanopy.org

GRASSHOPPER TAKES TO THE TREES ON PRAIRIE RESEARCH SITE

Principal Investigators:

Ted Hopkins, Konza Prairie LTER Site <thopkins@ksu.edu>

Media Contacts:

Cheryl L. Dybas, NSF (703) 292-7734 <cdybas@nsf.gov>

Grass stretches as far as the eye can see across the U.S. Great Plains, and more than 100 species of grasshoppers live in the swaying fronds. But one plains-dwelling grasshopper species prefers trees to grass, as a discovery at the National Science Foundation's (NSF) Konza Prairie Long-Term Ecological Research (LTER) site shows.

A Kansas student from Fort Riley Middle School collected the first specimen while participating in Konza's LTER schoolyard project. According to Valerie Wright, Konza's education coordinator, the specimen was not recognized at first to be a new species to inhabit the Konza Prairie.

Konza scientist Ted Hopkins later identified the rare, tree-dwelling creature as the grizzly spur-throat grasshopper. "LTER schoolyard projects provide wonderful opportunities for students of all ages to become involved in the excitement of science," said Henry Gholz, LTER program director at NSF. "Often, in cases such as this, students are responsible for collecting valuable field data and increasing our knowledge of the natural world."

Melanoplus punctualatus was first identified in the United States in 1862. It's usually found in eastern hardwood forests and in the pine forests of the southeast. The species had been reported only twice in Kansas.

"Its discovery on Konza is a big surprise," Hopkins said. He discovered two of the unusual grasshoppers basking in the sun on the wall of an old house located on the Konza site. Wright, who is also an entomologist, later found five more on tree trunks near the house.

The grasshopper is a large, slow-moving insect, Hopkins said, "and given its protective coloration—medium-gray speckled with dark dots, sometimes with yellowish and whitish areas—it disappears against lichen-covered tree bark."

Hopkins thinks the Konza Prairie grasshoppers are found only along wooded areas near creeks. He is continuing his research near trees where the grasshoppers have been seen, watching for tiny first-stage insects that hatch from eggs and trying to collect enough adults to determine their feeding habits.



The grizzly spur-throat grasshopper is a large, slow-moving insect that is nearly impossible to see against lichen-covered tree bark. Konza Prairie LTER site

CONTRIBUTE TO WHAT'S UP?

The International Canopy Network is currently seeking articles and information for the upcoming issue of What's Up?, set for publication in December, 2005. ICAN accepts articles, meeting, workshop and job announcements, relevant website addresses, and citations. Contributions can be sent via e-mail attachment, fax, or snail mail. Articles up to 1500 words are accepted (WORD format preferred) and graphics are welcomed. The deadline for submissions is November 15, 2005. For further information or to send contributions, please contact the ICAN office:

Hannah Anderson - Program Manager/Editor; 2103 Harrison Avenue NW, PMB 612, Olympia, WA 98502; (360) 867-6788; <canopy@evergreen.edu>.

SCIENCE HIGHLIGHT

Canopy Insect Herbivores in the Azorean Laurisilva Forests: Key Host Plant Species in a Highly Generalist Insect Community.

*Ribeiro et al. Ecography 2004
spribeiro@iceb.ufop.br*

This article explores patterns of insect herbivore distribution in the canopy of the Laurisilva forests on seven islands in the Azores archipelago. To our knowledge, this is the first extensive study of this type in tree or shrub canopies of oceanic island ecosystems.

One of the most frequently debated characteristics of such ecosystems is the likely prevalence of ill-defined niches due to taxonomic disharmony. For instance, an increase in ecological opportunities for generalist species is expected due to the lack of predator groups and reduced selection for chemical defence in host plants. The following two questions were addressed: (1) Are specialist species rare, and insect herbivore species randomly distributed among host plant species in the Azores? (2) Are the variances in insect herbivore species composition, frequency and richness explained by host plants or by regional island effects?

We expect a proportional distribution of herbivore species between host plants, influenced by host frequency and distinct island effects. Otherwise, deviation from expectation might suggest habitat preference for specific host tree crowns. Canopy beating tray samples were performed on seven islands, comprising 50 transects with 1 to 3 plant species each (10 replicates per species), giving 1320 samples from ten host species trees or shrubs in total.

From a total of 129 insect herbivore species, a greater number of herbivore species was found on *Juniperus brevifolia* (s=65) and *Erica azorica* (s=53). However, the number of herbivore species per individual tree crown was higher for *E. azorica* than for any other host, on all islands, despite the fact that it was only the fourth most abundant plant.

In addition, higher insect species richness and greater insect abundance were found on the trees of Santa Maria Island, the oldest in the archipelago. Insect species composition was strongly influenced by the presence of *E. azorica*, which

was the only host plant with a characteristic fauna across the archipelago, whereas the fauna of other plant crowns was grouped by islands.

The great insect occurrence on *E. azorica* reflects strong habitat fidelity, but only four species were clearly specialists. Our findings indicate a broadly generalist fauna. The simplicity of Azorean Laurisilva contributed to the understanding of insect-plant mechanisms in canopy forest habitats.

MEETINGS AND EVENTS

Primer Congreso Colombiano de Primatología

2-4 Noviembre 2005. Bogota, Columbia

<<http://www.geocities.com/primatescolumbia/congreso.htm>>

Plants 2010 Conference 2005

23-25 October 2005. Dublin, Ireland

<<http://www.plants2010.org>>

A global partnership for plant conservation - Supporting national implementation of the Global Strategy for Plant Conservation.

1st Diversitas International Conference on Biodiversity

9-12 Noevember 2005. Oaxaca, Mexico

<<http://www.diversitas-osc1.org/>>

Integrating Biodiversity Science for Human Well-Being.

IX Congreso de la Sociedad Mesoamericana para la Biología y Conservación

15-21 November 2005. La Ceiba, Honduras

<<http://www.parksinfo.net/smbc/index.html>>

Special Canopy Session :

Joint Annual Meeting - Society for Northwestern Vertebrate Biology & The Washintgon Chapter of The Wildlife Society.

27 March - 1 April 2006.

The Evergreen State College, Olympia, WA, USA.

<www.evergreen.edu/ican> <www.snwvb.org>

Challenges of a Changing World: Historical Perspectives and New Innovations.

**Association for Tropical Biology and Conservation
Annual Meeting**

18-21 July 2006. Xishuangbanna, China

<www.atbio.org>

Tropical Biology: Meeting the Needs of Changing Tropical
Ecosystems.

9th International Pollination Symposium

23-28 July 2006. Iowa State University, USA

<<http://www.ucs.iastate.edu/mnet/plantbee/home.html>>

Host-Pollinator Biology Relationships - Diversity in Action.

NEW! FROM CABI PUBLISHING

**Forest Climbing Plants of West Africa:
Diversity, Ecology and Management**

Edited by F Bongers and M P E Parren, Wageningen University, The Netherlands and D Traoré, University of Cocody, Côte d'Ivoire

June 2005 288 pages £44.00 (US\$80.00)

Climbing plants, including lianas, represent a fascinating component of the ecology of tropical forests. This book focuses on the climbing plants of West African forests. Based on original research, it presents information on the flora (including a checklist), diversity, ecology and ethnobotany. Forestry aspects, such as their impact on tree growth and development, and the effects of forestry interventions on climbers, are also covered.

Tropical Rainforests of the Guiana Shield

Edited by D Hammond, formerly of the Iwokrama International Centre for Rain Forest Conservation and Development, Georgetown, Guyana

July 2005 560 pages £60.00 (US\$112.00)

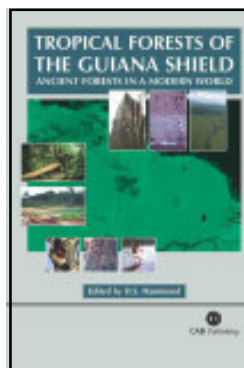
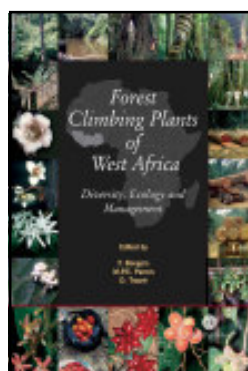
The Guiana Shield is an ancient geological formation located in the northern part of South America, covering an area of one million square kilometres. Despite its hostile environment, it is home to many unusual and highly specialized plants and animals, which constitute a rich area of biodiversity. This book represents a comprehensive detailed review of the ecology, biology and natural history of the forests of the area. Subjects covered range from hydrology and soils, to plant-animal interactions, nutrient cycling, and conservation.

TEXTBOOK: Forestry in a Global Context

R Sands, University of Canterbury, New Zealand

July 2005 272 pages £20.00 (US\$40.00)

This introductory text sets world forestry in the context of social, environmental, historical, economic and conservation issues. It explores how people relate to forests and how forests have been used from the time of hunter-gatherers up to the present day. It covers a host of topics including: the development of forests, grassland and humans from the Devonian through to the Age of Agriculture; the factors determining the distribution of forests; the classification of forest types; the value and benefits of the forest; and the products of the forest and their associated trade. It also explores issues such as sustainable forest management, current patterns of deforestation and reforestation, and future challenges facing our forests.



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RECENT CITATIONS IN CANOPY SCIENCE

Since there is no central journal on canopy science, it is useful to publish citations on canopy studies in the recent literature. Some of the papers listed below were obtained from ICAN subscribers sending in reprints; most were discovered through weekly literature searches on Current Contents on Diskette (CCOD).

FOREST STRUCTURE

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- MacKinnon, W. E., and D. A. MacLean. 2003. The influence of forest and stand conditions on spruce budworm defoliation in New Brunswick, Canada. *Forest Science* 49:657-667.
- Rodriguez, R., G. Hofmann, M. Espinosa, and D. Rios. 2003. Biomass partitioning and leaf area of *Pinus radiata* trees subjected to silvopastoral and conventional forestry in the VI region, Chile. *Revista Chilena de Historia Natural* 76:437-449.
- Salvador-Van Eysenrode, D., J. Bogaert, V. ZakMnacek, and R. Ceulemans. 2003. Sapling diversity in canopy gaps in an Ecuadorian rain forest. *Forest Science* 49:909-917.

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