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WHAT'S UP?

THE NEWSLETTER OF THE INTERNATIONAL CANOPY NETWORK

NALINI NADKARNI, EDITOR DAVID FRANKLIN, EDITORIAL ASSISTANT

Report from the canopy down under

Arthropod diversity in stringybark *Eucalyptus obliqua*

As winter arrives in the northern hemisphere, we are beginning our second summer of mapping and trapping arthropods in the treetops of the stringybark *Eucalyptus obliqua* in southern Tasmania, Australia. We had a busy field season last year, catching insects with sticky traps and generating detailed maps of the branching architecture of these massive trees. We are testing the hypothesis that older trees have more diverse fauna than younger trees, and investigating the habitats that may be responsible for these distributions.

We use single-rope access methods and mapping techniques utilized by Robert Van Pelt's field crew. The rope techniques were generated while mapping coniferous trees with ICAN in the summer of 2001. Fishing line is launched by projectile over a branch, ascenders are used to climb, and arborist doubled rope lanyards are used to gain access to the top of the tree. Upon reaching the top, a cord is left in place to facilitate future access.

Maps have been created with 3D computer-aided design software to generate virtual models of these trees. The mapping techniques were modified from those developed by Steve Sillett, Robert Van Pelt, and Nalini Nadkarni for measuring the structure of coniferous trees. We modified their methods to compensate for less-specialized surveying equipment and to clarify the topological branching patterns that occur in angiosperm crowns.

Last year, we used sticky traps to compare different locations within trees, and this year we will be using omnidirectional flight traps and bark funnel traps made from recycled soda bottles to sample a wider range of animals. Based on a sample size of four trees (with 8 traps in each), we found several statistically-significant differences. Beetle species richness was higher in traps placed in upper branches than in lower branches. Fly abundance was higher on branches compared to trunks, while bug and spider abundances were higher on trunks than branches.

Virtual 3D model of a tree

The stringybarks, along with the nearby *Eucalyptus regnans*, dominate the world's largest and tallest angiosperm forest. They are the center of much controversy in Tasmania. The forestry industry and state government continue to harvest the old-growth forests, while an active and motivated "green" population has made the clear-felling and wood-chipping of these forests a national concern. Research on the arthropod biodiversity associated with these trees will add to the knowledge available when debating a future for these forests and the industry.

If you are interested in getting involved, seeing photographs, rendering 3D tree models, trapping canopy invertebrates, or sharing information on how specifics within tree habitats contribute to the overall big picture, visit ‹‹*http://www.geog.utas.edu.au/yoav*›› .

Thanks to all field helpers, the Australian Geographic Society, and Vertical Pty. Ltd.

Yoav Daniel Bar_Ness; Geography and Environmental Studies, University of Tasmania, Hobart, Australia, ‹*ybarness@utas.edu.au*›.

The effects of forest type and elevation on the diversity of litter invertebrate communities in a montane tropical rainforest in Puerto Rico

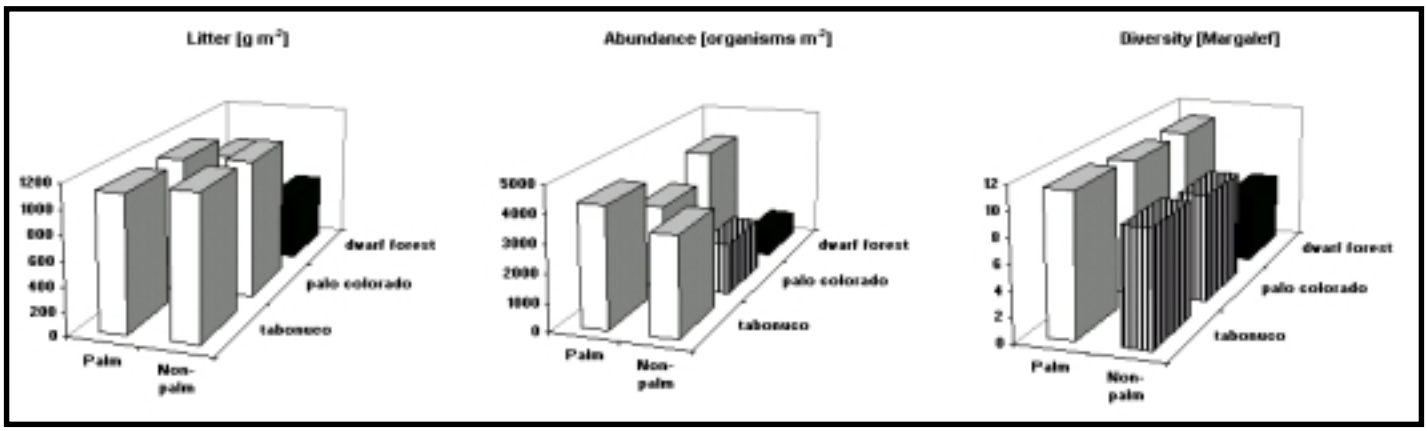
Canopy leaves, twigs, fruit, and seeds, which provide habitat for herbivores, inevitably become canopy litter. The litter lodges in epiphytes and treeholes and falls to the forest floor, forming a new habitat for detritivore and fungivore invertebrate communities.

Microcosms and microhabitats provide a useful way of investigating changing parameters along gradients because they can be quantified. This is impossible in whole-forest or other major ecosystems. At the Luquillo Experimental Forest (LEF) in eastern Puerto Rico, we studied the detrital and aquatic communities of bromeliad microcosms along an elevational, temperature and rainfall gradient (Richardson 1999, Richardson *et al.* 2000) over a three-year period and in three forest types: tabonuco (400 m), palo colorado (750 m), and dwarf forest (1000 m).

teristics and differences in forest structure. There was no control for forest type.

In the LEF, the sierra palm *Prestoea montana*, provides this control, as it occurs in stands along the whole elevational gradient. By sampling palm and non-palm forest floor litter within each forest type over three years, we were able to distinguish between the effects of climate and those due to the chemical and physical characteristics of the litter. Animals were extracted using Tullgren funnels, counted, and identified. The dried litter was weighed and chemically analyzed.

In general, palm litter samples were richer in minerals than non-palm litter, significantly so at the highest elevation, where leaching might have been expected in the palm as well as non-palm litter. Palm litter supported a higher animal bio-



Amounts of litter and abundance and diversity of invertebrates in palm and non-palm litter of three forest types at different elevations in the Luquillo Experimental Forest, Puerto Rico [means of pooled data over 3 yr].

Animal abundance declined along the gradient coinciding with a decline in minerals in the litter trapped by the plants, and a decline in forest net primary productivity. Animal species richness was also at its lowest in the dwarf forest at the summits, but peaked at mid-elevation in the palo colorado forest. These results are consistent with those reported for other forests and a variety of animal and plant groups, and have usually been interpreted as due to the primary effects of climate change along an elevational gradient. However, it was impossible to distinguish between these causes and the secondary effects of forest type providing different litter charac-

mass than non-palm litter and animal abundance mirrored the pattern of mineral amounts. As in the bromeliad study, animal abundance declined significantly along the elevational gradient in the non-palm litter, but there was no corresponding decline in the palm litter, despite differences in climate along the gradient. This pattern could be seen in all groups, as diverse as isopods, centipedes and millipedes, dipteran larvae, ants, beetle larvae and adults, and Homoptera and Hemiptera.

Species richness showed the same pattern, and declined along the gradient in the type-forests along the gradient but

was remarkably consistent in palm litter. We did not detect a mid-elevational peak, as we did in the bromeliad communities.

Communities were compared between adjacent forests and the most widely separated tabonuco and dwarf forests, using Sørensen's Index of Similarity. Palm litter communities were more similar to each other than non-palm communities, which became less similar up the gradient. Even between the most widely-separated palm forests, there was a high degree of similarity.

The differences observed from the lower slopes to the summits, in abundance, species richness, and uniformity of communities are better explained by the contribution of different forest canopies rather than a direct elevational effect of temperature and rainfall differences. It would be tempting to assume that the significant differences in animal abundance and species richness between palm and non-palm litter at the same elevation are due to its higher mineral content, but palm litter is physically very different from other litter types. The flat fronds form layers like wet blotting paper as they decay, and it may be that it provides a more stable and favorable humid habitat in which animals can survive better than in other litter types, especially in the dry season.

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Forest canopy studies mini-course for graduate students

One of the characteristics of an emerging field of science is the development of training programs for the next generation of researchers and educators. At this time, the field of canopy studies lacks any formal graduate program. Students who seek training at the graduate level must currently either rely on a single researcher, or piece together courses and fieldwork from multiple institutions and mentors without a facilitating structure. Graduate-level courses in canopy studies have only been presented in a very few institutions (e.g., Dr. Steve Sillett, Humboldt State University, Arcata, California). However, interest in graduate-level classes and programs in canopy studies is high and increasing as the field continues to expand.

As a first step in creating a scientifically-sound curriculum in canopy studies, staff at the International Canopy Network (ICAN) are creating a set of lectures and supporting materials aimed at students at the graduate level. ICAN will disseminate this set of "distance learning lectures" via the web so that it will be available to any faculty member or student around the world. The "Forest Canopy Studies Mini-Course" will augment the ICAN's educational mission.

The materials will be presented in the format of a set of "topic units", each of which will conform to a harmonized structure and comprise of the following: 1) a set of lecture notes; 2) an accompanying Power Point presentation with relevant graphics; 3) a downloadable (.pdf) file of a primary reading; 4) a list of background text readings, websites, videos, and other resources; and 5) a videotape of a person giving the lecture, available upon request by mail from the ICAN office.

Although the primary audience is students focused on canopy studies, the Mini-Course can also be used as a teaching tool for academics wishing to present information about the forest canopy to their students in other disciplines and courses (e.g., ecology, forestry, botany, conservation). For example, our lecture notes and accompanying visuals on forest-atmosphere interactions within canopy forests could provide a professor teaching plant ecology the necessary information and framework for a well-rounded lecture on epiphyte ecology or the effects of global climate change on forest vegetation.

Preparing a comprehensive presentation of a fledgling and fragmented scientific discipline such as canopy studies will take more than the efforts of a single person. We welcome input from others in the canopy research and education community. This could take three forms. First, you could review and comment on the overall structure and components of the

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Canopy insect biodiversity in a Missouri state park

In conjunction with a tree canopy project on cryptogam biodiversity (Counts *et al.* 2000; Snell *et al.* 2003), we obtained baseline data on insect biodiversity. Our aims were to construct a list of taxa collected in the canopy and seek correlations between insect diversity and tree species and tree size. Four "Santa Fe canopy traps" (Fig. 1), or "composite flight-intercept traps" (Basset *et al.*1997), were placed in trees from 13-20 m above the ground from 6-21 July 2002 at Big Oak Tree State Park, Mississippi County, Missouri. The traps were rotated among nine species of trees for five-day periods per tree. We used the following taxa: shellbark hickory *(Carya laciniosa*, persimmon (*Diospyros virginiana*), green ash *(Fraxinus pennsylvanica*), pumpkin ash (*Fraxinus tomentosa*), sweetgum *(Liquidambar styraciflua)*, eastern cottonwood *(Populus deltoides)*, swamp chestnut oak *(Quercus michauxii)*, baldcypress (*Taxodium distichum*), and American elm *(Ulmus americana)*. Insects fell into collecting bottles containing 70% isopropyl alcohol and were identified to order, family, and "morphospecies". In all, 14 orders, 106 families, 276 "morphospecies" and 2,268 individuals were collected.

Fig. 1: Santa Fe canopy trap

Order	*Families*	*Species*	*Individuals*
Coleoptera	25	85	255
Hemiptera	19	54	1,307
Hymenoptera	18	40	147
Diptera	22	56	448
Lepidoptera	10	25	54
Miscellaneous Orders	13	23	77

Table 1. Summary of insect taxa collected in canopy traps at Big Oak Tree State Park

The most abundant families included the bark beetles (Coleoptera: Scolytidae), aphids (Hemiptera: Aphidae), leafhoppers (Hemiptera: Cicadellidae), chalcidoid wasps (Hymenoptera: Chalcidoidea), ants (Hymenoptera: Formicidae), midges (Diptera: Chironomidae), biting midges (Diptera: Cecidomyiidae), and leafminer moths (Lepidoptera: Gracillariidae).

Rarities and oddities included springtails (Collembola:Entomobryidae), which have been found living along branches in canopy habitats (Prinzing 1997, Palacios-Vargas *et al.* 1998), a dusty-wing (Neuroptera: Coniopyterygidae), a cedar beetle (Coleoptera: Rhipiceridae), an achilid planthopper (Hemiptera: Achilidae), and a shore bug (Hemiptera: Saldidae). One important find was a flatid planthopper (*Metcalfa pruinosa*), a species that has spread rapidly since its introduction to southern Europe (Wilson and Lucchi 2001). Finding 13 specimens in the canopy supports the assumption that these insects are present in the treetops, not just near the ground.

Our analyses of the data indicated that there were no correlations among the number of insect taxa and tree species, tree height, tree size (measured at DBH), or canopy trap height. This suggests that insects captured in canopy traps were moving through the canopy and were not necessarily associated with tree species. Numerous factors such as temperature, wind, and tree location within forested areas are likely to affect canopy trap captures. Future studies should focus on the relationship of particular insect taxa and those factors likely related to their presence in the canopy.

This research project, entitled "Tree canopy Biodiversity in Selected Missouri State Parks", was funded by the Missouri Department of Natural Resources.

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Original painting of maple tree by Chuck Willyard ‹*willoyard@msn.com*›

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*›.

GCP Global Canopy Programme

GLOBAL CANOPY PROGRAMME UPDATE

"Pro-Dosel" 2003, Cuba's first canopy workshop

Other than Jorge Ferro's studies of epiphytes over the past 20 years, very little is known about the ecology of species in the canopy of Cuba's forests, Tropical wet forests exist on the steep mountains in the east. The extraordinary and inaccessible limestone mountains of Viñales National Park in the west support numerous endemic species yet to be documented. Cuba support the richest diversity of palms anywhere in the world; some 50% of its plant species are found nowhere else.

Cuba held its first canopy workshop, "Pro-Dosel 20O3", at World Heritage Site at Viñales in October, 2003. The workshop was organised by ICAN representative Dr Jorge Ferro Diaz, an ecologist with ECOVIDA. Andrew Mitchell, Director of the GCP, and Peter Horchler, Research Manager of the Leipzig canopy crane in Germany, each presented papers to approximately 25 Cuban researchers from Havana and the province of Pinar del Rio. There was considerable interest in modern methods of gaining access to the canopy.

Francisco Cejas Rodriguez, Director of CENBIO, the Center for Biodiversity in Havana, discussed the comprehensive biodiversity information on Cuba's research community and its activities. A website to communicate this, including detailed species databases, will be online in the near future. This website is part of Cuba's commitment to the Convention on Biological Diversity (CBD) Clearing House Mechanism and the Global Biological Information Facility of the OECD. Cejas also presented Cuba's National Biodiversity Strategy Action Plan to the GCP. Topics of other papers included birds, bats, epiphytes, and other groups in Cuban forests, as well as on EU mechanisms for supporting forest research in Cuba.

Outcomes of the meeting included commitments to:

1. Exchange information with the GCP and the Botanical Institute in Leipzig to help foster canopy science in Cuba;
2. Seek funding to enable Cuban participation in the GCP Canopy Training Course in Brazil (managed by the University of Ouro Preto) with funds from the Environment Fund of the UK Foreign and Commonwealth Office;
3. Collaborate to create a specific canopy-focused project for Cuba;
4. Hold a canopy-focused session as part of the Caribbean regional biological conference to be held in Havana in November 2003.

ICAN members who wish to participate or who can offer support to Cuba's efforts to explore its canopies should contact Jorge Ferro ‹*jferro@ecovida.pinar.cu*› or Andrew Mitchell: ‹*a.Mitchell@globalcanopy.org*›

Project IBISCA , Panama

Over 35 entomologists from 15 countries participated in Project IBISCA's "International Biodiversity and Systematics" symposium. Conducted in San Lorenzo National Park on Panama's Caribbean coast between September and November 2003, the Symposium investigated the Biodiversity of Soil and Canopy Arthropods. The project was designed by Bruno Corbara (Université Blaise, Pascal, France) and Yves Bassett (Smithsonian Tropical Research Institute (STRI)), and was supported by the French pharmaceutical and chemicals group company SOLVAY with additional support from STRI and the GCP. This project marked the first attempt to use both mobile and static systems (cranes, balloons, the canopy raft, and climbers) to comprehensively investigate vertical stratification and beta diversity of arthropods in a rainforest, along with spatial and temporal replication of sampling sites. Results will be critical to better understand the distribution of diversity on earth. A second survey is planned for May 2004. Look for a report in a future edition of "What's Up?"

graduate mini-course, from page 3

program, alerting us to pieces that are missing. Second, you could contribute an entire (or partial) "topic unit" for which you have expertise, e.g., submit a set of lecture notes, power point presentation, images, and/or reading lists for inclusion and dissemination. Third, you could augment or modify materials in an existing topic unit. We particularly seek materials on the topics of "effects of human activities", "invertebrates and vertebrates in the canopy" and "future directions for canopy studies".

Our preliminary outline for the mini course is as follows:

1. Introduction to the field of forest canopy research
   - General development pathways of scientific fields
   - Methods of access in canopy studies
   - Progression of development in types of studies, data exchange, communication, relevance to society
   - Current issues and challenges in canopy studies
   - Case study: canopy seed bank dynamics in tropical montane cloud forest

2. The forest canopy environment
   - Physical gradients and stratification
   - Distribution of light
   - Effects of canopy structure on gases
   - Physical mdification of atmospheric fluids
   - Deposition, modification, and retention of airborne particulates
   - Canopy soils

3. Forest canopy structure
   - Historical approaches to studying canopy structure
   - Geographical trends (temperate, tropical, boreal)
   - Spatial categorization of canopy structure
   - Spatial scaling in forest canopy studies
   - Fractals and topological issues

4. Forest canopy functions
   - Interception and modification of atmospheric inputs
   - Light/energy
   - Water
   - Nutrients
   - Habitat for animals

5. Canopy-dwelling vascular plants
   - Biodiversity
   - Biogeography
   - Physiological adaptations to canopy life
   - Seed bank distribution
   - Germination and growth
   - Response to disturbance; succession

6. Canopy-dwelling non-vascular plants
   - Biodiversity
   - Biogeography
   - Physiological adaptations to canopy life
   - Response to disturbance; succession

7. Invertebrates in the canopy
   - Biodiversity & global patterns
   - Physiological adaptations to canopy life
   - Plant-insect interactions - pollination, dispersal
   - Response to disturbance; succession

8. Vertebrates in the canopy
   - Biodiversity and issue of global patterns
   - Physiological adaptations to canopy life (flight, prehensile tails, gliding flaps)
   - Plant-vertebrate interactions (pollination, dispersal, transport, frugivory)
   - Canopy as corridors for vertebrates
   - Response to disturbance; succession

9. Effects of human activities on canopy biota
   - Air pollution
   - Fragmentation
   - Global climate change
   - Hunting pressures
   - Harvesting (e.g., mosses, leave trees, orchids)

10. Future directions for canopy studies
   - Research
   - Experimental approaches
   - Modelling approaches
   - Mapping technologies, remote sensing
   - Education
   - Outreach to non-scientists
   - Conservation – the canopy ethic
   - Economics - links to conservation & market valuation
   - Political issues and global challenges

Additional information and academic materials sought for each topic unit is available on the ICAN website ‹‹*http://www.evergreen.edu/ican*››.

We anticipate that the institution of this "centributed" mini-course might satisfy the immediate need of having graduate-level materials available to a widespread audience. We hope it will lead to more extensive offerings at particular institutions in the future. We welcome your suggestions.

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Announcements

What's up with ICAN and canopy projects?

We are pleased to announce that back issues of "What's Up?" are now available online in PDF format. Visit ‹‹*http://www.evergreen.edu*››.

As a new benefit for ICAN members, you can now have your CV posted online via the ICAN website. If you are a current member and would like to take advantage of this benefit, please e-mail us your formatted CV in Word or PDF format, along with a photo. Posted CV's can be viewed under the "Research" section of the website.

ESA's 89th Annual Meeting will be held August 1 to August 6, 2004 in Portland, Oregon at the Oregon Convention Center. As part of the meeting, we are proposing to organize a symposium on canopy research. The title of the proposed symposium is "Forest canopies as participants in ecosystem and landscape ecology". Following is a description:

Forest canopies as participants in ecosystem and landscape ecology

The emerging field of forest canopies has matured to produce insights into some of our most pressing ecological and environmental issues. A recent summary article on canopy research in the journal Science described results and upcoming efforts that are critical to understand global climate change, maintenance of biodiversity, and sustainable use of forest resources. With greater access from tools such as canopy cranes, as well as long-term and large-scale data sets derived from remote sensing, nanotechnology, and permanent canopy study sites, canopy researchers are now able to place their research on forest canopy microenvironments, biota, and processes into the context of whole ecosystems and landscapes. Speakers will draw upon research in tropical, temperate, and boreal forest canopies. They will link their research on forest canopies to the forest as a whole, from the atmosphere to the soil. They will discuss the role of canopy flora and fauna in issues such as: maintaining forest biodiversity, atmospheric deposition, nutrient interception and retention, hydrology, carbon sequestration, and creation of wildlife habitat. Each speaker will suggest research questions and approaches for the future.

You can read more about symposia and the ESA meeting at: ‹‹*http://www.esa.org/portland/proposal.html*››.

Unique Canopy Access Opportunity in Lowland Forest in Costa Rica:

The CARBONO research group, ‹‹*http://www.Carbono.org*››, a multidisciplinary team studying the stocks and flows of carbon in tropical rainforest, announces a unique opportunity for collaboration in canopy research. Funding from the National Science foundation will support a field campaign of approximately 35 vertical canopy transects in old growth forest at the La Selva Biological Station in Costa Rica ‹‹*http://www.ots.ac.cr/en/laselva/*›› beginning in June 2003. The vertical transects will be permitted by erecting a walk-up scaffolding tower at each site for approximately 2 weeks.

The primary project goal of the Towers project ‹‹*http://www.fiu.edu/~carbono/tower.htm*›› (What's Up?, Vol. 9:4) is to conduct vertical measurements of forest structure and physiology. However, we recognize the unique opportunity presented by access to vertical transects from understory to above-canopy in tropical rainforest to researchers outside of our field of interest. We welcome collaborators with their own funding to conduct research off of the tower that does not interfere with our research. Examples might include study of canopy epiphytes, secondary compounds along vertical transects, canopy insects, bird and mammal observation, etc. Unfortunately, due to CARBONO personnel limitations, we will be unable to collect samples for collaborators. The field campaign is scheduled to last about 20 months. The vertical transect sites will be randomly located in old-growth forest stratified for canopy height.

Those who are interested should send an e-mail to Steve Oberbauer at Florida International University ‹oberbaue@fiu.edu›. Research and collecting permits are required to conduct research at La Selva and can be obtained with help from OTS ‹‹*http://www.ots.ac.cr*››. For samples to be taken out of county, export permits are also required.

Websites

TreeLink: The Community Forest Resource

TreeLink was created to provide information, research, and networking for people working in urban and community forestry. Included in the site is a learning center that provides educational information, books, information on how to take action, news and updates, talk forums, and other useful links and resources.

Visit: ‹‹*http://www.treelink.org*››.

School-based forest education in the northern forest

An updated, downloadable version of the National Community Forestry Center's School-based Forest Education in the Northern Forest can be found at ‹‹http://www.ncfcnfr.net/pubs.html››. The booklet, now in its 4th edition, gives brief summaries of forestry-focused, school-based programs throughout the northern forest region. If you know of any educational resources that would be beneficial to share or would like to have included in the next edition of School-based Forest Education, please e-mail a description of the resource and how to obtain it to ‹mary@yellowwood.org›.

4th International Canopy Conference, 10-17 July 2005, Leipzig – Germany

Canopy ecology – tropical versus temperate forests

The 4th International Canopy Conference will bring together experts in forest canopy biology from all over the world to share research results and ideas, strengthen existing collaborations, and establish new ones. As agreed during the 3rd International Canopy Conference in Cairns, Australia, the conference will take place in Leipzig, Germany, and will be organized by the University of Leipzig and the Centre for Environmental Research Leipzig-Halle (UFZ). It is planned to have morning and evening plenary talks and up to three parallel sessions on different topics like canopy structure, epiphytes, effects of climate change, plant physiology, phenology, pollination, etc.

The city of Leipzig is suitable for such a conference, as its university has hosted two canopy crane projects, one in the northern Amazon (Venezuela) and one in the forest of Leipzig. Leipzig offers a unique mix of traditional and modern cultural life. The conference will take place from 10th-17th of July 2005, just one week before the World Conference of Botany in Vienna, accompanied by excursions to various crane sites or other sites of interest.

Because there are permanent canopy access facilities in both temperate forests and tropical rainforests (including the COPAS system in French Guyana), it is appropriate to compare the ecology and functioning of whole forests, including their canopies, in both geographic regions. We will have morning and evening plenary talks and up to three parallel sessions on topics such as canopy structure, epiphytes, effects of climate change, plant physiology, phenology, and pollination.

We especially encourage our colleagues from non-US and non-European countries to apply early and to seek travel support.

For any further information please contact:

Peter Horchler ‹horchler@uni-leipzig.de› or Wilfried Morawetz ‹morawetz@uni-leipzig.de›.

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Contribute to What's Up?

The International Canopy Network (ICAN) is currently seeking articles and information for the upcoming issue of What's Up?, set for publication in March, 2004. ICAN accepts articles, meeting and workshop announcements, related 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 isFebruary 15, 2004. For further information or to send contributions, please contact the ICAN office:

David Franklin, Outreach Coordinator/Editorial Assistant; 2103 Harrison Avenue NW, PMB 612, Olympia, WA 98502; (360) 866-6788; ‹canopy@evergreen.edu›.

Save a tree-receive "What's Up?" electronically!

In keeping with our mission of conservation, ICAN is pleased to announce the option of receiving "What's Up?" in .pdf format. Our intention is to reduce the amount of paper used for printing, as well as offering convenience for members who prefer electronic materials. The average size of the newsletter in .pdf format is 500 KB.

If you would prefer to receive the newsletter in .pdf format, please send an e-mail with your correct e-mail address to ‹*canopy@evergreen.edu*› and indicate your preference. Note that unless you request this option, you will continue to receive "What's Up?" in hard-copy format. You may change your preference at any time.

For more information or questions, please contact the ICAN office: (360)866-6788; ‹canopy@evergreen.edu›.

RECENT CITATIONS IN CANOPY SCIENCE

[Ed. note: 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).

Canopy Structure

Sander, C., and D. Eckstein. 2001. Foliation of spruce in the Giant Mountains and its coherence with growth and climate over the last 100 years. Annals of Forest Science **58**:155-164.

Xiao, Y., E. J. Jokela, and T. L. White. 2003. Species differences in crown structure and growth performance of juvenile loblolly and slash pine. Forest Ecology and Management **174**:295-313.

Ecosystem Processes

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