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WHAT'S UP?

THE NEWSLETTER OF THE INTERNATIONAL CANOPY NETWORK

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WHAT'S UP WITH ICAN?

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The International Canopy Network celebrated its tenth anniversary last year. For over a decade, our staff and Board have enhanced communication among researchers, educators, and conservationists concerned with forest canopies and forest ecosystems.

When we established the ICAN, our major focus was to provide pathways for canopy researchers to exchange information and data amongst themselves. We developed a canopy citations database that now has over 5400 papers, 70% of which are archived and available in hard copy or in .pdf format in the files at the ICAN headquarters. Our Board and our members have organized and participated in numerous scientific symposia and meetings in the USA and overseas.

Over the years, however, awareness of the importance of forest canopy organisms and processes has grown among scientists and non-scientists. Our activities have broadened to include the development of educational materials for school children, college students, policymakers, the media and the general public. Many of our members have participated in such activities by giving public lectures, consulting to journalists, and being featured in television and films.

We continue to foster scientific research with our ongoing listing of recent papers published on canopy-related topics at the end of every newsletter. We welcome you to send us citations - for both scientific and popular articles- that we can list for the benefit of others. We also welcome your submissions of articles and notes for the body of each newsletter.

This issue of What's Up highlights some of ICAN's recent activities along with other programs housed in the forest canopy lab at The Evergreen State College. Although very different in approach, geographical location and scope, they share a common theme of understanding forest canopies and sharing that understanding with others.

ICAN POSTERS NOW AVAILABLE !



photo by Chuck Willyard

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THE CANOPY DATABASE PROJECT

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The Canopy Database Project, based at The Evergreen State College in Olympia, WA, is a National Science Foundation-funded collaboration between canopy ecologists and computer scientists. Co-led by Drs. Nalini Nadkarni and Judy Cushing, the project's mission is to address issues of data acquisition, management, analysis and exchange relating to canopy studies at all stages of the research process. We develop informatics tools for canopy scientists, document and publish datasets that demonstrate use of these tools, characterize (and formalize in informatics terms) fundamental structures of the forest canopy, and relate those structures to functional characterizations for retrospective, comparative, and integrative studies.

The project has three main foci:

1. **Informatics tools and information artifacts for canopy scientists.** We are developing software to help canopy scientists design databases, publish forest structure and functional data, and visualize and analyze scientific data:
 - a. A database design and warehouse tool (*DataBank*) presents our vision of how ecologists might design, archive, and mine field databases.
 - b. A visualization tool (*CanopyView*), creates data visualizations from *DataBank* datasets.
 - c. An Internet reference site for canopy research (the *Big Canopy Database* – canopy.evergreen.edu/bcd) which consolidates information of interest to forest canopy researchers.
2. **Data acquisition and database development for collaborating researchers.** We conducted fieldwork on forest structure and function for eight sites in a 1000-year chronosequence (ranging from 90 to 950- years) in the western Cascades of Washington State (1kcs). Various other canopy research datasets, and LTER ecology datasets, have also been represented as *DataBank* databases, with several publicly available from *DataBank*.
3. **Conceptual and theoretical ecology.** To develop useful informatics tools we also need general conceptual structures, and have begun to formulate generalized spatial categories and associated database components (*templates*) for forest canopies. This conceptualization of canopy structural space is based on 500 canopy and forest structure papers.



Connected to our focus on eco-informatics, staff Research Associate Anne Fiala will be presenting a half-day eco-informatics workshop at the 4th International Canopy Conference in Leipzig, Germany on July 16, 2005

(See <<<http://www.uni-leipzig.de/leipzigcanopycrane/conference/>>> for more information on the conference and our workshop). Our workshop will start by demonstrating the use of databases in research, and their potential advantages over more traditionally-used spreadsheet programs. We will then demonstrate the functionality of our tool for creating an MS Access database package (*DataBank*), which ‘automagically’ creates a database along with data-entry forms and metadata (ecological metadata language - EML). Participants will work on transferring their own datasets into a database using *DataBank*. We will also present the functionality of our visualization tool (*CanopyView*) using a sample dataset. This workshop will enhance each participant’s ability to efficiently carry out their research, including synthetic research, which demands combining of data from multiple sources.

Associated with our focus on data acquisition, this summer, along with several collaborators, we will be revisiting the 1kcs field sites to conduct additional field studies. The first project is titled “Molecular and biochemical analyses of microbial communities in old-growth Douglas-fir canopy and terrestrial soils.” This will be a collaborative project with Dr. Ann Auman and two of her undergraduate students from Pacific Lutheran University. Although bacteria in forest canopies have been shown to affect nutrient cycling and humus production, there is no information about the identities of these bacteria, the extent of their biochemical capabilities and their relative diversity compared to forest floor soil communities. Our study will use molecular and biochemical techniques to assess microbial communities from forest tree canopy soils compared with terrestrial soils. Six overstory ca. 650-yr-old trees at Cedar Flats Research Natural Area will be climbed using traditional rope-climbing techniques and soil samples will be collected from each of two heights in each tree: at an intermediate height and near the top of each tree. Soil samples will also be collected for the ground soil located directly below each tree. Our team of microbiologists will then use culture-independent techniques to analyze bacterial ribosomal gene sequences to establish evolutionary relationships among the bacteria present. Biochemical characterizations will also be performed to examine the physiological capabilities of these microbial communities.

The second project is titled “Vertical distribution of light among a structural diversity gradient in Douglas-fir forests of the southwestern Washington Cascades”. This project will be completed by students and researchers from

the Canopy Database Project team. We will be following-up on hemispherical photos taken on the ground at 40 systematic locations at each of the eight 1kcs sites to quantify canopy cover. To supplement these ground-based data, we will be taking photos at multiple heights ranging from the ground to the upper surface of the canopy using a Nikon Coolpix 5400 digital camera outfitted with a FC-E9 fisheye lens. Photos will be analyzed for indirect site factor as a measure of canopy openness using Gap Light Analyzer (see <<<http://www.ecostudies.org/gla/>>> for more information).

The third project is titled “Comparison of songbird communities among a structural diversity gradient in Douglas-fir forests of the southwestern Washington Cascades.” This pilot project is a collaboration between our team and Adrian Wolf, who is currently finishing up his master’s thesis work on the foraging behaviors of songbirds in Wind River, WA. Adrian has been involved with the project for the past year, and we developed a database with data entry forms using *Databank*, that he now uses to enter his field data. This study will be a census of the bird communities that are found in the 1kcs sites, and we will be investigating differences in the communities among the sites and look for correlations with the structure of the forests. This study will be completed in 2006.

Our efforts to create database tools for the canopy research community will push forward the emerging field of canopy science. These efforts can be viewed as a model for other emerging areas of ecology where data-integration and sharing can be effective in integrating results from different studies. We seek input from researchers in the field of canopy studies to contribute to the online *Databank* study center <<<http://scidb.evergreen.edu/databank/studycenter/>>> , and from those outside the field who may have insights into making this process efficient and productive. We also plan to conduct further field studies at the 1kcs sites next summer (2006) and we welcome interest from other researchers who may be interested in conducting field research at our sites. These researchers can then take advantage of the existing canopy and forest structure data for the 1kcs sites.

For more information on the 1kcs sites visit:

<<http://canopy.evergreen.edu/research_dataArchives_1kcs.asp>>

For further information on the project and upcoming field research please contact
Anne Fiala at <fialaa@evergreen.edu>

CANOPY OUTREACH IN COSTA RICA

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Tourism is the largest industry in Costa Rica and canopy eco-tourism is the main draw in the cloud forests. Visitors to Monteverde, a premier cloud forest eco-tourism and research site may choose to walk over tall bridges suspended at different heights above the forest floor or they can ride high above the forest canopy harnessed to canopy zip lines or cables. The cloud forests of Monteverde have also been a hot spot for canopy research. Over 30 years of research has been conducted there by a number of researchers.

Canopy eco-tourism provides the ideal setting for people to gain knowledge about the life of the forest canopy. Far too often, however, eco-tourists are not provided with interpretive or educational materials while visiting canopy parks. In accordance with ICAN's mission to blend research with education and outreach, ICAN staff and Board members have initiated a model project to bring canopy information to the general public at *Selvatura*, one of the largest canopy tourism parks <<www.selvatura.com>>. We have worked to bridge the gap between what the researchers know and what the visitors learn about the forest canopy.

In April 2005, ICAN President Nalini Nadkarni and staff member Hannah Anderson, met with the director of the beautiful canopy park in Monteverde to discuss a partnership and address this disparity. A family business, bought in part to preserve the ever-decreasing cloud forest, *Selvatura* consists of a series of eight bridges or walkways suspended at various heights from 30 to 80 m above the forest floor. They

also boast over 5 km of canopy "zip" lines, providing visitors a thrilling ride through and above the treetops. The *Selvatura* President, Mario Solano and the Director of *Selvatura*, Mario Andres Solano, expressed enthusiasm about a partnership with ICAN and the potential to provide visitors with accurate ecological information about the canopy while they catch a glimpse of this complex ecosystem invisible from the ground. It was rewarding to work with such a forward-thinking Director who understands the value of public outreach, science, research and conservation.

There were many aspects of the project to be addressed – the amount of information to provide, the quality of that information and in what forms it would be best communicated and the economic and ecologic impacts of canopy parks on both the human and forest communities. During our first meeting with the Director, we outlined some preliminary products and pathways to achieve our outreach goal. We decided that ICAN would conduct visitor surveys at *Selvatura* to get an idea about the interests and opinions of canopy park visitors. We surveyed visitors, both orally and with a

written form, about their desire to have educational materials, what aspects of canopy ecology they wished to learn about, their interest in various media for learning and their potential for providing research support. *Selvatura* staff continue to give out and collect these surveys. Preliminary results indicate that visitors to *Selvatura* are very interested in having written educational materials made available to them.

We toured the site on our own and also interacted with the interpretive guides to get a feel for the



ICAN Program Manager, Hannah Anderson and *Selvatura* Park Director, Mario Andres Solano.

information already being transmitted to visitors. With information from canopy researchers, the ecological literature and private guides, ICAN produced a small handout for *Selvatura* visitors regarding general forest canopy ecology. The handout, in both Spanish and English, is now given to every visitor to *Selvatura* along with a map of the grounds. The flyer describes the ecology of the cloud forest, the uniqueness of the forest canopy, the animals of the cloud forest, mutualisms between species and conservation.

The next step of the project includes the creation of signs to be posted at each walkway, each discussing a different aspect of canopy ecology. We also plan to create text and content for the *Selvatura* website, write and publish a field guide aimed specifically at the biota found in the *Selvatura* forest, and create an up to date training manual for guides hired at *Selvatura*. In the longer term, ideas for the future entail a resident naturalist or biologist on staff at *Selvatura* and A lecture series about canopy ecology to be held there. With funding, a research station could be set up at *Selvatura*. Additionally, other canopy sites with ICAN sponsored educational materials could be connected as “sister walkways.”

There are no shortage of ideas and no limit to the directions this project could take. ICAN is currently attempting to secure funding to ensure the long life of the project. We encourage other walkway sites to use this project at *Selvatura* as a model for connecting visitors to canopy research. ICAN would be happy to hear comments or suggestions regarding this or other canopy walkway projects. Please contact Hannah Anderson at <canopy@evergreen.edu>.

We acknowledge the enthusiastic support and collaboration of Mario Andres Solano, *Selvatura* Director and Mario Solano, *Selvatura* President and the *Selvatura* staff. This project is conducted in



View of canopy walkway and Monteverde cloud forest at *Selvatura* Park, Costa Rica.

conjunction with the Research Ambassador project<<www.evergreen.edu/researchambassador>>, an innovative public outreach project funded by the National Science Foundation, Informal Science Education Program.

SAVE A TREE - RECEIVE “WHAT’S UP?” ELECTRONICALLY!

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. The average size of the newsletter in .pdf format is 500 KB. 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)867-6788; <canopy@evergreen.edu>.

MOSS IN PRISONS PROJECT

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Collection of mosses and other “secondary forest products” from the forests of Washington and Oregon is a growing industry for the horticultural trade (Muir 2004). Recent studies have shown collecting mosses from branches and trunks of trees in old-growth forests is not sustainable. However, collecting continues, both legally and illegally. The President and staff of ICAN have initiated a project to investigate ways of relieving the stresses on wild moss populations by growing or “farming” mosses for the horticultural trade in a sustainable fashion. To investigate methods to farm mosses, we approached the administrators of a local prison to enlist the help of inmates to grow mosses. A volunteer who worked with the inmates, Raymond Price, forged the initial contact.

The Cedar Creek Corrections Center (CCCC) in Littlerock, WA agreed to allow their prisoners to participate in the moss-growing endeavor. CCCC is a minimum custody federal prison located just south of Olympia, WA. About 400 male adult offenders with less than 4 years on their sentence are housed in the facility. CCCC is considered a work camp: all offenders are required to work in preparation for re-entry to the community.

Exposure to growing plants can be therapeutic to the prisoners. Further, the skills learned by growing plants could be applied to earn money once prisoners are released. To date, no other prison has initiated a program to grow moss; yet mosses lend themselves to the prison environment due to their small stature, hardiness and lack of need for sharp implements.

Four moss genera were selected for the study – *Eurynchium*, *Dicranum*, *Metaneckera* and *Isoetecium*.

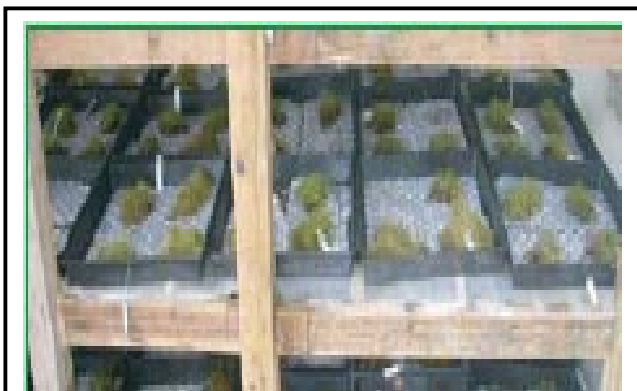
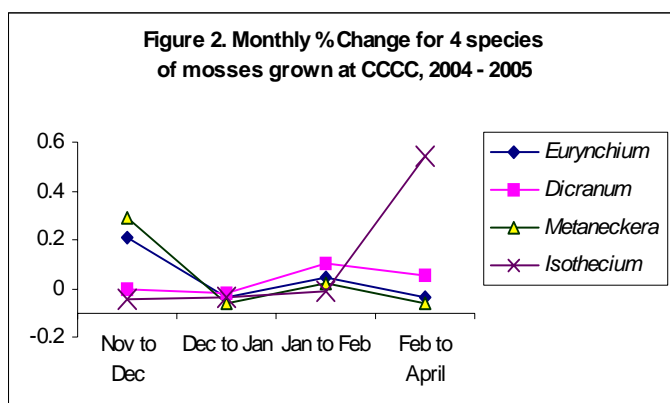


Figure 1. The four species of moss are grown in trays in a shed housed at CCCC. Inmates participate in the sampling for dry-weight equivalents to document growth rates.

Mosses were collected with a permit from the Olympic National Forest in Washington State. We drew upon basic research on moss growth to develop methods to grow mosses, including growing the wild-collected gametophytes in hanging mesh bags and in plastic flats with varying amounts of shade and water



(Figure 1). Growth activity is being documented on a monthly basis by participating inmates and is monitored by ICAN staff and graduate students at The Evergreen State College. Preliminary data indicate that of the four species collected, *Isoetecium* shows the best chance of cultivation under the current growing method (Figure 2).

The “Moss in Prisons” project is enthusiastically supported by the administration at CCCC, The Evergreen State College and The International Canopy Network. The inmates are eager and seem to benefit from participation in the project. The overall goal to provide sustainably grown moss to the horticultural trade shows real promise. More work and testing is necessary, but the preliminary results give us hope for a sustainable future.

This project has led to the development and implementation of a regular lecture/seminar series at the prison on “Sustainable Living, Sustainable Lives”. Each month, a visiting researcher delivers a talk on an aspect of sustainability or ecology at the CCCC, and the talk is attended by both prisoners and staff/administrators. This is part of the Research Ambassador Program, a public outreach program supported by the National Science Foundation, Informal Science Education Program.

For more information go to:

<<www.evergreen.edu/researchambassador/moss>>



Global Canopy Programme Update

WHOLE FOREST OBSERVATORIES: AN INTERNATIONAL NETWORK FOR MONITORING CANOPY BIODIVERSITY AND GLOBAL CLIMATE CHANGE. OXFORD WORKSHOP.

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*Research & Conservation Programme Manager
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In March 2005, the GCP announced approval of its ambitious plans for a global network to monitor biodiversity loss and the impact of climate change in the world's forest canopies. The United Nations Environment Programme (UNEP), with financial support of the Global Environment Facility (GEF) for proposal development, has given its backing to this proposal to establish a series of 'Whole Forest Observatories' (WFO) across the tropics. These new facilities will be linked to others already in existence, mainly in temperate forests and some tropical forests around the world. The aim of the network will be to investigate how climate change might alter the way forests function and what risks this poses to humans and the biodiversity such forests contain. The network will also attempt to determine the socio-economic value forests canopies offer in regards to ecosystem services to humans.

Between the 5th – 9th June 2005, the GCP held an International Workshop to discuss the development and implementation of this project in Oxford, UK with delegates from

Brazil, Ghana, Madagascar, India, Malaysia, Australia, The Netherlands, UNEP, Panama and the UK. This meeting was the first time the project partners had been brought together

and was a great achievement with every partner leaving the meeting with a keen interest to ensure that the project was a success. During the meeting, delegations from each focal country presented their progress to date on the project and received presentations on the potential activities that could be achieved using the network. The main outcomes of the meeting were the formation of the WFO project Steering Committee and the election of the GCP as the International Execution Agency of the project. The National Execution agencies were also confirmed as INPA, (Brazil);

Forest Research Institute of Ghana (Ghana); Madagascar Institute for the Conservation of Tropical Environments (Madagascar), Ashoka Trust for Research in Ecology and the Environment (India) and Institute for Tropical Biology and Conservation (Malaysia). The development of activity plans for each of the project partners for the PDFB 'design'



Delegates after BCAP climbing demonstration in Wytham woods, UK. From left to right: Jan Wolf, The Netherlands; Andrew Oteng-Amoako, Ghana; Roger Kitching, Australia; Soubadra Devy, India; Yves Basset, Panama; Max Zieren, UNEP; Datin Huzaimah Yusoff, Malaysia; Nelson Edinaldo, Brazil; Ainuddin Nuruddin, Malaysia; Steve Turton, Australia; Glen Reynolds, UK; Braulio Dias; Kamal Bawea, India; Fredua Agyeman, Ghana; Luiz Miranda, Brazil; TGanesh, India and Henry Bernard, Malaysia.

continued on page 8

(GCP - continued from page 7)

phase of the project was also established and is due to start in 2006.

If the \$17 million network is fully funded, the first five WFO's will be set up in Brazil, Ghana, Madagascar, India and Malaysia. The Governments of all five countries have given their backing to the plan. A harmonized research programme will be set up across the sites mostly using canopy cranes, to provide mobility within the whole forest from treetops to soil. Towers will also be installed to monitor fluxes of water, oxygen and carbon dioxide between the canopy and the atmosphere. The project will also investigate the potential for canopy based ecotourism and canopy horticulture to provide sustainable benefits for communities dependent on forests. Each observatory will be set up to act as a monitoring and early warning system for signs of climate change and will deliver critical information to a network of stakeholders, including governments and communities.

GEF has earmarked almost \$6 million for the WFO project and the challenge now is to raise matching funds in both cash and in-kind support for the full project to go ahead.

<<www.globalcanpoy.org>>

MEETINGS AND EVENTS

WIND RIVER CANOPY CRANE TO BE FEATURED AT SMITHSONIAN

JUNE 23-JULY 4, 2005 WASHINGTON, DC.

The Wind River Canopy Crane Research Facility will be among the featured interpretive and interactive displays at the Smithsonian Folklife Festival <<<http://www.folklife.si.edu/center/festival.html>>>. This is the 100-year anniversary of the US Forest Service, and the Folklife Festival will be featuring many aspects of forest service culture, community, and science. See <<<http://www.folklife.si.edu/festival/2005/forestry/index.html>>>. One aspect is the Crane's research and programs. Rick Meinzer (USFS Research Scientist, and Principal USFS Investigator for the Crane) and Dave Shaw (WRCCRF Research Scientist) will be manning an interactive exhibit that will include a canopy access system (cherry picker) to access a tree crown on the mall. They will be doing various interpretive projects, such as hunting for herbivores in the crown of a tree and demonstrating water use and photosynthesis. Voice communication with the ground will be included in the display. Several hundred thousand people are expected to visit the mall during this two week July 4th holiday period.

UPDATE:

4TH INTERNATIONAL CANOPY CONFERENCE

UNIVERSITY OF LEIPZIG, GERMANY

10-17 JULY 2005

The University of Leipzig, Institute of Botany, the UFZ Centre for Environmental Research Leipzig-Halle and the City of Leipzig will be hosting the 4th International Canopy Conference in Leipzig, Germany this summer.

The theme for The Conference will be "Canopy Ecology - Tropical versus Temperate Forests". This is appropriate as permanent canopy access facilities are located worldwide in both tropical and temperate forests. The term 'temperate' is meant here to also include boreal forests. The Conference is intended to bring together experts in forest canopy biology from all over the world in order to spread and share research results and ideas, to strengthen existing collaborations, and to establish new projects.

Session Topics Include:

- * Vascular epiphytes
- * Fungi and fungal organisms in the canopy
- * Canopy climate I: Canopy / atmosphere interactions
- * Canopy climate II: Competition for light in forest canopies
- * Physiological, biomechanical and allometric constraint on tree height
- * Floral ecology, reproductive systems, pollination and seed dispersal
- * Arthropods in temperate and tropical forest canopies I
- * Forest canopy herbivores and herbivory across the globe
- * Evolution, biodiversity and genetics
- * Informatics workshop
- * Arthropods in temperate and tropical forest canopies II

book of abstracts available in pdf form at:

<<http://www.uni-leipzig.de/leipzigcanopycrane/conference/downloads/canopy_2005_conferencebook.pdf>>

The Leipzig crane site will also be providing crane lifts to conference attendees. Lifts will take place twice a day (morning and afternoon) from Monday to Friday. Cost is EUR 15 per person. You may register for the crane lift on site in Leipzig.

For more information go to:

<<<http://www.uni-leipzig.de/leipzigcanopycrane/conference/index.htm>>>

IN MEMORIAM, WILLIAM C. DENISON, 1928-2005.

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Bill Denison died in April of this year after a long illness. He is survived by his wife Margo, his children Becky, Tom, Glenn, and Ford, four grandchildren, a seemingly endless number of students who have gone on to careers in the biological sciences, and a new field in biology – exploration of the canopies of tall trees.

Bill began his lofty exploits shortly after his move to Oregon State in 1966. He had spent his previous 11 years at Swarthmore College where he taught biology to many of us and learned vertical (now called technical) caving techniques from some of us. If he hadn't been thinking about Life in Tall Trees* before moving to Corvallis, he certainly did soon after arrival. The Denisons lived in town their first few years, but they soon built a house just across a pass on what was then a gravel road, in a bottomland area of Douglas-fir perhaps 150 years old. I can imagine Bill looking up at those first branches, thinking about slingshot, bow, and mortar as ways of getting a rope over them. Also about that time, Warren Harding and friends were bolting their way methodically up Yosemite's blank walls. With the help of several undergraduate OSU rock rats, the Yosemite bolt technique was adapted to Douglas-fir, and in no time, scientists were wandering the giant misshapen branch systems collecting plants and critters that had only been seen previously lying battered and bruised on the forest floor – victim to wind or chainsaw. It was now possible to study canopy life in its proper habitat and gauge its role in forest ecosystem dynamics.

Cyanophycophilous lichens abound in Douglas-fir canopies, and Douglas-fir forests were already known to be nitrogen limited, so one of their early goals was to measure rates of N fixation in the canopy. Working with George Carroll, of the University of Oregon, and yet another of Bill's Swarthmore students, the "tree climbers" came up with a value of about 6 kg/ha/yr N fixation, a number that I used in the first nutrient budget for an old-growth forest and which has not, to my knowledge, been superseded. A second issue revolved around small debris that fell not just onto the litterfall screens that we had placed throughout the forest, but right

through them. Termed "microcrud", I think by George Carroll, the material weighed too little to matter in a stand carbon budget, but the microcrud was exceptionally N rich – not surprising since much of it was reproductive parts and lichen debris. George and Bill were the first that I know of to consider this pathway of nitrogen flux to the forest floor. Later work with Bill Massman documented many hydrological aspects of these old-growth canopies.

Looking back it may be hard to comprehend the novelty of these early studies. Canopy research sites across the world routinely measure many aspects of canopy gas exchange, hydrology, and energy balance. Unlike pioneers before him, Bill didn't have new continents to explore. But perhaps the mark of a pioneer is simply to realize that there's a place people have never been, then find a way to go there. Bill Denison did this and deserves the credit due pioneers.

*Denison, W.C. 1973. Life in tall trees. *Scientific American* 228: 74-80.

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 September, 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 August 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>*.

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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).

CANOPY STRUCTURE

- Johansson, T. 2004. Changes in stem taper for birch plants growing in tree shelters. *New Forests* 27:13-24.
- Lu, P. X., D. G. Joyce, and R. W. Sinclair. 2003. Effect of selection on shoot elongation rhythm of eastern white pine (*Pinus strobus* L.) and its implications to seed transfer in Ontario. *Forest Ecology and Management* 182:161-173.
- Miura, M., and S. I. Yamamoto. 2003. Effects of sprouting and canopy states on the structure and dynamics of a *Castanopsis cuspidata* var. *sieboldii* sapling population in an old-growth evergreen broad-leaved forest. *Forest Ecology and Management* 183:387-400.
- Teske, M. E., and H. W. Thistle. 2004. A library of forest canopy structure for use in interception modeling. *Forest Ecology and Management* 198:341-350.

ECOSYSTEM PROCESSES

- Carrara, A., A. S. Kowalski, J. Neiryck, I. A. Janssens, J. C. Yuste, and R. Ceulemans. 2003. Net ecosystem CO₂ exchange of mixed forest in Belgium over 5 years. *Agricultural and Forest Meteorology* 119:209-227.
- Hedin, L. O., P. M. Vitousek, and P. A. Matson. 2003. Nutrient losses over four million years of tropical forest development. *Ecology* 84:2231-2255.
- Lesica, P., H. E. Atthowe, and F. M. Dugan. 2003. Incidence of *Perenniporia fraxinophila* and its effects on green ash (*Fraxinus pennsylvanica*) woodlands in eastern Montana, USA. *Forest Ecology and Management* 182:153-159.
- Limpens, J., J. T. A. G. Raymakers, J. Baar, F. Berendse, and J. D. Zijlstra. 2003. The interaction between epiphytic algae, a parasitic fungus and *Sphagnum* as affected by N and P. *Oikos* 103:59-68.

FOREST MANAGEMENT

- Hall, J. S., D. J. Harris, V. Medjibe, and P. M. S. Ashton. 2003. The effects of selective logging on forest structure and tree species composition in a Central African forest: implications for management of conservation areas. *Forest Ecology and Management* 183:249-264.
- Hedenas, H., and L. Ericson. 2003. Response of epiphytic lichens on *Populus tremula* in a selective cutting experiment. *Ecological Applications* 13:1124-1134.
- Romme, W. H., M. L. FloydHanna, D. D. Hanna, and P. Kemp. 2002. Experimental thinning and burning of ponderosa pine forests in southwestern Colorado: effects on canopy structure, understory composition, and fuels. US Dept Agr, Forest Serv Rocky Mt Forest & Range Exptl Stn, FT Collins, CO 80526 USA.
- Stuart Smith, A. K., and J. P. Hayes. 2003. Influence of residual tree density on predation of artificial and natural songbird nests. *Forest Ecology and Management* 183:159-176.
- van Gardingen, P. R., M. J. McLeish, P. D. Phillips, D. Fadilah, G. Tyrie, and I. Yasman. 2003. Financial and ecological analysis of management options for

logged-over Dipterocarp forests in Indonesian Borneo. *Forest Ecology and Management* 183:1-29.

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