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WHAT'S UP?

The Newsletter of the International Canopy Network

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National Geographic Documentary on Forest Canopies on Prime-Time Television

Tropical treetops and the biota they support came to the living rooms of millions of American's on January 30, 1999, in the form of a National Geographic Television Special on NBC. This film, titled "Heroes of the High Frontier", is the first full-length documentary on the diverse world of the forest canopy. It features the research of four canopy researchers - the organisms they have discovered, the ways they climb trees, and the importance of the forest canopy to global health of our planet. The film was three years in the making, and involved film crews ascending to heights 200 feet above the forest floor of tropical forests on three continents, using access methods that involved mountain-climbing ropes, catwalks, towers, and hot-air balloons.

A preview of the film and interview with Dr. Nalini Nadkarni (faculty member at The Evergreen State College and President of ICAN), one of the canopy researchers featured in the film, was aired on *NBC DATELINE*, a prime-time news magazine show, on January 29, 1999.

The release of the film has been accompanied by an innovative "companion website" created by a group of canopy researchers and the filmmakers under the auspices and using the resources of the ICAN. Sections of the website include scientifically sound information about the distribution of rainforests and canopy biota; ecology and behavior of canopy animals portrayed in the film; distribution and physiology of canopy plants; curricula vitae of the researchers featured in the film; and images and descriptions of the making of the film.

The website is the brainchild of Producer/Director of the film, Tim Scoones, and Nalini Nadkarni. They have used the opportunity of an anticipated international audience of 50 million viewers to inform the general public about the joys and perils of canopy access, the diverse communities of plants and animals that live their entire lives in tropical treetops, human use of canopy resources, and conservation activities with which the viewers can get involved. The website is accessible at: <<www.evergreen.edu/ican>>.

To order a copy of the film (which includes eight minutes that was cut from the original film for commercial television), contact the video department of the National Geographic Society (1-800-437-5521, US and Canada; 1-515-362-3353, International), or check out the website at: <<www.nationalgeographic.com>>.

Shot of a Harpy Eagle's nest from the National Geographic Documentary . Photo: by Kike Arenal

PROBING HOW MUCH CARBON THE WORLD'S FORESTS STORE

(Article reprinted with permission from UNISCI On-line, December 11, 1998, <<unisci.com/news2.html>>.

With remote sensing techniques, scientists have recently uncovered the intricate architecture of a large area of tropical rainforest in Costa Rica. The research promises to help answer a key question in global warming: how much carbon do the world's forests store?

Results from the Costa Rica mission were presented by scientists from the University of Maryland and NASA's Goddard Space Flight Center during the Fall Meeting of the American Geophysical Union in San Francisco. "Having a baseline estimate of forest biomass will be extraordinarily useful for future carbon modeling," said University of Maryland geographer Ralph Dubayah.

Determining the amount of carbon in tropical forests is very important because most changes in Earth surface carbon occur in the tropics as a result of changing land use". Scientists need to understand whether forests and human activities in forests, such as deforestation, are acting to increase or decrease carbon in the atmosphere, thus potentially accelerating or inhibiting global warming. Excessive deforestation adds carbon into the atmosphere. Some deforested areas rebound, and the growing trees act as carbon sinks, pulling carbon out of the atmosphere.

Satellite images have long been able to record how much land area is covered by forest. However, estimating the amount of carbon from conventional two-dimensional images is unreliable because these images cannot measure tree heights, how densely the trees grow, or the thickness of the tree canopy.

Using an instrument called the Laser Vegetation Imaging Sensor (LVIS) aboard a NASA C-130 aircraft, scientists took measurements of over 1500 ha of tropical forest within the La Selva Biological Research Station in Costa Rica this spring. Using a new digital data analysis technique developed at Goddard, scientists from Goddard, the University of Maryland, and University of Maryland graduate students Birgit Peterson, Laura Rocchio and Jason Drake, were able to make estimates of tree canopy height, the amount of leaves and branches in a vertical column, and the underlying topography of the land surface.

The LVIS instrument, developed by Goddard engineer Bryan Blair, is a wide-swath, airborne laser altimeter or LIDAR (light detection and ranging). LIDAR works by sending pulses of laser energy to the Earth's surface. The laser energy interacts with leaves and branches and reflects back to the instrument. What are uncovered are not only tree heights and the ground level below, but what is in between. The variability of the return signal going down through the canopy reveals the architecture of the canopy.

A second growth tropical forest in the Santa Elena Nature Preserve, Costa Rica. Photo: by Amber Neilson.

The Costa Rica mission is a test for a laser instrument that will fly on the first of NASA's Earth System Science Pathfinder missions in May 2000. The Vegetation Canopy LIDAR's (VCL) main objective is to measure how much carbon is locked up in vegetation on the Earth's land surface by making measurements of forest structure. The mission is led by the University of Maryland, which is responsible for all elements of the program, from the spacecraft to the final data products. Dubayah, principal investigator on the VCL mission, said that researchers have used the new method to study coniferous forests in the Sierra Nevada of California and eastern deciduous forests of the mid-Atlantic region around the Chesapeake Bay.

The Costa Rica project was the greatest challenge because of the extremely dense canopy of trees. The denser the canopy, the more difficult it is for the laser light to penetrate all the way to the ground because it is intercepted by leaves and branches, just as sunlight is filtered by a thick canopy.

La Selva forest ecologist David Clark from the University of Missouri, St. Louis, works from the ground to measure tree heights and determine how LVIS distinguishes between old-growth forests and young, re-growing forests. The two forests look completely different from the ground, said Clark, but in conventional images from space, they look the same. VCL will be able to tell the relative age of forests much better than these two-dimensional imaging satellites because it measures the canopy structure. An old-growth forest contains about 2-10 times more biomass than a young, re-growing forest.

For more information, contact: Don Radler, UniSci On-line Chief Editor, <unisci@unisci.com>.

ICAN Requests Input for Development of Educational Outreach Programs

The ICAN was founded in 1994 under its mission "to promote forest canopy conservation through the integration of research and education". Since 1994, ICAN has established resources (e.g., "What's UP?", e-mail bulletin board, citations database) that bring the canopy science community together, enabling efficient communication and networking between researchers.

Increased exposure resulting from the ICAN's updated web page and recent media coverage on forest canopies has brought numerous inquiries regarding the availability of educational materials, programs, and resources accessible to the general public. The time has come for ICAN to enhance its educational resources and programming to the public community. As a graduate student in the Masters of Environmental Studies program at The Evergreen State College, I will work with ICAN and the Wind River Canopy Crane to develop an educational outreach program on forest canopies. We seek educational program ideas, curriculum, and/or resources, as well as input and suggestions towards the organization's educational vision.

If you have had experience developing an educational curriculum or program, or are interested in becoming involved with the process, please contact us. We are currently establishing an email advisory panel to aid us in our educational outreach development. Send your name and a brief description of how you can contribute.

Amber Neilson, Outreach Coordinator, ICAN, Phone: 360-866-6788; <canopy@elwha.evergreen.edu>.

ICAN's Newest Work-in-Progress: Canopy Citations database under construction

Over the past six years, ICAN has been collecting journal articles regarding canopy science. The bibliography was recently imported into a new citations program, Endnote 3.0. Endnote is a bibliographic manager which allows users to search for authors, dates, keywords, and more. ICAN currently has over 1000 references in the database, seventy-five percent of which are available as reprints in the ICAN office. Presently, ICAN members can send in a search-request and receive a listing of citations on the topic of their choice. In the near future, this database will be available on-line to ICAN members.

Your help is requested. Email or snail mail us your reprints, bibliographies, or databases. If you have your citations in a bibliographic software package or in the Z39.50 file format, please consider donating this information to ICAN.

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ICAN seeks researchers and environmental professionals for innovative collaboration in Costa Rica

The International Canopy Network (ICAN), a non-profit organization based in Washington State, and the Rain Forest Aerial Tram (RFAT), a business venture of Dosel, S.A. in Costa Rica, have agreed to collaborate on the development of information pathways between scientific researchers and the general public at the RFAT site near San José, Costa Rica.

The rain forest facility in Costa Rica, in its fifth year of operation, has developed a successful formula for maintaining the integrity of the rain forest reserve's ecosystem while attracting a high volume of eco-tourists. This has been accomplished by using low-impact aerial tram technology, which gives visitors the opportunity to experience the three dimensions of the rain forest without the impact that accompanies crowded trails or roads.

In order to develop a more comprehensive research program and enhance visitor experience, RFAT has turned to ICAN to provide research and interpretive expertise at the site. ICAN and RFAT are seeking researchers and professionals at the graduate level or higher who have backgrounds in tropical biology, field biology, environmental sciences, or science education. RFAT will pay room and board for an agreed-upon period (generally from two weeks to a month) while the research is underway. In exchange for living expenses and a field site, the researcher will provide expertise for the development of interpretive programs at the site. This may include offering a weekly lecture and workshop to train guides in a certain aspect of the site's ecology, or making/translating interpretive materials. The researcher's work will add to the database of information available to visitors at the site. RFAT and ICAN will receive copies of the research results and all publications and reports will acknowledge the support of both organizations.

The RFAT site is located within an hour's drive of San José, the capital of Costa Rica. The 450 ha reserve is composed of wet tropical and pre-montane rain forest adjacent to the pristine, 45,000 ha Braulio Carrillo National Park. The tram and interpretive trails occupy only a small portion of the reserve. The research agenda for the site includes developing a stem map for the tram transect (1.6 km long), conducting biodiversity surveys of the reserve, providing an inventory of rare/endangered species, and developing interpretive materials based upon these studies. Research that lends itself well to interpretation will be an early focus of the program.

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TROPICAL FOREST CANOPY LIGHT AND HABITAT SELECTION

Light is the most variable physical factor in tropical forests, both in space and time. The architecture of the vegetation, sun angle, and weather generate multiple light environments, which greatly differ in intensity and spectra (Endler 1993). Light is typically intense and whitish in large canopy gaps, and scarce in greenish forest shade. Forest light spectra directly affect photosynthesis, plant morphogenesis, visual communication, and the effectiveness of plant-animal interactions, which suggests potential consequences for habitat selection by forest plants and animals.

Both morphology and physiology of canopy leaves are adapted to high irradiance, UV, and IR radiation in canopy light. Canopy leaves are thicker, more vertical, and have higher specific leaf mass, lower chlorophyll density, and higher chlorophyll *a/b* ratio than understory leaves (Givnish 1987, Fetcher *et al*. 1994). Canopy leaves have higher light-saturated photosynthetic rates than conspecific leaves positioned lower in the canopy, and pioneer species have higher light-saturation points than climax trees or shade plants (Chazdon *et al*. 1996). Light quality varies with light environments and position within the forest, so morphogenetic processes may differ among species living in different light environments (Endler 1993). This is potentially a strong feature of habitat selection and niche differentiation.

Among tropical forest trees, shade-tolerant and light-demanding species are well recognized (Denslow 1987). Little evidence supports differentiation with gap size or light (Brown & Jennings 1998). Bongers & Sterck (1998) also showed that too little data are available on light levels of trees larger than saplings to draw conclusions differentiation of tree species in light habitats.

Pittendrigh (1948), who distinguished "exposure", "sun" and "shade-tolerant" species, described vertical partitioning with respect to light in epiphytic bromeliads. Each species group is characterized by morphological and physiological adaptations to light and water levels. Species of the "exposure" and "sun" group are characterized by CAM, a photosynthetic pathway adapted to drought and high irradiance, whereas "shade" species often have lower light-compensation and light-saturation points typical of C3 photosynthesis (Benzing 1995). Because light availability decreases with cloud cover, the shade group is not represented at the wettest sites; that exposure group prevails at sites with lower precipitation (Griffiths & Smith 1983). Physiological adaptations of epiphytes (Benzing 1995), hemiepiphytes (Williams-Linera & Lawton 1995), and non-vascular epiphytes (Rhoades 1995), contribute to species partitioning in relation to light availability.

The spectra of ambient light and background greatly affect the conspicuousness of color signals (Endler 1986, 1990, 1993; Endler & Théry 1996). This can be used in communication among animals (predation; recognition of species, sex, and age; sexual selection), and in communication between animals and plants (herbivory, pollination, seed dispersal). Different flower, fruit, or animal colors are more conspicuous in some tropical forest light environments and backgrounds than others (Endler 1993, Craig 1996, Endler & Théry 1996). Studies on the relationship between color vision systems and specific plant color signals concluded that visual systems optimize discrimination of green leaves by dichromatic mammals or terrestrial vertebrates (Lythgoe & Partridge 1989, Fleishman *et al*. 1997), discrimination of flowers by hymenoptera (Chittka & Menzel 1992), and detection of canopy fruit by red howler monkeys (Regan *et al*. 1998).

The influence of light on bird courtship display was studied in lek-breeding manakins and in the cock-of-the-rock (Théry 1987, 1990; Théry & Vehrencamp 1995; Endler & Théry 1996). These birds maximize their conspicuousness to mates and minimize their conspicuousness to predators by selecting light habitats in times and places that generate differences in conspicuousness (Théry 1990, Endler & Théry 1996). In five sympatric species of lekking manakins, the disposition of color patches on upper- or underparts can be explained by display height and light incidence in relation with vegetation geometry (Théry 1990). In the white-throated manakin, light properties of the display site and attendance of the male determine the attractiveness of male display to females (Théry & Vehrencamp 1995). As in guppies, color and/or brightness contrast is highest at times and places of courtship display to females, and colors are used for mate choice.

Logging alters the relative abundance of light environments because it alters the fraction of the sky that illuminates objects within the forest (Endler 1997). The number and diversity of light environments decrease with the intensity of disturbance, so measurements of light spectra can provide an estimate of the structural impacts of forest exploitation. Because forest light spectra directly affect animal and plant reproduction and growth, its measurement may also provide a functional explanation of anthropogenic effects on tropical forest diversity.

To test this hypothesis, we measured ambient light spectra and censused manakin birds and plants in the Melastomaceae family along a deforestation gradient in French Guiana (Théry & Endler *unpubl.data*). We measured and analyzed the ranges of spectral parameters in the expectation that sites with more variation in light could support more species that are light-environment specialists. We found positive correlation between hue range and manakin diversity, and between the

range of red/far-red ratio and melastome diversity (Théry & Endler *unpubl.data*). These correlations are both an indicator of general habitat loss through anthropogenic disturbance and a direct measure of habitat requirements. This recent study shows that it is crucial to investigate the use, distribution, and importance of light environments in conservation projects.

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CYCLONE HITS AUSTRALIA'S CANOPY CRANE SITE

On 12 February the east coast of Australia was hit by a category 3 cyclone. The eye of the cyclone passed a few kilometres south of the site of the new Australian canopy crane in a rainforest close to Cape Tribulation. The rainforest in the vicinity of the crane was severely damaged with much of the top canopy being removed and many large trees being brought down. The crane is untouched and in operation. We estimate that wind speeds of at least 170 kmph hit the area from a westerly direction.

Although we had not planned for a cyclone so soon, we are now taking advantage of this opportunity to study faunal and floral recovery in the region. A team of several new PhD. and Honours students are starting to assess the site under the supervision of myself, Prof. Roger Kitching, Dr. Steve Turton and Dennis Rodgers.

The site now has very little canopy cover as the vine towers were brought down and leaves and top branches stripped off trees. Some large trees were also uprooted. The result is that the forest is now extremely exposed and the ground very difficult to access. My preliminary assessment is that the canopy cover will return very quickly, particularly the vines and rattan.

If anyone is interested in joining our team studying the recovery and regeneration of the site then I would be very interested to hear from them. Hurricane Hugo several years ago was a great opportunity for similar studies. This time though we have a crane on site to look at the canopy recovery.

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ICAN'S SLIDE LIBRARY

ICAN is currently updating the slide and video library, as part of our educational resource development. We are looking for canopy images that can be incorporated into slide show presentations. We are seeking donations from ICAN members. Please mark your name on the slide along with a general description of the picture and send them to the ICAN address. Thanks for your donations!!!

FEATURE ARTICLE

TRUTHING A GROUND-BASED CANOPY MODEL USING THE WIND RIVER CANOPY CRANE, WASHINGTON STATE, USA

Figure 1. A small section of the mapped stand as modeled in the computer based on measurements collected using the canopy crane. The trees were simulated using 3-D software (Metacreations 1998).

We used the Wind River Canopy Crane, in Carson, Washington, to test a ground-based canopy model that estimates the volume of occupied space in old-growth forest canopies and to generate visual images of the trees (Fig. 1). A total of 126 trees in a 0.25 ha area were sampled from the ground and from above, using the crane. The trees were located in a low-elevation, old-growth forest plot containing 21 Douglas-fir (41-148 cm) (Fig. 2), 56 Western hemlocks (5-109 cm DBH) (Fig. 3), 40 Pacific yew (5-32 cm) (Fig 4), and 9 other trees of four species. The ground-based model used six measurements and an assumption about individual crown shape (e.g., conic, parabolic). The crane-based estimates required up to 377 measurements per tree. The two models were then compared, both by species and by crown position, to see where the major discrepancies occurred (Table 1). Although the model results worked well at the stand-scale, individual trees were often significantly over-estimated or under-estimated. Douglas-fir crown volume, on the average, were over-estimated by 10.6% (Fig. 5); Pacific yews were over-estimated by 0.8%; but Western hemlocks were under-estimated by 1.9% (Fig. 6). Although these errors were smaller than that for Douglas-fir, their standard deviations were much higher: 0.09 for Douglas-fir and 0.13 and 0.12 for Pacific yew and Western hemlock, respectively. The upper crowns of trees tended to be fully and fairly uniform, but the lower crowns were not. Epicormic branching and irregular shading causes highly irregular lower crowns. As a result, 87% of the differences between the two models among all Douglas-fir trees were in the lower half of the crowns. Similarly 74% of the Western hemlock error and 58% of the Pacific yew error were from differences in the lower crowns.

Robert Van Pelt, University of Washington, Seattle, WA, USA; and Malcolm North, Pacific Southwest Research Station, Fresno, CA, USA; <abies2@u.washington.edu>.

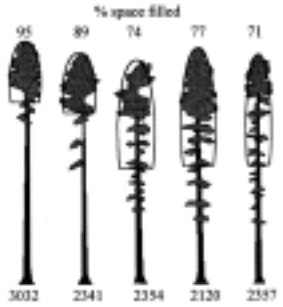

Figure 2. Cross-sections of five Douglas-fir trees showing profiles modeled using both methods. The crane based model is shown in gray, and the ground-based shown as an outline. The % difference between the two is shown at the top of each tree profile.

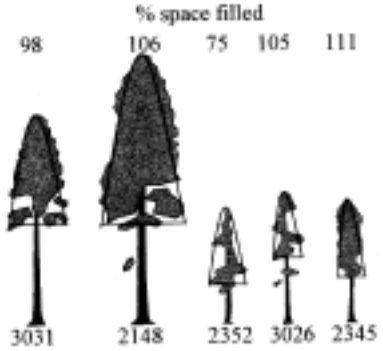

Figure 3. Cross-sections of five western hemlock trees showing profiles modeled using both methods. See description for Figure 2.

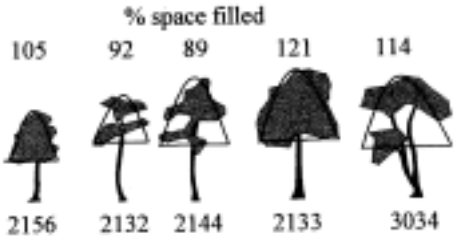

Figure 4. Cross-sections of five Pacific yew trees showing profiles modeled using both methods. See description for Figure 2.

Table 1. Comparisons between the two methods. The standard deviations (SD) for western red cedar, Pacific silver fir, and grand fir are not useful due to small sample sizes. Based on all trees within the 50 m X 50 m plot.

		Canopy Volume (m^3)		%	
Species	N	Crane-based	Ground-based	Difference	SD
Douglas-fir	21	14,043	15,680	+10.4	0.09
W. Hemlock	56	17,823	17,481	-1.9	0.12
Pacific Yew	40	735	758	+0.8	0.13
W. red cedar	3	1,591	1,542	-0.3	0.1
P. silver fir	2	33	30	-0.9	--
Grand fir	1	54	59	+0.9	--
Other	3				
Totals	126	34,279	35,550	+37	--

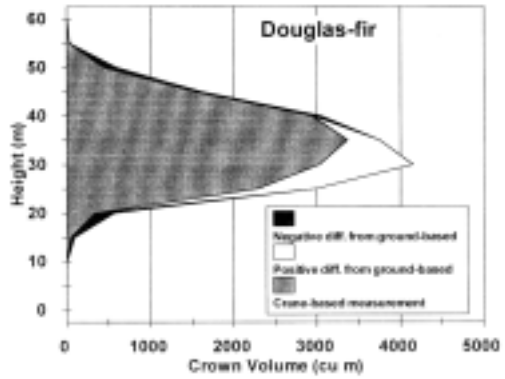

Figure 5. Canopy volume profile for Douglas-fir. The ground-based methods underestimated crown volumes at both the top and bottom of the crowns, and overestimated the mid to lower crowns. The ground-based model filled in too much in the sparse lower crown, although stopped before the absolute crown base.

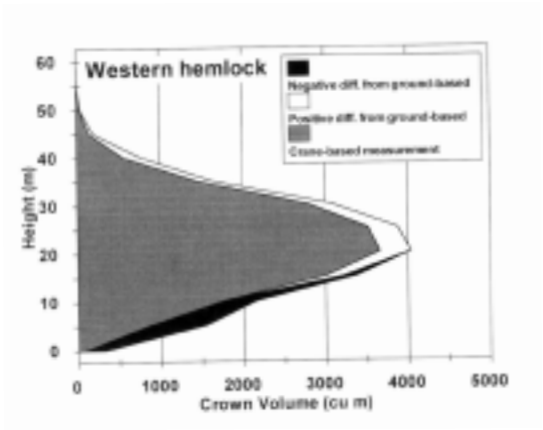

Figure 6. Canopy volume profile for hemlock. The differences between the two models tended to be greater, although largely negating each other out for the stand as a whole. The ground-based model filled in too much in the lower crowns although it tended to be slightly scant in the upper crown.

Why plant size matters in ecophysiological studies with vascular epiphytes

Due to an increased general interest in canopy-dwelling organisms and the availability of portable field equipment, the number of ecophysiological studies with vascular epiphytes has greatly increased in recent years (Lüttge 1997). A central objective of many of these studies is the establishment of mechanistic explanations for plant distributions in time and space. An important, but often ignored, question arises as to the nature of the organisms that should be used as representative in experiments.

In the past, plant size was commonly ignored in this context: only eight out of 125 reviewed publications dealing with the ecophysiology of epiphytes during the last decades provide a precise description of their study organisms. Recent studies in my lab (Zotz and Thomas 1999, Zotz 1997, Zotz and Ziegler 1999) have demonstrated considerable size-related variability of physiological traits. Photosynthetic capacity, for example, may differ by almost an order of magnitude in conspecifics varying in size, but growing side by side under virtually identical environmental conditions. To achieve reproducible results in studies with vascular epiphytes, size can no longer be ignored.

Currently, we are studying the physiological mechanism behind these differences. Because size may correlate with age (Zotz 1998), we must separate age and size as confounding factors. Results from a series of experiments indicate a high plasticity in physiological traits in vascular epiphytes, which apparently results from differential investment of resources into different organs (leaves, shoots, roots). This had been predicted earlier (Zotz 1997), applying the economic analogue introduced by Bloom *et al*. (1985): if water availability limits gas exchange in smaller plants more than in larger conspecifics, then "valuable" resources such as nitrogen should not be invested in "disposable" organs such as leaves, but stored in long-lived organs such as stems for later use in leaves of a then larger – and less drought-stressed – plant.

However, irrespective of the actual mechanistic explanation, our findings have bearing on future studies with vascular epiphytes: since published data of specimens of unspecified size are of rather limited value, physiological ecology needs a demographic approach.

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ANNOUNCEMENTS

Conservation Ecology, Volume 2, Issue 2, is now complete and available on-line. Topical issues presented include: ecological sustainability of birds in boreal forests; mammalian herbivores in the boreal forests: their numerical fluctuations and use by man; bridging the gap between economics and ecology; monitoring impacts of natural resource extraction on lemurs of the Masoala Peninsula, Madagascar; tracking the genetic effects of global warming, and much more. Find the reports at at *<<www.consecol.org/Journal/vol2/iss2>>*.

BP Conservation Programme assists and encourages international teams of university students to undertake conservation research projects with long-term impacts. Projects must address a conservation issue of global importance, have a strong affiliation with the country where the project is located, and team members must be full-time or part-time students. Funding is a cooperative initiative between Birdlife International, Fauna and Flora International, and British Petroleum. Contact: *Katharina Gotto, BP Conservation Programme, Wellbrook Court, Griton Road, Cambridge CB3 OMA, UK; Phone: (44) 1223-277318; <bp-conservation-programme@birdlife.org.uk>*.

The International Foundation for Science (IFS) is an international NGO mandated to promote high quality research on the management, use, and conservation of biological resources and their environment. The IFS provides small research grants to scientists in and from developing countries or to those employed at a developing country institution. IFS also funds projects that fall within the IFS Scientific Domain, which focuses on biological resources and their environment. Contact: *The International Foundation for Science, Grev Turegatan 19, 114 38 Stockholm, Sweden; Phone: (46) 8-545-818-00; <info@ifs.se>*.

Study site in Borneo for research/field courses. Field station in the middle of one of the best remaining patches of mixed dipterocarp forests in Borneo is accepting research proposals. Contact: *Colin Maycock, Research Coordinator, Kuala Belalong Field Studies Centre, <cmaycock@ubd.edu.bn>*.

Computers for Nonprofits. The investment firm Piper Jaffray recently donated 2,000 computers to DRAGnet, a nonprofit organization that refurbishes and recycles computers. The computers are distributed to disadvantaged people, families, schools, and non-profit organizations nationwide for a nominal fee. Contact: *DRAGnet; Phone: (1) 612-378-9796; Fax: (1) 612-753-1943; <info@dragnet.org>*.

WEBSITES OF INTEREST

People and Plants On-line. This website includes publications, discussion papers, handbooks, and working papers dedicated to ethnobotany, conservation, and community development. People and Plants is accepting professional contributions and relevant website links. Contact: *Gary Martin, Regional Coordinator; Fax: (2) 12-4-301511; <peopleandplants@cybernet.net.ma>; <<www.kew.org.uk/peopleplants>>*.

The CIDA Forestry Advisers Network's (CFAN) - "Kid's Corner". This Internet presentation is intended to give students information on tropical forests, why they are important, what can be done to help save them, as well as what the Canadian International Development Agency (CIDA) has been doing to help promote resource conservation and forest mangement. *<<www.rcfa-cfan.org>>*.

On-line Bibliography of African Entomology- Partial bibliography of systematics and ecology of Afrotropical insects, with over 4500 citations to papers on the systematics, distribution, and ecology of insects residing in Africa, south of the Sahara.<<www.icipe.org/icipedata/biodiversity/Africasearch.cfm>>.

Methods of Entomological Survey and Analysis. Some 900 citations to papers on the use of insects and other terrestrial and freshwater arthropods in biodiversity studies. *<<www.icipe.org/icipedata/biodiversity/Methodsearch.cfm>>*.

North American Lichen Project. These remarkable life forms are presented to introduce their amazing diversity of forms and colors. Among the other sections are those describing roles played by lichens in the environment, with people, and with animals. *<<www.homeworkcentral.com/toplinks/304.html>>*.

On-line Index to American Botanical Literature. The New York Botanical Garden web site now includes a searchable version of the "Index to American Botanical Literature". The Index contains entries on various aspects of extant and fossil American plants and fungi, including systematics (traditional and molecular) and floristics, morphology, and ecology, as well as economic botany and general botany. *<<www.nybg.org/bsci/iabl.html>>*.

Coleoptera Webpage On-line. This website displays an international Coleoptera database, links to relevant sites, a bibliographic database, an images and sound library, and links to scientific equipment suppliers and computer software; *<<www.coleoptera.org>>*.

MEETINGS OF INTEREST

Annual Meeting of the Northwest Scientific Association. March 24-26, 1999. Tacoma, Washington, USA. This annual meeting will be held in association with the celebration of the 100th anniversary of the establishment of Mt. Rainier National Park. Contact: *University of Washington, CFR, Continuing Education, PO Box 352100, Seattle, Washington,USA 98195-2100; Phone: 206-543-0867; <<www.cfr.washington.edu/Outreach/NWSA99.html>>.*

Aldo Leopold and Conservation on Private Lands. April 9 & 10, 1999. University of Wisconsin, USA. This 129th Annual Conference of the Wisconsin Academy of Sciences, Arts, and Letters, is being held with the Wisconsin Chapter of The Wildlife Society, and the Aldo Leopold Chapter of the Society for Conservation Biology. Contact: *Wisconsin Academy of Sciences, Arts, and Letters, 1922 University Ave., Madison, WI 53705, USA; Phone: 608-263-1692; <<www.wildlifer.com/aldo>>.*

The Application of Scientific Knowledge to Decision-Making in Managing Forest Ecosystems. May 3-6, 1999. North Carolina, USA. Contact: *Dr. H.M. Rauscher, USDA Forest Service, Bent Creek Experimental Forest, 1577 Breverd Road, Asheville NC 28806, USA; Phone: 828-667-5261; <mrauschers/srs bentcreek@fs.fed.us>.*

International Conference on Biodiversity and Renewable Natural Resources. May 13-14, 1999. Ifrane, Morocco. This conference is organized by the School of Science and Engineering (SSE) of Al Akhawayn University in Ifrane (AUI) and seeks to allow academic and industrial scientists, as well as decision makers to exchange their views and expertise. Contact: *Dr. Bachir Raissouni, Dean of the School of Science & Engineering, Al Akhawayn University in Ifrane PO Box 104, Avenue Hassan II, Morocco; Phone: (212-5) 862114/15; <<www.alakhawayn.ma/>>.*

Tropical Restoration for the New Millenium: Tropical, Urban Forest Ecosystem Restoration International Conference. May 23-28, 1999. San Juan, Puerto Rico. Contact*: J. Parrotta, IITF, USDA Forest Service, P.O. Box 25000, Rio Piedras, PR 00928-5000, USA; Phone: 787-766-5335; <j_parrotta@upr1.upr.clu.edu>.*

Remote Sensing in the 21st Century: Economic and Environmental Applications. May 31-June 2, 1999. Valladolid, Spain. Contact: *Mrs. M. Godefroy, EARSel, 2 Avenue Rapp, 75340 Paris Cedex 07, France; Phone: (33) 1-455-676360; <earsel@meteo.fr>.*

International Conference on Remote Sensing and Forest Monitoring. June 1 - 3, 1999. Rogow, Poland. Sponsored by IUFRO and the Faculty of Forestry at Warsaw Agicutural University. Contact: *Secretary of Remote Sensing and Forest Monitoring Conference, Rakowiecka 26/30, 02-528, Warsaw, Poland; Phone: 508-767-7557; <<giswitch.sggw.waw.pl/rogow99/>>.*

The 5th International Interdisciplinary Conference on the Environment. June 23-26, 1999. Baltimore, Maryland,. You may participate as session organizer, presenter of papers, chair, moderator, discussant, or observer. Contact: *Demetri Kantarelis, IEA, Assumption College, 500 Salisbury Street, Worcester, MA 01615, USA; Phone: (508) 767-7557; <dkantar@EVE.ASSUMPTION.EDU>.*

International Conifer Conference. June 22-25, 1999. Kent, United Kingdom. Contact: *L. von Schlippe, Royal Botanic Gardens, Kew, Richmond, Surrey, UK; Phone: (44) 1-813-325198; <L.von.schlippe@rbgkew.org.uk>.*

International Society for Ecological Modelling Annual Meeting. August 8-12, 1999. Spokane, Washington, USA. Abstracts may be on any topic in systems ecology and ecological modelling. Contact: *Guy R. Larocque, Laurentian Forestry Centre; Phone: (418) 648-5791; <glarocque@cfl.forestry.ca>; <<ecomod.tamu.edu/~ecomod/isem.html>>.*

The VIII International Aroid Conference. August 9-11, 1999. Missouri Botanical Garden, St. Louis, Missouri, USA. This conference will provide a forum for the presentation and discussion of current topics on the plant familiy Araceae, including their biology, ecology, taxonomy and horticulture. Contact: *Beth L. Cosgriff, Secretary General, Missouri Botanical Garden, P.O. Box 299, St. Louis, MO 63166-0299, USA; Fax: 314-577-9596; <bcosgriff@lehmann.mobot.org>.*

CONTRIBUTE TO "WHAT'S UP?"

"What's Up?: Newsletter of the ICAN" is distributed to members all over the world and is a great resource for networking information. ICAN accepts articles, meeting and workshop announcements, related web site addresses, and citations for our spring newsletter. Contributions are due by May 15, 1999, and can be sent via e-mail attachment or snail mail. Articles up to 1500 words are accepted (Word format preferred) and graphics are welcomed (.tif or .jpg format preferred). Please contact the ICAN office for details.

Amber Neilson, Outreach Coordinator; Phone: (360) 866-6788; <canopy@elwha.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 by doing monthly on-line literature searches (AGRICOLA, CAB, and FORESTRY ABSTRACTS) and going through Current Contents on Diskette.]

CANOPY ANIMALS

Adis, J., A.Y. Harada, C.R.V. Fonesca, W. Paarmann, & J.A. Rafael. 1998. Arthropods obtained from the Amazonian tree species "Cupiuba" (*Goupia glabra*) by repeated canopy fogging with natural pyrethrum. Acta Amazonica **28**:273-283.

Allison, A., G.A. Samuelson, & S.E. Miller. 1997. Patterns of beetle species diversity in *Castanopsis acuminatissima* (Fagaceae) trees studied with canopy fogging in mid-montane New Guinea rainforest. Pp. 224-236 *in* N.E. Stork, J. Adis and R.K. Didham, eds. Canopy arthropods. Chapman and Hall, London.

Allison, A., G.A. Samuelson, & S.E. Miller. 1993. Patterns of beetle species diversity in New Guinea rain forest as revealed by canopy fogging: preliminary findings. Selbyana **14**:16-20.

Floren, A., & K.E. Linsenmair. 1998. Non-equilibrium communities of Coleoptera in trees in a lowland rain forest of Borneo. Ecotropia **4**:55-67.

Ganesh, T., & P. Davidar. 1997. Flowering phenology and flower predation of *Cullenia exarillata* (Bombacaceae) by arboreal vertebrates in Western Ghats, India. Journal of Tropical Ecology **13**:459-468.

Murakami, M. 1998. Foraging habitat shift in the narcissus flycatcher, *Ficedula narcissina,* due to the response of herbivorous insects to the strengthening defenses of canopy trees. Ecological Research **13**:73-82.

Murakami, M., & N. Wada. 1997. Difference in leaf quality between canopy trees and seedlings affects migration and survival of spring-feeding moth larvae. Canadian Journal of Forest Research **27**:1351-1356.

Rogers, D.J., & R.L. Kitching. 1998. Vertical stratification of rain forest Collembola (Collembola: Insecta) assemblages: description of ecological patterns and hypothesis concerning their generation. Ecography **21**:392-400.

Taulman, J.F. 1998. Observations on quantitative cognition in Southern flying squirrels, *Glaucomys volans.* The Canadian Field-Naturalist **112**:347-349.

Wahungu, G.M. 1998. Diet and habitat overlap in two sympatric primate species, the Tana crested mangabey *Cerocebus galertius* and yellow baboon *Papio cynocephalus*. African Journal of Ecology **36**:159-173.

Witt, J.W. 1998. Distribution of the Marbled Murrelet in southwestern Oregon. Northwest Science **72**:96-101.

CANOPY PLANTS

Gauslaa, Y., & H. Holien. 1998. Acidity of boreal *Picea abies*-canopy lichens and their substratum, modified by local soils and airborne acidic depositions. Flora **193**:249-257.

Gauslaa, Y., & K.A. Solhaug. 1998. The significance of thallus size for the water economy of the cyanobacterial old-forest lichen *Degelia plumbea*. Oecologia **116**:76-84.

Rydgren, K., R.H. Økland, & T. Økland. 1998. Population biology of the clonal moss *Hylocomium splendens* in Norwegian boreal spruce florests. 4. Effects of experimental fine-scale disturbance. Oikos **82**:5-19.

CANOPY STRUCTURE

Asdak, C., P.G. Jarvis, P. Gardigen, & A. Fraser. 1998. Rainfall interception loss in unlogged and logged forest areas of Central Kalimantan, Indonesia. Journal of Hydrology **206**:237-244.

Battaglia, M., M.L. Cherry, C.L. Beadle, P.J. Sands, & A. Hingston. 1998. Prediction of leaf area index in eucalypt plantations: effects of water stress and temperature. Tree Physiology **18**:521-528.

Cutini, A., G. Metteucci, & G.S. Mugnozza. 1998. Estimation of leaf area index with the Li-Cor LAI 2000 in deciduous forests. Forest Ecology and Management **105**:55-65.

Doruska, P.F., & J.E. Mays. 1998. Crown profile modeling of loblolly pine by nonparametric regression analysis. Science **44**:445-453.

King, D.A. 1998. Relationship between crown architecture and branch orientation in rain forest trees. Annals of Botany **82**:1-7.

King, D.A. 1998. Influence of leaf size on tree architecture: first branch height and crown dimensions in tropical rain forest trees. Trees **12**:438-445.

Kucharik, C.J., J.M. Norman, & S.T. Gower. 1998. Measurements of branch area and adjusting leaf area index indirect measurements. Agricultural and Forest Meterology **91**:69-88.

Kucharik, C.J., J.M. Norman, & S.T. Gower. 1998. Measurements of leaf orientation, light distribution and sunlit leaf area in a boreal aspen forest. Agricultural and Forest Meterology **91**:127-148.

Liu, S. 1998. Estimation of rainfall storage capacity in the canopies of cypress wetlands and slash pine uplands in North-central Florida. Journal of Hydrology **207**:31-41.

Niinemets, Ü. 1998. Adjustment of foliage structure and function to a canopy light gradient in two co-existing deciduous trees. Variablity in leaf inclination angles in relation to petiole morpholgy. Trees **12**:446-451.

Tanaka, T., J. Yamaguchi, & Y. Takeda. 1998. Measurement of forest canopy structure with a laser plane range-finding method - development of a measurement system and applications to real forests. Agricultural and Forest Meteorology **91**:149-160.

Thomsen, M.G., & C. Nellemann. 1994. Isolation of natural factors affecting crown density and crown color in coniferous forest: implications for monitoring of forest decline. Ambio **23**:251-254.

Murcia, C. 1996. Forest fragmentation and the pollination of neotropical plants. Pp. 19-36 *in* J. Schelhas and R. Greenberg, eds. Forest patches in tropical landscapes. Island Press, Washington D.C., USA.

Oyarzun, C.E., R. Godoy, & A. Sepulveda. 1998. Water and nutrient fluxes in a cool temperate rainforest at the Cordillera de la Costa in southern Chile. Hydrological Processes **12**:1067-1077.

Ukonmaanaho, L., M. Starr, & T. Ruoho-Airola. 1998. Trends in sulfate, base cation and H+ concentrations in bulk precipitations and throughfall at integrated monitoring sites in Finland 1989-1995. Water, Air, and Soil Pollution **105**:353-363.

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Marshall, D.D., D.L. Johnson, & D.W. Hann. 1997. A forest management information system for education, research and operations. Journal of Forestry **10**:27-30.

Gratani, L., & I. Foti. 1998. Estimating forest structure and shade tolerance of the species in a mixed deciduous broad-leaved forest in Abruzzo, Italy. Ann. Bot. Fennici. **35**:75-83.

FOREST-ATMOSPHERE INTERACTIONS

Condit, R. 1998. Ecological implications of changes in drought patterns: shifts in forest composition in Panama. Climatic Change **39**:413-427.

Corlett, R.T. & J.V. LaFrankie, Jr. 1998. Potential impacts of climate change on tropical Asian forests through an influence on phenology. Climatic Change **39**:439-453.

Hassika, P., P. Berbigier, & J.M. Bonnefond. 1997. Measurement and modelling of photosynthetically active radiation transmitted in a canopy of maritime pine (*Pinus pinaster)*. Annales des Sciences Forestierès **54**:715-730.

Hollinger, D.Y., F.M. Kelliher, E.-D. Schulze, G. Bauer, A. Arneth, J.N. Byers, J.E. Hunt, T.M. McSeveny, K.I. Kobak, I. Milukova, A. Sogatchev, F. Tatarinov, A. Varlargin, W. Zielgler, & N.N. Vygodskaya. 1998. Forest-atmosphere carbon dioxide exchange in eastern Siberia. Agricultural and Forest Meteorology **90**:291-306.

Hulme, M., & D. Viner. 1998. A climate change scenario for the tropics. Climatic Change **39**:145-176.

Lee, X. 1998. On micrometeorological observations of surface-air exchange over tall vegetation. Agricultural and Forest Meteorology **91**:39-49.

Mäkipää, R., T. Karjalainen, A. Pussinen, M. Kukkola, S. Kellomäki, & E. Mälkönen. 1997. Applicability of a forest simulation model for estimating effects of nitrogen deposition on a forest ecosystem: test of the validity of a gap-type model. Forest Ecology and Management **108**:239-250.

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Nordlund, G., & H. Tuomenvirta. 1998. Spatial variation in wet deposition amounts of sulphate due to stochastic variations in precipitation amounts. Atmospheric Environment **32**:2913-2921.

Piirainen, S., L. Finér, & M. Starr. 1998. Canopy and soil retention of nitrogen depostion in a mixed boreal forest in eastern Finland. Water, Air, and Soil Pollution **105**:165-174.

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Brunner, A. 1998. A light model for spatially explicit forest stand models. Forest Ecology and Management **107**:19-46.

Hassika, P., & P. Berbigier. 1998. Annual cycle of the photosynthetically active radiation in an evergreen forest. Agricultural and Forest Meteorology **90**:157-171.

Marks, D., J. Kimball, D. Tingey, & T. Link. 1998. The sensitivity of snowmelt processes to climate conditions and forest cover during rain-on-snow: a case study of the 1996 Pacific Northwest flood. Hydrological Processes **12**:1569-1587.

THROUGH-FALL

Burghouts, T.B.A., N.M.V. Straalen, & L.A. Bruijnzeel. 1998. Spatial heterogeneity of element and litter turnover in a Bornean rain forest. Journal of Tropical Ecology **14**:477-506.

TREE PHYSIOLOGY

Damesin, C., S. Rambal, & R. Joffre. 1998. Co-occurrence of trees with different leaf habitat: a functional approach on Mediterranean oaks. Acta Oecologica **19**:195-204.

Goetz, S.J., & S.D. Prince. 1999. Modelling terrestrial carbon exchange and storage: evidence and implication of functional convergence in light-use effeciency. Advances in Ecological Research **28**:57-92.

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Kull, O., & Ü. Niinemets. 1998. Distribution of leaf photosynthetic properties in tree canopies: comparison of species with different shade tolerance. Functional Ecology **12**:472-479.

Leuning, R., F.X. Dunin, & Y.-P. Wang. 1998. A two-leaf model for canopy conductance, photosynthesis and partitioning of available energy. II. Comparison with measurements. Agricultural and Forest Meteorology **91**:113-125.

Molau, U., & J.M. Alatalo. 1994. Foliage and fine root longevity of pines. Ecological Bulletins **43**:136-153.

Tanaka, T., S. Tsuchiya, & H. Shibano. 1996. Characteristics of evapotransipiration in the southwestern slope of Mt. Merapi. Journal of the Japan Society of Erosion Control Engineering **48**:25-36.

Tanaka, T., E. Uchida, O.-A. Siaw, Y. Takeda, & O. Tomatsu. 1993. Effect of the lag time of sap temperature on sap-flow measurements using the heat-balance method. Journal of the Japanese Forestry Society **75**:554-557.

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Hodson, M.J., & A.G. Sangster. 1998. Mineral deposition in the needles of white spruce [*Picea glauca* (Moench.) Voss]. Annals of Botany **82**:375-385.

Oberbauer, S.F., & M. Noudali. 1998. Potential carbon gain of shingle leaves in juveniles of the vine *Monstera tenius* (Araceae) in Costa Rica. American Journal of Botany **85**:850-854.

Schoettle, A.W., & W.K. Smith. 1999. Interrelationships among light, photosynthesis and nitrogen in the crown of mature *Pinus contorta* ssp. *latifolia*. Tree Physiology **19**:13-22.

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