

## Overview

The Brazil Program consists of several components that are independently managed but closely coordinated to provide the greatest possible payoff to Brazilian and United States forest managers and forest users. The Sustainable Forest Management Project provides baseline biological and socioeconomic information underlying the development of advanced forest management strategies, providing assistance with institution building and analysis for silviculture, environmental conservation, and ecotourism. It is closely linked with Brazilian Space Agency (INPE) and NASA led Large-Scale Atmosphere/Biosphere project. Silvicultural development has concentrated on the multiple advantages of low-impact harvesting. The Forest Management Project has been focused on the Tapajós National Forest, but also includes development and training at Cauaxi in conjunction with the Tropical Forestry Foundation.

The Fire and Environmental Change Project is a coordinated series of research and development activities addressing questions of biomass burning, global change, and fire-danger rating in Brazilian ecosystems. The project contributes remote sensing for fire detection and mapping, and compiles inventories of fire activity and air pollution through cooperation by the Pacific Southwest Research Station and NASA with IBAMA and other Brazilian institutions. A fire-hazard rating system, used to anticipate flammability and fire effects in tropical ecosystems, is being developed by the Pacific Northwest Research Station in collaboration with the Brazilian Space Institute and others.

This progress report, covering the six-month period of March 2002 through October 2002, is one in a series of outputs describing the mission, scope, activities, and accomplishments of the USDA Forest Service/USAID Program in Brazil. Additional information can be obtained from the Latin America Program Coordinator or the Forest Service's International Programs website at:

[www.fs.fed.us/global/globe/l\\_amer/brazil/welcome.htm](http://www.fs.fed.us/global/globe/l_amer/brazil/welcome.htm)

## **Fire and Environmental Change Program**

### *Highlights*

- The FireMapper technology and fire remote-sensing database developed by the Forest Service-IBAMA Cooperation is now the subject of discussions regarding a Tropical Fire Mapping Mission to be based aboard the Brazilian SSR (Remote Sensing Satellite). The Working Group held meetings in June 2002 with INPE, IBAMA, the President of the Agência Espacial Brasileira (Brazilian Space Agency), and ATECH, (a Brazilian non-governmental foundation) to further the design concept and discuss working agreements among the agencies.
- The Fire and Environmental Research Applications Team of the USDA Forest Service, Pacific Northwest Research Station, continued a successful and active cooperative program with Brazilian counterparts. Collaborative projects continue with the Brazilian Agency for the Environment (IBAMA), University of Brasilia, INPE's combustion laboratory, the University of the State of Sao Paulo, and the University of Washington.
- FERA and the University of Brasilia (UnB) conducted the first training workshop on the use of photo series. The training was coordinated by IBAMA in Brasilia.
- The first photo series workshop was a success. The workshop's agenda included (1) a description of the photo series, (2) an introduction to fire behavior and fire effects in the cerrado with several fire behavior and fire effects exercises, (3) three exercises on how to use the photo series, and (4) four field exercises for the students to practice using the photo series.
- FERA and UnB researchers visited the Fazenda Fartura near Santana do Araguaia, Para in September 2002. Several sites were selected for a new photo series volume. Two sites were also selected for flammability and vegetation change trials that are being funded by NASA-LBA and IPAM in an area that transitions from Cerrado to primary and secondary forests.
- Data analysis from one experimental burn in 2001 was completed in the arc of deforestation, in Alta Floresta, state of Mato Grosso. Two papers produced with data from those burns have been submitted for publication in international journals. Posters and papers were prepared for presentation at ENCIT 2002 and the International Fire Research Conference in Portugal.
- Full instrumentation for analysis of combustion gases is also being implemented at INPE's combustion laboratory with a field campaign on smoke analysis in flaming and smoldering combustion scheduled for 2003, 2004 and 2005. Laboratory tests will provide improved combustion rates and better smoke emission factors from Amazon forest burning. It will also enhance the capacity to assess carbon fluxes and paths during burning in the Amazon forest.

### **Fire and Environmental Change**

#### *Activities and Progress*

The Fire and Environmental Research Applications Team (FERA) of the Pacific Northwest Research Station, USDA Forest Service, continued an active and successful cooperative program with Brazilian counterparts. Collaborative projects continue with IBAMA, University of Brasilia (UnB), the Brazilian Space Agency (INPE) combustion laboratory, the University of the State of Sao Paulo (UNESP), and the University of Washington. It has recently expanded to include the Universidade Estadual de Mato Grosso, and more extensive participation of local firefighters is being sought for 2003.

**Photo Series to Assess Flammability in the Cerrado**

In order to address wildfire issues, the USDA Forest Service has been working with several partners in Brazil for the past nine years on the *Fire and Environmental Change in Tropical Ecosystems* program. Specifically, the US-Brazil team has focused on developing a component of this large-scale research—the *Stereo Photo Series for Quantifying Cerrado Fuels in Central Brazil*. A tool for assessing biomass loading and flammability in the *Cerrado* or the Brazilian Savannah, the photo series can also be used as a quick and cheap way to evaluate different fuel and vegetation conditions.

In June 2002, the Fire and Environmental Research Applications Team of the Forest Service and the University of Brasilia—the team responsible for developing and publishing this photo series—hosted the first of a succession of workshops. Through these workshops, the two organizations can transfer the photo series technology to land managers in Brazil.

For the first session in June, the team invited eighteen IBAMA park directors from several national parks in the *Cerrado* region. The workshop agenda included one day that covered (a) a description of the photo series, (b) an introduction to fire behavior and fire effects in the cerrado with several fire behavior and fire effects exercises, and (c) three exercises on how to use the photo series. The second day included four field exercises for the students to practice using the photo series.



The workshop was well attended and was received very favorable reaction by all workshop participants. A summary table is presented of the evaluation ranking of the workshop.

Question	Poor	Fair	Good	Excellent
Were the objectives of the workshop met?			6	12
Did the presentations meet expectations?			6	12
Did the exercises meet expectations?			5	13
Did the overall workshop meet objectives?		1	8	9

IBAMA and the directors from cerrado parks and conservation areas have requested additional training workshops. During the reporting period, FERA and Brazilian collaborators continued the distribution of the first volume of the cerrado photo series in Brazil and the United States. A mass mailing of a bilingual brochure is being distributed by UnB to promote the photo series among federal and state park and conservation area managers, and other agencies and institutions involved in conservation and management of the cerrado region.

The cerrado photo series publication was presented on a poster and display at the NASA International Workshop on Global Emissions at the University of Maryland in July 2002. Several copies were distributed by request to world scientists concerned with global emissions, management, and conservation of cerrado and tropical savannas. The photo series publication was regarded by the group as the most complete data set and tool to assess biomass, carbon stocks, and fluxes in the tropical savannas.

Researchers traveled to visit the Fazenda Fartura near Santana do Araguaia. They selected additional photo series sites in a new cerrado physiognomic type and in the cerrado transition into primary and secondary forests. Some of the sites included human disturbance as suggested by the Environment Officer in the Brazil USAID Mission during a visit in June. Also selected were potential sites for flammability and vegetation change trials that are being funded by the NASA's LBA Program.

Researchers have located sites in the parque cerrado physiognomic type that have not been covered in the photo series volume I for the second photo series volume. The parque cerrado occurs in large areas where there is periodic flooding during the wet season. The area is covered with grasses between islands of higher ground where cerrado tree and shrub species occur. The spacing between the mounds varies and determines the density of the trees and shrubs compared to the grass.

The team also located 2-4 sites in the transition from cerrado to forest. This transition area is often only a few hundred meters wide and contains species found both in the cerrado and in the Amazon forest. The photo series protocol will be redesigned to accommodate this transition vegetation type since the site will include smaller cerrado species that transition very quickly into taller Amazonian species. An indepth literature search will also be required to locate biomass equations for Amazonia tree species and any new cerrado tree species found in the parque cerrado and transition sites.

### **Flammability Study**

The second study that FERA will be involved at the Fazenda Fartura is to establish a flammability, fire, and vegetation study in the cerrado as it transitions into an Amazon forest. The site design will be identical to the IBGE fire study plots. The sites will be burned at different times of the year with special observations of flammability and how far fire enters into the forest from the cerrado. Two excellent sites were located for this study. The first site is typical cerrado with a transition into a secondary (probably disturbed) forest. The area will be sectioned into several plots that can be burned during different times of the year.

The second site is also a cerrado site but transitions into a primary Amazon forest. It can also be easily sectioned into several blocks for burning. Vegetation changes will be tracked as well as flammability thresholds. This study is sponsored by Woods Hole Research Center with a professor from UnB as a co-investigator



## **Combustion and Carbon Emissions from Tropical Biomass**

FERA continues a successful collaboration between IBAMA, INPE's combustion laboratory, the University of the State of Sao Paulo (UNESP), and the University of Washington, in Alta Floresta, Mato Grosso, Brazil. A new INPE scientist and new UNESP graduate students have joined the group. A faculty and student group from the Biology and Forestry Departments at University of the State of Mato Grosso joined the group to support the field campaign in Alta Floresta. The project has been expanded by INPE and UNESP to include a smoke emissions and chemistry component.

Data analysis from one experimental burn in 2001 was completed in the arc of deforestation, in Alta Floresta, state of Mato Grosso. Two papers produced with data from that burn have been submitted for publication in international journals. Additional papers and reports are being prepared for publication and distribution. The FERA team and Brazilian cooperators continue to participate in Brazilian conferences and workshops to disseminate results generated by this cooperation. Posters and papers were prepared for presentation at ENCIT 2002 and the International Fire Research Conference in Portugal. Group participants are frequently asked to give seminars in Brazilian universities regarding biomass burning in the Amazon forest.

Laboratory tests continue in the combustion furnace at INPE's laboratory facilities in Cachoeira Paulista. Testing for Ph.D. candidate from UNESP has been completed. Two new graduate students at UNESP started working in the project, they will continue the previous work and expand to charcoal production, flammability of interface between land clearing and forest, and smoke chemistry.

Full instrumentation for analysis of combustion gases is also being implemented at INPE's combustion laboratory with a field campaign on smoke analysis in flaming and smoldering combustion scheduled for 2003, 2004 and 2005. Laboratory tests will provide improved combustion rates and better smoke emission factors from Amazon forest burning. It will also enhance the capacity to assess carbon fluxes and paths during burning in the Amazon forest.

As part of the project's expanded objectives, and to completing reports and papers of previous field and laboratory work, two of our Brazilian collaborators visited the Seattle, Washington, and Missoula Montana this year. A technician from INPE spent three weeks in February at the USDA Forest Service, Missoula Fire Laboratory in Missoula, Montana, and at the Seattle Forestry Laboratory in Seattle, Washington. A Brazilian Professor from INPE/UNESP spent two weeks visiting the same two places in September 2002.

The group has received requests by the Fire Chemistry project at the Missoula Fire Laboratory and the University of Montana to collaborate on a project funded by the National Science Foundation (NSF) on ground-aerial-satellite assessment for smoke emissions and chemistry from tropical biomass burning. This component of the project would start in 2003 and would include other groups of INPE, USP, and NASA's LBA program. The cooperation with the Missoula group will also participation in a multinational research project to assess smoke



emissions by combustion phases in Africa, Brazil, and Indonesia in 2003, 2004 and 2005. The proposal has been submitted to NSF and Missoula collaborators are waiting for a response from NSF to formalize an agreement to cooperate.

During the visit to the United States by our Brazilian collaborators, FERA met with the Fire Chemistry project lead by researchers from the Missoula Fire Laboratory and the Chemistry Department, University of Montana. During this meeting terms and activities were defined to be will be accomplished as part of a cooperative research on gas analysis from biomass burning in the Amazon forest in 2003 and 2004.

The data and publications from FERA and collaborator's work in the arc of deforestation were presented on a poster and display at the NASA International Workshop on Global Emissions Assessment using Remote Sensing at the University of Maryland in July of 2002. Copies of papers were distributed on request to world scientists concerned with global emissions, management, and conservation of evergreen tropical forests. The data that the group has published is considered as the most complete and consistent data set to assess biomass burning and Carbon fluxes in fires in the evergreen tropical forest of Brazil. This science community has already started using the data generated by the group on several of the global emission assessments using remote sensing technology.

### **Remote sensing deployment and technology transfer**

The Forest Service Pacific Southwest Research Station has worked with IBAMA since 1992 in the development of remote-sensing technology, and its application to monitoring of wildland and agricultural burning and natural resources. This has included eight aircraft campaigns employing Brazilian or U.S. aircraft. At IBAMA's request, the PSW Station prepared for a 3-week mission to assess fires in Roraima using PSW's Airborne Sciences Aircraft during early 2002, in anticipation of an extreme fire season there. The mission was fully prepared, but flight clearance, which was being obtained by IBAMA from the Brazilian Government, was not forthcoming until after the start of seasonal rains in Roraima. The Forest Service did provide training in the U.S. for two IBAMA personnel on the use of the FireMapper system and submitted for publication a scientific paper synthesizing our work on fire remote sensing in Brazil. The Forest Service also launched the development of a FireMapper 2.0 thermal imaging radiometer, which will be transferred to IBAMA for its use on a Brazilian aircraft. FireMapper is an advanced remote-sensing instrument designed specifically for fire measurements. It was first deployed aboard a Forest Service aircraft for a four-week mission to Brazil in September 2000. Progress during this reporting period included the following:

- An agreement between PSW and Space Instruments, Inc., was amended to include development of the FireMapper 2.0 for IBAMA.
- Engineering for mechanical components and installation was done and mechanical parts were manufactured.
- Component electronics for the camera were acquired.
- FireMapper display and control software were rewritten to accommodate the newer FireMapper 2.0 detector.
- An export license for the FireMapper 2.0 was obtained from the U.S. Department of Commerce.

The FireMapper technology and fire remote-sensing database developed by the Forest Service-IBAMA Cooperation is now the subject of discussions regarding a Tropical Fire Mapping Mission to be based aboard the Brazilian SSR (Remote Sensing Satellite). The Working Group held meetings in June 2002 with INPE, IBAMA, the President of the Agência Espacial Brasileira (Brazilian Space Agency), and ATECH, (a Brazilian non-governmental foundation) to further the design concept and discuss working agreements among the agencies. A series of generalized tasks and responsibilities were agreed upon and a workshop of potential users of the fire monitoring data was planned. The Working Group is continuing to work with INPE and IBAMA to define the required sensor performance, remote sensing concepts, and the mechanical and electrical requirements of the proposed system. The Ministry of the Environment (MMA) and AEB also prepared an agreement for cooperation in development of the Tropical Fire Mapping Mission.

## **Fire climate**

The Experimental Climate Prediction Center at Scripps Institution of Oceanography (SIO) continued during early 2002 the climate simulations begun during 2000 under the supplemental program of fire management support to IBAMA. IBAMA has developed a source of validation data, and discussions have continued regarding further model validations. Simulations are applying a Regional Spectral Model (RSM) of climate (see <http://ecpc.ucsd.edu/projects/brazil.html>) to provide daily to seasonal predictions of fire-weather severity and assess climate variables affecting smoke accumulation and long-term changes in forest susceptibility to fire. A cooperative agreement between SIO and the PSW Station was extended during September 2002 to provide for continued simulations and model validation.

## **Prehistoric fire in the Amazon Rain Forest**

The Amazon Rain Forest is known worldwide by its biodiversity, complexity, rapid secondary succession, and for being the largest area of rain forest in the world. Nevertheless, the structure and functioning of the ecosystem is still poorly understood, especially if one considers the consequences of the introduction of fire as a management tool for conversion of native vegetation into crop fields and pasture. Recent studies have shown that fire has been present in the region since 7000 BP and that burning can be related to human activity. However, the occurrence of fire in the Amazon forest before human presence has not yet been reported. To determine the fire occurrence in this region prior to human occupation, a paleoecological study was begun by UnB to determine the presence and possible distribution of charcoal particles in a 100,000 year-old sediment core collected at Lago Maicuri I in the State of Pará. The results will contribute to the knowledge of the fire dynamics in this Biome and will help to relate changes in fire frequency with human activity in the region.

## **Publications**

Carvalho, E.R.; Veras, C.A.G.; Carvalho, J.A.: Experimental investigation of smouldering in biomass, *Biomass and Bioenergy*, 22(4):283-294, 2002.

J. A. Carvalho Jr., C. A. G. Veras, E. C. Alvarado, D. V. Sandberg, R. Gielow, E. R. Carvalho, and J. C. Santos Fire spread from a forest-clearing site in the Amazonian arc of deforestation. Paper submitted to the *Journal of Geophysical Research Letters*. 2002.

Gielow, R.; Forti, M.C.; Carvalho, J.A.; Veras, C.A.G.; Alvarado, E.C.; Sandberg, D.E.; Santos, J.C., Chemical Composition of the Soilwater in the Subsurface after the Slashing and Burning of Two "Terra Firme" Forest Parcel in Northern Mato Grosso. Submetido para apresentação na 2. Conferência Científica do LBA, Manaus, AM, julho de 2002a.

Gielow, R.; Forti, M.C.; Carvalho, J.A.; Alvarado, E.C.; Sandberg, D.V.; Santos, J.C., Chemical Composition of the Soilwater in the Subsurface after the Slashing and Burning of a "Terra Firme" Forest parcel in Southeastern Amazonia (North Mato Grosso, Brazil). Aceito para apresentação na 4. International Conference on Forest Fire Research/2002 Wildland Fire Safety, Coimbra, PT , 16 a 23 de novembro de 2002b.

Igor Trosnikov, Ralf Gielow, João Andrade de Carvalho Jr, Carlos Alberto Gurgel Veras, Ernesto Alvarado, David Victor Sandberg, José Carlos dos Santos., Modelagem Do Transporte Atmosférico De Co<sub>2</sub> Resultante Da Queima De Biomassa De Fonte Isolada No Norte De Mato Grosso. Submetido para apresentação na 2. Conferência Científica do LBA, Manaus, AM, julho de 2002a. Also presented as a poster at the XII Congresso Brasileiro de Meteorologia in 2002.

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## **Sustainable Forest Management Program** *Highlights*

- The Mahogany Project in Acre & southeast Pará has been working towards institutional strengthening of IBAMA through information extension (providing technical information about forest management and mahogany silviculture) and through an advisory role to these departments as part of the Technical Working Group on Mahogany, a working group formed by the Regional Commission on Environmental Regulation in Amazonia (MMA/Ibama) to draft national legislation for mahogany's sustained-yield management in Brazilian Amazonia.
- Synthesis of field results from southeast Para plus planning for field activities in Acre lead to an AMAZON publication: Grogan, J., P. Barreto and A. Verissimo, 2002, *Mahogany in the Brazilian Amazon: Ecology and Perspectives on Management*, Imazon, Belém, Pará, Brazil, 64 pp.) has been published in hard copy in portuguese (1500 copies) and will be published in hard copy in english (1500 copies) in October 2002.
- The Mahogany Project initiated reduced-impact logging with silvicultural treatments for establishing mahogany regeneration in July 2002. FFT field personnel traveled to the Sena Madureira project site where they spent 2 weeks training local logging crews. This year's activities, wrapping up in late September due to the onset of the rainy season, were concentrated in 100 hectares of primary forest. Lessons learned this year will assist next year's activities on larger scales (250-500 ha).
- Research on mahogany life history continued in southeast Pará at three field sites where studies have been conducted since 1995-1996. This year's activities included a recensus of diameter increment growth by over 500 trees >10 cm diameter, assessment of fruiting effort by all reproductively mature trees, and assessment of survivorship by natural regeneration and seedlings in experimental outplantings between 1996-1998.
- Analysis of Landsat images compared detailed field observations at the Fazenda Cauaxi shows that simple band comparisons and textural analysis are insufficient for estimation of logging damage although textural analysis may be useful for location of logging activity. More recent work by the same team shows that a linear mixing model of Landsat bands can be used to estimate canopy damage. This paper in press in *Ecological Applications* opens new possibilities for logging detection and analysis using readily available satellite data.

## **Sustainable Forest Management** *Activities and Progress*

### **Big-leaf mahogany (*Swietenia macrophylla* King) in the Brazilian Amazon: its life history and management in natural and artificial systems Project**

The Mahogany Project in Brazil now has research and management objectives in two geographical regions within Amazonia: southeast Pará, where studies of mahogany's growth and regeneration ecology have been on-going since 1995, and the western Amazonian state of Acre, where both basic and applied research were initiated in October 2001. In Acre, management recommendations derived from field research in Pará for mahogany's sustained-yield production from natural forests are being tested as part of a pilot management project implemented within a private land-holding of approximately 8000 hectares located near Sena Madureira.

Field activities since April 2002 at three southeast Pará sites focused on recensusing diameter increment and fruit production by nearly 500 adult and sub-adult trees monitored annually since 1996. As well, natural and artificial regeneration at the study's principal research site, Marajoara, was recensused for survivorship.

At the Acre site, inventory and preparation for the 2002 logging season continued until early July, when Fundação Floresta Tropical (FFT) field personnel arrived from Belém and Cauaxi to train an Acrean field crew in reduced-impact logging techniques appropriate to highly dissected local terrain. FFT personnel were joined by a former chief civil engineer at the Jarí project with expertise in reduced-impact logging on steep West Virginian mountain terrain.

Mahogany and 15 associated high-value timber species were logged in the first 100-ha division at the Sena Madureira site. After tree selection and accounting for permanent preservation areas along seasonal stream banks and on especially steep slopes, only ~6.5 m<sup>3</sup>/ha were extracted. This was lower intensity than expected, but possibly appropriate given this forest type's extremely open structure and patchy dominance by vines and invasive bamboo. Regeneration treatments for mahogany and three other species, mainly enrichment planting in treated logging gaps with some cleaning around advance regeneration, accompanied extraction. Logistical problems associated with access and heavy equipment limited this year's activities to a single 100-ha division. However, expanded activities during the 2003 logging season is being planned in 450 ha.

Through its affiliation with the Instituto do Homem e Meio Ambiente da Amazônia (IMAZON), the Mahogany Project is making a direct contribution to forest policy in the Brazilian Amazon through various public fora and publications. Presentations were made at the TFF/Embrapa conference on mahogany held in Belém in early May addressed technical and policy aspects of forest management issues in Brazil. In September, an IMAZON researcher was invited by the Regional Commission on Environmental Legislation, an advisory board convened by the Ministry of the Environment, to sit on a Technical Working Group drafting legislation that will govern the sustainable management of mahogany in primary forests. And the IMAZON publication "Mogno na Amazônia Brasileira: Ecologia e Perspectivas de Manejo", by Grogan, Barreto & Veríssimo, was translated into English and made available in electronic and booklet forms.



Measuring a mahogany tree in the state of Acre.

### **Effects of Harvesting on the Tapajos National Forest**

The Effects of Harvesting on the Tapajos National Forest project has 2 goals: (1) To evaluate the effect of selective timber harvest at the Tapajos National Forest on a wide range of ecosystem functions, and (2) To evaluate the economic efficiency and effects on harvest system sustainability for alternative methods of land management. Research activities can be grouped into 6 themes. Divisions among these themes are somewhat arbitrary and function primarily to illustrate the range of activities that the USFS and IBAMA will pursue as part of the Tapajos Project. Harvest is ongoing at the FLONA Tapajos. In 1999 only 100 ha were harvested, in 2000 nearly 1000 ha were harvested, in 2001 approximately 600 ha were harvested. An additional 600 ha is underway for timber harvest from June through December 2002. With current progress, the entire concession of 3200 ha will be logged by the end of the calendar year 2003.

### **Harvesting Systems**

Researchers from Auburn University and the Federal University of Para surveyed a recently harvested (Quadra 2, Block 1) and adjoining undisturbed control area in 2002. They took samples to measure the effects of harvesting on

soil properties. This area was previously surveyed in 1996 in preparation for this study. Several students from Auburn University and FCAP participated. Data analysis continues.

Researchers from the Fundação Floresta Tropical, Stanford University and the U.S. Forest Service have done detailed comparisons of the effects of reduced impact logging (RIL) and conventional logging (CL) on canopy opening. RIL caused only about half as much canopy damage as CL. A paper has been published by *Forest Ecology and Management*.

During July 2002, researchers from the the University of New Hampshire continued measurements of logging residues (coarse woody debris) generated by the harvest activity in four 100 ha logged blocks and two control areas. They made re-measurements to quantify ongoing branch-fall and tree mortality following logging. Logged blocks are compared to controls. A preliminary analysis of data from Tapajos and also the Fazenda Cauxi in Paragominas Municipality, Para State was presented as a poster at the Second LBA Scientific Conference. The poster will be included as an appendix to this report. This analysis shows that reduced impact logging (RIL) produced only half as much logging residue one year following single tree selection harvests as conventional logging (CL). This has important implications for carbon budgets and recovery.

### **Biophysics**

Eddy covariance studies of carbon dioxide and water vapor flux are continuing at the tower sites. Logging took place around the tower at km 83 from August 2001 through January 2002. A control site is has been operational at km 67 since April 2001. Researchers from USC – Irvine, the University of São Paulo and Harvard University have acquired more than 2 years of continuous data at the logged site. The data is publicly available (<http://beija-flor.ornl.gov/lba/>). Resaerchers from EMBRAPA and the U.S. Forest Service have operated automated chambers and time domain reflectometry probes to measure soil respiration and soil moisture at the control site since April 2001. Data on the soil chambers and time domain reflectometry results were presented at the Second LBA Scientific Conference.

To complement the carbon budget effort researchers are studying the cycling and decomposition of coarse woody debris in harvested and undisturbed blocks at the FLONA Tapajos and Cauaxi. They are also currently planning measurements of the rate of decay of coarse woody debris.

### **Biogeochemistry**

Researchers continue to monitor nutrient and trace gas effects of harvesting. A second survey was completed on sandy-clay soil. Preliminary indications are that timber harvesting increases nitrous oxide and methane emissions measurably. However, when these emissions are extrapolated to a wider area, the effects of harvesting on trace gases (expressed as a Global Warming Potential) are far smaller than the effects from the carbon loss.

### **Remote Sensing of Logging**

Researchers from Stanford University, Forest Service, EMBRAPA and the Fundação Floresta Tropical are developing methods to detect logging and to estimate canopy damage using remote sensing analysis. Work do date has focused on readily available Landsat multispectral imagery. Analysis of Landsat images compared detailed field observations at the Fazenda Cauaxi shows that simple band comparisons and textural analysis are insufficient for estimation of logging damage although textural analysis may be useful for location of logging activity. More recent work by the same team shows that a linear mixing model of Landsat bands can be used to estimate canopy damage. This paper in press in *Ecological Applications* opens new possibilities for logging detection and analysis using readily available satellite data. Conversion of the algorithms developed by this research team into applications usable by government agencies, business enterprises, and non-governmental organizations would represent a major new practical tool for monitoring of logging in tropical forests. A practical tool could be developed with a limited amount of new funding needed to support a programmer as well as professionals who could help translate the research approach into a practical product.

## **Publications**

Pereira, R., J.C. Zweede, G.P. Asner, and M. Keller. 2002. Forest Canopy Damage and Recovery in Reduced Impact and Conventional Selective Logging in Eastern Para, Brazil. *Forest Ecology and Management*. 168: 77-89.

Grogan, J. E., J. Galvão, L. Simões and A. Verissimo. 2002. Regeneration of bigleaf mahogany in closed and logged forests of southeastern Pará, Brazil. Pages 193-208 in A. Lugo and J. C. Figueroa, eds., *Mahogany Ecology, Genetics and Management*. Springer-Verlag, New York, NY, USA.

## **In Press**

Asner, G.P., Keller, M. Pereira Jr., R., Zweede, J.C. and Silva, J.N. In Press. Canopy Damage and Recovery Following Selective Logging in an Amazon Forest: Integrating Field and Satellite Studies. *Ecological Applications*

## **Poster Presentations**

Michael Palace, Michael Keller, Gregory P. Asner Rodrigo Pereira Jr., and Jose Natalino Silva. Coarse Woody Debris in Logged and Undisturbed Forests: Determination of Stocks Using a New Methodology for Wood Density and Void Estimation. Presented at the Second LBA Scientific Conference, Manaus, Brazil, July 8-10, 2002.

<ftp://lba.cptec.inpe.br/posters/TG/TG-07/Manaus2002/MPAL-0003-01.pdf>

Hudson Silva, Patrick M. Crill, Michael Keller, Jadson Dias, Peter Czepiel, Michael Palace, Eraclito Sousa Neto, Raimundo Cosme de Oliveira Junior. Soil-Atmosphere Flux of Carbon Dioxide in Undisturbed Forest at the FLONA Tapajos, Brazil. Presented at the Second LBA Scientific Conference, Manaus, Brazil, July 8-10, 2002.

<ftp://lba.cptec.inpe.br/posters/TG/TG-07/Manaus2002/HSIL-0052-001.pdf>

Raimundo Cosme De Oliveira Junior, Jose Pinheiro Lopes Neto, Michael Keller  
Calibration of the Campbell Cs-615 Water Content Reflectometer in High Clay Content Yellow Latosol in the FLONA Tapajos. Presented at the Second LBA Scientific Conference, Manaus, Brazil, July 8-10, 2002.

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