

Ecosystem Transitions from Andean Cloud Forest to the Lowland Amazon: a Pan-American Advanced Studies Institute on Tropical Ecology, Biogeochemistry, and Climate in Peru

The Amazon Basin contains the largest tropical forests on earth, unparalleled biological diversity, and a vast store of organic carbon. It is a potent engine in global water and energy cycles. Large changes in Amazonian biodiversity and in biogeochemical cycling of carbon and water, expected to occur with climate change or deforestation, could have global as well as local impact. Hence it is critically important to understand the ecological and biogeochemical mechanisms that drive forest-climate interactions in Amazônia. Yet such understanding is hampered at multiple levels, including the remoteness and lack of science infrastructure of pristine tropical locations; the lack of collaboration between biological and physical science disciplines needed to achieve the necessary integrated understanding; and finally, insufficient emphasis in the institutions of higher education on the skills and training needed to develop authentic international collaboration.

Motivated by these concerns, we propose a Pan-American Advanced Studies Institute (PASI) in the Amazon that will integrate focused instruction, interactive discussion, and field-based short research projects. The Institute's activities will take place along an elevational transect in Peru, beginning at a 3,000 m Andean cloud forest and finishing at a lowland Amazon forest site. The theme of the Institute (spanning 16-18 days during June-July, 2011) will be framed by the question: ***What is the future of Amazon forests under climate change?*** We will use the Institute's curriculum to explore how differences along the elevational transect – in climate, forest structure (that of the physical arrangement of the canopy as well as of the taxonomic community), ecophysiology, hydrology, and soil biogeochemistry – may give insight into answers to this question.

Intellectual Merit: The intellectual merit of this proposal is in the design of the PASI: discussion sessions will probe current debates about tropical forest ecology, biogeochemistry, and climate change, while the lectures will advance the core activity of the course: the intensely focused short field research projects, to be conducted by 5-6 groups. These group projects will be designed by students in collaboration with their instructor/mentors to address cutting edge research questions with open ended outcomes, with the results of each project presented to the whole Institute on the last day. The intent of the group projects is to test new ideas by collecting and analyzing datasets that could form the basis of collaborative international research projects to be pursued after the PASI (for example, as post-doctoral research projects).

The PASI will leverage intellectual and financial resources by collaborating with an existing NSF-funded Partnership for International Research and Education (PIRE) (operating in the central Amazon of Brazil), as well as a Gordon and Betty Moore Foundation funded Amazon-Andes Project (focused on the Peruvian Amazon). Instructors will be international leaders in their fields, drawn from the fields of ecology, atmospheric science, and hydrometeorology in Brazil, Peru, the U.K., and the U.S. We expect to attract approximately 30-35 advanced graduate students and post-doctoral scientists from the U.S., Brazil, and Peru, including (with separate funding) several from the U.K.

PASI organization and international collaboration will be facilitated by a PASI website, linked to related project websites, which will provide a portal for course planning, dissemination of materials and results, and a web-based student application to the Institute.

Broader Impacts: This project will impact broader society by advancing international collaboration and education to improve scientific understanding of the future of the Amazon under climate change. We will start by leveraging the University of Arizona's strong minority recruitment program and its traditionally strong Hispanic and Native American enrollments to bring underrepresented minorities to the PASI. We will engage a diverse group of young scientists in rigorous *interdisciplinary* science and *international* field work through hands-on projects to foster relationships to lay the ground for future collaborations with their Brazilian, Peruvian, and British counterparts. Ongoing interaction and dissemination of results will be facilitated by a PASI website. For outreach we will partner with UofA's NSF GK-12 project, BioME, to bring a graduate student and Tucson biology teacher to Peru, who will then draw on it to jointly prepare a high school lesson plan on Amazon conservation. Together, these activities will help foster members of a new generation of culturally experienced scientific leaders prepared to address global environmental problems via international collaboration.

PROJECT DESCRIPTION

1. Background and motivation

The Amazon Basin contains the largest extant tropical forests on earth, with unparalleled biological diversity, and a vast store of organic carbon. It is a potent engine in the global water and energy cycles. Large changes in Amazonian biodiversity (Janzen, 1967; Feeley and Silman, 2009), together with those in biogeochemical cycling of carbon and water, expected to occur with climate change (Betts et al., 2004) or deforestation (Nobre et al., 2009) could have global as well as local impacts. Some models predict that these forests may be vulnerable to catastrophic collapse due to global warming-induced increases in drought or fire, whilst others do not (Malhi et al., 2009b). Hence it is critically important to understand the ecological and biogeochemical mechanisms that drive forest-climate interactions in Amazônia. It is also a key region for engaging the talents and interests of young scientists, in the US, Brazil, and Peru.

Yet such understanding and engagement is hampered by multiple factors, including the remoteness and lack of science infrastructure near pristine tropical locations; the lack of collaboration between biological and physical science disciplines needed to achieve the necessary integrated understanding; and finally, insufficient emphasis amongst institutions of higher education on the skills and training needed to develop genuine international collaboration.

International education, including on-the-ground collaboration with international colleagues, is critical for developing a culturally experienced U.S. scientific workforce prepared to address global environmental problems. Unfortunately, in 2005, fewer than 1% of US college students participated in study-abroad experiences, and science and engineering majors were a tiny fraction of those few students (NAS, 2006). In environmental science, cultural barriers can reinforce the divide between the most-studied systems (primarily in the U.S. and Europe), and systems where new knowledge and data are most needed, e.g. tropical forests with great biodiversity and a disproportionately large influence on global biogeochemical cycles. Likewise, interdisciplinary education, rigorously grounded in the fundamentals of relevant science disciplines, is urgently needed if earth system sciences are to bridge the gap between biological and physical sciences (Hedin et al., 2002), and to integrate processes across spatial and temporal scales (Shuttleworth 1988; Levin, 1992; Moorcroft, 2006).

2. A Pan-American Advanced Studies Institute on Tropical Ecology, Biogeochemistry, and Climate

To address these concerns, we propose a Pan-American Advanced Studies Institute (PASI) in the Amazon, drawing from disciplines in biological and earth system sciences, and combining international collaboration and interdisciplinary education. This PASI will consist of focused instruction, interactive discussion, and field-based short research projects. The Institute's activities will take place along an elevational transect in Peru, beginning at an Andean cloud forest (3,000 m above sea level) and finishing at a lowland Amazon forest site (300 m above sea level). The theme of the Institute (spanning 16-18 days during June-July, 2011) will be framed by the question: **What is the future of Amazon forests under climate change?** We will use the

Institute's curriculum to explore how differences along the elevational transect – in climate, forest structure (that of the physical arrangement of the canopy as well as of the taxonomic community), ecophysiology, hydrology, and soil biogeochemistry – may give insights into an answer to this question.

This PASI will be organized by a collaboration between an NSF-funded Amazon-PIRE project (a U.S.-Brazil partnership including University of Arizona, Harvard, the University of Sao Paulo, EMBRAPA, and the Brazilian Institute for Amazon Research, INPA) and the RAINFOR Amazon-Andes project (a U.K.-Peru collaboration including Oxford University, and Universidad San Antonio Abad and other institutions of Peru). The Amazon-PIRE brings Brazilian partners and students, and also provides collaborative support for the PASI, supporting the travel of most of the U.S. student/post-doctoral participants and instructors, as well as the travel of the Brazilian instructors to Peru, and distributing the cost of course-associated field expenses within Peru. The RAINFOR Amazon-Andes project (Malhi et al., 2002) is extensively involved in research at the Peruvian sites, and so brings site-specific expertise, research data that can be used for the PASI project component, logistical support, and the Peruvian partners and students.

2.1. Course Description

The proposed Amazon-Andes PASI Field Course offers an advanced exploration of the theory and practice of scientific research on tropical forest ecology and the associated biogeochemistry of water, carbon, and trace gases. Just as important, the course also provides a foundation for sustained international collaboration between participants from the Americas, and further afield. The course takes place at field stations in the most biodiverse region of the Amazon basin - the slopes of the Andes.

It combines classroom lectures and field-based instruction by an international group of instructors, interactive discussion about cutting edge controversies in tropical ecology and climate, and small group projects that will advance research while providing theoretical and practical tools to tackle global change problems.

The group projects are the core activity of the course: these are intensely focused short field research projects, intended to be conducted in groups of 5-6 with 1-2 mentors each. These group projects will be designed by students in collaboration with their instructor/mentors to address cutting edge research questions with open ended outcomes, with the results of each project presented to the whole Institute on the last day. The intent of the group projects is to test new ideas by collecting and analyzing datasets that could form the basis of collaborative international research projects to be pursued after the PASI (for example, as post-doctoral research projects). Such project-oriented field courses have proven effective at stimulating student pursuit of research and international collaboration. Field projects at our antecedent 2008 and 2009 Amazon-PIRE courses in Brazil have already led to several conference presentations (e.g. Powell et al., 2008); an undergraduate honor's thesis on its way to publication (Leitold 2009); a manuscript (van Haren et al., in prep); and at least four graduate degree projects at University of Arizona and three at the Brazilian Institute of Amazon Research (INPA). We expect that a project-based PASI course in the Peruvian Amazon will likewise catalyze new collaborations and research among participants.

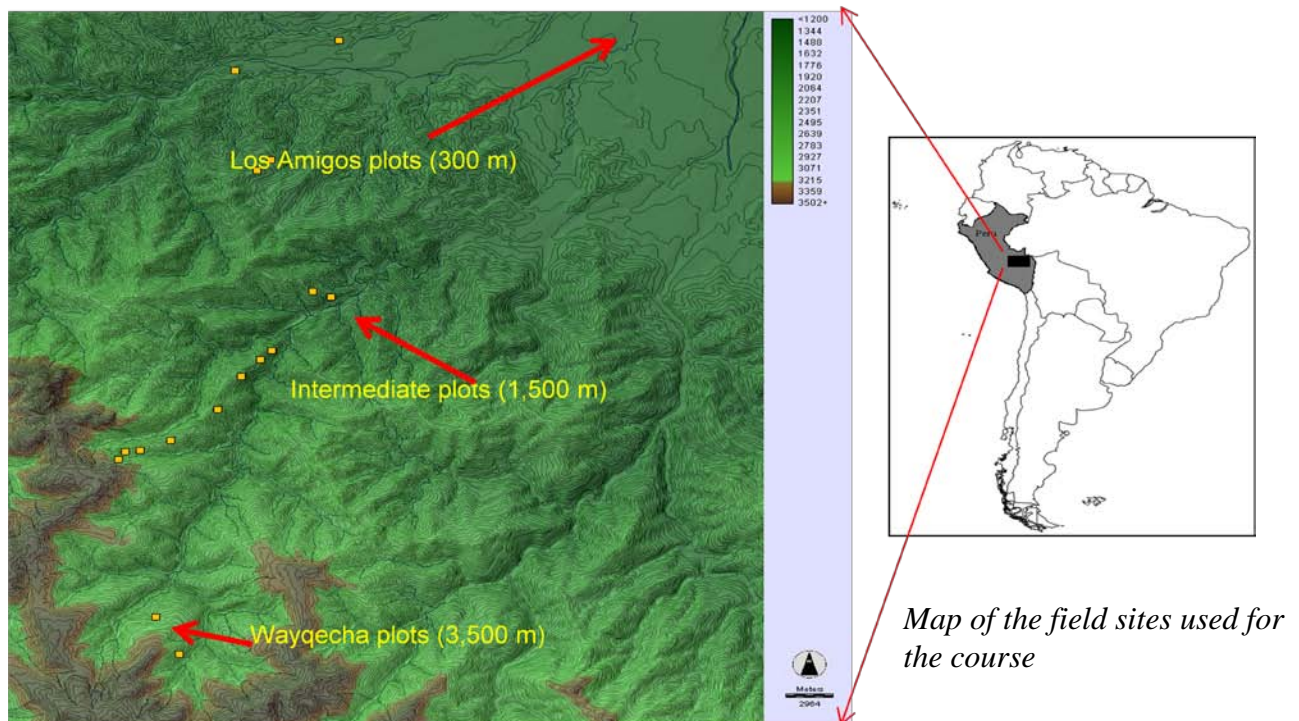
The primary language of the course lectures will be English, but we will organize opportunities for U.S. participants to acquire basic Spanish and Portuguese before and

after the course (eventual acquisition of the relevant foreign language is a good predictor of success in long-term international collaboration). Based on previous experience, we expect the discussions and informal interactions to include a mix of Spanish or Portuguese with interpretation flowing freely in both directions.

2.2. *Locale: the Amazon-Andes Transect*

The proposed course spans the forests of the eastern Andean flank: from montane cloud forest down the foothills to the vast lowland forest expanse that stretch all the way across the continent. Steep gradients in temperature and rainfall and the Earth's highest biodiversity make this a perfect laboratory for studying plant ecology in the context of global climate change. In the heart of this region, a series of intensive ecological monitoring plots have been established near several scientific field stations along an old Inca trading route, from the foot hills of the Andes at 300 m above sea level up to the top of the mountains at 3,500 m above sea level. This work has provided unique insights into the biodiversity and biogeochemistry of this valuable and vulnerable but understudied transitional zone (Aragao, et al., 2009; Butt et al., 2009; Malhi et al., 2006; Zimmermann et al., 2009a,b). The plots have two functions: **(1)** To establish a base-line suite of measurements of forest structure, diversity and carbon storage for monitoring over time, and **(2)** To serve as a natural laboratory for studies on the effects of temperature (mean annual temperature decreases with every 1000 m increase in altitude) on ecological processes. These plots and datasets will be available to course participants, to identify and fill critical gaps still existing, and build upon the scientific foundation established to date.

At 3500 m, the Wayqecha field station provides an ideal base for investigation of the ecology of the surrounding cloud forest, and nearby forest – grassland boundary zone. Two nearby (10 minutes walk) forest plots been inventoried for plant species





Wayqecha field station (3,500 m above sea level) will be the base for the portion of the course focused on montane rainforest processes. For more details visit their website: http://www.amazonconservation.org/ourwork/research_wayqecha.html

composition, and since 2003 these sites have been the focus of a comprehensive suite of measurements quantifying all major carbon stocks and fluxes (Malhi et al., 2006).

Adjacent to one plot is a canopy access walkway around 150 m in length suspended up to 40 m above the ground. This unique facility was just completed 3 months ago and provides an unparalleled opportunity to easily access and make *in situ* measurements within the canopy of the forest. Nearby (> 20 minutes drive) are several fire and landslide scars of varying, known ages which provide a perfect opportunity to assess recovery over time from these two key regional disturbance events. Within two hours drive down the mountain are more intensive carbon monitoring plots at 1,500 m above sea level (see map above), providing opportunities



Canopy access walkway near Wayqecha fieldstation

for day trips (and perhaps overnight stays) to compare the ecology of these forests intermediate between the archetypal upland montane and lowland forests.

At Los Amigos field station, a large expanse of primary lowland forest is easily accessible from an extensive surrounding trail system, and two satellite outpost stations (4 and 20 km from the main station) all with their own labs and accommodation. The site is one of the best instrumented and measured forests in the Amazon (search the collection of publications from the site:



Los Amigos field station (300 m above sea level) will be the base of operation for the lowland portion of the field course. For more details visit their website: <http://www.amazonconservation.org/ourwork/research.html>

http://atrium.andesamazon.org/biblio_search.php) with several towers for accessing the canopy, and a range of soil (different fertility and structure) and forest types (seasonally flooded swamp, drier forest) within easy reach. Two other lowland forest field stations (Tambopata Explorers Inn: www.explorersinn.com; Manu Learning Center: http://www.crees-expeditions.com/lodges_mlc.htm) are also being considered as potential back-up or additional destinations.

3. Syllabus, Rationale, and Schedule

3.1. Syllabus

As indicated by the course description, the proposed course consists of three integrated components: focused instruction, interactive discussion, and field-based short research projects.

The “*Focused instruction*” component covers the core subject matter and associated field methods of the course, including:

- Ecology and Botany of the Andean slope of the Peruvian Amazon.
- Ecophysiology of tropical trees
- Soil biogeochemistry and fluxes of CH₄, N₂O and CO₂
- Remote sensing of tropical forest structure and function (including ground-based surveys with upward-looking LIDAR and using hyperspectral imaging to characterize leaf traits)
- Biological scaling laws and methods, from leaf traits to landscapes
- Biosphere-Atmosphere water, energy and carbon dioxide exchange

The material will be developed in lectures and associated course readings (which will be drawn from the primary literature).

The lectures will be complemented by the second component, *interactive discussions* on selected evenings. These discussions will focus on cutting edge debates and questions about tropical forest function and climate, where the principals involved in the debates include the course instructors. These questions, along with associated key references (italicized references indicate that an author or co-author will be participating as a PASI instructor), are:

- What is the carbon balance of tropical forests? (*Phillips et al*, 1998; *Saleska et al*, 2003; *Malhi et al*, 2009a; *Aragao et al*, 2009) and can we reconcile methods-based controversies about this question? (e.g atmospheric vs. ground based methods: *Wofsy et al.*, 1988; *Chou et al.* 2002; *Lloyd et al.* 2007; *Gatti et al*, 2010 – or selection bias in forest plot selection: *Fisher et al.* 2008 vs. **Gloor et al.**, 2009)
- What is the seasonality of tropical forest metabolism? (*Borchert*, 1983; *Van Schaik et al*; 1993; *Huete, et al.*, 2006; *Saleska et al.*, 2009)
- What is the effect of climate extremes on tropical forest function? (*Hutyra et al.*, 2005, 2007; *Fisher et al* 2007; *Nepstad et al.* 2007; *Phillips et al.*, 2009) And, can we use remote sensing methods to reliably assess forest response to climate variation? (*Saleska et al.*, 2007 vs. *Samanta et al.*, 2010; *Brando et al.*, 2010)
- What is the fate of biological diversity of tropical rainforest systems? (*Bush et al*, 2005; *Silman et al*, 2006)

- Is the distribution and abundance of tropical tree species and their associated traits also important for biogeochemistry? (*van Haren et al.*, 2005, 2010; *Townsend et al.*, 2008; *Baker et al.*, 2009)
- What is the fate of Amazon forests under climate change? (*Betts et al.*, 2004; *Malhi et al.*, 2008, 2009b)

The third component is *group research projects*. It is with projects at the different sites that we will directly explore the theme of the course: Can we use differences along the transect in climate, forest structure, ecophysiology, hydrology, and soil biogeochemistry to give insights into the fundamental question: **What is the future of Amazon forests under climate change?** We will bring to the field a suite of equipment and instruments to enable sophisticated measurement and analysis for cutting edge experiments and projects. The instrumentation includes:

- Licor 6400 photosynthesis systems for leaf-gas exchange and fluorescence measurements (e.g. *Dominguez et al.*, 2005; *Doughty et al.* 2006);
- Hyperspectral leaf absorbance/reflectance scanning systems for characterizing the optical properties (and hence photosynthetic capacity) of leaves (e.g. *Rascher and Pieruschka*, 2008);
- Portable backpack LIDAR system for measurement of forest canopy structure (e.g. *Parker et al.*, 2004);
- Balloon system and associated gas analyzers for conducting atmospheric profiles of CO₂ and water vapor to enable estimates of nighttime boundary layer budgets (*Acevedo et al.* 2008);
- Portable gas chromatograph system for measurement of important green-house gases: methane, nitrous oxide, and carbon dioxide (*van Haren et al.*; 2010);

Proposed research projects enabled by this instrumentation includes:

- (1) Are previously detected differences in aboveground productivity and biomass (*Malhi et al.*, 2006, 2009a) of forests along the Amazon transect reflected in differences in physical forest structure along gradients from cloud forest to lowland? This student project will use ground LIDAR surveys in RAINFOR forest survey plots to detect and quantify forest structure, and possibly to compare to recently completed airborne LIDAR surveys.
- (2) Community ecology and ecophysiology from cloud forest to lowland:
 - a. At each site a project will compare canopy ecophysiology in RAINFOR plots (which ties in with already-published papers on tree growth rates): what is the relation between tree growth, height from the water table, and pre-dawn water potentials and ecophys measurements (and associated leaf spectra?)
 - b. at sites with tower or canopy access, we will focus on canopy as well as subcanopy plants; looking for relations between, e.g., eddy flux tower-derived light response curves and leaf level light curves or other ecophys/spectral characteristics.
- (3) We will conduct a project on soil fluxes and nutrient dynamics in cloud and lowland forests (or to test a hypothesis motivated by *Zimmerman et al.* 2009b that there is no differences across tree lines). CO₂, N₂O, CH₄ fluxes will be measured along with the soil type and nutrient status.

(4) We will use balloon measurements of CO₂ in the atmospheric boundary layer to interpret eddy flux tower data in complex forest terrain (as in Acevedo et al., 2008).

These projects provide the opportunity for multiple-layered collaboration between groups. For example, measurements of leaf optical properties which can be remotely sensed can be overlaid on a project measuring leaf ecophysiology so that the two measures may be compared in a systematic way.

3.2. *Dual Rationale for choice of topics*

First, we are approaching a critical junction for understanding the fate of changes in the Amazon, expected to occur with climate change or deforestation (Betts et al., 2004; Malhi et al, 2008a). Some models imply that these forests are vulnerable to catastrophic collapse due to global warming-induced increases in drought or fire, whilst others do not (Malhi et al., 2009b). Thus there is an urgent need for students and post-docs that are trained to address these pressing questions, in a way that brings together the fundamental biology and earth system science that underlies the practical concerns. Second, these topics fit squarely within those encouraged by the NSF solicitation (at p. 4) for PASI's in the biological sciences, namely "biodiversity," "regional-scale ecology," as well as "climate change," (highlighted for the geosciences); the instructors assembled for this course are world leaders in this science, and are ideally suited to create an exciting, compelling, and scientifically excellent educational and research experience for an advanced group of young north and south-American scientists.

3.3. *PASI Course Schedule*

Table 1. Planning Schedule: 26th June (Sunday) to 13th July (Wed)

(note: for planning purposes. Dates or sites may be adjusted as PASI planning proceeds)

Day # Date and Activity

0. Saturday 25th June

Arrival in Cuzco. Group checks into hotel early. Optional short tour around the historic center of Cuzco. Meet for group dinner and outline travel schedule for the next day.

1. Sunday 26th June

Leave around 8:00 on several minibuses/one large bus for Wayqecha, arrive around 12:00.

- **13:00 – 13:20:** Introduction to the course (Scott Saleska/Plinio Camargo)
- **13:20 – 13:40:** Working safely in the forest
(Wayqecha field staff: Javier Silva Espejo / Walter Huarasca)
- **13:40 – 14:20:** Cloud forest diversity, biogeochemistry and climate
(Miles Silman/Yadvinder Malhi/Norma Salina Revilla)
- **15:00 – 17:00:** Guided walk around the Wayqecha Moore monitoring plot and/or canopy walkway.
- **18:00 – 19:00: Dinner**
- **19:30 – 21:30:** Description of potential projects and break-out discussions amongst preliminary project groups (ALL INSTRUCTORS)

2-5. Monday 27th June – Thursday 30th June

INSTRUCTOR PRESENTATIONS. These will be split into daily themes: Tropical climatology (Monday), Forest carbon inventory methods (Tuesday), Plant ecophysiology (Wednesday), Remote sensing and modeling (Thursday)

6-9. Friday 1st July – Monday 4th July

GROUP PROJECTS

10. Tuesday 5th July

Leave around 10:00 on several minibuses/one large bus for Cuzco, arrive around 15:00. Check entire group into one hotel by late afternoon.

11. Wednesday 6th July: Rest day in Cuzco

12. Thursday 7th July

Leave around picked up 9:00 on plane from Cuzco airport to Puerto Maldonado. At 10:00 get picked up at the airport and transferred to the riverside by 12:00, take boat up the river and arrive at Los Amigos at 18:00.

- **15:00 – 15:40:** Lowland forest diversity, biogeochemistry and climate (Plino Camargo/Scott Saleska/Yadvinder Malhi)
- **16:00 – 17:00:** Guided walk through the Los Amigos forest to the eddy flux tower.
- **18:00 – 19:00: Dinner**
- **19:30 – 21:30:** Planning meeting amongst groups (All instructors)
- **22:30 – 00:00:** Optional guided night walk through the forest.

13-16. Friday 8th July – Monday 10th July

GROUP PROJECTS

17. Tuesday, 11th July

Final analysis of project data and writing of 20 minute presentations

18. Wednesday 13th July

GROUP PRESENTATIONS

19. Thursday 14th July

Leave Los Amigos round 6:00, get plane to Cuzco at 14:00. Leave that day or the next from Cuzco to final destination.

4. Organization, Field Site Logistics, and Financial support

General Organization: Resources for Advance Preparation and Planning. The PIs and PASI organizing committee collectively have extensive research and travel experience in both the Brazilian and Peruvian Amazon, allowing effective planning for course and field work, including obtaining vehicles, drivers, accommodations, insurance, safety, and shipping. This experience will be distilled into a written FAQ reference to PASI participants (a recent example from an Amazon-PIRE course in Brazil is at: <http://amazonpire.org/PDF/fc2009/CourseInfoPacket2009.pdf>), and this will supplement the formal resources available at the participating universities for planning for travel abroad, which include:

Logistics of Passports, visas, immunizations, air travel: Offices of International affairs at UofA and Harvard are a resource for the basic logistics of travel abroad for U.S. participants, and will assist in preparing PASI participants for travel to Peru.

Language and Cultural Training Programs: The Spanish and Portuguese Language Program at the UofA enrolls around 500 students per year, providing opportunities (both before and after the PASI) for U.S. students to acquire linguistic and cultural knowledge necessary to for full-fledged collaborations in Latin America.

While the image of the Amazon forest conjures fear and wonder for many Americans, our proposed field sites are exotic but not especially dangerous. We have years of experience in the field without serious disease or injury. The sites do not have

endemic malaria, and are fully equipped with first aid equipment. Transport by truck will be available 24 hours per day in order to evacuate a sick or injured person to a hospital within a few hours. These forests have hazards (poisonous snakes, scorpions, and centipedes) that can pose some risk if cornered. We will acquire fresh stocks of anti-venom prior to the course, to be applied in emergencies by trained physicians available at local hospitals. As stinging insects are a hazard to those with allergies, susceptible participants are required to carry injectable epinephrine (*Epipens* available by prescription). The field course will include a safety training component to inculcate basic precautions for field work and basic first aid, and will include among staff, instructors and students personnel trained in tropical wilderness emergency first aid.

Details about our main potential bases of operation for the field course are described below. Transport to these field sites is now economical, safe, and uncomplicated. The nearest large city, Cuzco, Peru, is served by the modern jet aircraft of many major airlines. The field stations themselves have diesel-generated electricity for use of computers and other equipment. Well-staffed kitchen facilities provide meals at low cost. Rooms are available for lectures and preparation of student projects. Sites have a long history of research including roads, trails, and in some cases towers or walkways for canopy access.

Field Site Descriptions

The course will be held at two to four sites along the Amazon-Andes transect. The field stations are the cloud forest site at Wayquecha (3450 m), and three possible sites for the lowland Amazon locale: Tambopata (200 m), Los Amigos (300 m), and the Manu Learning Center (700 m).



The key locations for the course. In blue are the bases (accessible by airplane) for transport to the field sites. In green, are the four potential field sites.

Site 1: Cloud Forest Site, Wayquecha field station (3450 m)

Cost: US\$40 for cabin beds, US\$15 for camping.

Travel: Five hours drive from Cuzco.

Food & Accommodation: 24 beds (3 cabins x 8 beds) and washing facilities. In addition are four double tent sites (8 people total) in the station compound and 6 “unofficial” bunk beds which we may be able to negotiate to use, with communal washing facilities. As a back up, ten minutes walk from the camp is a large camping area (accommodating ~ 40 people) with a tap.

Power: 6:00 – 23:00 every day from a gas generator. (supplemental generator fuel needed for maintaining all night instrumentation, e.g. Gas Chromatographs)

Communication: Satellite internet is not currently available but should be repaired before the proposed course, radio contact to Cuzco.

Scientific infrastructure: Around 8 km of trails around the station. Two RAINFOR project carbon measurement sites, and a canopy access by a walkway. 10/20 minutes walk (few minutes drive) along the main road to 2 RAINFOR sites and to the canopy walkway. The site can also serve as a base for movements down the altitudinal transect: several RAINFOR plots at 1500 m are a few hours drive away so groups could access these for a day or camp there overnight. Similarly, the forest transition to Puna grassland is very close to the field station. Desks, tables and power points available in the canteen/meeting room which could accommodate ~ 30 people seated. Space in the cabins also for small work groups.

Previous scientific measurements: RAINFOR plot measurements here include: basic meteorology, leaf area index, specific leaf area, litter fall, tree species, stem mass, growth and mortality, root mass and growth, respiration from all major components. Other datasets include: some leaf ecophysiology work (though not using the canopy walkway), soil chemistry above and below the tree line, epiphyte diversity, water chemistry.

Possible Projects: Building on/complementing data collected at the RAINFOR sites, fire comparison, tree-line transect, landslide study.

Other: Very beautiful site, very unusual forest even for people with previous tropical experience.

Site 2: Lowland Amazon forest site, Tambopata Explorers Inn (200 m)

Cost: US\$40 for camping/beds (need to negotiate)

Travel: 40 minutes plane from Cuzco to Puerto Maldonado, then 2 hours boat. Realistically, if you leave Cuzco in the morning you'll get there in the early/mid afternoon.

Accommodation: > 50 beds in cabins with mosquito net provided and washing facilities. However, it's unclear how many of these we'll have access to at a reduced rate. Otherwise, there's a large cabin where ~ 30 people could sleep on the floor. Meals included in the cost.

Power: Usually only in the morning and evening. We would need to purchase fuel to run gas powered generator for power needed outside of these hours.

Communication: Unreliable internet for use by one person at a time. Radio contact to the base in Puerto Maldonado

Scientific infrastructure: Large number of well-maintained trails. A canopy tower for eddy flux measurements is planned for late 2010, and should be available for the course. The canteen has seats and tables for ~ 40 people outside of meal times. The cabins and front porches provide space for smaller groups.

Previous scientific measurements: Two RAINFOR carbon measurement sites (our longest running best-maintained sites) are 10 and 40 minutes walk from the station, and include (among other datasets): leaf area index, specific leaf area, tree and palm litter fall, tree species, stem mass, growth and mortality, root mass and growth, respiration from all major components.

Possible projects: Complements to RAINFOR plot data: tower profile measurements, comparison between soils (fertility, extent of seasonal flooding), transect to the water's edge.

Other: The site is a tourist station, with comparatively less flexibility for research and teaching.

Site 3: Lowland Amazon Forest site, Los Amigos field station (300 m)

Cost: US\$30-\$40 for cabin beds.

Travel: 40 minutes plane from Cuzco to Puerto Maldonado, then 6 hours boat. Realistically, if you leave Cuzco in the morning you'll get there in the late afternoon/evening.

Accommodation: 40 beds in cabins with washing facilities; camping capacity is 60.

Power: 6:00 – 23:00 every day from a gas generator.

Communication: Wireless internet available when power is on. Radio contact with Puerto Maldonado.

Scientific Infrastructure: Well kept, extensive trail system. Labs, offices and a lecture hall available. 200 foot observation tower. Two satellite field stations, 2 and 15 miles from the main station, each with their own labs and lodging.

Previous scientific measurements: Extensive research has been done at the site however, (see bibliography at: http://atrium.andesamazon.org/biblio_search.php)

Possible projects: Profile measurements up the tower, comparison between soil types (fertility, extent of seasonal flooding), transect to the waters edge

Other: Better infrastructure than Tambopata and enthusiastic involvement of the science director already, but our team has less direct knowledge/experience of the site.

Site 4: Lowland Amazon forest site, Manu Learning Centre (700 m)

Cost: US\$30 for beds and meals.

Travel: Thirteen hours drive from Cuzco, or six hours drive from Wayqecha

Accommodation: > 50 beds in cabins with mosquito net provided and washing facilities.

Power: 7:00 – 22:00 every day from a gas generator.

Communication: Wireless internet.

Scientific infrastructure: Large number of well-maintained trails. The canteen area has seats and tables for ~ 40 people. Cabins and front porches outside provide space for smaller groups.

Previous scientific measurements: Several measurement plots have been surveyed, within which we have tree species identity and diameter at breast height. There are also around three years of canopy phenology and structure data from different forest types.

Possible projects: Complementing data collected at the established measurement plots, several secondary forest plots nearby enable a study on changes in forest processes with succession, comparison between soil types (fertility, extent of seasonal flooding), transect to the waters edge, also possible to link into a Reducing Emissions from Deforestation and degradation (REDD) scheme established at a nearby farm holdings to verify if conversion of agriculture to forest does sequester more carbon.

Other: The head of the center would be an enthusiastic partner and would be able to coordinate everything for us. The site has no tower.

5. Follow-up activities of the PASI and Outreach

Follow-up activities. We will include two kinds of substantive followup: First all the planned material (lectures, student presentations, etc.) will be posted on the PASI website (see section below, “PASI website and Information Technologies” in sect. 6, below) . Second, we plan to see some fraction of the course projects evolve into subsequent research projects, and then, as findings are ready, into published papers. .

Follow up will also include two broader impact components, at no cost to the PASI:

First, we will partner with UofA’s NSF-funded “Biodiversity from Molecules to Ecosystems” (BioME) program. BioME provides NSF graduate teaching fellowships (funded by NSF’s Division of Graduate Education’s GK-12 program) to UofA students to develop educational activities about biodiversity with K-12 teachers and students at Tucson-area schools. Our PASI will partner with the BioME program (the BioME PI is Judie Bronstein, a participant in the collaborating PIRE program) to develop funds for participation by BioME teacher-fellow pairs in the international research and education course in the Amazon. A BioME student-teacher pair will use their participation in the

PASI to incorporate material into their K-12 educational programs back in Tucson. Upon return to Tucson, the BioME partners will design effective curricular materials at the K-12 level about Amazon-forest ecology, biology and biogeochemistry.

Second, we will aim for broad public outreach by bringing a professional photographer, Jake Bryant, to the PASI. Bryant specializes in scientific photography of field-based sciences (see <http://www.envirofoto.com/>). UofA's PASI investigators will seek, in concert with the Amazon-Andes collaborators of the PASI who work in Peru (Malhi, Metcalfe et al.), to fund curation of a roving photographic exhibit drawn from Mr. Bryant's photo documentation of the PASI. This will exhibit at the UofA's Biosphere 2 (<http://www.b2science.org/>, Huxman et al., 2009) as part of the Biosphere 2 public tour of its tropical rainforest biome. With almost 100,000 visitors per year, its mission to cultivate a deeper understanding of environmental and earth system science with the general public will be much enhanced by a photographic exhibit of research and education in the actual Amazon.

6. Management, Recruitment of Participants, Assessment, and PASI website

The Principal Investigator (Saleska) will serve as chair of an organizing committee for the PASI, as required by the PASI solicitation. Other members of the committee will be:

Organizing Committee:

Plinio Camargo, University of Sao Paulo, Brazil

Dr. Camargo is an ecosystem and soil scientist with extensive experience in Amazon forest carbon cycling. He is an expert in measurement and analysis of stable isotopes and radiocarbon in organic matter samples, and manages the world-class analytic and isotope laboratories at CENA / U. of São Paulo in Piracicaba. Together with Dr. Raimundo Cosme Oliveira (Brazilian PI of the subcontract to Brazil) Dr. Camargo will coordinate the outreach to and selection of Brazilian students and recruitment of an additional Brazilian instructor.

Dan Metcalfe, Swedish University of Agricultural Sciences, Sweden

Dr. Metcalfe is an Assistant Professor in Forest Ecology and Management with 6 years of experience in both montane and lowland tropical forest across South America. He is responsible for coordinating measurements on carbon stocks and fluxes at sixteen forest plots in Brazil, Bolivia and Peru, including some situated near proposed course field sites. With his extensive experience and knowledge of both the logistics and the science at these sites, Dr. Metcalfe will coordinate with Dr. Yadvinder Malhi (his former Post-Doctoral advisor) and with Peruvian collaborators to plan and implement course logistics and content.,.

Norma Salinas, Universidad San Antonio Abad, Peru

Dr Salinas is Professor of Tropical Botany at the Universidad Nacional da San Antonio Abad del Cusco, Cuzco, Peru. She is a world expert on the plant species inhabiting the cloud forest of the Andean Amazon, and has conducted expeditions at the proposed field sites for many years. She is a point of contact for Peruvian collaborators and will coordinate outreach to and selection of Peruvian students for the course.

The organizing committee will draw on the expertise and experience of key collaborators who are also at two of the main proposed field sites:

Quinn Meyer, Manu Learning Center

Mr Meyer is founder and director of the CREES Foundation, a not-for-profit charity for advancing economic, environmental and social harmony of the Manu region in Peru. The Foundation manages research and capacity building programmes at its facility, the Manu

Learning Centre, on the Alto Madre de Dios river within the Manu Biosphere Reserve. Mr Meyer is also directs CREES Expeditions, a logistics company specializing in managing educational and research expeditions to the Manu Biosphere Reserve. CREES Expeditions will assist with permits, planning and design as well as logistics and management.

Adrian Tejedor, Amazon Conservation Association

Dr Tejedor is Science Manager for the Amazon Conservation Association (ACA) which runs the proposed Wayqecha and Los Amigos field stations and will manage the Peruvian subcontract for providing course-related services within Peru. Dr. Tejedor has worked extensively in the Neotropics studying evolution and biogeography. He is the representative and point of contact for ACA

Selection of Lecturers. We have confirmed an initial core of instructors and lecturers. In addition to the organizing committee, these include Co-PI Steven Wofsy (Harvard), Travis Huxman and Alfredo Huete (U. of Arizona), Miles Sillman (Wake Forest), and Yadvinder Malhi (Oxford University). The organizing committee will select final lecturers (see Table 2 for a pool of candidate lecturers). In making these selections, we aim to balance several priorities: (1) extensive familiarity with the Peruvian research sites, the regional ecology and climatology, and the research projects and data availability for the course; (2) diversity in disciplinary background and excellence in academic achievement; (3) diversity in terms of gender and ethnic balance.

Table 2. Candidate Instructors/Organizers

UNITED STATES

University of Arizona

Scott Saleska, Assistant Professor, PI *

Dept. of Ecology & Evolutionary Biology

Brian Enquist, Professor

Dept. of Ecology & Evolutionary Biology

Alfredo Huete, Professor *

Soil, Water and Environmental Sciences

Travis Huxman, Associate Professor *

Dept. of Ecology & Evolutionary Biology

Francina Dominguez, Assistant Professor

Dept. of Ecology & Evolutionary Biology

Harvard University

Paul Moorcroft, Professor

Organismal & Evolutionary Biology

Steven Wofsy, Professor, Co-PI *

Earth & Planetary Sciences,

Division of Engineering & Applied Sciences

Wake Forest University

Miles Silman, Professor * (letter of commitment)

EUROPE

Yadvinder Malhi, Professor *

Oxford University, United Kingdom

Daniel Metcalfe, Assistant Professor *

Swedish University of Agricultural Sciences,

BRAZIL

Plinio B. de Camargo, Professor *

University of Sao Paulo

Rafael Oliveira, Assistant Professor

UNICAMP

Raimundo Cosme de Oliveira, Researcher *

Agricultural Research Agency (EMBRAPA)

Santarém, Brazil

PERU

Adrian Tejedor *

Amazon Conservation Association

Norma Salinas * (letter of commitment)

Universidad San Antonio Abad

Quinn Meyer

Manu Learning Center

(* = Biosketch included)

Selection of Student Participants. The course will be advertised within the participating institutions, and all interested participants, from all countries, will apply via the PASI website. The organizing committee will select students based on:

- Academic excellence

- Representation of all institutions participating in the PASI
- Diversity in disciplinary background
- Field experience
- Ability to speak and understand adequate English (for Brazilian and Peruvian participants). (course will be taught in english).

Minority Recruitment: Maria Teresa Velez, Associate Dean of the UofA Graduate College, will oversee minority recruitment efforts at the UofA, for the PASI, and PASI Co-PI S. Wofsy will perform this role at Harvard, where he is Associate Dean for Academic Affairs at Harvard's School of Engineering and Applied Science.

The Graduate College at the UofA has long championed recruitment of a diverse graduate student body through programs which start with qualified undergraduates. These programs include summer research programs for undergraduates (UofA currently sponsors ~100 underrepresented ecology, environmental and earth sciences majors each summer); vigorous recruitment at Minority Serving Institutions (HBCUs, Hispanic Serving Institutions in the Southwest and Puerto Rico, and Tribal Colleges); and GRE Preparation, graduate application workshops, and application waivers. Once admitted, the Graduate College maintains financial support to these students through Graduate Diversity Fellowships, and joint programs, among them, the UofA/Sloan Partnership for American Indians, currently supporting 33 Native Americans pursuing graduate studies in science and technology fields (the highest such enrollment in the U.S.). In Spring 2007, 19.5% of graduate students at UA come from minority backgrounds.

The UofA will draw on this legacy to recruit underrepresented U.S. graduate students for the PASI. Given common borders within the Amazon forest of several countries in Latin America (Venezuela, Colombia, Ecuador and Peru) and the interest in environmental concerns in the Southwest and Puerto Rico in minority communities, we anticipate that there will be a significant pool of underrepresented graduate students who would be attracted by the science of the proposed PASI program.

Assessment of the PASI: Through collaboration with Associate Professor Ralph Renger of the UofA College of Public Health (who is performing a similar role for the overall Amazon-PIRE project at UofA), we are designing a PASI performance assessment to provide critical feedback on program success. The assessment will be composed of evaluations of process (to what extent was the program delivered as intended?) and of impact (what was the effect of the program on the participants?).

The *process evaluation* will use anonymous surveys to answer such questions as: Did the PASI program provide students with sufficient exposure to cultural elements to bridge international differences? Did the PASI promote opportunities for development of true collaborative relationships with international colleagues, including both peers and more senior mentors?

The *impact evaluation* will focus on follow-up, and, using logic modeling (Renger and Titcomb, 2002; Renger and Hurley, 2006) will assess PASI participants (who will be entered into the same web-based database that has been developed for the Amazon-PIRE and will be assessed along with PIRE students) and the PASI on two key markers of program success: first (and primarily), *effectiveness in international collaboration* (i.e., are there international collaborations that grow out of the PASI?), and secondly, *success in subsequent professional life* (including authorship of papers, immediate

placement after graduation (first position), and (eventually) longer-term career trajectory. In the case of the PASI, the longer-term evaluation components will not be conducted within the two-year funding horizon of the grant, but the entry of all PASI participants into the database, and the conduct of the early-stage evaluation offers the opportunity for longer-term assessment at a later time.

PASI Website and Information Technologies. Overall coordination, exchange of information and data, and access to educational materials and webcasts (e.g. from the field course or from media products) will be facilitated by a web-based collaboration tool linking a public PASI website, ftp sites at each participating institution for the transfer of datasets and files, and a password-protected WIKI site, accessible to and editable by all project personnel in both the U.S. and South America, for web-based collaboration, including joint analysis of project data, joint authorship of papers, planning for group activities and field courses, etc. WIKI web collaboration tools (e.g. PBworks at <http://pbworks.com/>) operate like a “whiteboard” on the web: all users can write, post files or links, add new pages, etc., and are designed to facilitate collaboration and information exchange among large groups in disparate locations.

PASI website will draw on the established web presence developed for the Amazon-PIRE: the main website is www.amazonpire.org, and the WIKI web collaborations include: <http://amazonpire.pbworks.com/> (for coordinating all PIRE wiki sites), <http://pirefieldcourse.pbworks.com/> -- a wiki for instructors and staff of the annual PIRE fieldcourse (for planning and coordination), and <http://pireresearch.pbworks.com/>, a wiki for research planning activities, exchanging proposal text and paper drafts, and data exchange, for research projects of the Amazon-PIRE project

7. Results from Prior NSF support

NSF OISE-0730305, 9/1/2007 – 8/31/2012: “PIRE: Carbon, water and vegetation dynamics of Amazon forests under climatic variability and change,” PI: S. Saleska, University of Arizona; Co-investigators: A. Huete and W.J. Shuttleworth (University of Arizona), S.C. Wofsy (Harvard University). Multiple publications are in preparation from the first 2 years of the project, 3 with contributions from PIRE are published/accepted: Saleska, S., H.R. da Rocha, B. Kruijt, and A. Nobre. 2009. Ecosystem carbon fluxes and Amazon forest metabolism. peer-reviewed chapter for *Amazonia and Global Change*, World Scientific Publishing. Hutyra, L.R., J.W. Munger, E.-H. Pyle, S.R. Saleska, et al.. Resolving systematic errors in estimates of net ecosystem exchange of CO₂ and ecosystem respiration in a tall-stature forest: application to a tropical forest biome. 2008. *Agric. Forest Meteorology*. 148: 1266-1279. van Haren, J.L.M., R.C. de Oliveira, Jr., N. Restrepo-Coupe, L. Hutyra, P.B. de Camargo, M. Keller, S.R. Saleska (2010). Do plant species influence soil CO₂ and N₂O fluxes in a diverse tropical forest?, *J. Geophys. Res.- Biogeosciences*. (accepted).

NSF BIO-0721140, 9/1/2007 – 8/31/2009 (with no-cost extension to 8/31/2010), “Collaborative Research -- Airborne LIDAR surveys of forest canopy structure across Amazonian landscapes to infer large-scale forest biomass and carbon balance.” PI: Scott Saleska, Co-investigator, G.G. Parker, Smithsonian Environmental Research Center. This project, still underway, is the basis of multiple publications in preparation, including those from 3 Ph.D. dissertations, and from one completed undergraduate thesis:

Leitold, V. 2009. “Canopy structure and function in the Tapajós National Forest in equatorial Amazonia, Brazil,” undergraduate honors thesis, Earth and Planetary Sciences, Harvard College.

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(Names of authors who are committed to participate in the proposed PASI are highlighted in **bold**)

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(a) Professional Preparation

Massachusetts Institute of Technology (Physics) B.S. 1986
University of California, Berkeley (Energy and Resources Group) Ph.D., 1998
Harvard University (Dept. of Earth & Planetary Sciences), Post-Doctoral fellow 1999-2001

(b) Appointments:

2005-present: *Assistant Professor*, University of Arizona, Ecology & Evolutionary Biology
2002-2004: *Research Associate*, Harvard University, Dept. of Earth & Planetary Sciences

(c) Selected publications

(i) Five publications closely related to the proposed project

Saleska, S., H.R. da Rocha, B. Kruijt, and A. Nobre. (2009) Ecosystem carbon fluxes and Amazon forest metabolism. Invited peer-reviewed book chapter for Michael Keller, Mercedes Bustamante, John Gash, and Pedro Silva Dias, Editors, Amazonia and Global Change, Geophysical Monograph Series, Volume 186, 576 pp., ISBN 978-0-87590-476-4.

Saleska, S.R., K. Didan, A.R. Huete, and H.R. da Rocha. (2007). Amazon forests green-up during 2005 drought. Science, 318: 612. (Published online 20 Sep 2007, doi: 10.1126/science.1146663).

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Harte, J, S.R. Saleska, T. Shih. 2006. Shifts in plant dominance control short and long-term carbon-cycle responses to widespread drought, Env. Res. Lett. 1: 014001. (Online at stacks.iop.org/ERL/1/014001).

Saleska, S.R., S.D. Miller, D.M. Matross, M.L. Goulden, S.C. Wofsy, H. da Rocha, P.B. de Camargo, P.M. Crill, B.C. Daube, C. Freitas, L. Hutya, M. Keller, V. Kirchhoff, M. Menton, J.W. Munger, E.H. Pyle, A.H. Rice, H. Silva (2003). Carbon in Amazon forests: unexpected seasonal fluxes and disturbance-induced losses. Science. 302: 1554-1557.

(ii) Five other significant publications

van Haren, J.; R.C.de Oliveira Jr., N. Restrepo-Coupe, L. Hutya, P.B. de Camargo, M. Keller, S.R. Saleska, in review, Do plant species influence soil CO₂ and N₂O fluxes in a diverse tropical forest?, submitted to J. Geophys. Res., Biogeosci.

Saleska, S; J. Shorter, S. Herndon, R. Jimenez, B. McManus, D. Nelson, M. Zahniser (2006). What are the instrumentation requirements for measuring the isotopic composition of net ecosystem exchange of CO₂ using eddy covariance methods? Isotopes Env. Health Studies, 42 (2), 115-133.

Hutya, L.R., J.W. Munger, E.-H. Pyle, S.R. Saleska, N. Restrepo-Coupe, P.B. de Camargo, B.C. Daube, S.C. Wofsy. 2008. Resolving systematic errors in estimates of net ecosystem exchange of CO₂ and ecosystem respiration in a tall-stature forest: application to a tropical forest biome. Agric. Forest Meteorology. 148: 1266-1279.

Dunne, J.A., S.R. *Saleska*, M.L. Fischer, J. Harte. Integrating experimental and gradient methods in ecological climate change research. 2004. *Ecology*. 85: 904-916.

Saleska, S.R.; M.R. Shaw, M. Fischer, J. Dunne, C.J. Still, M. Holman, and J. Harte (2002). Plant community composition mediates both large transient decline and predicted long-term recovery of soil carbon under climate warming. *Global Biogeochemical Cycles*. 16(4): 1055, doi:10.1029/2001GB001573.

(d) Synergistic Activities

- Director, *Amazon-PIRE*, an NSF-funded 5-year (2007-2012) “Partnership for International Research and Education” (PIRE) focusing on Amazon forest-climate interactions. Partners include Harvard, University of São Paulo (Brazil), Federal University of Pará (in the Brazilian Amazon), and the Brazilian National Institute for Amazonian Research.
- Member, Science Steering Committee, UofA Biosphere 2 (2007 to present)
- Panel Reviewer for NASA (Carbon Cycle Science) and NSF (Ecosystems Panel)
- Associate Editor, *J. of Geophys Research – Biogeosciences*
- Reviewer for *Ecological Applications*, *Ecology Letters*; *Global Change Biology*; *Global Biogeochemical Cycles*; *Isotopes in Environmental and Health Studies*; *Nature*; *Oecologia*; *Philosophical Transactions of the Royal Society*; *Plant, Cell and Environment*; *Proceedings of the National Academy of Sciences*; *Science*

(e) Collaborators and other affiliations

Collaborators in the past 48 months: P.B. de Camargo, U-Sao Paulo, Brazil; P.M. Crill, Uppsala University, Sweden; B.C. Daube, Harvard University; K. Didan, U-Arizona, D. Fitzjarrald, SUNY-Albany; L.G. de Goncalves, NASA-Goddard; M.L. Goulden, U.C. Irvine; J. Harte, U.C. Berkeley; S. Herndon, Aerodyne Research, Inc; A. Huete, U-Arizona; L. Hutya, Boston University; Rodrigo Jimenez, Harvard University; M. Keller, NEON, Inc.; B. Kruit, Wageningen University, Netherlands; M.L. Lefsky, Colorado State University; A. Manzi, INPA, Brazil; B. McManus, Aerodyne Research, Inc.; S.D. Miller, SUNY-Albany; P. Moorcroft, Harvard University; J.W. Munger, Harvard University; D. Nelson, Aerodyne Research, Inc.; A. Nobre, INPA, Brazil; H. da Rocha, U Sao Paulo Brazil; Y.E. Shimabukuro, INPE, Brazil; S.C. Wofsy, Harvard University; M. Zahniser, Aerodyne Research, Inc.

Graduate and Post-Doctoral Advisers

John Harte, U.C. Berkeley (PhD. advisor)

Steven Wofsy, Harvard University (post-doctoral advisor)

Graduate student thesis advisees: Joost van Haren (current), Bradley Christoffersen (current), Scott Stark (current, co-advised by B. Enquist), Jin Wu (current)

Post-doctoral advisees: Natalia Restrepo-Coupe (current), Richard Wehr (current), Virginia Rich (current)

Steven C. Wofsy

Harvard University, School of Engineering & Applied Sciences, and Dept. of Earth and Planetary Science, Pierce Hall 110D, 29 Oxford St., Cambridge MA 02138; swofsy@seas.harvard.edu

a. Professional Preparation: University of Chicago, B.S., Chemistry, 1966; Harvard University, Cambridge, MA. M.A. in Chemistry, 1967; Ph.D. in Chemistry, 1971; Post doctoral fellow, Harvard University –Division of Engineering and Applied Science, and Smithsonian Astrophysical Observatory, 1971-1973.

b. Appointments:

February, 1995-present, Abbott Lawrence Rotch Professor of Atmospheric and Environmental Chemistry, Harvard University, School of Engineering and Applied Science, and Dept of Earth and Planetary Sciences (EPS).

September 2006- . Director of Undergraduate Studies, Earth and Planetary Science

September, 2003-2006 . Associate Dean, Faculty of Arts and Sciences, Harvard University

July, 1982 to February, 1995. Senior Research Fellow (Harvard DEAS).

July 1977 to June 1982. Associate Professor of Atmospheric Chemistry, (Harvard DEAS).

September 1973 to June 1977. Harvard DEAS, Lecturer/Res. Fellow, Atmospheric Chemistry

c. Selected Publications: (i) Five publications related to the project

Dunn, A. L., C. C. Barford, S. C. Wofsy, M. L. Goulden, B. C. Daube, A long-term record of carbon exchange in a boreal black spruce forest: means, responses to interannual variability, and decadal trends, *Global Change Biology* 13 (3): 577-590, 2007.

Hutyra, L., J. W. Munger, S. R. Saleska, E. W. Gottlieb, B. C. Daube, A. L. Dunn, D. F. Amaral, P. B. de Camargo, and S. C. Wofsy, Seasonal controls on exchange of carbon and water in an Amazonian rainforest, *J. Geophys. Res. - Biogeosciences* 112 (G3), Art. No. G03008, 2007.

Lin, J. C., C. Gerbig, S. C. Wofsy, V. Y. Chow, E. Gottlieb, B. C. Daube, and D. M. Matross, Designing Lagrangian experiments to measure regional-scale trace gas fluxes, *J. Geophys. Res. - Atmospheres* 112 (D13), Art. No. D13312, 2007.

Oliveira, P. H. F., P. Artaxo, C. Al. Pires Jr, S. de Lucca, A. Procópio, B. Holben, J. Schafer, L. F. Cardoso, S. C. Wofsy, S. Miller, H. da Rocha, The effects of biomass burning aerosols and clouds on the CO₂ flux in Amazonia, *Tellus B -CHEMICAL AND PHYSICAL METEOROLOGY*, 59,338-349, 2007.

Saleska, S. R.S. D. Miller, D. M. Matross, M. L. Goulden, S. C. Wofsy, H. R. da Rocha, P.B. de Camargo, P. Crill, B. C. Daube, H. C. de Freitas, L. Hutyra, M. Keller, V.W. H. Kirchhoff, M. Menton, J. W. Munger, E. H. Pyle, A. H. Rice, H. Silva, Carbon in Amazon forests: unexpected seasonal fluxes and disturbance-induced losses, *Science* 302, 1554-1557, 2003.

(ii) Five other significant publications

Fan, S., S. C. Wofsy, P. S. Bakwin, and D. J. Jacob, and D. R. Fitzjarrald. Atmosphere-Biosphere Exchange of CO₂ and O₃ in the Central Amazon Forest. *J. Geophys. Res.* 95: 16,851-16,864, 1990.

Chou, Wendy W., Steven C. Wofsy, Robert C. Harriss, John C. Lin, C. Gerbig, and Glenn W. Sachse, Net fluxes of CO₂ in Amazônia derived from aircraft observations, *J. Geophys Res.* 107 (D22), 4614, 10.1029/2001JD001295, 2002.

Wofsy, S. C., K. A. Boering, B. C. Daube, Jr., M. B. McElroy, M. Loewenstein, J. R. Podolske, J. W. Elkins, G. S. Dutton, and D. W. Fahey. Vertical Transport Rates in the Stratosphere in 1993 from Seasonal Observations of CO₂ and N₂O. *Geophys. Res. Lett.*, 21, 2571-2574, 1994.

Wofsy, S. C., S.M. Fan, D.R. Blake, J. D. Bradshaw, S.T. Sandholm, H.B. Singh, G.W. Sachse, and R.C. Harriss, Factors Influencing Atmospheric Composition Over Subarctic America During Summer. *J. Geophys. Res.*, 99, 1887-1897, 1994.

Pyle, Elizabeth Hammond, Gregory W. Santoni, Henrique E. M. Nascimento, Lucy R. Hutyra, Plinio B. Carmago, Simone Vieira, Daniel J. Curran, Joost van Haren, Scott R. Saleska, V.Y. Chow, William F. Laurance, and Steven C. Wofsy, Effects of disturbance on biomass, structure and carbon balance in two Amazonian Forests, *Global Biogeochemical Cycles* 113, article G00B08, 2008.

Synergistic activities

National Academy of Science, Panel on Methods to Estimate Greenhouse Gas Emissions (current)
National Academy of Science, Working group on the Atmosphere, Panel on Climate, Energy and National Security (current)

Carbon Cycle Science Steering Group, Interagency Committee on the Carbon Cycle
Amazon PIRE (“Partnership for International Research and Education”), co-PI; instructor.
IPCC 4th assessment, Lead Author, Working Group I, Chapter 7.

PhD Advisor: Wm. Klemperer; **Post-doctoral advisors,** A. Dalgarno and M. McElroy (Harvard)

Collaborators last 48 Months

Coursolle C (U Laval), Margolis HA (U Laval), Barr AG (Env Canada), Black TA (U British Columbia), Amiro BD (U. Manitoba), McCaughey JH (Canada), Flanagan LB (Canada), Lafleur PM (McGill), Roulet NT (McGill), Bourque CPA (McGill), Arain MA (U Toronto), Dunn A (Worcester State coo), Morgenstern K (U Oregon), Orchansky AL (U Oregon), Bernier PY (U. Quebec), Chen JM (U. Toronto), Kidston J (Canada), Saigusa N (Canada), Hedstrom N. (Canada), Gerbig, C.(Max Planck- Jena), J. C. Lin (U. Waterloo), J.W. Munger (Harvard) , Hollinger, D.Y. (USFS), Richardson, A.D. (Harvard), Stoy, P.C. (U. Montana), Monson, R.K. (U Colorado), Hurst , DF (NOAA), Horii CV (Curry Coll), Munger JW (Harvard), Zahniser M (Aerodyne), Nelson D (Aerodyne), McManus JB (Aerodyne), P. A. Romashkin (NCAR), B. C. Daube (Harvard), B. D. Hall (NOAA), J. W. Elkins (NOAA), Kucharik CJ (Wisconsin), Barford CC (Wisconsin), El Maayar M (Wisconsin), Baldocchi DD (Berkeley), Goldstein A H (Berkeley), Law BE (Oregon), Oechel W (San diego State), Running SW (Montana), Saleska SR (Arizona), Andrews AE (NOAA), Turner DP (Minnesota), Goulden ML (Irvine), Emmons L. K. (NCAR), G.G. Pfister (NCAR), D.P. Edwards (NCAR), J.C. Gille (NCAR), G. Sachse (Langley NASA), D. Blake (Irvine), Marcy T. P (NOAA), P.J. Poppa (NOAA), R.S. Gao (NOAA), D.W. Fahey (NOAA), E.A. Ray (NOAA), E.C. Richard (NOAA), T.L. Thompson (NOAA), E.L. Atlas (Miami), M. Loewenstein (Ames NASA), Park S (Korea), Mahoney MJ (JPL), Artaxo P (U Sao Paulo), Conway T (NOAA), Urbanski, S. (USFS), Fitzjarrald D R (SUNY Albany), Pfister L (NASA Ames), A. J. Weinheimer(NCAR), Vesala t (Finland), Hutyra L (Boston U), J. Eluszkiewicz (AER), B. B. Stephens (NCAR), J. B. Miller (NOAA), T. Nehrkorn (AER), J. O. Kaplan (Heidelberg), S. Houweling (Netherlands), Laurence Wm. (Smithsonian), Medvigy D (Princeton), Braswell R (UNH), Lou Y (Oklahoma)

CURRICULUM VITAE

PLÍNIO BARBOSA DE CAMARGO

Brazilian

18 de julho de 1960

Address: Av. Centenário 303,
13416-000, Piracicaba, SP, Brasil

fone: 55 19 34294068

email pcamargo@cena.usp.br

Professional preparation:

1981 – 1984, Agronomy

Escola Superior de Agricultura "Luiz de Queiroz" - ESALQ/USP-Piracicaba, SP

1985 – 1990, Master, Dissertation: Nitrogen dynamics of the fertilizers urea (^{15}N) and aquamônia (^{15}N) in the soils with sugar cane.

Center for Nuclear Energy in Agriculture / University of Sao Paulo

1992 – 1997, Doctor, Thesis: Soil carbon organic matter dynamics in the soils of Amazonia because land use change.

Center for Nuclear Energy in Agriculture / University of Sao Paulo

Appointments: Professor at CENA/USP (Center for Nuclear Energy in Agriculture / University of Sao Paulo) since 1990, in the Isotope Ecology Lab, working with Biogeochemistry and Ecosystems Terrestrial Function.

Selected Publications:

1. HUTYRA, L ; MUNGER, J ; HAMMONDPYLE, E ; SALESKA, S ; RESTREPOCOUPE, N ; DAUBE, B ; DECAMARGO, P ; WOFYSY, S . Resolving systematic errors in estimates of net ecosystem exchange of CO_2 and ecosystem respiration in a tropical forest biome. *Agricultural and Forest Meteorology*, v. 148, p. 1266-1279, 2008.

2. SALOMÃO, M. S. M. B. ; COLE, J. J. ; CLEMENTE, C. A. ; SILVA, D. M. L. ; CAMARGO, P. B. ; VICTORIA, R. L. ; MARTINELLI, L. A. . CO_2 and O_2 dynamics in human-impacted watersheds in the state of São Paulo, Brazil. *Biogeochemistry*, v. 88, p. 271-283, 2008.

3. BRANDO, PAULO M. ; NEPSTAD, DANIEL C. ; DAVIDSON, ERIC A. ; TRUMBORE, SUSAN E. ; RAY, DAVID ; CAMARGO, PLÍNIO . Drought effects on litterfall, wood production and belowground carbon cycling in an Amazon forest: results of a throughfall reduction experiment. *Philosophical Transactions of the Royal Society of London. Biological Sciences*, v. 363, p. 1839-1848, 2008.

4. HUTYRA, L. ; MUNGER, J.W. ; SALESKA, S.R. ; GOTTLIEB, E. ; DAUBE, B.C. ; DUNN, A. L. ; AMARAL, D. ; CAMARGO, P. B. de ; WOFYSY, S.C. . Seasonal controls on the exchange of carbon and water in an Amazonian rain forest.. *Journal of Geophysical Research*, v. 112, p. G03008, 2007.

5. LEFSKY, MICHAEL A. ; KELLER, MICHAEL ; PANG, YONG ; DE CAMARGO, PLINIO B. ; HUNTER, MARIA O. . Revised method for forest canopy height estimation from Geoscience Laser Altimeter System waveforms, v. 1, p. 013537, 2007.

6. CARMO, J.B. ; KELLER, M.M. ; DIAS, J.D. ; CAMARGO, P. B. de ; CRILL, P.M. . A source of methane from upland forests in the Brazilian Amazon. *Geophysical Research Letters*, v. 33, p. 1-4, 2006.

7. LEFSKY, M.A. ; HARDING, D.J. ; KELLER, M.M. ; COHEN, W.B. ; CARABAJAL, C.C. ; ESPIRITO SANTO, F.B. ; HUNTER, M.O. ; OLIVEIRA JUNIOR, R.C. ; CAMARGO, P. B. de . Estimates of forest canopy height and aboveground biomass using ICESat. *Geophysical Research Letters*, v. 33, p. 1-4, 2006.

8. TRUMBORE, S.E. ; COSTA, E.S. ; NEPSTAD, D.C. ; CAMARGO, P. B. de ; MARTINELLI, L.A. ; RAY, D. ; RESTOM, T. ; SILVER, W. . Dynamics of the fine root carbon in Amazonian tropical ecosystems and the contribution of roots to soil respiration. *Global Change Biology*, v. 12, p. 217-229, 2006.

9. XIAO, X. ; ZHANG, Q. ; SALESKA, S.R. ; HUTYRA, L. ; CAMARGO, P. B. de ; WOFYSY, S.C. ; FROLKING, S.; BOLES, S. ; KELLER, M.M. ; MOORE III, B. . Satellite- based modeling of gross primary production in a seasonally moist tropical evergreen forest. Remote Sensing of Environment, v. 94, p. 105-122, 2005.

10.VIEIRA, S.A. ; TRUMBORE, S.E. ; CAMARGO, P. B. de ; SELHORST, D. ; CHAMBERS, J.Q. ; HIGUCHI, N. ; MARTINELLI, L.A. . Slow growth rates of Amazonian trees: consequences for carbon cycling. PNAS. Proceedings of the National Academy of Sciences of the United States of America, WASHINGTON, v. 102, n. 51, p. 18502-18507, 2005.

Synergistic Activities:

2003-2010 Project "Composition, structure and functioning of Ombrophylus Dense of cores Picinguaba and Santa Virginia Ridge, State Park, CENA/USP. FAPESP. Contributor. Coordinator: Dr. Carlos Alfredo Joly and Dr. Luiz A. Martinelli. (\$ 1,000,000)

2007-2012 International collaboration project "Dynamics of carbon, water and vegetation of the Amazon, under the effects of climate variability" Ordinance MCT No 283, 6 May 2008. NSF program PIRE (International Partnership in Research and Education-process: 0730305). National Coordinator: Plinio Barbosa de Camargo. (\$ 200,000)

2005-2010 Project "Interference effects in dynamics of carbon in the Amazonian forest of old-growth: model algorithm development and individual trees synthesis" CENA/USP and Tulane University Evolutionary Biology and Ecology. NASA/USA. Brazilian Coordinator and USA Coordinator, Dr. Jeffrey Chambers. (\$ 200,000).

Graduate and Post-Doctoral Advisers

Luiz Martinelli, University of São Paulo (PhD. Advisor)

Susan Trumbore, University of California – Irvine (post-doctoral advisor)

Graduate student advisees

Eduardo Ballespi de Castro Vasconcellos - master

Marcos Augusto da Silva Scaranello - master

Mauricio Tassoni Filho - master

Tatiana Morgan Berteli de Andrade - PhD

Jadson Desincourt Dias – PhD

Collaborators in the last 48 months:

Niro Higuchi, Joaquim dos Santos, Jeffrey Chambers, Scott Saleska, Scott Stark, Lucy Hutyra, Michael Keller, Michael Lefsky, Steven Wofsy, Susan Trumbore, Simone Vieira, Luiz Martinelli, Jean P. H. Ometto, Raimundo Cosme Oliveira, Eric Davidson, Paulo Brando, Xiangmin Xao, Wendy Silver.



Piracicaba, January 13, 2010

Biographical Sketch: Alfredo R. Huete

a. Professional Preparation

University of Arizona	Soil and Water Science	Ph.D 1984
University of California at Berkeley	Soil and Plant Biology	M.S. 1982
University of Arizona	Range Ecology	B.S. 1977

b. Appointments

1995 - present	Professor in Soils and Remote Sensing, Soil, Water and Environmental Science Department, University of Arizona
1989 - 1995	Associate Professor (with tenure) in Soils and Remote Sensing, Department of Soil and Water Science, University of Arizona
1984 - 1989	Assistant Professor in Soils and Remote Sensing, Department of Soil and Water Science, University of Arizona

c. Publications (relevant)

- Anderson, L., Shimabukuro, Y., **Huete, A.R.**, 2010, Fraction images for monitoring intra-annual phenology of different vegetation physiognomies in Amazonia”, *International Journal of Remote Sensing* (In press).
- Huete, A.**, Didan, K., van Leeuwen, W., Miura, T., and Glenn, E., 2009, MODIS Vegetation Indices, In: (Ramachandran, B., Justice, C.O., and Abrams, M., eds.) *Land Remote Sensing and Global Environmental Change: NASA’s Earth Observing System and the Science of ASTER and MODIS*, Springer-Verlag (in press).
- Huete, A.R.**, Restrepo-Coupe, N., Ratana, P., Didan, K., Saleska, S.R., Ichii, K., Panuthai, S., Gamo, M., 2008, Multiple site tower flux and remote sensing comparisons of tropical forest dynamics in monsoon Asia, *Agric. & Forest Meteorology*, 148/5, 748-760 (doi 10.1016/j.agrformet.2008.01.012).
- Glenn, E.P., **Huete, A.R.**, Nagler, P.L., Nelson, S.G., 2008, Relationship between remotely-sensed vegetation indices, canopy attributes and plant physiological processes: What vegetation indices can and cannot tell us about the landscape, *Sensors* 8, 2136-2160.
- Saleska, S.R., Didan, K., **Huete, A.R.**, and da Rocha H.R. 2007, Amazon forests green-up during 2005 drought, *Science*, **318**: 612. (Published online 20 Sep 2007, doi: 10.1126/science.1146663).
- Huete, A.R.**, Kim, Y., Ratana, P., Didan, K., Miura, T., and Shimabukuro, Y.E., 2007, Assessment of phenologic variability in Amazon tropical rainforests using hyperspectral and MODIS satellite data, In: (Kalacska M., Sanchez-Azofeifa, A., eds.), *Hyperspectral Remote Sensing of Tropical and Sub-Tropical Forests* (in press).
- Myneni, R.B., W. Yang, R. R. Nemani, **A. R. Huete**, R.E. Dickinson, et al., 2007, Large seasonal swings in leaf area of Amazon rainforests, *Proc. National Academy of Science*, 104(12): 4820-4823.
- Huete, A.R.**, K. Didan, Y. E. Shimabukuro, P. Ratana, S.R. Saleska, L.R. Hutyrá, D. Fitzjarrald, W. Yang, R.R. Nemani, and R. Myneni, 2006, Amazon rainforests green-up with sunlight in the dry season, *Geophysical Research Letters*, 13, doi:10.1029/2005GL025583.

- Yang, F., K. Ichii, M.A. White, H. Hashimoto, A.R. Michaelis, P. Votava, A.X Zhu, A. Huete, S. Running, and R.R. Nemani, 2007, Developing a continental-scale measure of gross primary production by combining MODIS and AmeriFlux data through support vector machine, *Remote Sens. Environ.* 110: 109-122.
- Ichii, K., Hashimoto, H., White, M.A., Potter, C., Hutyyra, L., Huete, A.R., Myneni, R.B., and Nemani, R.R., 2006, Constraining rooting depths in tropical rainforests using satellite data and ecosystem modeling for accurate simulation of GPP seasonality, *Global Change Biology*, 13 (1): 67-77.

d. Synergistic Activities

MODIS Science Team Member: Member of the science team since 1991. Responsible for the development, implementation, and validation of the MODIS vegetation index products.

NPP Science Team Member: Member of the NPOESS Preparatory Project science team and responsible for the evaluation of vegetation indices for environmental data records (EDRs) as well as in assessing their use as climate data records (CDRs).

e. Collaborators in the past 48 months

S. Saleska, Univ. Arizona; L. Ferreira, Brazil; K. Franklin, Hermosillo, Mexico; E. Glenn, Univ. Arizona; Y. Honda, Chiba Univ., Japan; Jiaguo Qi, Michigan State Univ; L. Hutyyra, Harvard Univ.; T. Huxman, Univ. Arizona; T. Miura, Univ. Hawaii; S. Moran, USDA-ARS, Tucson; R. Myneni, Boston Univ; P. Nagler, USGS; R. Nemani, NASA-Ames; C. Potter, NASA-Ames; J. Privette, NASA GSFC; B. Reed, USGS-Flagstaff; D. Dye, USGS; Y. Shimabukuro, INPE, Brazil; D. Simms (Ball State, Indiana; W. van Leeuwen, Univ. Arizona; C. Watts, Hermosillo, Mexico; X. Zeng, Univ. Arizona; K. Didan, Univ. Arizona; M. Simard, JPL; N. Pinto, JPL; J. Luvall, NASA; A. Budge, Univ. New Mexico.

Graduate student thesis Advisees (17):

M. Abd-elwahed (Cairo, Egypt), E. Ariyasu (Japan), R. Solano (current), U. Nguyen (current); G. Ponce (current); C. Bresloff (current); H. Barbosa (FUNCEME, Brazil), L. Ferreira (Goias, Brazil), X. Gao (COLA, Md), L. Goins (Georgia), D. Gonzalez, Concepcion, Chile; J. Kaurivi (Namibia University), H. Kim (North Dakota State Univ.), Y. Kim (Univ of Montana), T. Miura (Univ. Hawaii), E. Sano (EMBRAPA, Brazil), N. Sirikul (Thailand)

Biographical Sketch – TRAVIS E. HUXMAN

Ecology and Evolutionary Biology
University of Arizona
Tucson, AZ 85721

Tel: (520) 626-1229
Fax: (520) 626-0793
E-mail: huxman@email.arizona.edu

(i) Professional Preparation

California State University, San Bernardino	Biology	BS 1993
California State University, San Bernardino	Biology	MS 1996
University of Nevada, Las Vegas	Biology	PhD 2000
University of Colorado, Boulder	Biology	2000-2001

(ii) Appointments and Titles

Director, Biosphere 2 & B2 Earthscience	2007 – present
Associate Professor of Ecology and Evolutionary Biology, University of Arizona	2007 – present
Assistant Professor of Ecology and Evolutionary Biology, University of Arizona	2001 - 2007
Postdoctoral Associate Department of EPO Biology, UC-Boulder	2000 - 2001
Research Assistant Department of Biological Sciences, UNLV	1996 - 2000

(iii) Publications

(i) 5 publications most closely related to the proposed project

- Huxman TE**, Venable DL, Barron-Gafford G, Gerst K, Angert AL, Tyler A (2008) Photosynthetic resource-use efficiency and demographic variability in desert annual plants. *Ecology* 89:1554-1563..
- Huxman TE**, Wilcox BP, Scott RL, Snyder K, Hultine K, Small E, Breshears D, Pockman W, Jackson RB (2005) Ecohydrological implications of woody plant encroachment. *Ecology* 86:308-319.
- Huxman TE**, Cable JM, Ignace DD, Eilts AJ, English N, Weltzin J, Williams DG (2004) Response of net ecosystem gas exchange to a simulated precipitation pulse in a semiarid grassland: the role of native versus non-native grasses and soil texture. *Oecologia* 141:295-305.
- Huxman TE**, Smith MD, Fay PA, Knapp AK, Shaw MR, Loik ME, Smith SD, Tissue DT, Zak JC, Weltzin JF, Pockman WT, Sala OE, Haddad BM, Harte J, Koch GW, Schwinning S, Small EE, Williams DG (2004) Convergence across biomes to a common rain-use efficiency. *Nature* 429:651-654.
- Huxman TE**, Snyder KA, Tissue D, Leffler AJ, Pockman W, Ogle K, Sandquist D, Potts DL, Schwinning S (2004) Precipitation pulses and carbon balance in semi-arid and arid ecosystems. *Oecologia* 141:254-268.

(ii) 5 other significant publications

- Jenerette GD, Scott RL, **Huxman TE** (2008) Whole ecosystem metabolic pulses following precipitation events. *Functional Ecology* 22:924-930.
- Angert AL, Barron-Gafford G, Gerst K, **Huxman TE**, Venable DL (2007) Interspecific and seasonal variation in growth and allocation in a guild of desert winter annuals. *Journal of Ecology* 95:321-331.
- Enquist BJ, Economo EP, **Huxman TE**, Allen AP, Ignace DD, Gillooly JF (2003) Scaling metabolism from organisms to ecosystems. *Nature* 423:639-642
- Huxman TE**, Smith SD (2001) Photosynthesis in an invasive grass and native forb at elevated CO₂ during an El Niño year in the Mojave Desert. *Oecologia*, 128:193-201.

Smith SD, **Huxman TE**, Zitzer SF, Charlet TN, Housman DC, Coleman JS, Fenstermaker LK, Seemann JR, Nowak RS (2000) Elevated CO₂ increases productivity and invasive species success in an arid ecosystem. *Nature* 408:79-82.

(iv) Synergistic Activities

2009 – Member of ESA’s Rapid Response Team for Deserts, Grasslands and Rangelands;

2007 – NEON Experiment Design TIGER Team; Associate editor *Ecology and Ecological Monographs*;

2005 – Panel member, NSF-DEB *Ecology*;

2004 – Distinguished Alumnus, College of Natural Sciences, California State University, San Bernardino;

(v) Collaborators & Other Affiliations

(a) Collaborators and Co-Editors

J. Bronstein - University of Arizona

G. Davidowitz - University of Arizona

B. Enquist - University of Arizona

A. Huete - University of Arizona

M. Loik - Univ. of California, Santa Cruz

R. Monson - Univ. of Colorado

K. Ogle – Princeton University

S. Schwinning – UTexas San Marcos

R. Scott - USDA ARS Tucson

W.J. Shuttleworth - University of Arizona

S. Smith - Univ. of Nevada, Las Vegas

J. Sparks - Univ. of Colorado

D. Tissue – Texas Tech University

L. Venable - University of Arizona

J. Weltzin - Univ. of Tennessee

D. Williams - University of Wyoming

N. Grimm – Arizona State University

D. Goodrich – USDA ARS Tucson

(b) Graduate and Postdoctoral Advisors.

Dr. Michael E. Loik, Dept of Environmental Studies, University of California, Santa Cruz

Dr. Stan Smith, Department of Biological Sciences, University of Nevada, Las Vegas

Dr. Russ Monson, Department of EPO Biology, University of Colorado, Boulder

(c) Thesis Advisor and *Postgraduate-Scholar Sponsor (primary advisor for 8 graduate students, 5 post-docs total).

Henry Adams – University of Arizona

Alex Eilts - University of Michigan

Enrico Yopez - University of New Mexico

Vanya Moreno - University of Arizona

Daniel Potts – Buffalo State University

Cristian Solari - University of Arizona

Danielle Ignace - University of Arizona

Greg Barron-Gafford – University of Arizona

Kathy Gerst – University of Arizona

Jason Field – University of Arizona

*Mitch Pavao-Zuckerman – University of Arizona

*Amy Angert – Colorado State University

*Darrel Jenerette – University of California, Riverside

Kirsten Bittel – University of Arizona

Jessie Cable - University of Wyoming

Sergio Castrezana - University of Arizona

Chuck Price - University of Arizona

Megan McCarthy - University of Arizona

Kate Baird - University of Arizona

Anna Tyler - University of Arizona

Nate Swenson – University of Arizona

Scott Stark – University of Arizona

Juan Villegas – University of Arizona

*Ed Bobich – Cal Poly, Pomona

*Sarah Kimball – University of Arizona

*Sujith Ravi – University of Arizona

Yadvinder S. Malhi Environmental Change Institute, University of Oxford, OX1 3QY, UK,
Email: yadvinder.malhi@ouce.ox.ac.uk; Web: <http://www.geog.ox.ac.uk/staff/ymalhi.html>

(a) Professional Preparation

University of Cambridge, UK (Natural Sciences)	B.Sc., 1990
University of Reading, UK (Meteorology)	Ph.D., 1993
University of Edinburgh, UK (Ecology)	Post-Doctoral Associate., 1994 - 1999
University of Edinburgh, UK (Environment)	Royal Society Research Fellow., 1999 - 2004

(b) Appointments:

2005 - Present: *Professor of Ecosystem Science*, University of Oxford, UK.

(c) Selected publications

(i) Five publications closely related to the proposed project

Malhi, Y., Saatchi, S., Girardin, C. and Aragão, L.E.O.C. (2009) Biogeochemistry and Ecology of Terrestrial Ecosystems of Amazonia. Sn. III in, Keller, M., *et al.* (eds.) Amazonia and Global Change. American Geophysical Union, Geophysical Monograph Series, Vol. 186.

Malhi, Y., Roberts, J.T., Betts, R.A., Killeen, T.J., Li, W. and Nobre, C.A. (2008) Climate change, deforestation and the fate of the Amazon. *Science*, 319(5860): 169-172.

Malhi, Y. (2007) Carbon in the atmosphere and terrestrial biosphere in the early Anthropocene. In, P. Sammonds (ed.) *Advances in Science*, Cambridge University Press.

Malhi Y. and Wright J. (2004) Spatial patterns and recent trends in the climate of tropical forest regions. *Philosophical Transactions of the Royal Society of London Series, B*, 359: 311-329.

Malhi, Y. and Phillips, O.L. (2004) Tropical forests and global atmospheric change, a synthesis. *Philosophical Transactions of the Royal Society of London Series B*, 359: 549-555.

(ii) Five other significant publications

Malhi, Y. and Grace, J. (2000) Tropical forests and atmospheric carbon dioxide. *Trends in Ecology & Evolution*, 15: 332-337.

Grace, J. and **Malhi, Y.** (2002) Global change - Carbon dioxide goes with the flow. *Nature*, 416: 594-595.

Malhi, Y et al. (2002) An international network to understand the biomass and dynamics of Amazonian forests (RAINFOR). *Journal of Vegetation Science*, 13:439-450.

Malhi, Y et al. (2006) The regional variation of aboveground live biomass in old-growth Amazonian forests. *Global Change Biology*, 12(7): 1107-1138.

Phillips, O.L. *et al* (including **Malhi, Y**) (2009) Drought Sensitivity of the Amazon Rainforest. *Science*, 323: 1344-1347.

(d) Synergistic Activities

- Programme Leader in Ecosystems Research, Environmental Change Institute

- Member of a the following panels: Royal Society Advisory Panel on Climate Change and Ocean Acidification, 2006-present; Scientific Steering Committee of the Large-Scale Biosphere-Atmosphere Experiment in Amazonia, 2001-present; Co-ordinator, Programme for the Advancement of Networked Science in Amazonia (Pan-Amazonia), 2004-2007; “Science in Society” Committee of the Royal Society, 2004-2007; Grant Review Panel of the Royal Society COPUS grants for the public understanding of science, 2003-2004.
- Given a large number of interviews publicizing environment and climate issues in the radio, TV and print media (e.g.: Sky News, BBC news, Science in Action, Daily Telegraph)

(e) Collaborators and other affiliations

Collaborators in the past 48 months: M. New, U-Oxford, UK; N. Butt, U-Oxford, UK; D. Galbraith, U-Oxford, UK; T. Marthews, U-Oxford, UK; C. Girardin, U-Oxford, UK; N. Salinas Revilla, U-Oxford, UK; L. Aragao, U-Exeter, UK; P. Meir, U-Edinburgh, UK; M. Williams, U-Edinburgh, UK; M. Zimmermann, U-Edinburgh, UK; M. Bird, U-St Andrews, UK; T. Baker, U-Leeds, UK; M. Gloor, U-Leeds, UK; J. Lloyd, U-Leeds, UK; S. Lewis, U-Leeds, UK; O. Phillips, U-Leeds, UK; R. Betts, U-Exeter, UK; J. Fisher, NASA, S. Saatchi, NASA; E. Davidson, Woods Hole Research Center; USA; R. Roman-Cuesta, CREAM, Spain; A da Costa, U. Federal do Para, Brazil; S. Almeida, Museu Paraense Emilio Goeldi, Brazil.

Daniel B Metcalfe Dept. of Forest Ecology and Management, Swedish University of Agricultural Sciences, Skogmarksgränd, SE 901 83, Umeå, Sweden.
Email: daniel.metcalfe@sek.slu.se; Web: <http://www.eci.ox.ac.uk/people/metcalfedan.php>

(a) Professional Preparation

University of Bristol, UK (Geology and Biology)	B.Sc., 2002
University of Leeds, UK (Biodiversity and Conservation)	M.Sc., 2003
University of Edinburgh, UK (Global Change Group)	Ph.D., 2006
Swedish University of Agricultural Sciences, Sweden	Post-Doctoral Associate., 2007
University of Oxford (Environmental Change Institute)	Research Fellow., 2008-2009

(b) Appointments:

2010: *Assistant Professor*, Swedish University of Agricultural Sciences, Sweden

(c) Selected publications

(i) Five publications closely related to the proposed project

- Metcalfe DB et al.** (2007). Factors controlling spatio-temporal variation in carbon dioxide efflux from surface litter, roots and soil organic matter at four rain forest sites in the eastern Amazon. *Journal of Geophysical Research–Biogeosciences* Vol. 112, G04001, DOI: 10.1029/2007JG000443.
- Metcalfe DB et al.** (2008). The effects of water availability on root growth and morphology in an Amazon rainforest. *Plant & Soil* **311**: 189-199.
- Meir P, **Metcalfe DB et al.** (2008). The fate of assimilated carbon during drought: impacts on respiration in Amazon rainforests. *Philosophical Transactions of the Royal Society of London – B* **363**: 1849-1855.
- Malhi Y, Aragão LEOC, **Metcalfe DB et al.** (2009). Carbon stocks, productivity and allocation in three Amazonian forests. *Global Change Biology* **15**: 1255-1274.
- Aragão LEOC, Malhi Y, **Metcalfe DB et al.** (2009) Above- and below-ground net primary productivity across ten Amazonian forests on contrasting soils. *Biogeosciences* **6**: 2441-2488.
- Metcalfe DB et al.** (2010). Impacts of experimentally imposed drought on leaf respiration and morphology in an Amazon rain forest. *Functional Ecology* DOI: 10.1111/j.1365-2435.2009.01683.x

(ii) Five other significant publications

- Högberg P, Högberg MN, Gottlicher SG, Betson NR, Keel SG, **Metcalfe DB et al.** (2007). High temporal resolution tracing of photosynthate carbon from the tree canopy to forest soil microorganisms. *New Phytologist* **177**: 220-228.
- Metcalfe DB et al.** (2008). Sample sizes for estimating key ecosystem characteristics in a tropical *terra firme* rainforest. *Forest Ecology & Management* **255**: 558-566.
- Subke JA, Vallack HW, Magnusson T, Keel SG, **Metcalfe DB, et al.** (2009). Short term dynamics of abiotic and biotic soil ¹³CO₂ effluxes after *in situ* ¹³CO₂ pulse labelling of boreal pine forest. *New Phytologist* **183**: 349-357.
- Högberg MN, Briones MJI, Keel SG, **Metcalfe DB et al.** (Accepted) Quantification of effects of season and nitrogen supply on tree belowground carbon transfer to ectomycorrhizal fungi and other soil organisms in a boreal pine forest. *New Phytologist*.

Da Costa ACL, Galbraith D, Almeida S, Portela BTT, Da Costa M, Athaydes J, Fisher R, Phillips O, **Metcalf DB** *et al.* (Accepted) Effect of seven years of experimental drought on the aboveground biomass storage of an eastern Amazon rainforest. *New Phytologist*

(d) Synergistic Activities

- Author of methods manual “Measuring tropical forest carbon allocation and cycling” used by international scientific networks across South America (Pan-Amazonia, RAINFOR) and Europe (CarboEurope).
- Reviewer for *New Phytologist*, *Forest Ecology and Management*, *Plant and Soil*, *Journal of Tropical Ecology*, *Tropical Ecology*, *Annals of Botany*

(e) Collaborators and other affiliations

Collaborators in the past 48 months: Y. Malhi, U-Oxford, UK; D. Galbraith, U-Oxford, UK; T. Marthews, U-Oxford, UK; C. Girardin, U-Oxford, UK; N. Salinas Revilla, U-Oxford, UK; L. Aragao, U-Exeter, UK; P. Meir, U-Edinburgh, UK; M. Williams, U-Edinburgh, UK; J. Subke, U-York, UK; M. Briones, U-York, UK; P. Ineson, U-York, UK; H. Vallack, U-York, UK; J. Fisher, NASA, USA; S. Keel, U-Princeton, USA; R. do Vale, U-Tecnica da Lisboa, Portugal; JP. Maroco, Inst. De Tecnologia Quimica e Biologica, Portugal; M. Chaves, Inst. Superior de Agronomia, Portugal; A da Costa, U. Federal do Para, Brazil; S. Almeida, Museu Paraense Emilio Goeldi, Brazil; C. Campbell, Umeå Plant Science Center, Sweden; V. Hurry, Umeå Plant Science Center, Sweden; M Högberg, Swedish University of Agricultural Sciences (SLU), Sweden; P. Högberg, SLU, Sweden; T. Näsholm, SLU, Sweden; S. Linder, SLU, Sweden.

Graduate and Post-Doctoral Advisers

Patrick Meir, University of Edinburgh (PhD. advisor)

Mathew Williams, University of Edinburgh (Secondary PhD. advisor)

Peter Högberg, Swedish University of Agricultural Sciences (Post-doctoral advisor)

Yadvinder Malhi, University of Oxford (Post-doctoral advisor)

César Morán-Cahusac Avenida Oswaldo Baca 402, Urbanización Magisterio, Cusco, Peru.
Email: cmoran@amazonconservation.org

(a) Professional Preparation

La Molina National Agrarian University, Peru (Animal Sciences)
Yale University (Environmental Management)

B.S., 1993
M.Sc., 2005

(b) Appointments:

2007 - Present: Executive Director of the Amazon Conservation Association (Asociación para la Conservación de la Cuenca Amazónica, Puerto Maldonado and CICRA, Peru.

2006 – 2007: Conservation Director of the Amazon Conservation Association (Asociación para la Conservación de la Cuenca Amazónica, Puerto Maldonado and CICRA, Peru.

1997 – 2002: Program Coordinator for the Macchu Picchu Program

1994 – 1996: Environmental Education Project Coordinator for the La Molina Universidad Nacional Agraria, Peru.

(c) Selected publications

(i) Five publications closely related to the proposed project

C. Moran-Cahusac (2000) Fire Prevention Plan for the Machu Picchu Historical Sanctuary
Machu Picchu Program PROFONANPE

C. Moran-Cahusac (2002) Guide for Composting toilets. *Machu Picchu Program PROFONANPE* Cesar Moran-Cahusac

C. Moran-Cahusac (2002) Training Booklets for Inca Trail Porters: Rules and Regulations in the Machu Picchu Historical Sanctuary, Solid Waste Management, Cultural Values in the Machu Picchu Historical Sanctuary, Natural Aspects in the Machu Picchu Historical Sanctuary. *Machu Picchu Program PROFONANPE*

T.W. Clark, D. N. Cherney, I. Angulo, R B de Leon, **C. Moran-Cahusac**. (2004) A Problem Oriented Overview of Podocarpus National Park Management Policy, Ecuador *Journal of Sustainable Forestry*.

T.W. Clark, D.N. Cherney, I. Angulo, R.B de Leon, **C. Moran-Cahusac** (2004) Ecotourism in Podocarpus National Park: is it Loja or Zamora? *Journal of Sustainable Forestry*

(d) Synergistic Activities

- Training in Environmental protection and sustainable development (2002, US State Department, Bureau of Education and Cultural Affairs), Environmental planning and management (1995, British Council), Agro-ecology (UC Berkeley)
- Extensive experience of successfully planning, implementing, monitoring and evaluating large-scale environmental projects.

RAIMUNDO COSME DE OLIVEIRA JUNIOR

A. PROFESSIONAL PREPARATION

BACHELOR'S DEGREE

Course: Agronomy

Concentration: Agronomy

Institution: Faculdade de Ciências Agrárias do Pará - FCAP, Belém, Pará, Brasil.

Date: Marc / 1977 until December / 1980.

DOCTORAL DEGREE

Course: Agropecuária Tropical

Concentration: Soil Science

Thesis: **A erosividade das chuvas na parte leste do Estado do Pará.**

Institution: Faculdade de Ciências Agrárias do Pará - FCAP, Belém, Pará, Brasil.

Date: Marc / 1985 until october / 1988.

B. APPOINTMENTS

Researcher A

Institution: Centro de Pesquisa Agroflorestal da Amazônia Oriental - CPATU/ Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA.

Endereço: Rua Vera Paz, s/n - Bairro Salé

Fone: (093) 3523.2629

CEP: 68035-110 - Caixa Postal 261 - Santarém-Pará

Project Coordinator

Concentration: Soil conservation

Institution: Centro de Pesquisa Agroflorestal da Amazônia Oriental
Belém - PA

From July/1995 until present

C.1. Five Related Publications

POTTER, Christoffer ; KLOOSTER, Steven ; HUETE, A. ; GENOVESE, Vanessa ; BUSTAMANTE, M. ; OLIVEIRA JUNIOR, R. C. ; ZEPP, R. . Terrestrial carbon sinks in the Brazilian Amazon and Cerrado region predicted from MODIS satellite data and ecosystem modeling. Biogeosciences discussion (Online) ^{JCR}, v. 6, p. 947-969, 2009.

Grant, R. F. ; Hutyra, L. R. ; Oliveira, R. Cde ; Munger, J. W. ; Saleska, S. R. ; Wofsy, S. C. . Modeling the carbon balance of Amazonian rain forests: resolving ecological controls on net ecosystem productivity. Ecological Monographs ^{JCR}, v. 79, p. 445-463, 2009.

Fitzjarrald, David R. ; Sakai, Ricardo K. ; Moraes, Osvaldo L. L. ; OLIVEIRA JUNIOR, R. C. ; Acevedo, Otávio C. ; Czikowsky, Matthew J. ; Beldini, Troy . Spatial and temporal rainfall variability near the Amazon-Tapajós confluence. Journal of Geophysical Research ^{JCR}, v. 113, p. G00B11, 2008.

McGroddy, M. E. ; Silver, W. L. ; de Oliveira, R. C. ; de Mello, W. Z. ; Keller, M. . Retention of phosphorus in highly weathered soils under a lowland Amazonian forest ecosystem. Journal of Geophysical Research ^{JCR}, v. 113, p. G04012, 2008.

SAMPAIO, I. C. G. ; OLIVEIRA JUNIOR, R. C. ; KELLER, Michael ; PEREIRA, Cleuton ; OLIVEIRA, Kemerson . Análise Do Fluxo De Metano Na Interface Solo-Atmosfera De Uma Plantação De Arroz, Uma Plantação De Soja E Uma Floresta Tropical, Na Amazônia Oriental. Espaço Científico (ULBRA) ^{JCR} , v. 1, p. 1-6, 2006.

C.2. Five other Publications

KELLER, M., VARNER, R.K.; DIAS, J.D.; SILVA, H.; CRILL, P.M.; OLIVEIRA JR., R.C.de; ASNER, G.P. Soil-Atmosphere Exchange of Nitrous Oxide, Nitric Oxide, Methane, and Carbon Dioxide in Logged and Undisturbed Forest in the Tapajos National Forest, Brazil. *Earth Interactions*. Vol. 9, Paper 23, 2005.

LEFSKY, Michael A ; HARDING, David J ; KELLER, Michael ; COHEN, Warren ; CARABAJAL, Claudia C ; SANTO, Fernando Del Bom Espirito ; HUNTER, Maria O ; OLIVEIRA JUNIOR, R. C. Estimates Of Forest Canopy Height And Aboveground Biomass Using ICESat. *Geophysical Research Letters* ^{JCR} , Estados Unidos, v. 32, p. 1-4, 2005.

OLIVEIRA JUNIOR, R. C. de. A erosividade das chuvas no município de Conceição do Araguaia, Estado do Pará. EMBRAPA-CPATU, 1996. 20p. (EMBRAPA-CPATU. Boletim de Pesquisa, 165)

OLIVEIRA JUNIOR, R. C. de; VALENTE, M. A.; RODRIGUES, T. E. & SILVA, J. M. L. da. Caracterização físico-hídrica de cinco perfis de solo do nordeste paraense. EMBRAPA-CPATU, 1997. 27p. (EMBRAPA-CPATU. Boletim de Pesquisa, 177)

OLIVEIRA JUNIOR, R. C. de; RODRIGUES, T.E.; SILVA, J. M. L. da; VALENTE, M.A. Caracterização físico-hídrica dos principais solos da região de Marabá-Carajás, Estado do Pará. Belém: EMBRAPA/CPATU, 1998. 43p. (EMBRAPA-CPATU. Boletim de Pesquisa, 205)

E. Collaborators & Other Affiliations:

Plinio Camargo (co-authored a paper) – pcamargo@cena.usp.br

Michael Keller (co-authored a paper and divided TG-07 coordination) - mmkeller@gmail.com

Megan McGroddy (co-authored a paper) – megan.mcgroddy@mail.wvu.edu

Christopher Potter (co-authored a paper) – cpotter@gaia.arc.nasa.gov

Jose Francisco Ramos (PhD advisor) – jramos@ufpa.br , joseramos@amazon.com.br

Scott Saleska (collaborator) – saleska@email.arizona.edu

Whendee L. Silver (co-authored a paper) – wsilver@nature.berkeley.edu

Norma Salinas Revilla

Environmental Change Institute, University of Oxford, Oxford, OX1 3QY, UK.

Email: norma.salinas@ouce.ox.ac.uk

(a) Professional Preparation

Universidad Nacional San Antonio Abad del Cusco, Peru (Botany)	B.Sc. 1983
Facultad Latinoamericana de Ciencias Sociales, Costa Rica (Botany)	M.Sc., 1997
University of Oxford, UK (Environmental Change Institute)	Ph.D 2008-Present

(b) Appointments:

1999 - Present: *Professor*, Universidad Nacional San Antonio Abad del Cusco, Peru.
2001 – Present: Director of Research Center on Medicinal and Nutritional Plants at the Universidad Nacional San Antonio Abad del Cusco, Peru.
2003 – Present: Member of Science Committee for the Manu National Reserve, Peru.

(c) Selected publications

Salinas N. *et al.* (2006) Anatomía y morfología de *Corryocactus erectus* (Backeberg) Ritter (CACTACEAE). *Zonas Áridas* **10**: 102-114.

Castillo S, Salinas N *et al.* (2006) Gentianaceae endémicas del Perú. *Revista Peruana de Biología* **13**: 339-354.

Leon B, Salinas N (2006) Alstroemeriaceae endémicas del Perú. *Revista Peruana de Biología* **13**: 685-689.

(d) Synergistic Activities

- Coordinator of the following research projects “Dynamics of two types of Amazon forests in the Madre de Dios area, Peru”; “Vegetation and climate throughout the Kosñipata valley” running from 2003 – Present; “Evaluating biodiversity of the Cuzco valley” running from 2002 – 2003.
- Botanist participating in a Paleoambiental study of the historical sanctuary of Machu Picchu, administered by the Royal Holloway University of London, UK. 2002.
- Member of the Orchids Project of the Historical Sanctuary of Machu Picchu, funded by PROFONANPE. Described several new species of Orchids and made an inventory of orchids of the historical sanctuary of Machu Picchu. 2001 – 2002.
- Botanist responsible for a research and conservation project of the Yungueños Forests of the Proposed Archaeological Park of Choquercamiri, La Paz - Bolivia. 2001 - 2001
- Botanist responsible for environmental impact study on the behalf of the Electric Company of Bolivia (Cobe) 1998 – 2000.

(e) Collaborators and other affiliations

Collaborators in the past 48 months: Y. Malhi, U-Oxford, UK; M. New, U-Oxford, UK; C. Girardin, U-Oxford, UK; L. Aragao, U-Exeter, UK; O. Phillips, U-Leeds, UK; D.B. Metcalfe, Swedish University of Agricultural Sciences, Sweden; R. Roman-Cuesta, Universidad Autonoma de Barcelona, Spain.

Graduate and Post-Doctoral Advisers

Y. Malhi, University of Oxford (PhD. advisor)

BIOGRAPHICAL SKETCH: MILES R. SILMAN

Department of Biology
Wake Forest University

A. Professional Preparation

University of Missouri-Columbia Biology B.A., *s.c.l* 1989

Duke University, Department of Zoology, Ph. D. 1996

Smithsonian Tropical Research Institute, Tropical Forest Ecology, Post Doc. 1997-1998

B. Appointments

Associate Professor, Wake Forest University *current*

Assistant Professor Wake Forest University 1998-2004

Teaching Instructor Duke University 1996-1997

C. Publications

i. 5 most closely associated with current proposal

Feeley, K.J. and **M. R. Silman**. 2009. Extinction rates of Amazonian plant species. PNAS. USA. 106:12382-12387

Silman, M.R. 2007. Plant species diversity in Amazonian forests. Ch. 11 *in* Flenly, J. and Bush, M. eds. *Tropical Rain Forest Responses to Climate Change*. Springer-Praxis, London.

Feeley, K.J. and **M. R. Silman** 2010. Land-use and climate change effects on population size and extinction risk of Andean plants. GLOBAL CHANGE BIOLOGY. doi: 10.1111/j.1365-2486.2010.02197.x

*Bush, M. B., ***M. R. Silman** and D. Urrego. 2004. 48,000 years of climate and forest change in a biodiversity hotspot. SCIENCE 303:827-829. (**These authors contributed equally to this work*).

Pitman, N. C. A., J. Terborgh, **M. R. Silman**, P. Núñez V., D. A. Neill, C. E. Cerón, W. A. Palacios, and M. Aulestia. 2001. Dominance and diversity of tree species in upper Amazonian *terra firme* forests. ECOLOGY 82(8): 2101–2117

ii. 5 additional publications related to current proposal

Silman, M.R., J. Terborgh, and R. Kiltie. 2003. Population regulation of a dominant rain forest tree by a major seed predator. ECOLOGY 84(2): 431-438.

Terborgh, J., K. Feeley, **M. R. Silman**, P. Núñez and V.B. Balukjian. 2006. Vegetation dynamics of predator-free land-bridge islands. Journal of Ecology 94: 253-263.

Bush, M. B. and **M. R. Silman**. 2004. Observations on Late-Pleistocene cooling and precipitation in the lowland Neotropics. JOURNAL OF QUATERNARY SCIENCE 18(7): 677-684.

Silman, M. R., E. J. Ancaya, and J. Brinson. 2003. Bamboo forests of western Amazonia. In: Alto Purus: Biodiversity, Conservation, and Management. R. Leite, N. Pitman, P. Alvarez eds. Center for Tropical Conservation Press.

Bush, M. B., **M. R. Silman**. 2007. Amazonian exploitation revisited: Ecological asymmetry and the policy pendulum. FRONTIERS IN ECOLOGY AND THE ENVIRONMENT 5 (9): 457-465.

D. Synergistic Activities

(1) Advising or integrating foreign nationals into my laboratory. I currently work with 14 Peruvian and 2 Colombian students, including advising and funding certification theses, and have brought 2 of them to study their MSc at Wake forest. Also, incorporation of WFU and Peruvian undergraduates into field research in s.e. Peru (17 Peruvians, 22 WFU).

(2) Andes Biodiversity and Ecosystem Research Group (ABERG). Steering committee and development of an online educational curriculum for Andean ecology and conservation (www.andesresearch.org). Establishment of research infrastructure that has attracted >\$3M in addition funding to collaborators.

(3) Developed curriculum that integrates research program and current results in conservation biology into general undergraduate education (*Introduction to Ecology and Evolution, Community Ecology, Introduction to GIS and Remote Sensing*) at WFU.

(4) Speaking to general audiences (university donors, boards of visitors, clubs, civic groups) about research, global change, and the importance of basic science to society.

(5) Visit elementary (K-8) schools in Yadkin County, N.C.

E. Collaborators and Other Affiliations

i. Collaborators: **M. Aulestia** (Herbario Nacional, Ecuador), **J. Bradford** (Missouri Botanical Garden), **M. Bush** (Florida Institute of Technology), **J. Clark** (Duke University), **C. E. Cerón** (Universidad Central de Ecuador), **L. Hanna** (CABS, Conservation International), **R. Kiltie** (University of Florida), **Y. Malhi** (University of Oxford), **P. Meir** (University of Edinburgh), **D.A. Neill** (Herbario Nacional, Ecuador), **P. Núñez V** (Herbario Vargas, UNSAAC, Cusco), **W. A. Palacios** (Herbario Nacional, Ecuador), **N. C. A. Pitman** (Duke University), **I. Poole** (Utrecht), **H. Schlichter** (Duke University), **J. Terborgh** (Duke University), **C. Wang** (Florida Institute of Technology), **Ken Feeley** (Current postdoc at WFU)

ii. Advisors: John W. Terborgh (Ph. D. Advisor)
Julie S. Denslow (Postdoctoral Advisor)

iii. Student Advisees:

Emilio Ancaya, M.S. 2002

Julie Lea Wyatt, M.S. 2002, Ph.D. 2009

Erin McManus, M.S., 2003

Delphine Masse, M.S. 2004

Kerenza Alley, M.S., 2006

Rachel Hillyer, M.S., 2009, Ph.D. *in progress*

Karina Garcia Cabrera, M.S., *in progress*

William Farfan Ríos, M.S., *in progress*

Craig Moretz, Ph.D., *in progress*

Joshua Rapp, Ph.D., *in progress*

Noah Yavit, Ph.D., *in progress*

Adrian Tejedor Los Amigos Biological Station, Madre de Dios, Peru.
Email: atejedor@conservationamazonica.org

(a) Professional Preparation

University of Miami (Biology)	B.S., 2000
City University of New York (Ecology, Evolution and Behaviour)	M.Sc., 2002
City University of New York (Vertebrate Zoology)	Ph.D., 2006

(b) Appointments:

2008 - Present: Science Manger for Amazon Conservation Association (Asociación para la Conservación de la Cuenca Amazónica, Puerto Maldonado and CICRA, Peru.

(c) Selected publications

(i) Five publications closely related to the proposed project

Tejedor, A. 2005. A new species of funnel-eared bat (Natalidae: Natalus) from Mexico. *Journal of Mammalogy* 89: 1109–1120.

Tejedor, A., Tavares, V. da C., & Silva Taboada, G. 2005. A revision of extant Greater Antillean bats of the genus *Natalus* (Chiroptera: Natalidae). *American Museum Novitates* 3493: 1–22.

Tejedor, A. 2004. First Record of *Saccopteryx canescens* (Chiroptera: Emballonuridae) for Southeastern Peru. *Chiroptera Neotropical* 9: 162–164.

Tejedor, A., Silva Taboada G. & Rodríguez Hernández, D. 2004. Discovery of extant *Natalus major* (Chiroptera: Natalidae) in Cuba. *Mammalian Biology*. 59: 153–169.

Tejedor, A. & B. W. McAlpin, 2000. *Ophioglossum pendulum* L. naturalized in Miami, Dade County, Florida. *American Fern Journal*. Jan. March 90 (1): 46–47.

(ii) Other significant publications

Mancina C.A., Echenique-Díaz L.M., **Tejedor A.,** García L., Daniel-Álvarez Á., Ortega-Huerta M.A. 2007. Endemics under threat: an assessment of the conservation status of Cuban bats. *Hystrix* 18: 3–15.

Tejedor, A. 2006. The type locality of *Natalus stramineus* (Chiroptera: Natalidae). *Acta Chiropterologica* 8:361–380.

Tejedor, A., Tavares, V. da C., and Rodríguez Hernández, D. 2005. New Records of bats from Caribbean Hot Caves. *Boletín de la Sociedad Venezolana de Espeleología*. 39:10–15.

(d) Synergistic Activities

- Led eight research expeditions across the Neotropics over the last two decades, participated in a wide range of research projects on the flora and fauna of the Amazon.
- University level teaching experience

(e) Collaborators and other affiliations

Graduate and Post-Doctoral Advisers

Nancy Simmons, City University of New York (PhD. advisor)