An overview of the Los Amigos watershed, Madre de Dios, southeastern Peru

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INTRODUCTION

> "...and ever since some maps of South America have shown a short heavy line running eastward beyond the Andes, a river without a beginning and without an end, and labeled it the River of the Mother of God. That short heavy line... has always seemed the perfect symbol of the Unknown Places of the earth."
>
> -Aldo Leopold (1924)
> "The River of the Mother of God"

Nearly a century has passed since Leopold wrote those lines, and southeastern Peru is no longer one of Earth's Unknown Places. Although most of it remains a roadless wilderness, and vast stretches will remain unexplored for decades to come, its flora and fauna are very well known relative to other areas in the Amazon basin. Most of the region's vascular plants and vertebrates have been collected and identified, more than 2,200 articles, books, academic theses, and reports have been written about the biology of the region (Pitman et al. 2007), and at least nine biological stations are currently active in Madre de Dios. Southeastern Peru is also one of the best-known corners of Amazonia for non-scientists. Over the last two decades it has replaced Iquitos as Peru's leading destination for Amazonian ecotourists—some 70,000 visit each year (Goulding et al. 2003)—and its national parks are world-famous.

Thus it is surprising how hard it remains to track down basic information on this landscape: how rainfall varies across the region, which soils are dominant, or which direction the wind blows in April. Part of the reason is that while a great deal has been written about southeastern Peru, most publications are either highly specialized articles written in English and published in scientific journals in the United States or Europe, or reports, theses, and assorted gray literature written in Spanish, published or distributed privately in Peru, and available in a few scattered libraries in Lima, Cusco, and Puerto Maldonado (Pitman et al. 2007).

This document presents basic information on the geography, biology, and history of the Los Amigos watershed in southeastern Peru. It is intended as a background for research in and around the Los Amigos field stations. I have tried to include enough specialized information to make it a useful source of facts on the region without entering into great detail on any one topic. Earlier descriptions of the Los Amigos landscape are given by ACCA (2001b) and Forsyth et al. (2002). Valuable descriptions of other sites in Madre de Dios are given by Terborgh (1983) for Cocha Cashu, Pitman (2000) for Manu, Erwin (1985) and Napravnik Pesce (2004) for Tambopata, and ONERN (1965; 1972; 1977; 1982) for a variety of other sites around Madre de Dios. A broader overview of the Madre de Dios watershed is given by Goulding et al. (2003) and a survey of Amazonian Peru has been published by Kalliola et al. (1993); both are highly recommended. Appendix 1 of this document lists especially helpful documents for understanding the landscape, history, and flora and fauna of Madre de Dios.

This survey draws on published and unpublished reports from the region, conversations with long-time residents of the Los Amigos area, and research to date at Los Amigos. Since that research remains in the early stages, some of the text here has been adapted from a preliminary survey of Manu National Park (Pitman 2000).

For the moment this document is an incomplete, unpublished draft; corrections and other suggestions are welcome and should be emailed to the author. To cite this version of the manuscript, please see the instructions in the acknowledgments section.

GEOGRAPHY AND HYDROLOGY

Regional context

At the southwestern margin of the Amazon basin, Andean rivers descending to the lowlands are diverted to the north or to the south by the Fitzcarrald Arch, a low geologic formation jutting out into the lowlands. Rivers to the north and west of the arch flow into the shallow Ucayali basin, heading northwards to Iquitos before draining into the Amazon and continuing eastwards towards the Atlantic. Rivers to the south and east of the arch flow into the shallow Madre de Dios-Beni basin, skirting the base of the Andes eastwards before heading north into the Madeira River and finally into the Amazon near Manaus, ~1,600 air km away (Kalliola and Puhakka 1993).

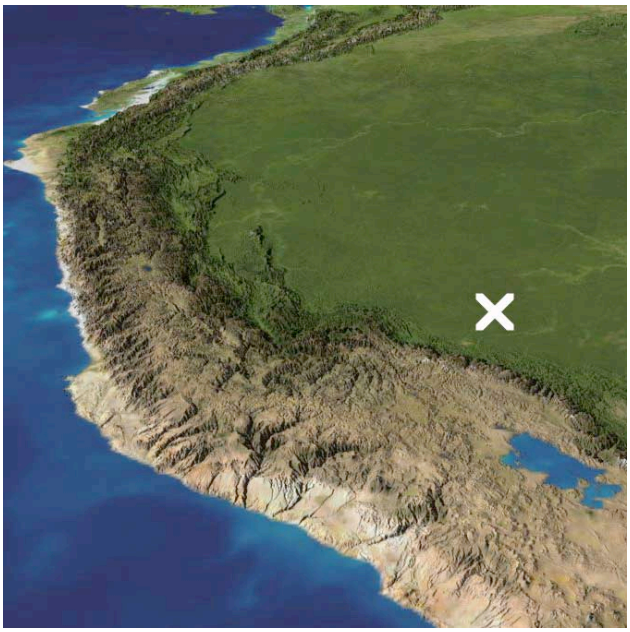

Figure 1. Location of the Los Amigos watershed in western South America. The lake in the lower right-hand corner is Titicaca. Image courtesy of William Bowen.

The Los Amigos River forms part of this river system to the south of the Fitzcarrald Arch (Figure 1). At the scale of the entire Madre de Dios-Beni-Madeira watershed, the Los Amigos is a very small river indeed. Its watershed of 4,415 km^2 represents less than half of one percent of the entire drainage; think of a twig on a towering kapok tree. The Los Amigos is the sixth largest watershed in the Madre de Dios headwaters in Peru—much smaller than the Las Piedras (the largest at nearly 20,000 km^2), as well as the Manu, Alto Madre de Dios, Inambari, and Tambopata, but larger than the Colorado, Azul, and Blanco (Goulding et al. 2003). The mouth of the Los Amigos lies just 500 km from the beaches of the Pacific Ocean, but roughly 2,600 km in a straight line from the mouth of the Amazon.

The Los Amigos watershed is part of the 85,183 km^2 department of Madre de Dios. Madre de Dios is the third-largest Amazonian department in Peru, after Loreto and Ucayali; 82% of it is below 500 m elevation. The Los Amigos watershed is centrally located in Madre de Dios, just a few kilometers south of the department's geographic centroid. (The centroid, an otherwise trivial cartographic feature, has attained modest importance in recent years because some databases of biological collections use it as a default locality for collections that were made in the department but whose labels lack specific locality data; the irony is that the centroid is in a very remote part of the Las Piedras watershed where it is unlikely that any biologist will ever collect a specimen.) The western portion of the Los Amigos drainage belongs to the Distrito and Provincia de

Manu, while the eastern portion belongs to the Distrito de Laberinto and the Provincia de Tambopata.

The Los Amigos watershed is entirely lowland, although both its mouth and its headwaters are only 50 km north of the Andean foothills. The river runs roughly parallel to the Andes for its entire length of 353 km.

Geographic locations of the watershed, concession, and field stations
Los Amigos is at about the same latitude as Lima. The same line runs through Salvador (Brazil), northernmost Madagascar, and northern Australia. (Comparable latitude in the northern hemisphere runs through Nicaragua, Senegal, and southern India.) Longitude at Los Amigos is the same as that in Boston (USA) and Tierra del Fuego.

The Los Amigos conservation concession covers 145,918 ha in the lower third of the watershed, including its southernmost and easternmost points, and has a perimeter of 450 km. (At its establishment the concession measured 135,832 ha and included some isolated patches that were still logging concessions; those became part of the conservation concession in early 2005.)

The CICRA station is at approximately 12°34’07”S 70°05’57” W, or 380500E 8610297N 19S in UTM coordinates; elevation is ~268 masl. Elevation on the CICRA terrace is ~41 m above the arbitrary zero mark of the Madre de Dios River at the CICRA dock (see hydrology) and ~80 m above the city of Puerto Maldonado, but nearly 100 m lower than the upland terraces around Cocha Cashu. Elevation througout the Los Amigos watershed is much higher than most of northern Amazonian Peru; Iquitos is at ~100 masl.

The CM1 station is at approximately 12°34’17”S 70°04’29”W, or 383789E 8609498N 19S in UTM; elevation there is ~238 masl. The CM2 station is at approximately 12°26’57”S 70°15’06”W, or 363960E 8623430N 19S in UTM; elevation there is ~259 masl.

The geographic position data given above are taken with GPS near the center of each station and are accurate to a few tens of meters. There are not yet any permanent reference markers in the Los Amigos watershed that have been surveyed for geographic position and elevation with cm-level accuracy; establishing such markers at both CICRA and CM2 is a short-term goal. In 2003-2004 ACA placed permanent cement markers along the border of the conservation concession, but precise (i.e., <10 m accuracy) coordinates and elevations are not yet available for them.

Some other organizations have also placed permanent cement markers in the Los Amigos area. Markers at the corners of mining concessions are topped with a circular brass marker inscribed with a place name, a number, and the words “Catastro Minero Nacional MEM (Ministerio de Energía y Minas).” Coordinate and elevation data for these markers are available from the Ministerio de Energía y Minas office in Puerto Maldonado, but it is not known how accurate the data are. The Proyecto Especial de Titulación de Tierras (PETT) of the Ministerio de Agricultura has also placed some cement markers in the region to demarcate private properties. One is located in the CICRA clearing, near the weather station, and reads “PETT-CBS-6”. The geographic information associated with the PETT markers is not especially reliable (D. Pogois, personal communication).

A variety of cartographic resources are available for the Los Amigos watershed. Topographic maps at the scale 1:100,000 are available in Carta Nacional sheets 25-u, 25-v, and 26-v, for sale in Lima at the Instituto Geográfico Nacional (www.ignperu.gob.pe). Dozens of GIS layers, satellite images, and maps of the watershed are now publicly available at atrium.andesamazon.org.

Madre de Dios, like all of Peru, is five hours behind Greenwich mean time; it is in the same time zone as the eastern seaboard of the United States, but does not follow daylight savings time. At the December solstice, the sun in this part of Peru rises at 5:09 and sets at 6:01. At the June solstice, the sun rises at 5:56 and sets at 5:20. The shortest day of the year (21 June) has 11:24 of sunlight, while the longest day (21 Dec.) has an hour and a half more. The sun passes directly overhead Los Amigos on around 27 October and 16 February. Days at Los Amigos are never symmetric around noon, i.e., there is always more daylight between sunrise and noon than between noon and sunset. This is because we are significantly east of the Standard Time Meridian for our time zone (75°W). Another result of this is that the sun always reaches its zenith at Los Amigos before 12:00 noon local time.

The declination in Los Amigos, as of June 2006, is 5°16' W, increasing by 0°9' W each year. In other words, compasses at Los Amigos point at a magnetic north pole that is five degrees to the west of the line to the geographic north pole. To walk in a straight line towards the geographic north pole with a compass at Los Amigos, one must aim five degrees east of magnetic north. In general, to walk at *n* degrees to geographic north, one must follow the compass *n* + 5 degrees. Declinations change over time; the current declination for Los Amigos can be calculated at the following website: www.ngdc.noaa.gov/seg/geomag/jsp/Declination.jsp

The closest settlement to CICRA is Boca Amigos, ~3 km to the SE and about ten minutes' travel downriver from the station by outboard canoe. The closest large town is San Juan Grande, ~12 km to the W of CICRA, about 40 minutes' canoe travel upriver from the station. The closest city is Puerto Maldonado, ~90 km E of CICRA, about three hours' travel downriver by outboard canoe and an hour's travel by road. Appendix 5 provides air distances from CICRA to various landmarks and field stations in this part of the world.

Hydrology

Large rivers

Very little of the physical setting in the Los Amigos watershed makes sense without reference to the river systems that successively build up and tear down the landscape. There are at least two kinds of large rivers in the area: steep-gradient, high-energy torrents roaring down from the Andes—like the Alto Madre de Dios and the Inambari—and lower-gradient, meandering lowland rivers like the Los Amigos, the Manu, and the Las Piedras. The high-gradient rivers tend to produce braided channels and carry a heavy sediment load—from sand to gravel to large boulders—while the lowland rivers twist back and forth across broad floodplains dotted with abandoned oxbow lakes, moving mostly silt and sand. High-gradient rivers are generally classified as white-water rivers, with neutral chemistry and high levels of suspended sediments. Lowland rivers throughout Amazonia tend to be slightly more acidic and with a lighter sediment load, and are placed at an intermediate position in the black- and white-water dichotomy

(Kalliola and Puhakka 1993). In contrast with other areas of Amazonian Peru, there are no large blackwater rivers in Madre de Dios.

Rates of lateral migration are poorly known for the high-energy rivers, and course changes may be sudden rather than gradual. As the beds of these rivers accumulate more and more gravel, rocks, and other debris, they gain elevation relative to the surrounding landscape, thereby increasing the likelihood that rivers will find a lower gradient elsewhere and jump abruptly to new routes during high water events. Thus it is no surprise that the soils of the high terraces to either side of the Alto Madre de Dios River (and many other locations in the uplands south of the Madre de Dios) are full of gravel; they are the product of high-energy braided rivers that have scythed back and forth across the landscape for some ten million years, leaving trails of rocky debris from the Andes.

Meandering rivers such as the Manu carry mostly fine particles, and migrate laterally through a sandy floodplain at a rate of 5-25(-200) m/yr. It has been estimated that such rivers can cut down and rebuild their several-kilometer-wide floodplains every few hundred years (Terborgh 1990; Kalliola and Puhakka 1993). However, the ubiquity of oxbow lakes and their sometimes impressive age—Cocha Cashu, for instance, may be ~2,500 years old (M. Silman, personal communication)—suggest that some of the floodplain has been untouched by river migration for several thousand years (but see Foster 1990). Schroeder and Zimmermann (unpublished data) have estimated from a comparison of remote sensing images taken of the Manu River in 1962 and 2001 that floodplain 1 km distant from the river is disturbed, on average, every 2,000 years by meandering dynamics. Puhakka and Kalliola (1995) have quantified some aspects of river meandering and oxbow lake formation on the Madre de Dios and Los Amigos rivers. The oldest known aerial images of the landscape around Los Amigos were taken in 1960, so it will soon be possible to reconstruct a more complete meander history of both rivers.

Flooding events on all rivers in the region are poorly recorded. Since September 2001 the level of the Madre de Dios River has been recorded twice daily (morning and evening) at the CICRA docks. River level is measured against marked posts set out around an arbitrary zero. The +5 m level is maintained, for the time being, as a mark on the supports of the CICRA sign at the docks; a more permanent calibration point is needed, as the riverbank beneath the sign appears to be slumping. The best measurements to date suggest that the arbitrary zero on the CICRA river gauge is at approximately 227 masl. A similar river gauge was established on the Amigos River at the CM2 station in December 2005 and is likewise being monitored twice daily. River level is also being monitored on the Madre de Dios at Puerto Maldonado (C. Cañas, personal communication), but the Los Amigos gauges and the Puerto Maldonado gauge have not been calibrated one to the other.

Data from the CICRA river level gauge are given in Figure 2. Low water is typically in September, while high water is typically between December and February. The difference between the highest record and the lowest record in the dataset is 9.47 m, and the river is capable of rising or falling as much as 3 m in a 24-hour period. Significant areas of the CICRA trail system in the floodplains become impassable during high water on the Amigos and Madre de Dios rivers, but we do not yet have an effective way to relate river level as measured at the CICRA gauge with the flooding depth or duration of floodplain and swamp forests around the station.

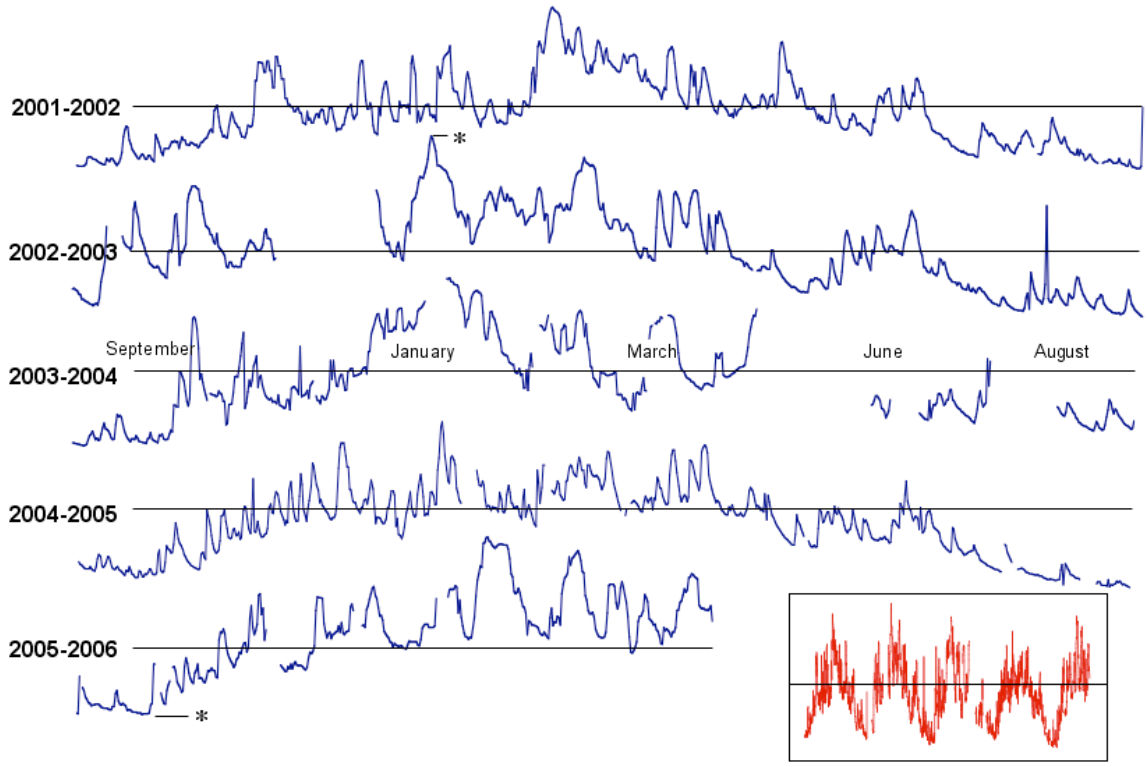

Figure 2. Variation in the level of the Madre de Dios River from August 2001 to April 2006, as measured twice daily at the Los Amigos dock. The horizontal lines mark the arbitrary zero. The absolute maximum and minimum values are marked by asterisks. The highest river level (+5.62 m) was recorded on 21 January 2003, when a state of emergency was declared in the region because of severe flooding. The lowest river level (-3.85 m) was recorded on 9 September 2005, at the end of one of the driest dry seasons ever recorded in Amazonia. The inset (red lines) shows all five years on the same vertical axis.

Barthem et al. (2003) summarize in detail the various changes in water chemistry and other river characteristics between periods of high and low water. During low water, the Madre de Dios is slower, warmer, more acidic, more transparent, and with higher conductivity. There is no significant difference in water oxygen levels in the two seasons. Goulding et al. (2003) speculate that approximately half of the water in the Madre de Dios River is runoff from the Andes; the rest is from the lowlands. Heavy rainfall in the Colorado watershed (the next large tributary of the Madre de Dios upriver from the Los Amigos) turns the Madre de Dios a characteristic bright orange, due to erosion of the colored clay that gives the Colorado its name. Water in the Los Amigos river is warmer than the Madre de Dios,

The channel of the Madre de Dios is ~xxx m wide at the CICRA dock. Goulding et al. (2003) give maximum depths of 15 m for the Madre de Dios, with high water means of 7-10 m and low water means of 2-5 m, and high water velocities of 11-14 km/hour.

Lakes

Nearly all lakes in the region are oxbows—known locally by the Quechua word for lake, *cocha*—sections of channel that have been abandoned by the meandering river and

begun a new life as lakes in the floodplain. There are ~40 *cochas* in the Los Amigos concession, and several larger ones in the Madre de Dios floodplain around the mouth of the Los Amigos. The only significant lake in the region that does not appear to be an oxbow is the Pozo Don Pedro, a tiny blackwater lagoon in the palm swamp to the northwest of CICRA. Mining operations have also created dozens of small ponds in the Madre de Dios floodplains around the station; it is not clear how long these will persist.

Cocha water undergoes seasonal changes similar to those seen in large rivers (Goulding et al. 2003). Although most *cochas* are no longer connected to the river that formed them, and receive river water only during especially high floods, most do receive water year-round from small streams that drain the uplands. As a result, water acidity and conductivity in *cochas* tend to be intermediate between that of rivers and upland streams. *Cochas* vary significantly in age and size, for obvious reasons, but also in water chemistry, aquatic plant communities, and fish communities, for reasons that are not well understood (Davenport 2003).

Streams

Most rain in Madre de Dios falls in the uplands, far from lakes and rivers. Some of what does not evaporate back into the atmosphere runs directly off the uplands via small streams. Other rainwater is absorbed by the soil and filtered down to a water table well above river level, from which it seeps laterally out of hillslopes as small springs, supplying the streams during periods of low rainfall. Water in these streams is typically cooler, more acidic, and poorer in nutrients than that in large rivers (Goulding et al. 2003). Streams in the uplands often trace the dividing line between soils of different textures, so that one bank of a stream may be predominantly sandy while the opposite bank is mostly clayey (Osher & Buol 1997).

All streams, seeps, swamps, and other bodies of water on the CICRA trail system were visited and mapped, and their water characterized chemically in May 2006. An annotated map should soon be available (G. Barbieri, personal communication).

Drainage pattern dendritic (Khanal 2006).

GEOLOGY, TOPOGRAPHY AND SOILS

Regional context

Los Amigos sits in a shallow depression at the southernmost end of the crescent-shaped Amazonian foreland basin that runs along the eastern base of the Andes. The Madre de Dios-Beni sub-basin south of the Fitzcarrald Arch is in an aggradational stage, i.e., it is still accumulating alluvium carried down from the Andes by high-energy, high-volume rivers like the Alto Madre de Dios and the Inambari.

The geologic parent material underlying the region is recently deposited alluvium of the same kind. All of the upland terraces aged to date in the region date to <200,000 years old, with some dates possibly as recent as 30,000 years old (see next section). The material is anything but homogeneous. Stratigraphic sections reveal a jumble of differently-textured material corresponding to different kinds of historical deposition events—gravel layers indicating ancient river bottoms, sand deposited in point bars by laterally migrating rivers, and silt and clay deposited by occasional flooding events (Räsänen 1993).

Local geology
Information about the geology of the Los Amigos concession comes from: 1) seismic profiles of the oil industry (Huertas Castillo 2002), as well as at least two exploratory wells dug in the Los Amigos watershed (north of the concession) during 19xx by xxx; 2) the official Peruvian government geological survey of the area, carried out by the Instituto Geológico Minero y Metalúrgico and published as a book with geological maps at 1:20,000 (Chávez et al. 1998, available for sale at INGEMMET's office in Lima); and 3) studies of surficial geology by scattered groups of geologists and paleontologists. ACA has not yet obtained the relevant information from historical oil exploration in the region, in part because much of it remains privately owned.

Antoine et al. (2003) show the Los Amigos watershed sitting on top of a 3 to 4-km thick slab of alluvium deposited during the Neogene, i.e., over the last 25 million years. The dominant geological formation at the surface in the Los Amigos concession is the Madre de Dios Formation, dated indirectly at upper Miocene to Pliocene. Antoine et al. (2003) describe this formation as a series of alluvial, lacustrine, and tidal deposits, and suggest that some of it was deposited by an inner sea in the region during the upper Miocene. The Madre de Dios Formation overlies the older but similar Ipururo Formation, which becomes dominant to the north towards Acre. Below these formations is a basement of older alluvium. The basement tilts downwards in the direction of the Andes, pushed down by the weight of that huge mountain range. This same phenomenon is believed to be uplifting the Los Amigos landscape (Antoine et al. 2003). Presumably this tilting is also the reason why the Madre de Dios and the Los Amigos rivers do not run north, directly out into the Amazon lowlands, but instead run parallel to the base of the Andes.

The massive landslide 500 km NW of CICRA, overlooking the Madre de Dios, provides one of the longest and most accessible stratigraphies in southeastern Peru. Its deep red alluvial soils, sitting on a grey formation closer to the river, have been described in detail by Chávez et al. (1998), Antoine et al. (2003), and Hovikoski et al. (2005). The same outcrop has also produced some interesting plant and animal fossils. Antoine et al. (2003) carbon-dated an unidentified piece of wood embedded in the hillside a few meters above the river level, and estimated an age >45,000 yr. Campbell et al. (2000) and Alberdi et al. (2004) describe a fossil gomphothere discovered in the same landslide. The mining camp that occupied the CICRA terrace in 1982-1999 had on display the fossilized skull of a huge crocodilian. It is not clear where the fossil was discovered, but it is reasonable to suppose that it was also in the vicinity of CICRA. It seems likely that the skull belonged to *Purussaurus brasiliensis*, a Miocene giant that measured 14-18 m long and weighed more than *Tyrannosaurus rex*.

The youngest geological deposits are the thin strips of active floodplains along the major rivers. These accumulate sediment every few years, when rivers overflow their banks onto the adjacent floodplains. These deposits, and the river bottom itself, are the only places on the landscape with appreciable amounts of gold. Because the gold originates from the Andean foothills and travels down rocky rivers, most of the gold around Los Amigos is in the form of fine particles—nuggets are ground to sand on their way down the rocky rivers. The richest alluvial deposits are downriver of the Río Colorado, which drains the region's principal mining area, the Río Huaypetuhue.

Earthquakes, landslides, and other landscape disturbances
Los Amigos is about 50 km north of the Tambopata Fault, but earthquakes are rare in the region. There is also no significant vulcanism, past or present, in the region. Some

small hot springs exist along the upper Alto Madre de Dios and are being developed for tourism (C. Cañas, personal communication).

Probably the most important large-scale physiographic disturbances in the region, apart from the meandering rivers (see above), are landslides. These may be triggered by a combination of tremors, treefalls, and massive rainfall, or they may be the culmination of years of minute slippage. Larsen and Simon (1993), based on observations in Puerto Rico, suggested that 200 mm of rainfall in a 72-hour period is likely to set off a large number of landslides in hilly tropical terrain. This threshold has been reached once at CICRA in six years (240 mm).

Khanal (2006), examining 2003 air photos of a 1,634-km^2 area in the lower Los Amigos watershed, mapped 381 landslides. The largest measured 4 ha; the mean size was 0.24 ha. Together, these landslides accounted for 0.5% of the study area. Landslides were spatially autocorrelated up to around 2 km, but they were not clumped where one might naively expect them to be: around the steep cliffs overlooking the floodplain of the Los Amigos River. Instead, they seem to cluster in places where the terraced uplands and hilly uplands border each other, and where the steep cliffs along the river have long since collapsed to form young watersheds (N. Pitman, personal observation).

In 2005 Pascual Flores recalled the three major landslides that occurred during the nearly 20 years that he has lived on the CICRA terrace. None of them took place close to CICRA; all of them were in the bare hillside a few hundred meters upriver from the CICRA docks. Flores saw one of the landslides with his own eyes, and remembers being unimpressed by the spectacle until the cascading debris hit the river, whereupon it threw up a massive wave that traveled a long ways up and down the Madre de Dios River and washed into the forest on the opposite bank. Flores tells of walking through the forest on the opposite bank shortly after the landslide and finding several large fish on the forest floor, stranded there by the wave.

Physiography

Perhaps in compensation for the remarkable paucity of information on the region's soils, hydrology, geology, and climate, geographers have described physiographic features of southeastern Peru in exhaustive detail. Part of the reason is that describing topographic features is relatively easy to do with aerial photos or satellite images. Another reason is that many biogeographers have hoped that physiographic units might serve as proxies for plant and animal distributions: indeed, the leading forestry maps of Amazonian Peru are still based directly on topography rather than vegetation. Thus one description of the Los Amigos watershed distinguishes ten different physiographic units, encompassing terraces and hills of varying degrees of dissection, elevation, and steepness (ACCA 2001; the units seem to have been determined from a physiographic map of the region, but the original source is not given in the report).

Foster (2001) sensibly lumped these into three units which form fairly discrete and obvious blocks in Landsat images of the Los Amigos region: floodplains, terraced uplands, and hilly uplands. The terraces, "notable for being very flat with only infrequent cutting by small streams.... are the very western tip of a formation that forms a broad regional arc of weakly dissected uplands. This formation does not go south of the Rio Madre de Dios except in the vicinity of Puerto Maldonado (where it crosses over to just beyond the Rio Tambopata), but instead sweeps northeast into Pando, Bolivia, eastern Acre, Brazil, and beyond" (Foster 2001).

The hilly terra firme, he writes, are “highly dissected steep hills ~50-100 m high or higher. This is the southernmost end of a large regional physiographic formation, interrupted only by rivers, that stretches northwest and north for hundreds of kilometers into the Ucayali Department of Peru, western Acre, Brazil, and beyond. It also does not pass south of the Rio Madre de Dios, though it does appear to be on both sides of the Manu floodplain above the Rio Pinquen.”

Foster (2001) offers a variety of potential explanations for the existence of two physiographically distinct kinds of uplands. The best-supported seems to be that hills and terraces reflect the results of weathering on different soil types. As Osher and Buol (1997) have noted near Puerto Maldonado, coarse soils tend to produce gradual slopes, while fine-textured soils tend to produce steeper, convex slopes. Since upland terraces in Madre de Dios contain significant amounts of sand, the prediction is that soils in the hilly uplands have higher concentrations of clay.

(Availability of topographic data for the region.) Topography of the Los Amigos region is given in Figure x. The highest elevation within the watershed is ~433 m, and the lowest elevation is ~226 m (Khanal 2006). Terraced uplands and floodplains are the dominant physiographic formations around CICRA. All three main formations are accessible from the CM2 station.

Soils

Soils in Madre de Dios are either very complex or very simple, depending on one’s perspective. On the one hand, since the parent material that modern soils are derived from is a jumbled mosaic of clayey materials, sandy materials, silty materials, gravel, and various mixtures of these deposited by thousands of rivers that meandered unpredictably across the ancient landscape, soil texture can vary dramatically in the course of a short walk through a single forest type. For example, soils collected at half a dozen upland sites between Cocha Cashu and Los Amigos had sand contents ranging from 27 to 85% (N. Pitman, unpublished data). On the other hand, despite this significant spatial heterogeneity in texture, the vast majority of upland soils in the region fall into just two classes in the soil taxonomy system: the Ultisols and Inceptisols that dominate much of western Amazonia (Linna 1993, Mazer 1996, Osher & Buol 1997, Phillips et al. 2003, Pitman et al. 2001, Riley 1994).

It is still too early to draw detailed conclusions about the fertility of Madre de Dios soils relative to other sites in Amazonia or the Neotropics, but in general they occupy the fertile end of the gradient. There is no doubt that floodplain soils in the region are fertile; because much early work was done on the Cocha Cashu floodplain, the region gained a reputation among tropical biologists for relatively rich soils. Pitman et al.’s (2001) comparison of upland soils in Madre de Dios with the fertile upland soils of eastern Ecuador seemed to confirm this impression; no significant differences in nutrient availability were found.

The most detailed study of upland soils in Madre de Dios to date is an examination of a forested site on the road between Puerto Maldonado and Laberinto (Osher & Buol 1997). They found that “all upland soils classify as Ultisols, in clayey, fine-loamy or coarse-loamy families.” Upland soils were very acidic, with pH of 3.6-4.7. Acidity decreased, while clay content increased, with depth. The dominant clay mineral was kaolinite, while the dominant mineral in sandy samples was quartz.

Terra firme soils are consistently sandier, more acidic, and poorer in nutrients than floodplain soils (Mazer 1996). Among flooded forest samples, extremely young soils (i.e., new levees created by river dynamics) tend to be less acidic than older soils, and to concentrate nutrients at much greater depths than older soils (Riley 1994). The best study of alluvial soils in Amazonian Peru is from Loreto, but it probably applies well to floodplains in Madre de Dios (Paredes Arce et al. 1999). Thus a very simplistic picture of soil diversity in Manu shows >80% of the landscape covered with mostly coarse-textured and relatively poor upland soils derived from young alluvium and the remaining 10% composed of thin bands of fine-textured and relatively rich alluvial soils along streams and rivers.

The most striking edaphic feature in southeastern Peru are the clay licks scattered across the landscape and visited by birds, mammals, and other animals (Emmons & Stark 1979). These clay licks, known as *colpas* in Spanish orthography, *ccolpas* or *ccollpas* in Quechua, are valued by hunters and ecotourists for the abundance of animal life they attract. Twenty-five years after the first paper on the region's clay licks (Emmons and Stark 1979), biologists and soil scientists have yet to pinpoint the reasons that lead animals to eat soils (Brightsmith & Munoz-Najar 2004). Even less is known about the distribution of these economically and biologically important features across the department, across Amazonian Peru, or at larger scales in the Amazon basin. As of 2005, the map of clay licks on the Los Amigos River (Figure 3) was the only *colpa* map in existence for Madre de Dios, and perhaps for all of Amazonian Peru (D. Brightsmith, personal communication).

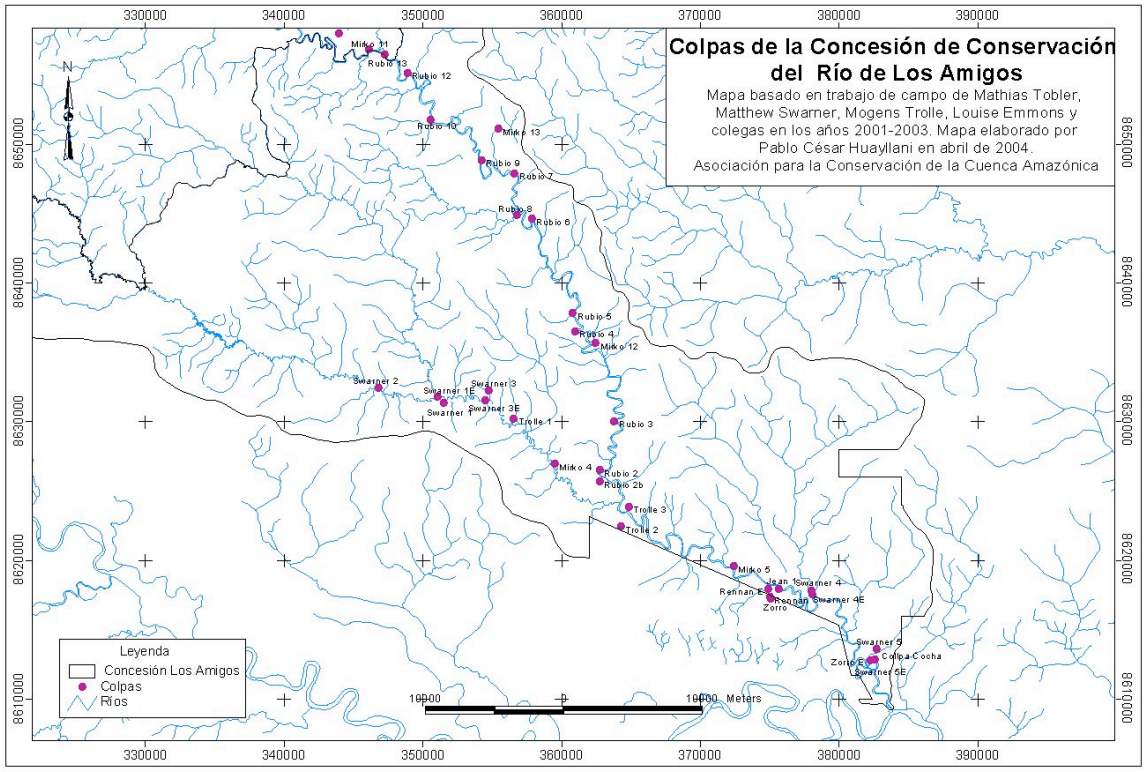

Figure 3. A preliminary map of clay licks in the Los Amigos watershed.

CLIMATE AND SEASONALITY

Climate overview

Climate in the region is warm, wet, and decidedly seasonal, with most rain falling outside of a pronounced three- to four-month dry season (see earlier overviews in Barthem et al. 2003, Schenck 1999, Terborgh 1983, 1990; Terborgh et al. 1986).

Large-scale weather maps show Los Amigos at the intersection of two climatic gradients (Kalliola et al. 1993). To the south, mean annual temperatures drop at least 20°C as elevation rises from <500 m in the lowlands to >4,000 m in the Andes, and along the same gradient precipitation reaches >7,000 mm at intermediate elevations, before decreasing again at higher elevations. To the east, rainfall declines dramatically, and forests give way to savanna in large areas of Bolivia, and Brazil. Figure x shows how the rainfall and seasonality of Los Amigos and other sites in Madre de Dios compare to well-known study sites elsewhere in the tropics.

Long-term, high-quality weather data from Los Amigos do not yet exist, and so a picture of the watershed's climate must be pieced together from a variety of other sources. While there is an abundance of scattered data—including a five-year record from CICRA 2000-2006, decades-long data from the five Peruvian government climate stations in the surrounding lowlands (Puerto Maldonado, Iberia, Iñapari, Pakitza, and Puerto Esperanza), several years' worth of data from a variety of privately operated weather stations (e.g., Cocha Cashu, Tambopata Research Centre, Explorers' Inn), and the personal observations of long-term residents and researchers (e.g., Foster and Terborgh 1998)—no one has yet compiled these into a single dataset. Part of the reason is that the best climate record in the region—from Puerto Maldonado, where rainfall, temperature, and humidity have been recorded daily (but not continuously) since 1948—is not publicly available. The Puerto Maldonado data can be purchased from Peru's Meteorology and Hydrology Service (SENAMHI) at very high cost (~US$9,000 as of December 2004). In the meantime, historical summaries (i.e., monthly means) of many of the SENAMHI stations are available on various public access websites.

Collating these data is a top short-term goal of ACA, because several important questions about the regional climate remain unanswered. How does climate vary across the lowlands of the region, over hundreds of kilometers (Cocha Cashu in the west vs. Cusco Amazónico in the east), over dozens of kilometers (CICRA vs. CM2), over a few kilometers (CICRA vs. the end of Huangana trail), and between different physiographic features (high terraces vs. adjacent floodplains)? How have the frequency and intensity of *friajes* (cold snaps) and windstorms varied over the 40-year climate record for Madre de Dios? How does the climate change during El Niño/Southern Oscillation and La Niña events? How do climatic factors affect plant phenology and animal behavior?

Fortunately, the region's weather is constant enough in many aspects that a ragged dataset provides a reasonably good picture of its basic features. Even Terborgh's (1983) initial survey of Cocha Cashu's weather, based on a single year of data recorded in 1976-77, still provides an accurate picture of basic weather patterns, despite several subsequent years' worth of record-collection at the same site. Casual observations of professional ten-day forecasts of the weather in Puerto Maldonado (available online at www.weather.com, www.accuweather.com, and other such sites) do a reasonably good job of predicting conditions at Los Amigos.

Weather at CICRA, Cocha Cashu, and Puerto Maldonado
(Description of measurement methods and available data from the three sites.)

Rainfall and temperature
Mean annual rainfall at CICRA in 2000-2006 was between 2,700 and 3,000 mm (Table x). There are at least three different ways to calculate this value from the available data. Summing monthly means for all 65 months of complete data gives 2,735 ± 853 mm (1 SD). Averaging the annual rainfall in the three complete years of data (2001-2003) gives 2,995 ± 455 mm. Finally, since >80% of rainfall in southeastern Peru falls during the October-to-May wet season, one can also examine annual rainfall totals for entire wet seasons, rather than breaking each wet season in two at the December/January mark and treating half the wet season data as belonging to one year and the other half as belonging to the next. When 12-month rainfall averages that include entire wet seasons are examined, averaging the three complete years of data gives 2,989.4 ± 348 mm.

All of these numbers are significantly higher than long-term means from Puerto Maldonado (2,259 mm) and Cocha Cashu (2,200-2,500 mm), but it is premature to conclude that these differences are statistically significant, since the CICRA record is based only on recent years. When annual rainfall at CICRA in 2000-2005 is compared for the three sites, xxx. In all three datasets rainfall is markedly seasonal, with >80% of the precipitation falling between October and April, when the convectional clouds of the intertropical convergence zone visit these latitudes. The driest months are June, July, and August, each averaging <80 mm of rain in both records, with May and September averaging only slightly more than 100 mm (Figure x). Relative humidity at Puerto Maldonado tracks precipitation, with only the seasonally dry months averaging below 80%. At CICRA, relative humidity averaged 87.3% between September 2004 and April 2005. Absolute minimum was 29.2%, recorded in a period of September-October 2004 when relative humidity around noon was often below 40%.

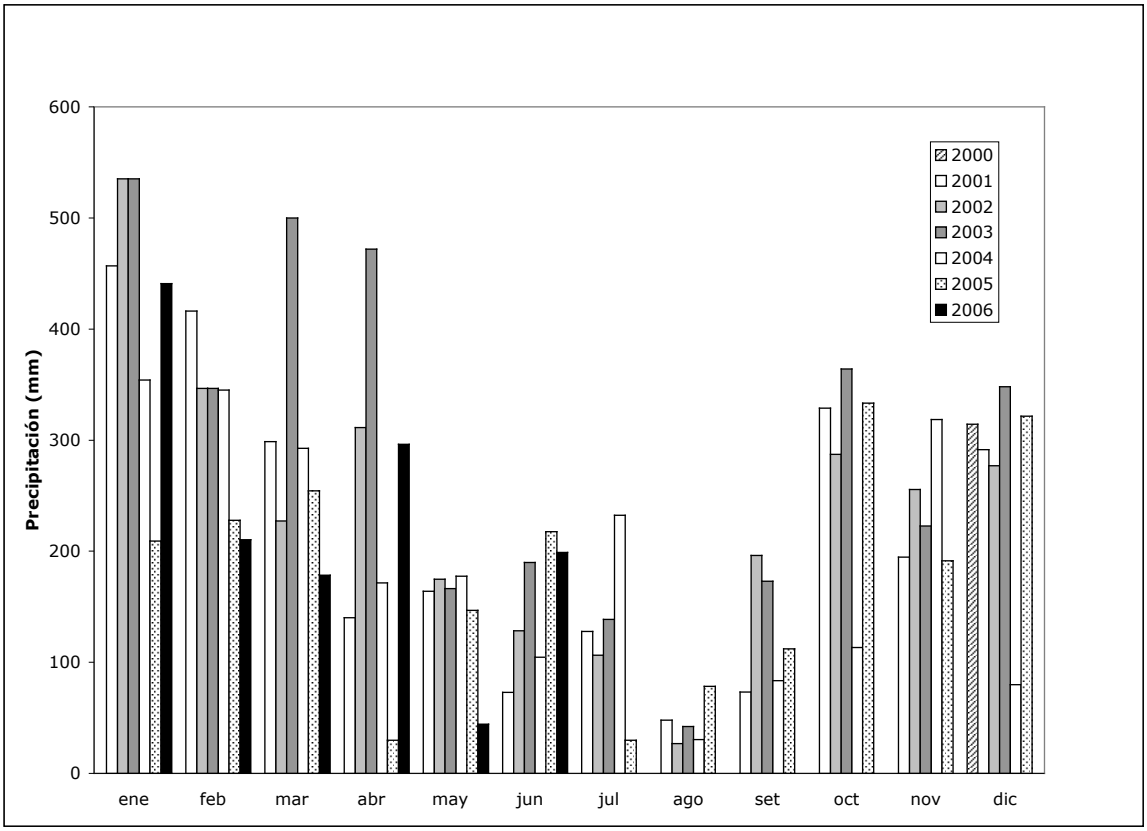

Figure 4. Monthly rainfall totals at the Los Amigos Biological Station from December 2000 to June 2006.

These average rainfall values mask a great deal of year-to-year variation, both in total annual rainfall and in the strength and duration of the dry season (Terborgh 1983). Annual rainfall at CICRA has been as low as 2,612 mm (2001) and as high as 3,498 mm (2003). Cocha Cashu has ranged from 1,600 mm (1983-84) to 2,700 mm (1993-95), and Puerto Maldonado from <2,000 to >5,000 mm (Barthem et al. 2003). Much of this variation appears to be due to a high variance in rainfall in the transitional months between the wet and dry seasons—April, May, September, and October (Figure 4). At CICRA, 472 mm of rain fell in April 2003, while <40 mm fell during April 2005. For every month of the year in the Puerto Maldonado dataset, maximum rainfall recorded for any given month is more than an order of magnitude higher than the minimum for that same month.

Rainfall in many tropical climates peaks in the afternoon, after many hours of evaporation and transpiration, but this is not the case for Los Amigos (Figure x). At Los Amigos rain is more likely during the morning; 25% of all rainfall occurs between 10 AM and 1 PM. Rain is least likely between 9 and 10 PM (just 0.7% of the total), and rises steadily from that minimum value to its peak value between 12 noon and 1 PM (which accounts for 9.6% of the total). After 1 PM the probability of rain declines steadily through the afternoon.

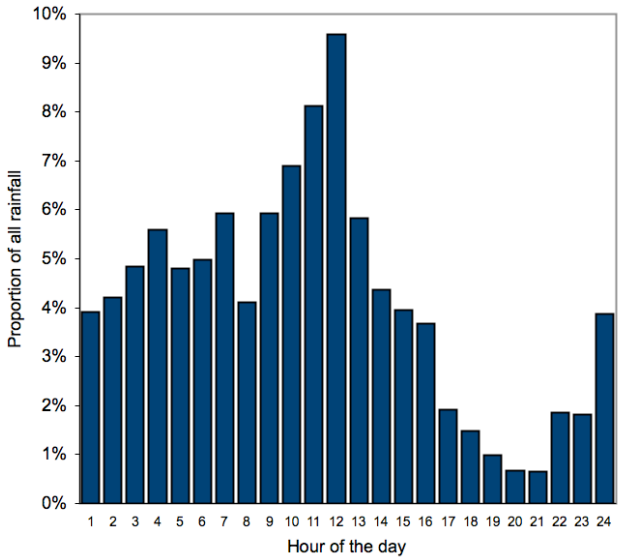

Figure x. Distribution of rainfall during the day at Los Amigos, based on data collected half-hourly at CICRA between September 2004 and October 2007.

Temperature shows a much milder seasonal signal. The dry season is slightly cooler than the wet season, but monthly means never depart from the range of 21-26° C. The highest temperature recorded at CICRA since 2000 is 39° C (37.1° C with the automated station), at Cocha Cashu since 1976 33°C, and at Puerto Maldonado since 1948 40°C. The first two complete years of data from the automated weather station at CICRA indicate a very slight increase in average temperature from 2005 to 2006. The mean temperature for 2006 (24.10° C) was 0.28% higher than that for 2005 (24.03° C).

Friajes

One of the region's most important climatic features are the periodic cold fronts, known locally as *friajes*, that sweep through Madre de Dios during the austral winter. These are large masses of cold air driven northwards from Patagonia into the Amazon basin—the southern hemisphere equivalent of the arctic fronts that periodically sweep down into the continental United States during the boreal winter (Marengo et al. 1984, 1997). During these phenomena temperatures can drop as much as 20° C in under 24 hours. Most *friajes* last between one and four days, but some last for more than 10 days, and consecutive cold fronts can keep daily minima below 20°C for as long as a month (Table x, Figure x). The historical lows at CICRA, Cocha Cashu and Puerto Maldonado are 8° C, 8° C, and 4.5° C respectively.

The arrival of a *friaje* at Los Amigos is typically heralded by strong winds sweeping in from the south and west. On the Los Amigos terrace the approach of these winds is audible several minutes before their arrival, as they come roaring through the surrounding forest or up the river. The first gust is often the strongest. Accompanied by a harrowing roar from the trees around camp, it comes tearing into camp, knocking over equipment, ripping off roof cornices, and sending the contents of clotheslines soaring off the cliff. For the next 30 minutes to an hour, these winds continue to blow, surging and subsiding like waves on a roughly two-minute cycle. In most cases the wind is

accompanied by heavy rain, which causes additional havoc as it is driven into rooms and laboratories by the strong winds.

In the forest on the CICRA trail system trees and branches are commonly flung down by these storms, and witnessing one from inside the forest is a dangerous and nerve-wracking experience. Although the most violent winds typically blow for less than an hour, steady westerly and southerly winds often continue for several hours after the front has passed. At the station, one lasting effect can be seen in the young trees around camp, many of whose trunks are permanently angled towards the west as the result of being pressed so insistently in that direction by these winter storms.

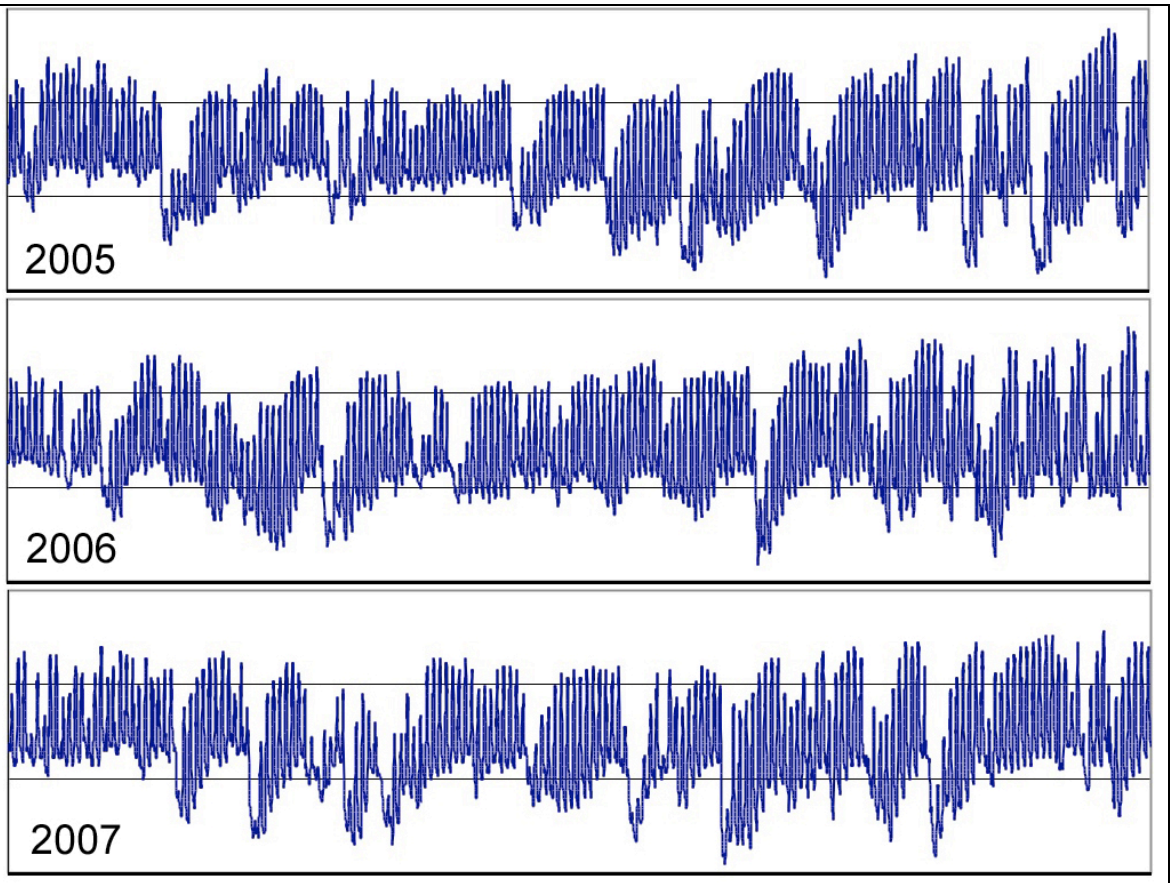

Figure x. Frequency of cold fronts, or *friajes*, at the Los Amigos Biological Station during the winter months of 2005-2007. Each graph shows temperature data at 30-minute intervals from 1 April to 30 September. In each graph the vertical axis ranges from 10 to 40 degrees Celsius, with gridlines at 20° and 30° C.

As the wind and rain die down, air temperature drops precipitously, often recording the cold front's lowest temperature during the first 24 hours after its arrival (Figure x). For the next several days, under skies that may remain overcast or cloud-free, temperature maxima and minima typically warm by about 1° C per day until normal temperatures are again attained or another cold front arrives.

While the frequency, duration and intensity of *friajes* vary from year to year, data collected at Los Amigos in the years 2005-2007 show some remarkably stable patterns.

To compare patterns among these years, I arbitrarily defined *friajes* as more than two consecutive days with daily minima <20° C, and severe *friajes* as more than two consecutive days with daily minima <15° C. By those definitions, the number of events varied very little in the winter months of 2005-2007: 14-17 *friajes* and 4-5 severe *friajes* per winter (Figure x, Table x).

Table x. Frequency of cold fronts, or *friajes*, at the Los Amigos Biological Station during the winter months of 2005-2007.

	2005	2006	2007
No. *friajes* (at least two consecutive days with minima <20° C)	14	16	17
Median no. consecutive days with minima <20°C	4	6	5
Longest no. consecutive days with minima <20° C	30	17	15
Proportion 30-minute records <20° C	24.2%	22.8%	24.2%
No. severe *friajes* (at least two consecutive days with minima <15° C)	5	4	5
Median no. consecutive days with minima <15°C	3	2.5	3
Longest no. consecutive days with minima <15° C	4	3	4
Proportion 30-minute records <15° C	4.3%	2.0%	4.2%

It is not yet clear what effect El Niño/Southern Oscillation events have on the climate in Manu. The weather in Puerto Maldonado was hotter and possibly rainier during the November 1997-January 1998 event, but this is not a consistent pattern, and the picture remains foggy for much of western Amazonia (Marengo 1998).

Light

In order to measure solar radiation, a silicon pyranometer and a datalogger that records readings every 30 minutes were established in the CICRA clearing in September 2004. In the 257 days of data available to date, the site has received a 24-hour average of 178.8 Watts/m^2. This is slightly lower than but quite similar to comparable data from Manaus, Brazil (181), and Cristóbal, Panamá (194; Müller 1982, Cubit et al. 1988). Seasonal variation in radiation is fairly predictable in the data to date: highest around the equinoxes and lowest around the winter solstice.

Wind

As in many other Amazonian forests, occasional, fierce, brief windstorms play an important role in the dynamics of Madre de Dios plant communities (Nelson et al. 1994). Foster and Terborgh (1998) document an easterly squall that moved across Madre de Dios in the fall of 1995, toppling thousands of trees. Ortiz (2002) describes a similar event in the Tambopata region. On June 21, 2005, strong winds flattened a large area of floodplain forest at the intersection of Cocha Lobo, Aguajina, and Lindero trails. The winds were apparently associated with a very heavy rainfall event that evening, but the CICRA wind speed meter did not record exceptionally high winds that day. Indeed, both average wind speed and wind gust for that day do not fall in the top 100 records for the preceding year. Taken together with the relatively local scale of damage, this suggests that the winds involved were especially strong gusts at a particular and rather small

area. We do not yet know if the same event created other similar clearings elsewhere in the area.

Satellite images and aerial photos of the Los Amigos region show at least four areas where large patches of forests appear to have been flattened by this type of windstorm between 1990 and 2000 (INRENA et al. 2004). All three of them are >25 ha; the largest appear to be >150 ha. Finding four blowdowns of this size in a relatively small area would seem to suggest that these are relatively frequent events across Madre de Dios. However, a recent study that compared 1990 and 2000 Landsat images of a >7 million ha area including Los Amigos watershed and Manu and Alto Purús National Parks did not detect any other large blowdowns during that decade (INRENA et al. 2004).

In a 2000 Landsat image, three of the four blowdown patches in the Los Amigos region have identical colors, suggesting that the disturbance there may have been simultaneous (i.e., caused by a single storm). In the false-color Landsat these three patches are the same color as beaches, indicating that most of their vegetation was obliterated. The fourth patch resembles secondary forests in the image. In 2004 a visit to this fourth patch confirmed that it has been recolonized by adult pioneer trees, suggesting that it is several years older than the other patches (J. Olivier, personal communication). The dominant pioneer tree in this patch, *Cecropia sciadophylla* (Cecropiaceae), is the same species that dominates second growth around the CICRA station, as well as large blowdown regeneration in northern Peru and Ecuador (Vriesendorp et al. 2004, 2005).

Seasonality

Seasonal changes in climate, hydrology, phenology, animal behavior, and land use are marked in Madre de Dios, but they have not yet been integrated into a single database that permits a global view of seasonality. In the meantime, here is a brief sampling of seasonal patterns. Large catfish migrate up the Madre de Dios River to spawn between December and April, and largely disappear from the river for the rest of the year (Goulding et al. 2003). Brazil nut trees put out flowers between October and January, drop fruits in December and January, and are visited by *castañeros* in January and February (Cornejo Valverde 2003). Giant otters give birth between May and June (Schenck 1999), river turtles lay their eggs on the Río Los Amigos between July and September (Mansilla et al. 2004), macaw visits to Tambopata clay licks peak in September (Brightsmith 2004), and spider monkeys disperse seeds of *Virola calophylla* at Cocha Cashu between September and December (Russo & Augspurger 2004). Most tree-cutting, mining, commercial fishing, ecotourist visits and scientific research in Madre de Dios take place during the dry season (Goulding et al. 2003).

It is not a trivial task to determine which seasonal changes drive which seasonal patterns in plant and animal communities, since many seasonal changes occur simultaneously. The dry season in Madre de Dios is also the season with the lowest air temperatures, the highest river water temperatures, the lowest solar radiation levels, the thickest leaf litter on the forest floor, the highest river water pH, the shortest days, the highest stream conductivities, and (because it is also a time of lower rainfall in the Andes) the lowest river levels (Goulding et al. 2003). Other seasonal patterns, like variation in air pollution, cloud cover, wind direction and intensity, storm intensity, lightning strikes, tree falls, and bamboo growth, are also potentially important drivers of seasonal patterns but are poorly documented. Meanwhile, the vast majority of seasonal patterns in plant and animal communities—changes in mycorrhizal fungi abundance, mosquito community structure,

disease incidence in primate populations, to name a few scattered examples—remain undocumented. Compiling data on these seasonal patterns into a single database that can provide a broad temporal context for research in the region, and that will allow us to track changes in seasonality with accelerating global change, is a leading priority for ACA.

VEGETATION AND FLORA

Regional overview and recommended bibliographic sources

The Los Amigos flora has been the subject of very intensive study and inventory by the Andes-Amazon Botany Project since 2001, and the accumulating results will soon provide an excellent picture of the watershed's vegetation (J. Janovec and colleagues, in preparation). These upcoming publications, maps, and other products should give us a good estimate of the size of the flora, an excellent description of its composition, high-quality maps and descriptions of the various forest types in the region, other insights into how the plant community changes from place to place, and a great deal of other broad and specific botanical information. In the meantime, photographs of thousands of plant species collected at Los Amigos, as well as accompanying ecological, geographic, and descriptive data, are available at atrium.andesamazon.org; a description of the Los Amigos botany team's work is available at www.andesamazon.org.

In this section I discuss a few broad topics that I consider especially important or interesting about the region's vegetation. Readers wanting a broad introduction to the vegetation of the region should try Foster (1990, 1994) and Gentry (1997). For references on more specific topics, see Table 2.

Table 2. Some recommended bibliographic sources for the vegetation of Madre de Dios, in English and Spanish.

Topic	*Key references in English*	*Key references in Spanish*
Primary succession along lowland rivers	Kalliola et al. (1991), Terborgh & Petren (1991)	Puhakka et al. (1993)
Lowland floodplain forests	Gentry & Terborgh (1990), Kvist & Nebel (2001), Hamilton et al. (in press)	Kvist & Nebel (2000)
Lowland herb and shrub communities	Foster (1990)	Foster (1986)
Bamboo-dominated forests	Griscom & Ashton (2003)	Silman et al. (2003)
The Pampas del Heath	Foster & Alban Castillo (1994)	Foster (2002)
Upper-elevation forests	?	?
Tree species abundance and distribution	Pitman et al. (1999, 2001)	Pitman et al. (2003, 2005)
Endemic species	Pitman et al. (1999)	León et al. (2007)
Secondary vegetation and invasive species	Gutte & Mueller (1989)	?
Paleobotany	Bush et al. (2004), Bush & Silman (2007)	?
Carbon sequestration by forests	Naughton-Treves et al. (2004)	Chambi (2001)
Fragmentation, deforestation,	Phillips et al. (2006)	INRENA et al. (2003, 2004)

and edge effects		
Ethnobotany	Lawrence et al. (2005), Alexiades (1999), Alexiades & Lacaze (1996), Phillips et al. (1994)	Lacaze & Alexiades (1995)

History of botanical work to date at Los Amigos
(suggested 3-4 paragraphs covering dates, places, and relevant people involved in broad floristic inventory and specific quantitative surveys; a map would be great)

The flora of Los Amigos
(suggested 2-3 pages that report the species/genus/family-level diversity recorded to date; note especially diverse families and genera, and relative contributions to the flora of different habit groups [e.g., trees are diverse, epiphytes aren't]; estimate prevalence of undescribed species in the flora; hypothesize broadly to what extent the flora is similar to those in Manu or Tambopata, and farther afield; and include a couple of floristic novelty stories. Abundant and repeated links to Atrium. It's important, though, to keep it brief. This isn't a summation of what we've learned but rather a quick reference for other Los Amigos scientists who need a thumbnail sketch of plant life there.)

(Regarding phenology, that could form a brief section of its own or a couple of paragraphs in this section.)

Vegetation of the Los Amigos watershed
(suggested 1-2-page broad-scale description of forest structure, composition, dynamics, and heterogeneity in the watershed. Again, the trick here is not to overdo it and write down everything we've learned but to provide a very simple description that acknowledges its simplicity and will stand the test of time reasonably well.)

Vegetation types in the Los Amigos watershed
(suggested 2-3 paragraph description of each of the principal kinds of vegetation at Los Amigos: mature upland forests, mature floodplain forests, aguajales, other swamps, bamboo patches, etc. Again, the trick here is not to overdo it and write down everything we've learned but to provide a very simple description that acknowledges its simplicity and will stand the test of time reasonably well.)

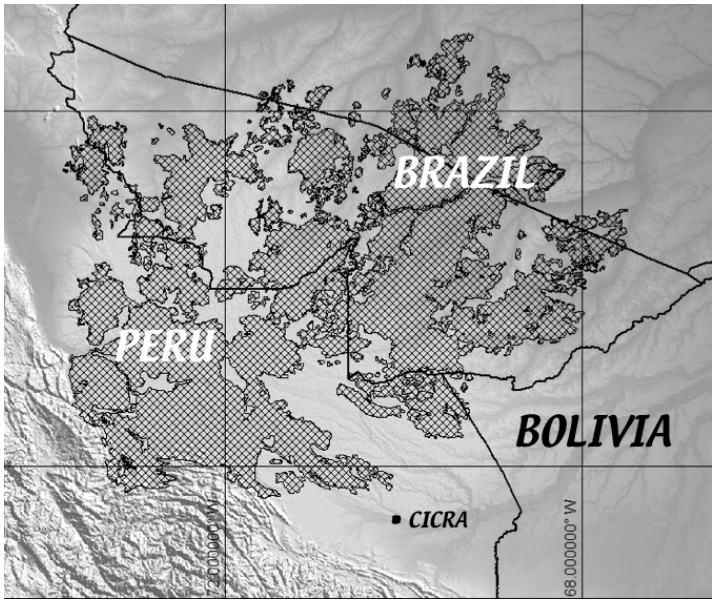

Figure 5. A map of southwestern Amazonia with the extent of bamboo-dominated upland forest, as estimated from remote sensing imagery, shown as the cross-hatched area. Adapted from Bianchini (2005).

Forests around CICRA
(suggested 2-3-page discussion on the flora and vegetation on the CICRA trail system. Given that this tiny patch is the only part of the watershed that most visitors see and collect data in, it deserves a couple of pages on its common forest types and idiosyncrasies. For example, I want to write a few paragraphs on the stronger-than-normal pioneer signal in forests throughout the CICRA trail system, and what may have caused it.)

(Ideally, we'd also have sections called "Forests around CM1" and one called "Forests around CM2". I don't know enough about those forests to contribute much, though.)

FAUNA
(under construction)

HUMAN HISTORY
Introduction
Deep History

1900-1982
We know very little about the history of the Los Amigos watershed for most of the 20th century. In part, this is because no one has made a concerted search for mention of Los Amigos in the hundreds of books and articles written about Madre de Dios during and following the rubber boom. For the time being, this section relies on a few scattered allusions I have found in geographers' and missionaries' accounts, and others which anthropologist James Graham has brought to my attention.

One of the first published mentions of the Los Amigos River is a 1902 map of the Madre de Dios River and tributaries by Rafael Baluarte. The map's tracing of the Los Amigos is cursory enough to suggest that it was drawn based on interviews rather than exploration. While the river's mouth is accurately mapped, its course is wildly misrepresented—draining from east to west rather than from north to south (Figure x). Three years after that map's publication, the Los Amigos is described briefly in an article in the *Boletín de la Sociedad Geográfica de Lima* as "a long river populated by Peruvian rubber tappers" formed by the confluence of two smaller rivers, the Aucaio and the Busamanu (Larrabure-Correa 1905: 92). Stiglich (1922) identifies Busamanu as the original name of the Los Amigos, although linguistic evidence suggests that these were names given by the rubber tappers' guides, members of the Takana language group, rather than the residents of the Los Amigos themselves, who more likely belonged to the Iñapari group (T. Moore, personal communication). What Busamanu and Aucaio mean is still to be discovered.

In a 1907 book, Stiglich confirms that the Los Amigos was one of the few tributaries of the Madre de Dios whose forests were at that time producing for the rubber trade; rubber tappers were unable to work in several other watersheds because of hostile indigenous inhabitants. Indeed, the name "Amigos" is apparently a tribute to a peaceful interlude between rubber tappers and an indigenous community that lived near the mouth of the river. Juan M. Ontaneda (1907: 423) explains: "One of [famous rubber tapper Carlos Fermín] Fitzcarrald's expeditions was attacked by some [mashcos], with whom they made peace on their return by giving them some of those cheap gifts that fascinate the savages. As this interaction took place at the mouth of a stream, Fitzcarrald named it 'Amigo....'"

Later in the same book, the author opens a window on earlier relations between rubber tappers and indigenous inhabitants of the Los Amigos, which are markedly less than friendly. He writes: "The explorers of this region had to fight with the fierce mashcos to clean them out of the Manu and Amigos rivers, which the explorers later occupied. The Mashcos who left the latter [apparently the Amigos] have since regrouped in the Colorado River" (Ontaneda 1907: 449). The earliest of these "explorers" were apparently rubber tappers led by a Peruvian named Alcibiades Torres (Stiglich 1922).

Who the indigenous inhabitants of the Amigos were and where their descendants are living today is still not clear. Avencio Villarejo (1959) describes a settlement of 50 people at the mouth of the Los Amigos River, inhabited by a group he calls the Manuquiaris, or Mashcos. The first name is synonymous with the Arasairi, Sapiteri and Toyoeri of the Amarikeri language family (J. Graham, personal communication). Ribiero and Wise (1978) have since suggested that the Manuquiaris are most closely associated with the Toyoeri, a group that they say has since integrated with the mestizo population of Puerto Maldonado.

Following the battles and forced migrations of the rubber boom period, conflict between indigenous inhabitants and mestizos has continued sporadically up to the present day (see previous section). In a 1940 account of a trip from Puerto Maldonado to the Colorado River, a Dominican missionary writes: "On the fourth day [of travel upriver from the mouth of the Inambari River] we arrived at the Los Amigos River, where Señor Troncoso and others have lived for several years. A son of his is traveling with us, and told us that in a nearby creek the maschos had killed two of his workers and left the bodies surrounded with arrows stuck in the ground as a sign that they would return

(Álvarez 1940: 177).” (The descendants of this Troncoso today own the Hotel Cabaña Quinta in Puerto Maldonado; they believe that this story is a tall tale.)

It would appear that by the 1940s no one was tapping rubber trees any longer in the vicinity of Los Amigos. Indeed, given that it is relatively easy to find scarred old trees in areas of northern Amazonian Peru that were worked by rubber tappers a century ago (N. Pitman, personal observation), the absence of scarred trees at Los Amigos is something of a mystery. Perhaps the tapped trees died of stress or disease, or perhaps they have yet to be found.

The Rosaurora farm plot (1974-1981)
In 1974, after their farm across the river from CICRA was flooded, the Luque family established a farm plot at what is now CICRA. According to Juana Luque, who was still living in the original family farm in 2006, the forest on the terrace appeared untouched when they arrived. Seven hectares were cleared and planted with mango, avocado, orange, and *Inga* trees, as well as manioc and other crops. The garden was seeded with the African livestock grass *Brachiaria*, which, as Mrs. Luque noted with satisfaction during a visit to CICRA in 2006, still grows in patches around the station. The new farm was named Rosaurora, after a pair of the Luque family’s pet parrots, but the land was sold shortly after to a mining company.

The mining camp (1982-1999)
Between 1982 and 1999, the site now occupied by CICRA was the center of operations for a series of gold mining concerns. In 1982-1983 three cement buildings—what are now CICRA’s first dormitory, dining hall, and laboratory—were constructed by a Panamanian mining company, Texas Gulf Peru S. A. From 1983 to 1985, as many as 120 men lived in the camp, which they used as a base for explorations throughout the region. Following the first election of Alán García as Peru’s president in 1985, the company changed hands and operations dwindled until there were only a handful of workers at the camp. In 1988-1990, the Peruvian company AURINSA reinitiated work at the camp, and again the campsite was crowded with workers struggling to rebuild a gigantic mining dredge that had been brought from Panama. This three-story dredge, measuring some 20 x 60 m, commenced operations in 1992. Because the dredge was mostly active upriver from CICRA, at Lago San Juan, only a few AURINSA caretakers lived at the Los Amigos camp during 1992-2000. In 1999, amid mounting financial problems, the mining company relocated the dredge to the Inambari River (where it sits abandoned today) and the Los Amigos camp was stripped of its remaining assets by frustrated employees. When ACCA purchased the property in 2000, what had been a modern complex a few years earlier was roofless and overgrown with weeds.

Today only a few reminders of the mining camp remain: the ruins of the original winch, standing in the yard west of the main dormitory; the cement table next to the washing basins at the eastern end of the laboratory, which was formerly used to clean the day’s catch of fish; the abandoned earthmoving equipment in the shed at the start of Carretera trail; and Carretera trail itself, which the mining company built as a road for heavy vehicles around 1992 (thus the rocks). Aerodromo trail is the continuation of this road, built during the clearing of the landing strip that same year. The landing strip was completed during the mining years but never used; the story has it that the only pilot to attempt a landing blanched at the rolling terrain at the last minute and landed at Lagarto instead.

The ecological impact of this large mining camp on the forests surrounding CICRA is hard to quantify. Throughout its existence, workers at the camp fished and hunted in the surrounding forests, because the company did not buy meat from Puerto Maldonado. When the camp was full, providing bushmeat was a full-time job for two camp employees. The favorite prey for hunters were deer, peccaries, tapirs, and agoutis, as well as monkeys and large birds; the favorite fishing spot was Pañacocha. Workers cut several large timber trees in the surrounding forest, especially *tornillo* (*Cedrelinga cateniformis*), which was used for building, and Brazil nut (*Bertholletia excelsa*), which was used for constructing mining barges. Trash was thrown over the cliff near where the staff quarters stand today. Had 120 men lived at the camp throughout its existence, the plant and animal communities around CICRA would have been very severely impoverished. Thus it is a stroke of luck for biologists that the mining camp stood largely empty for most of the 1990s.

Even so, some of those who saw the mining camp at the height of its activity today remember it with nostalgia. In retrospect, it is easy to imagine how, from the perspective of someone who climbed up the mining camp's long wooden stairway, lit up with electric lights, and stepped into a campsite thrumming with large generators, winches, and the bustle of 120 workers, today's CICRA is a sleepy place by comparison. Where the cabins stand today, not long ago stood a hangar and landing pad for the helicopter that transported the company's engineers to and from the city. The laboratory that once processed several kilos of gold per year is now a discolored patch in the grass near the dining hall. The forest along today's stairway is only a few years old; previously one could stand at the top of the stairs and look down at the docks, or survey the river to the south. Gone is the avocado plantation formerly around what is now the staff quarters, gone the field of corn, manioc, and watermelon on what is now the soccer pitch, and gone the small building that once stood at the entrance of Aerodromo trail, where the station's workers were entertained each month by company-sponsored *visitadoras* like those described in Vargas Llosa's novel.

The logging boom (1999-2002)

Forest structure. The impact of logging on forest structure in the Los Amigos watershed was trivial in the period 2001-2002, so the reduction in impact is correspondingly small. However, it is still measurable. The reasoning is as follows. Between 1 May 2001 and 30 April 2002, ACCA park guards recorded ~1.8 million board feet of mahogany and cedar leaving the Amigos watershed. Sixty-four percent of the wood was mahogany and 36% was cedar (ACCA 2002). Assuming 1,992 board feet/tree, and assuming that twice as many trees were felled as were harvested (after Schulte-Herbrüggen & Rossiter 2003), this gives a total of 1,820 large trees felled in the watershed during a one-year period: 1,156 mahogany and 664 cedar. Assuming that all of these trees were felled inside the 135,000 ha of what is now the conservation concession, this gives an impact of one tree felled every 74 ha. Because we know that some of the wood brought out of the Los Amigos during that time was felled outside of what is now the conservation concession, we can round that figure to an approximate average density of one large tree felled every 100 ha.

To put this in perspective, data from a 2002 study in Cocha Cashu suggest that roughly 730 very large (>70 cm dbh) trees grow in 100 ha of unlogged forest (N. Pitman & M.

Silman, unpublished data). Assuming 2% mortality, an average 15 of those trees will die of natural causes each year. By contrast, during the year of highest impact in the Los Amigos watershed, loggers felled just one tree per 100 ha. Even if the extrapolation exercise above underestimates impact by 100%, i.e., even if the loggers felled two trees per 100 ha, not one -- and even if this impact occurred every year, rather than being concentrated in one or two years -- the impact of logging remains <15% of the natural background rates of large tree mortality. Indeed, single windstorms in this part of Peru occasionally knock down more large trees in half an hour than were felled by loggers in the Los Amigos watershed in 2001-2002 (Foster & Terborgh 1998, Ortiz 2002).

(Additional thoughts re this question: Juan Carlos has some data on the additional impact of logging camps, trash, and trails. I believe these impacts are small. I can't even find a large logging camp I visited near CICRA in 1998, even though it was then surrounded by very wide trails.)

Animal communities. The reduced impact of hunting is easy to estimate, by combining ACCA's existing data on how many people and camps were in the Los Amigos watershed with Schulte-Herbrüggen & Rossiter's (2003) measurements of kg bushmeat consumed per person in logging camps on the Las Piedras River in 2002. ACCA has already quantified these impacts in its environmental impact report to INRENA in 2002. That document estimates that 12,884 kg of bushmeat were harvested in the Los Amigos watershed during 2001-2002. Since the fauna and hunter preferences are similar in the Los Amigos and Las Piedras watersheds, Schulte-Herbrüggen & Rossiter's (2003) data allow us to extrapolate a rough list of mammals killed during that time in the Los Amigos watershed: 206 *A. belzebuth*, 179 *T. pecari*, 144 *T. tajacu*, and 107 *A. seniculus*. The same sort of extrapolation can be done for birds. Compared with these numbers, zero kg of bushmeat were harvested in the concession in 2004.

The arrival of ACCA (2000-present)

Uncontacted indigenous groups
Huertas Castillo (2002), Michael & Beier (2003)

RESEARCH AT CICRA
Research priorities
As Webb (2005) has noted, "The field of conservation biology is in a unique position: in a world of increasing human health, wealth, and technological capacity, few other disciplines are waging losing wars." Faced with this gloomy tableau, ACA's approach to defining research priorities has been to keep things simple. Briefly, research priorities at Los Amigos are inventory, long-term monitoring and global change, regional topics, and public service, as described in more detail below.

- Biotic and abiotic inventories. The long-term goal is a comprehensive description of the Los Amigos landscape, flora, and fauna, so that our managers know what they are protecting. Outputs of inventory projects at Los Amigos range from simple species lists to field guides, taxonomic treatments, phylogenies, on-site synoptic collections, museum collections, and soil, vegetation, or other maps or GIS layers. ACA favors inventory projects that focus on poorly-known groups of

organisms, use new technologies to maximize efficiency, share information widely, and build links with our long-term monitoring programs. Biological inventories to date have focused on terrestrial mammals, birds, amphibians, reptiles, fish, various insect groups, flowering plants, lichens, mosses, and fungi (see Table 3). Coverage is weakest, predictably, on invertebrate taxa.

Table 3. Biological inventories in the Los Amigos watershed, 2000-2007.

Taxonomic Group	*Researchers and inventory dates*	*Number of species and morphospecies registered to date*	*List, guide or publication available?*
Microbial eukaryotes	David Bass and Thomas Richards, 2005	under study	in preparation
Ascomycete yeasts	Amy Berkov, 2004-2006	6	Berkov et al. (2007)
Fungi	Romina Gazis, 2003-2005	305	Gazis (2004, 2005), Gazis & Gómez (in preparation)
	Alejandro Sánchez, 2006	under study	in preparation
Lichens	Jorge Carrillo, 2003	under study	in preparation
Mosses	Piers Majestyk, 2002	58	Majestyk & Janovec (2004)
Pteridophytes	Benjamín Chambi, 2005-2006	176	in preparation
Angiosperms	John Janovec and colleagues, 2001-present	>2,000	species list available at atrium.andesamazon.org
Bivalves	Cristián Ituarte, 2006	under study	in preparation
Terrestrial gastropods	Gabriela Cuezzo and Rina Ramírez, 2006	under study	in preparation
Copepods	Diana López, 2006	under study	in preparation
Aquatic insects	Eduardo Oyague, 2004-2005	under study	in preparation
Scorpions	José Antonio Ochoa, 2005	5	Ochoa & Chaparro (2005)
Spiders	Mariajosé Deza, 2005-2006	under study	in preparation
Flies	Craig Gibbs, 2004-2005	under study	in preparation
	Steven Paiero & John Klymko, 2006	under study	in preparation
Butterflies	Phil Devries, 2003-2005	under study	in preparation
Moths	Pedro Centeno, 2004-2005	under study	in preparation
	Juan Grados, 2006	under study	in preparation
Ants	Various, 2004-2005	under study	in preparation
Army ants in the genus *Eciton*	Angélico Asenjo, 2006	5	unpublished species list
Meliponnine and euglossine bees	David Roubik, 2003	under study	in preparation
Megalopta bees	Simon Tierney, 2006	under study	in preparation
Cerambycid beetles	Amy Berkov, 2004-2005	37	unpublished species list
Curculionid beetles	Amy Berkov, 2004-2005	7	unpublished species list
Erotylid beetles	Dino Vanucci, 2003	28	unpublished species list
Scarabaeid beetles	Trond Larsen, 2000-2005	154	unpublished species list
Fish	Michael Goulding, Carlos Cañas, Hernán Ortega, Max Hidalgo, Soraya Martínez, Vanessa Chipollini and others, 2002-2006	292	Goulding et al. (2003), Barthem et al. (2003)
Amphibians	Rudolf von May and others, 2002-2006	82	von May (2004)
Reptiles	Rudolf von May and others, 2002-2006	~50	von May (2004)
Birds	Douglas Stotz, Tatiana	515	unpublished species list

	Pequeño, Renán Valega, Daniel Lebbin, and others, 2001-2006		
Terrestrial and arboreal mammals	Louise Emmons, Renata Leite, and others, 2001-2006	64	unpublished species list
Bats	Cristina López, Sandra Velazco, Adriana Bravo, and Jhony Ríos, 2005-2006	>33	in preparation
TOTAL		>3,817	

- Long-term monitoring and global change. Managing the conservation concession effectively over its 40-year lease requires an understanding of how its plant and animal communities change over time, both naturally and because of human-caused global change. Current monitoring projects at Los Amigos include the collection of basic weather and river level data, weekly surveys of animal populations along the Los Amigos River, monthly phenological, leaf-litter, and leaf area index surveys, and multi-year surveys of permanent tree plots. Long-term goals of the monitoring program at Los Amigos include 1) linking our monitoring efforts to those at other stations in the region, 2) monitoring the conservation status of globally threatened taxa, and 3) implementing Conservation International's standardized long-term monitoring program for plants, butterflies, ants, birds, and primates (TEAM).

- Regional topics. ACA has a special interest in projects that study the defining features of the southwestern Amazon landscape. These include colpas (clay licks), bamboo-dominated forests, wetlands, friajes (winter cold fronts), meandering rivers, economically important species like Brazil nut, mahogany, and tropical cedar trees, endemic species, and the environmental impacts of logging, gold mining, and ecotourism.

- Public service. Regardless of the research question, ACA favors research that generates some public good for the community. Examples include projects that provide training opportunities for Peruvian biologists, strengthen capacity in Peruvian museums and universities, share research projects widely, and make a special effort to build on prior scientific work at Los Amigos and the other well-studied sites in the region, like Cocha Cashu, Pakitza, and the Río Tambopata lodges. Collaborative projects with Bolivian and Brazilian researchers and institutions are highly encouraged.

Research in Los Amigos before ACCA

The massive landslide just upriver from CICRA, identified on geological maps as Cerro Colorado, has been studied by geologists and paleontologists since the 1980s (Campbell & Romero Pittman 1989, Chávez et al. 1998, Campbell et al. 2000, Hovikoski et al. 2005, Campbell et al. 2006)

In 1992, John Terborgh, Percy Núñez and Manuel Sánchez scouted forests in the Los Amigos watershed as part of a large-scale inventory of tree communities in Madre de Dios. Terborgh and colleagues had completed several tree inventories in the Manu watershed and were inspecting tree communities in other watersheds in Madre de Dios—an undertaking that took them to the Alto Madre de Dios, the Colorado, the

Pariamanu, the Las Piedras, the Tahuamanu and the Acre rivers, as well as the Los Amigos. In 1993, Núñez, Sánchez and Viviana Horna returned to Los Amigos to establish two 2-ha tree plots in upland forest. In 1998, Núñez, Sánchez and Nigel Pitman visited the two plots as part of Pitman's thesis work. One plot, now located in upland forest near CICRA between Castañal and Segundo Mirador trails, was recensused by Rolando Díaz in 2005. The other plot, located in upland forest near CM3, was relocated and recensused by Carlos Lazo and the Andes-Amazon Botany Project team in early 2007. Data from these plots have appeared in several articles and theses (Terborgh & Andresen 1998, Pitman 2000, Pitman et al. 2001, Condit et al. 2001, Pitman et al. 2002, Terborgh et al. 2002, ter Steege et al. 2004, Masse 2005, Latimer et al. 2006, Malhi et al. 2006).

In 2000, Wake Forest master's student Emilio Ancaya sampled woody vegetation the large palm swamp northwest of CICRA (Ancaya 2002). Miles Silman, Mark Bush, and Luis Imunda accompanied Ancaya as part of a project to sample swamp vegetation and pollen in lake sediments in the Manu and Madre de Dios watersheds.

Stern/Cornejo trip
FZS surveys

The first six years (2000-2006)
Research at CICRA began shortly after the purchase of the former mining camp by ACCA in 2000. The first researchers to work at Los Amigos under the auspices of ACCA were Trond Larsen and Alejandro Lopera, who surveyed dung beetles at CICRA in April and May 2000. Larsen recalled that: "The laboratory building was... overgrown and did not have any roof.... Our dung beetle laboratory consisted of a makeshift table under a tree in front of the dining hall (see Figure 6)."

Figure 6. The CICRA laboratory building in April 2000 (left) and September 2006 (right). Photos: Trond Larsen and Nigel Pitman.

Relatively few researchers visited the station in 2000-2003 as its infrastructure, staff, and management were being put into place (Figure 7). In each of those four years, the number of person-days of research averaged <2,000; in other words, fewer than five researchers and assistants were present at the station per day, on average, during that period. Notable projects included the start of the long-term botanical inventory by Dr. John Janovec, in 2001, a variety of rapid biological inventories (plants, birds, mammals) for the elaboration of the proposal conservation concession in 2001, and an intensive

inventory of fish communities and aquatic habitats around the station in 2001-2002, by Dr. Michael Goulding and colleagues (Goulding et al. 2003, Barthem et al. 2003).

Research traffic accelerated sharply in early 2004 as grantees from the new ACA grants program began arriving at the station and a large radio-tracking project led by Dr. George Powell got underway. During 2004 the average number of researchers and assistants rose to 18; by 2005 this number had risen to 31.

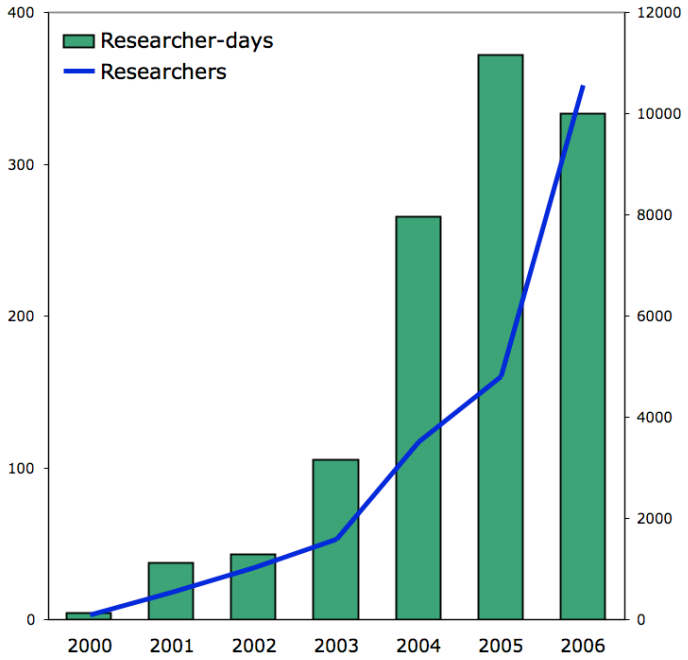

Figure 7. Growth in research activity at Los Amigos, 2000-2006.

Since 2003, ACA's grants program to support field research at Los Amigos has made 111 awards—an average of more than one grant every two weeks (Table 4). ACA has a special interest in providing support to Peruvian and Latin American scientists. Consequently, 60% of grants to date have been awarded to Peruvian researchers, and >15% of the remainder have been awarded to researchers from other Latin American countries. ACA offers three kinds of support: 1) grants to Peruvian undergraduates working on their thesis project, 2) grants to Peruvian and foreign graduate students working on their thesis project, and 3) grants to Peruvian and foreign established researchers starting the first year of a multi-year project at Los Amigos.

Table 4. Grants awarded by ACA's program to support field research at Los Amigos, 2003-2007. Figures in parenthesis are the number of awards given to Peruvian grantees.

Year	*Undergraduate grants*	*Graduate grants*	*Seed grants*	*All grants*
2003	8 (8)	3 (2)	2 (0)	13 (10)
2004	9 (9)	11 (3)	10 (4)	30 (16)
2005	8 (8)	8 (3)	10 (6)	26 (17)

2006	4 (4)	7 (2)	10 (5)	21 (11)
2007	7 (7)	7 (1)	7 (4)	21 (12)
TOTALS	36 (36)	36 (11)	39 (19)	111 (66)

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prevalent in the families Arecaceae, Myristicaceae, Moraceae, and Violaceae. The Ecuadorean forest is more diverse than the Peruvian forest at all taxonomic levels and all spatial scales. It also has a higher stem density, a larger proportion of smaller-statured species, a larger proportion of rare species, and higher-than-expected increases in the diversity of certain families. I argue that a large component of species composition and structure in these forests is homogeneous, and demonstrate that the tree communities in unvisited plots are largely predictable without any reference to local environmental conditions. However, I suggest that local processes related to the higher rainfall and higher stem density in Ecuador are more likely causing its higher diversity than large-scale or historical influences. Many of the observed patterns remain unexplained.

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*Pitman, N. C. A., J. W. Terborgh, M. R. Silman, P. Nunez, D. A. Neill, C. E. Ceron, W. A. Palacios and M. Aulestia. 2001. Dominance and distribution of tree species in upper Amazonian terra firme forests. *Ecology* 82(8): 2101-2117. ABSTRACT: Amazonian forests are the largest and most diverse in the tropics, and much of the mystery surrounding their ecology can be traced to attempts to understand them through tiny local inventories. In this paper we bring together a large number of such inventories scattered across immense areas of western Amazonia in order to address simple questions about the distribution and abundance of tropical tree species in lowland terra firme forests there. The goal is to describe patterns of commonness and rarity at local (1 ha), landscape (~10(4) km-2), and regional (>10(6) km-2) scales, and to fuse the results into a more complete picture of how tropical tree communities are structured. We present estimates of landscape-scale densities for ~1400 taxa, based on data from tree plots scattered over large tracts of terra firme forest in eastern Ecuador and southeastern Peru. A database of morphological, ecological, and other traits of >1000 of these species compiled from the taxonomic literature is then used to explore how species that are common in the inventories differ from species that are rare. Although most species show landscape-scale densities of <1 individual/ha, most trees in both forests belong to a small set of ubiquitous common species. These common species combine high frequency with high local abundance, forming predictable oligarchies that dominate several thousand square kilometers of forest at each site. The common species comprising these oligarchies are a nonrandom subset of the two floras. At both sites a disproportionate number of common species are concentrated in the families Arecaceae, Moraceae, Myristicaceae, and Violaceae, and large-statured tree species are more likely to be common than small ones. Nearly a third of the 150 most common tree species in the Ecuadorean forest are also found among the 150 most common tree species in the Peruvian forest. For the 254 tree species shared by the two data sets, abundance in Ecuador is positively and significantly correlated with abundance ~1400 km away in Peru. These findings challenge popular depictions of Amazonian vegetation as a small-scale mosaic of unpredictable composition and structure. Instead, they provide additional evidence that tropical tree communities are not qualitatively different from their temperate counterparts, where a few common species concentrated in a few higher taxa can dominate immense areas of forest. We hypothesize that most Amazonian forests are dominated at large scales by oligarchies similar in nature to the ones observed in Ecuador and Peru, and we argue that the patterns are more indicative of regulation of relative abundances by ecological factors than of nonequilibrium chance-based dynamics. The paper concludes with a discussion of the practical applications of predictable oligarchies over large areas of unexplored forest.

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Appendix 1.
A LIST OF RECOMMENDED TEXTS FOR BIOLOGISTS WORKING IN MADRE DE DIOS

compiled by N. Pitman and M. Silman, May 2005; please send comments to npitman@amazonconservation.org and silmanmr@wfu.edu

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- Excerpts from Kalliola, R., and M. Puhakka. 1993. Geografía de la selva baja peruana. Pages 9-21 in R. Kalliola, M. Puhakka, and W. Danjoy (eds.), *Amazonía peruana: Vegetación húmeda tropical en el llano subandino*. PAUT and ONERN, Jyväskylä, Finland.
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- Mazer, S. J. 1997. Floristic composition, soil quality, litter accumulation, and decomposition in terra firme and floodplain habitats near Pakitza, Peru. Pages 89-126 in D. E. Wilson and A. Sandoval (eds.), *Manu: The biodiversity of southeastern Peru*. Smithsonian Institution and Editorial Horizonte, Lima.
- A colpa paper – which?
- *Climate*: For regional context one of the basin-wide climate papers, maybe Jose Marengo's book chapter?
- A paleoclimate paper by Baker et al. or Bush et al.
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Cuenca Amazónica/Amazon Conservation Association, Lima.
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- Schenck, C., J. Groenendijk, F. Hajek, E. Staib and K. Frank. 2003. Giant otters in the Peruvian rainforest: Linking protected area conditions to species needs. Pages 341-357 in J. A. Bissonette and I. Storch (eds.), *Landscape ecology and resource management: Linking theory with practice*. Island Press, Washington, DC.
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- *Swamps*: Excerpts from Ancaya, E. J. 2002. *Floristics and hydrology of upper Amazonian swamps*. Master's thesis. Department of Biology, Wake Forest University, Winston-Salem, USA.
- *Floodplains*: Foster, R. B. 1990. The floristic composition of the Rio Manu floodplain forest. Pages 99-111 in A. H. Gentry (ed.), *Four Neotropical rainforests*. Yale University Press, New Haven, USA.
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Appendix 2.
RESEARCH PROJECTS ACTIVE AT LOS AMIGOS, 2000-2006

ordered by topic, then alphabetically
by surname of lead investigator

CLIMATE, GEOLOGY, SOILS, AND HYDROLOGY

Geology of the Los Amigos area
Dr. Pierre-Olivier Antoine (France), Dr. Patrice Baby (France), Dr. Stephane Brusset (France), Dr. Martin Roddaz (France), Wilber Hermoza (Peru)
Institut de Recherche pour le Developpement (France)
2003

Geology of the Cerro Colorado cliff
Dr. Kenneth Campbell, Jr. (USA), Dr. Lidia Romero-Pittman (Peru)
Natural History Museum of Los Angeles County (USA), Instituto Geológico, Minero y Metalúrgico (Peru)
2006

Global patterns of soil biodiversity: Implications for ecosystem function
Dr. Edward Ayres (USA), Dr. Richard Bardgett (UK), Dr. Johnson Nkem (Cameroon), Dr. Diana Wall (USA)
Colorado State University (USA), Lancaster University (UK)
2005

Hydrology of the Madre de Dios watershed
Dr. Michael Goulding (USA), Carlos Cañas (Peru), Rolando Barthem (Brazil), and others
Amazon Conservation Association and other institutions
2001-2003

Geomorphology and soil development in the Los Amigos area
Lars Jespersen (Denmark), Kristian Løkke Kristensen (Denmark), Christian Bjergager (Denmark), and Dr. Lars Rasmussen (Denmark)
Royal Veterinary and Agricultural University
2005

A GIS study of landslides in the lower Los Amigos foreland of Peru
Suresh Khanal (Nepal)
Texas Christian University (USA)
2005-2006

A reconnaissance of the transient storage properties and nitrogen dynamics of streams in the Los Amigos Concession
Dr. Jim McNamara (USA)
Boise State University (USA)
2004

Monitoring climatic conditions of palm swamps with a micro-sensor network
William Mantzell (USA)

Rice University
2004

The River Continuity Concept and its applicability to Neotropical river systems
Eduardo Oyague (Peru)
Universidad Nacional Agraria La Molina (Peru)
2004-2005

Chemical composition of colpa soils
Dr. Lars Rasmussen (Denmark)
Royal Veterinary and Agricultural University
2004

Exploratory research on Quaternary sedimentary history of fluvial terraces in the Madre de Dios basin
Dr. Catherine Rigsby (USA), Dr. Paul Baker (USA), Erin Hemric (USA)
East Carolina University (USA), Duke University (USA)
2005

Reconaissance of Madre de Dios streams
Dr. Bernard Sweeney (USA), Ing. Giancarlo Barbieri (Peru), Dr. Ralph Flowers (USA), Dr. David Funk (USA), Dr. Michael Gentile (USA), Dr. Jan Surma (USA)
Stroud Water Research Center (USA)
2006

VEGETATION
Inventory of Sapindaceae in the Los Amigos concession
Dr. Pedro Acevedo (USA)
Smithsonian Institution (USA)
2004

Inventory of commercially important tree species in the logging concessions north of CICRA
Ing. Jorge Alva (Peru), Ing. Percy Núñez (Peru), Dr. Nigel Pitman (USA)
Asociación para la Conservación de la Cuenca Amazónica (Peru)
2004-2005

Quantitative inventory of upland and floodplain tree plots
Dante Anton (Peru), Ing. Fernando Cornejo (Peru), Therany Gonzáles (Peru), Dr. John Janovec (USA), Piher Maceda (Peru), Ing. Percy Núñez (Peru), Dr. Nigel Pitman (USA), Dr. John Terborgh (USA), Mathias Tobler (Switzerland), César Vela (Peru), and others
Amazon Conservation Association (USA), Botanical Research Institute of Texas (USA), Duke University (USA), Universidad Nacional Agraria La Molina (Peru), Universidad Nacional San Antonio Abad del Cusco (Peru), and others
(1993-) 2002-2006

Spatial distribution of trees with different dispersal modes
Cecilia Blundo (Argentina) and Alejandra Tauro (Argentina)
Universidad de Córdoba (Argentina)
2005

Lianas at Los Amigos: Dominants, distribution, and habitat preferences
Dr. Robyn Burnham (USA)
University of Michigan (USA)
2006

Distribution of lichens in the Los Amigos Conservation Concession
Jorge Carrillo (Peru)
Universidad Peruana Cayetano Heredia (Peru)
2004

Taxonomy and diversity of pteridophytes in different vegetation types of the Los Amigos watershed
Benjamín Chambi (Peru)
Universidad Nacional San Antonio Abad del Cusco - Puerto Maldonado (Peru)
2005-2006

Genetic relationships and densities of *Hedyosmum* (Chloranthaceae) in montane and lowland forests of southeastern Peru
Carmen Chávez (Peru)
Wake Forest University (USA)
2004

Inventory of orchids
Miguel Chocce (Peru)
Universidad Nacional Mayor San Marcos (Peru)
2003

Inventory and harvest potential of *sangre de grado* and *copaiba* at CICRA
Mickelly Cuba (Peru)
Universidad Nacional Agraria La Molina (Peru)
2003-2004

Seed-fungal interactions of pioneer tree species in tropical forests
Dr. Jim Dalling (UK), Marcos Ríos (Peru)
University of Illinois (USA)
2006

Conservation prioritization of orchids in the Los Amigos Concession
Miluzka Damian (Peru)
Universidad Ricardo Palma (Peru)
2005

Genetic diversity in *Cedrela odorata* populations in Madre de Dios
Amanda De La Torre (Peru)
Universidad Nacional Agraria La Molina (Peru)
2003

Ecology and geographical distribution of *Inga* in Amazonian Peru
Kyle Dexter (USA)
Duke University (USA)
2004-2006

12-year recensus of a 2-ha permanent plot in terra firme forest near CICRA
Rolando Díaz (Peru) and others
Universidad Nacional San Antonio Abad del Cusco - Puerto Maldonado (Peru)
2005

Long-term monitoring of leaf area index in two forest types at CICRA
Dr. Marc Dubois (France) and Dr. Louise Emmons (USA)
CEA Saclay, Service de Physique de l'Etat Condensé (France) and Smithsonian Institution (USA)
2002-2006

Influence of light, soil moisture, and soil fertility in the early growth of *Cedrela* spp.
Ing. César Flores (Peru)
Yale School of Forestry (USA)
2001-2002

Inventory of Brazil nut trees in a 12-km^2 area on the CICRA terrace
Ing. César Flores (Peru) and others
Yale School of Forestry (USA)
2002

Preliminary inventory of the vegetation of Los Amigos
Dr. Robin Foster (USA), Ing. Hamilton Beltrán (Peru), and others
Field Museum (USA) and Museo de Historia Natural de UNMSM (Peru)
2001

Linking tree alpha-diversity to environmental gradients and remote sensing in western Peruvian Amazonia
Roosevelt García (Peru), Nallarett Dávila (Peru), Karla Meza (Peru), Marcos Ríos (Peru)
University of Missouri-St. Louis (USA)
2004

Influence of tree-fall gaps on the natural regeneration of five economically important timber species in the Los Amigos watershed
Therany Gonzales (Peru)
Universidad Nacional San Antonio Abad del Cusco-Puerto Maldonado (Peru)
2004

Vegetation mapping along 170 km of trails in and around the Los Amigos Conservation Concession
Therany Gonzales (Peru)
Universidad Nacional San Antonio Abad del Cusco-Puerto Maldonado
2005-2006

Structure and dynamics of *Mauritia flexuosa* populations in the Los Amigos Conservation Concession
Nelson Gutiérrez (Peru)
Université de Toulouse (France)
2004-2005

Vegetation types and hydrology of the Los Amigos area
Dr. Steve Hamilton (USA)
Michigan State University (USA)
2004

Ecophysiology of carbon uptake and water use by the palm *Mauritia flexuosa* L.
Viviana Horna (Peru), Reiner Zimmermann (Germany)
University of Goettingen (Germany)
2005-2006

Natural history, population biology, and pollination biology of vanilla orchids (*Vanilla* spp.)
Ethan Householder (USA), Alex Van Dam (USA)
Texas Christian University (USA), University of California-Riverside (USA)
2005-2006

Los Amigos botany project
Dr. John Janovec (USA), Ing. Fernando Cornejo (Peru), Piher Maceda (Peru), Pedro Maceda (Peru), Angel Balarezo (Peru) and others
Botanical Research Institute of Texas (USA)
2001-2006

The distribution, abundance, clump characteristics and techniques for managing *Guadua* cf. *angustifolia*, Bambuseae, a potential non-wood forest product, in Madre de Dios, Peru
Chris Kirkby (UK)
University of York (UK)
2001-2002

Inventory of mosses and lichens
Dr. Piers Majestyk (USA)
New York Botanical Garden (USA)
2002

Surveying vegetation with high-resolution aerial photographs in the Los Amigos Conservation Concession
Josué Mercado (Peru)
Universidad Nacional San Antonio Abad del Cusco (Peru)
2006

World herbivory project
Dr. Angela Moles (New Zealand), Therany Gonzales (Peru)
Macquarie University (Australia)
2005-2006

Los Amigos jungle cucumbers: A study of five sympatric *Gurania* species
Dr. Amanda Neill (USA)
Botanical Research Institute of Texas (USA)
2001-2002

Ecology and dynamics of bamboo

Jean Olivier (France), Sam Dubois (France)
Université de Toulouse (France)
2002-2005

Seedling recruitment and resource availability in the western Amazon
Timothy Paine (USA)
Louisiana State University (USA)
2005-2006

Light levels and Brazil nut regeneration
Ing. Ronald Rado Quispe (Peru)
Universidad Nacional San Antonio Abad del Cusco-Puerto Maldonado (Peru)
2001-2004

Effects of diminished seed disperser abundances on tree recruitment in tierra firme forests: A comparison of the spacing dynamics of the canopy tree communities of pristine vs. impacted sites
Varun Swamy (India)
Duke University (USA)
2005-2006

Structure, floristic composition, and ecology of epiphytic plant communities
Michael Vega (Peru)
Universidad Nacional Agraria La Molina (Peru)
2004

PLANT-ANIMAL INTERACTIONS
Impacts of peccaries on plant communities in Los Amigos and Cocha Cashu
Dr. Harald Beck (Germany), Karim Ledesma (Peru)
Towson University (USA)
2004-2006

Wood-boring cerambycid beetles associated with the tree family Lecythidaceae
Dr. Amy Berkov (USA), Pedro Centeno (Peru), Eulogio Condori (Peru)
City College of New York (USA)
2003-2006

Fauna associated with the bamboo *Guadua weberbaueri* Pilger
Patricia Feria (Mexico), Jon Dale (USA)
University of Missouri-St. Louis (USA)
2006

Seed dispersal by the yellow-footed tortoise, *Geochelone denticulata*, in Madre de Dios, Peru
Adriana Guzman (Colombia)
Universidad de Los Andes (Colombia)
2006

Ecology of birds specializing on bamboo forest
Dan Lebbin (USA)
Cornell University (USA)
2002-2004

Area requirements of Amazonian keystone species
Dr. George Powell (USA), Krista Adamek (Canada), Thomas Adamek (Canada), Dra. Renata Leite Pitman (Brazil), Rafael Mares (Panama), Sue Palminteri (USA), Raul Tupayachi (Peru), and others
World Wildlife Fund USA and other institutions
2003-2006

Habitat fragmentation and ecology of bird specialists on bamboo
Wendy Tori (Peru)
University of Missouri-St. Louis (USA)
2003

INVERTEBRATES
The evolution of social parasitism in *Megalomyrmex* ants
Rachelle Adams (USA)
University of Texas (USA)
2004

Long-term monitoring of butterfly and dung beetle communities at Los Amigos
Dr. Phil DeVries (USA), Trond Larsen (USA), Pedro Centeno (Peru), Eulogio Condori (Peru)
University of New Orleans (USA), Princeton University (USA)
2003-2005

Variation in the spider community during dry and wet seasons in the Los Amigos watershed
Mariajosé Deza (Peru)
Universidad Nacional Agraria La Molina (Peru)
2005-2006

Diversity, composition, distribution, and food plant use of ants in understory vegetation in Amazonian Peru
Megan Frederickson (USA)
Stanford University (USA)
2005

Assessing diversity and spatial organization of Neotropical drosophilids: The canopy as unexplored territory
Craig Gibbs (USA)
City University of New York (USA)
2004-2005

Biodiversity of the Arctiinae (Lepidoptera: Arctiidae) in the Los Amigos Conservation Concession
Juan Grados (Peru), Angélico Asenjo (Peru)

Museo de Historia Natural (Peru)
2006

Inventory of Mollusca assemblages in the Los Amigos watershed
Cristian Ituarte (Argentina), Gabriela Cuezzo (Argentina), Rina Ramírez (Perú)
Museo de la Plata (Argentina), Universidad Nacional de Tucumán (Argentina), Universidad Nacional Mayor de San Marcos (Perú)
2006

Ground beetles in bamboo forests: Community patterns and patch specificity in a heterogeneous landscape
Jenny Jacobs (USA)
San Francisco State University (USA)
2006

Biology of *Apterostigma* ants
Stephanie Johnson (USA)
University of Maryland (USA)
2005

Ecology of dung beetles
Trond Larsen (USA)
Princeton University (USA)
2000-2005

Evolutionary ecology of the Attine ant-microbe mutualism
Ainslie Little (USA), Dr. Matías Cafaro (Argentina)
University of Wisconsin (USA)
2004

Inventory of Cyclopoida copepods
Mabel López (Peru)
Universidad Nacional Mayor de San Marcos (Peru)
2006

Survey of leaf-litter ants and dung beetles at CICRA
Dr. Chris Marshall (USA), Dr. Ted Schultz (USA), Jeffrey Sosa-Calvo (Colombia), Smithsonian Institution (USA), University of Maryland (USA)
2004

Systematics and distribution of scorpions in the Madre de Dios watershed
Dr. José Antonio Ochoa (Peru), Juan Carlos Chaparro (Peru)
2005

Inventory of Diptera
Steven Paiero (Canada), John Klymko (Canada)
University of Guelph (Canada)
2006

Evolution of host plant use in the butterfly subfamily Satyrinae (Lepidoptera: Nymphalidae)

Carlos Peña (Peru)
Stockholm University (Sweden)
2005

A taxonomic revision of the Neotropical non-leafcutting fungus-growing ant genus *Mycocepurus*
Christian Rabeling (Germany)
Eberhard-Karls University Tübingen (Germany)
2004

Inventory of meliponnine and euglossine bees
Dr. David Roubik (USA)
Smithsonian Tropical Research Institute (USA)
2003

Molecular phylogeny of ants in the genus *Pheidole*
Corrie Saux (USA)
Harvard University (USA)
2004

Testing hypotheses of tropical diversification in leafcutter ants
Scott Solomon (USA)
University of Texas (USA)
2004

Revision of the Neotropical primitive fungus-growing ants in an Amazonian forest
Jeffrey Sosa-Calvo (Colombia)
University of Maryland (USA)
2004-2005

Inventory of erotylid beetles and their fungal hosts
Dino Vanucci (Peru)
Universidad Ricardo Palma (Peru)
2003

Behavioral and chemical ecology of Neotropical ant gardens
Elsa Youngsteadt (USA)
North Carolina State University (USA)
2004-2005

FISH
Ichthyological inventory of the Madre de Dios and Los Amigos rivers
Dr. Michael Goulding (USA), Carlos Cañas (Peru), Dr. Rolando Barthem (Brazil), and others
Amazon Conservation Association (USA), Asociación para la Conservación de la Cuenca Amazónica (Peru), and other institutions
2001-2003

Ichthyological inventory of the Amiguillos River
Max Hidalgo (Peru), Dr. Hernán Ortega (Peru), Soraya Martínez (Peru), Vanessa

Chipollini (Peru), and others
Museo de Historia Natural UNMSM (Peru), Universidad Ricardo Palma (Peru), Universidad Nacional Agraria La Molina (Peru)
2004-2006

AMPHIBIANS AND REPTILES

Long-term monitoring of fauna along the Los Amigos River
Hernán Collado (Peru), Wilberth Concha (Peru), Jerry Martínez (Peru), Alberto Melendez (Peru), Jorge Pérez (Peru), Fernando Pinto (Peru), Edwin Quispe (Peru), David Ttito (Peru), Eriberto Torres (Peru), Dr. Nigel Pitman (USA)
Asociación para la Conservación de la Cuenca Amazónica (Peru)
2004-2006

Elevated exposure to airborne pollutants in arboreal frog larvae of the neotropics
Dante Fenolio (USA), Jim Stout (USA)
University of Miami (USA)
2006

Reproductive ecology of *Hyla* frogs in the *leucophyllata* group
Giuseppe Gagliardi (Peru)
Universidad Nacional de la Amazonía Peruana (Peru)
2004-2005

Seed dispersal by the yellow-footed tortoise, Geochelone denticulata, in Madre de Dios, Peru
Adriana Guzman (Colombia)
Universidad de Los Andes (Colombia)
2006

Status and management of the river turtle, *Podocnemis unifilis*, in the Los Amigos River
Ana María Mansilla (Peru), David Ttito (Peru), Edwin Quispe (Peru)
Asociación para la Conservación de la Cuenca Amazónica (Peru)
2004-2006

Cannibalism in tadpoles of *Dendrobates biolat*
Eva Medina (Peru)
Universidad Ricardo Palma (Peru)
2003

Ecology of microteiid lizards (Gimnophthalmidae) at CICRA
Juana Suárez (Peru)
University Nacional Mayor de San Marcos (Peru)
2004-2005

Inventory of the Los Amigos herpetofauna
Rudolf von May (Peru)
Universidad Ricardo Palma (Peru)
2001-2003

Anuran beta diversity across forest types in a lowland Amazonian rainforest

Rudolf von May (Peru)
Florida International University (USA)
2005-2006

BIRDS

Long-term monitoring of fauna along the Los Amigos River
Hernán Collado (Peru), Wilberth Concha (Peru), Jerry Martínez (Peru), Alberto Melendez (Peru), Jorge Pérez (Peru), Fernando Pinto (Peru), Edwin Quispe (Peru), David Ttito (Peru), Eriberto Torres (Peru), Dr. Nigel Pitman (USA)
Asociación para la Conservación de la Cuenca Amazónica (Peru)
2004-2006

Ecology of birds specializing on bamboo forest
Dan Lebbin (USA)
Cornell University (USA)
2002-2005

Area requirements of Amazonian keystone species
Dr. George Powell (USA), Krista Adamek (Canada), Thomas Adamek (Canada), Dra. Renata Leite Pitman (Brazil), Rafael Mares (Panama), Sue Palminteri (USA), Raul Tupayachi (Peru), and others
World Wildlife Fund USA and other institutions
2003-2006

Preliminary study of the behavior and ecology of the warbling antbirds *Hypocnemis cantator peruviana* and *Hypocnemis cantator collins*
Dr. Nathalie Tobias (UK), Dr. Joe Tobias (UK), Paulo Pulgarín (Colombia)
Cambridge University (UK)
2004-2006

Inventory of the Los Amigos avifauna
Dr. Douglas Stotz (USA), Tatiana Pequeno (Peru)
Field Museum (USA), Museo de Historia Natural UNMSM (Peru)
2002

Habitat fragmentation and ecology of bird specialists on bamboo
Wendy Tori (Peru)
University of Missouri-St. Louis (USA)
2003

Ecological roles and habitat use of two species of forest-falcons in the Amazonian rainforest
Ursula Valdez (Peru), Peggy Shrum (USA), Raul Báez (Peru), Laura Riba Hernández (Costa Rica), and others
University of Washington (USA)
2004-2006

Ecology of *Tachycineta* swallows across the Americas
Dr. David Winkler (USA) and others
Cornell University (USA)

2003-2004

MAMMALS

Ecology and behavior of the emperor tamarin, *Saguinus imperator*
Israel Aragón (Peru)
Universidad Nacional San Antonio Abad del Cusco (Peru)
2003-2004

Frugivorous bats (Phyllostomidae) that visit clay licks in a Neotropical rainforest: Implications for seed dispersal and plant community structure
Adriana Bravo (Peru)
Louisiana State University (USA)
2005

Long-term monitoring of fauna along the Los Amigos River
Hernán Collado (Peru), Wilberth Concha (Peru), Jerry Martínez (Peru), Alberto Melendez (Peru), Jorge Pérez (Peru), Fernando Pinto (Peru), Edwin Quispe (Peru), David Ttito (Peru), Eriberto Torres (Peru), Dr. Nigel Pitman (USA)
Asociación para la Conservación de la Cuenca Amazónica (Peru)
2004-2006

Phylogeography of *Proechimys*
Maria de Angelo (USA)
Yale University (USA)
2004

Ecology of mineral licks: Function, effects on vertebrate biomass, and management implications
Dr. Louise Emmons (USA), Mogens Trolle (Denmark), Dyana La Rosa (Peru)
Smithsonian Institution (USA)
2000-2003

Inventory of giant otters and their habitat in the Los Amigos watershed
Freddy Ferreyra (Peru) and others
Frankfurt Zoological Society (Germany)
2004

Understanding the pair bond in *Callicebus brunneus*: Male and female interests
Jenna Lawrence (USA) and others
Columbia University (USA)
2002, 2004-2005

Diversity and conservation of bat communities at CICRA
Cristina Lopez Wong (Peru), Jhony Ríos (Peru), Giuseppe Gagliardi (Peru)
Universidad Nacional de la Amazonía Peruana (Peru)
2005-2006

Area requirements of Amazonian keystone species

Dr. George Powell (USA), Krista Adamek (Canada), Thomas Adamek (Canada), Dra. Renata Leite Pitman (Brazil), Rafael Mares (Panama), Sue Palminteri (USA), Raul Tupayachi (Peru), and others
World Wildlife Fund USA and other institutions
2003-2006

Ecology and systematics of marsupials in Neotropical rainforests
Oswaldo Ramírez (Peru), Margarita Arana (Peru), Enrique Bazán (Peru)
Universidad Cayetano Heredia (Peru)
2006

Historical distribution of giant otters in Madre de Dios
Marne Suárez (Peru)
World Wildlife Fund Peru (Peru)
2004

Ecology of tapirs (*Tapirus terrestris*) in the Los Amigos watershed
Mathias Tobler (Switzerland), Dr. Louise Emmons (USA), Carlos Sánchez (México), Darío Cruz, Jr. (Peru), Javier Huinga (Peru), and others
Texas A&M University (USA), Botanical Research Institute of Texas (USA), Smithsonian Insitution (USA)
2002-2006

Vertical stratification of bats in the genus *Artibeus* (Phyllostomidae) at CICRA
Sandra Velazco (Peru)
Universidad Nacional Mayor San Marcos (Peru)
2005-2006

OTHER
The diversity of the eukaryote microbial groups Alveolata and Cercozoa in a tropical rainforest environments using microscopy and molecular inference
David Bass (UK), Thomas Richards (UK)
University of Oxford (UK), Natural History Museum London (UK)
2005

Preliminary inventory of the mycoflora at CICRA
Romina Gazis (Peru)
Texas Christian University (USA), Universidad Ricardo Palma (Peru)
2003-2005

Autonomous radio-tracking project
Dr. Robert MacCurdy (USA)
Cornell University (USA)
2004

Bibliography of biology or conservation works from Madre de Dios
Dr. Nigel Pitman (USA)
Amazon Conservation Association (USA)
2004-2005

Inventory of polypore fungi at CICRA

Alejandro Sánchez Taranov (Peru)
Universidad Cayetano Heredia (Peru)
2006

Ecological applications of multispectral 3D aerial imagery in the Los Amigos reserve in eastern Peru
Dr. Dana Slaymaker (USA), Dr. Ken MacDicken (USA), Dr. Alfredo Unda (Canada), Aaron Dushku (USA)
Winrock International (USA)
2003-2005

Appendix 3.
COMPANION NOTES FOR THE PRINCIPAL TRAILS OF THE LOS AMIGOS RESEARCH STATION

The stairs

The station's infamously unwelcoming approach trail ascends 251 steps to the station terrace, some 40 m above the river. The oldest person to have made the climb was 75 years old at the time; upon reaching the top she triumphantly lit a cigarette. The youngest person to have made the climb with no assistance was three years old. She took her time going up, and so should you.

The forest to either side of the stairs is less than 20 years old; when the station was a mining camp this hillside was bare, and it was possible to see the port from the head of the stairs and vice versa. Near the base of the stairs (but not visible from them) is an overgrown plantation, where a small hillside planted in pineapple overlooks a stand of cacao, banana, and papaya trees. We are currently deciding whether to reactivate the plantation or remove it. The argument for reactivating the plantation is that it would relieve us of the absurd practice of bringing bananas from Puerto Maldonado. The argument for letting the area go back to nature is that only two forests in the Río Madre de Dios floodplain are currently protected from development, and this is one of them. The obvious compromise solution is to restore the plantation to wilderness and buy bananas from neighboring farms.

The hillside vegetation along the stairs already has a healthy understory of aroids, ferns and treeferns, *Costus*, *Piper*, and melastomes. A native bamboo (apparently *Guadua weberbaueri*) is scattered around the first and second *descansos* and dominates a large patch just behind the first. A couple of large mango trees at the first *descanso* and a smaller citrus tree on the slope below are reminders of the area's recent past. Several of the largest trees here belong to the genus *Erythrina*, a legume characteristic of disturbed river banks (there is one at the dock in Laberinto) with striking hummingbird-pollinated red flowers. There are also two large fig trees (*Ficus insipida*), one at the second descanso and one at the top of the stairs, as well as some fast-growing youngsters that will dominate the canopy of this forest in a few years.

Small monkeys are seen relatively frequently from the stairs, particularly emperor tamarins (*Saguinus imperator*), saddleback tamarins (*Saguinus fuscicollis*), and squirrel monkeys (*Saimiri sciureus*).

Trocha Aerodromo (1)

This trail is part of an old road built by the gold-mining company that occupied the camp in the 1980s and 1990s. (The rest of the road is now called Trocha Carretera; see below.) The road was paved with river stones so that the company could move its earth-moving equipment between the river, the camp, and the airfield. Its width (more than twice that of the other trails at the station) make it ideal for group walks, as well as one of the "luckiest" trails for observing wildlife; the long straight stretches give you a long-distance vista not available on any other trail here.

The vegetation along the entire trail is young secondary forest, littered with the huge, star-shaped leaves of *Cecropia sciadophylla*, the dominant pioneer tree species in western Amazonia. Only two short stretches of the trail are not typical secondary forest.

One, around meter 225 on the east side of the trail, is a large and essentially impenetrable patch of native grass and bamboo that stretches across Jean and Primer Mirador trails to the east. We do not know yet whether the patch is a natural feature or an indicator of disturbance by past inhabitants of the terrace, but we do know that it was already there when the mining company arrived in the early 1980s.

The other segment that is not secondary forest, from meter 425 to meter 565, is not part of the original road, but a detour built when a large stretch of the road collapsed in a landslide; the forest here is much older than that along the rest of the trail. Although the trail is just a few meters from the cliff overlooking the Madre de Dios River, rain that falls here drains in the opposite direction, following a long and circuitous route through the Los Amigos watershed before meeting the Madre de Dios where the two rivers come together.

At the start and the end of the detour small trails lead to the cliff's edge with a good view of the landslide, river, and floodplain forest. As from the station, on especially clear days the Andes are visible from this lookout. Note that the cliff is not stable and there is no safety rail, so observers should keep well away from the edge.

Despite the run-down appearance of the secondary forest along this trail, it is the preferred habitat of the endemic Rufous-Fronted Antthrush (*Formicarius rufifrons*), known only from this corner of Amazonia, and the emperor tamarin (*Saguinus imperator*), often seen accompanied by the saddleback tamarin. The short-eared dog (*Atelocynus microtis*) has been sighted several times on this trail. In 2005 it was common to find tapir tracks in the mud at meter 830.

Plataforma (2)
For much of its route, this trail follows the edge of the cliff that separates the terrace from the palm swamp at its base. The forest here is much older than that around the station and along Aerodromo trail, and the trail passes some of the largest and most beautiful trees on the Los Amigos trail system. Much of the "older" forest on this terrace falls into the same category: patches of large old trees and closed-canopy forest alternating with patches where trees are sparse, small, and often soft-wooded pioneer taxa.

Rubber trees are exceedingly common along this trail. During the dry season they are easy to pick out in the canopy because their leaves turn a fire-engine red before falling. During the wet season, rubber seedlings are ubiquitous in the understory, where they are easily distinguishable by their large trifoliate leaves, colored black when developing. And during a few sunny days between January and March, the trees announce their presence with sharp little explosions—the sound of the fruit capsules dispersing their seeds with a pop—a sound that is disarmingly similar to the tooth-clicking alarm call of white-lipped peccaries.

No one seems to know who tied the Brazil nut fruits to treelets in various places along this trail some time in 2005. It is either an abandoned experiment or a Blair Witch-type handicraft.

Pozo Don Pedro (17)
This short trail provides a quick introduction to one of the palm-dominated wetlands that cover a significant portion of the Madre de Dios floodplain. The change in the tree community from the uplands to the swamp is particularly noticeable at the beginning of

the wooden walkway, as the *Mauritia* palm and a couple of other swamp specialists become increasingly common in the saturated soils. The word “soils” is not especially appropriate, since by the time one steps onto the walkway the ground is more organic matter than mineral soil. Researchers have recently determined that this layer of rotting plant material is several meters deep in parts of the palm swamp.

Equipment in an ongoing experiment is wired to several trees near the start of the walkway. This is part of a long-term ecophysiology project to measure water use by *Mauritia* palms and other wetland trees. This project is also monitoring water, light, and temperature levels in the palm swamp, to understand how huge trees manage to make a living with no connection to mineral soil—teetering on a meters-thick, always-wet bed of natural compost.

Closer to the Pozo, several of the *Mauritia* trunks are festooned with thick-stemmed vines—a climbing orchid in the genus *Vanilla* and a relative of the plant that produces the vanilla you buy at the market. A master’s student at the station in 2005-2006 has been studying the biology of this plant and the four other species in the genus that grow in this wetland, in part in order to determine whether they might someday become a new crop plant for Madre de Dios farmers.

The Pozo itself is something of a mystery. It may have begun life as most other lakes on the Madre de Dios floodplain—as an oxbow suddenly cut off from the main current when the river shifted course. But it lacks the shape of a typical *cocha*, and it is much smaller than other oxbow lakes in the region. Its water is dark and acidic thanks to the stew of tannins and other chemicals steeping into in from the decaying plant matter. Pozo Don Pedro is apparently fed by water seeping out of the base of the terrace, and not by overflow from the Madre de Dios River.

The most popular faunal attraction of Pozo Don Pedro is a very large anaconda (*Eunectes murinus*), which can sometimes be seen coiled up and sleeping in the grass at the south end of the pond. Do not disturb the anaconda.

Primer Mirador (10)
This is the most direct route to the Los Amigos River from the station, leading straight across the terrace from the station to a lookout over the Los Amigos. The blizzard of multi-colored flagging along the way attests to the fact that this is one of the heavily-traveled trails at Los Amigos. It is also one of the most puzzling. The forest in the first ~700 meters is recovering from a severe historical disturbance, though it is not clear of what kind. It winds through vine tangles, bamboo thickets, and recent treefalls, but passes several large trees probably more than a century old. It also passes at least two huge stumps of timber trees harvested before the station was established.

Just before the intersection with Otorongo and Segundo Mirador trails, the trail passes abruptly into much older, structurally mature closed-canopy forest. Indeed the forest surrounding one at the intersection of these three trails is one of the most beautiful on the entire trail system.

Past the intersection the trail descends steeply to a lower terrace. By the time one reaches the bottom of this slope, the forest has again changed dramatically and is dominated by young pioneer trees. Close examination of this patch of forest reveals that

it—like many other patches on the trail system—is recovering from a powerful windstorm that toppled most large trees here, probably within the last 20 years.

The remainder of the trail is older forest, marked here and there by old timber extraction. The overlook of the Río Los Amigos is a good place to watch a meandering river doing its slow work of tearing down and building up the landscape, leaving different kinds of vegetation in its wake. This is also a good spot to scan the banks of the river with binoculars, to spot lurking fauna.

Carretera (15)
As its name indicates, this trail was once a gravel road connecting the station to a dock on the Madre de Dios River (see Aerodromo trail description). Some of the earth-moving equipment that traveled the road when the station was a mining camp is still parked around meter 75 of the trail. (The tangled bankruptcy proceedings of the mining company have so far prevented ACCA from donating, moving, or otherwise touching it.)

After a short start on the terrace the trail descends steeply towards the floodplain of the Madre de Dios River. Like the vegetation along Aerodromo trail, this forest is young and dominated by pioneer trees like *Cecropia*. Several spots along this sloping portion of the trail illustrate how the forest is slowly chipping away at the high terrace. Each time a tree falls here, it takes a little bit of the terrace with it; the death of an especially large tree or of a tree on an especially steep slope can take quite a lot of the terrace with it. These large landslides show up as prominent orange specks on high-resolution air photos of the Los Amigos concession.

At the base of the slope the trail crosses a stream on an old bridge (watch your step). This is the same stream that fills the reservoir which provides the station's water. A little farther on it disappears into a palm swamp, from which a small outlet trickles into the Madre de Dios.

The remainder of Carretera trail passes through a succession of abandoned gardens and plantations along the banks of the Madre de Dios. Because this land (like most floodplain forest along the Madre de Dios River) is within mining concessions, it continues to be visited (and illegally hunted, on occasion) by miners working the river banks. For many years, our neighbor's cows have invaded this part of the property, wandering as far as the intersection with Playa and Cocha Lobo trails. Our first solution to this problem—buying the cows and eating them—worked fine until the neighbor bought more cows. Our next solution will be a fence along the southern property line.

Cocha Lobo (14)
This trail leads to two oxbow lakes formed by past meanderings of the Río Los Amigos. The first, Cocha Seca, is old oxbow that only fills with water during floods or rainy periods; during the dry season one can walk across the lakefloor, which has filled in with dense vegetation. The second, Cocha Lobo, is a medium-sized oxbow lake that rises and falls with the seasons but never drains dry. The *cocha's* name refers to the giant river otters that visit occasionally, but have yet to establish a den. In the first six months of 2006, otters were seen here five times.

The first 100 m of the trail pass through young forest that was an agricultural plot not long ago. Banana and papaya trees grow along this section of trail, attracting an impressive suite of animals for secondary forest. (A researcher surprised a puma here in

May 2006.) To the south of the trail, just out of sight, is an old farm plot where several shadehouses were built in 2001 for a study on tropical cedar (*Cedrela* spp.) saplings. The shadehouses have since been abandoned and overgrown.

Past this short stretch of secondary forest the trail descends a short slope to the actual floodplain—land that is underwater during flooding of the Los Amigos and/or Madre de Dios. This a headwaters floodplain, which means that it is underwater for only a few days per year when especially strong rains in the Madre de Dios or Amigos watersheds push river levels above their banks, not permanently underwater for months on end as in downriver floodplains at Iquitos and Manaus.

The forest along most of this trail is old and well-developed, and is a good introduction to mature floodplain forest in Madre de Dios. Just after the intersection with Ficus trail, Cocha Lobo trail passes between two *Ceiba* trees so enormous that they are clearly visible from space, in the Ikonos image hanging in the dining hall.

Appendix 4.
A PRELIMINARY RED LIST FOR LOS AMIGOS

The Los Amigos Conservation Concession protects at least 27 species that are listed as globally threatened or near threatened in the 2004 IUCN Red List of Threatened Species. This list is preliminary to the extreme; most plant, invertebrate, fish, and reptile species in Madre de Dios have not been evaluated by the IUCN to date.

English name	Scientific name	Global Conservation Status
PLANTS		
Brazil Nut	*Bertholletia excelsa*	Vulnerable
(none)	*Caryocar amygdaliforme*	Endangered
Tropical Cedar	*Cedrela fissilis*	Endangered
Red Cedar	*Cedrela odorata*	Vulnerable
Fine-leaf Wadara	*Couratari guianensis*	Vulnerable
Bigleaf Mahogany	*Swietenia macrophylla*	Vulnerable
REPTILES		
South American Tortoise	*Geochelone denticulata*	Vulnerable
Yellow-spotted River Turtle	*Podocnemis unifilis*	Vulnerable
BIRDS		
Black-and-white Tanager	*Conothraupis speculigera*	Near Threatened
Rufous-fronted Anttrhush	*Formicarius rufifrons*	Near Threatened
Elusive Antpitta	*Grallaria eludens*	Near Threatened
Harpy Eagle	*Harpia harpyja*	Near Threatened
Crested Eagle	*Morphnus guianensis*	Near Threatened
Amazonian Parrotlet	*Nannopsittaca dachilleae*	Near Threatened
Orinoco Goose	*Neochen jubata*	Near Threatened
Blue-headed Macaw	*Propyrrhura (Ara) couloni*	Near Threatened
Peruvian Recurvebill	*Simoxenops ucayalae*	Near Threatened
MAMMALS		
White-bellied Spider Monkey	*Ateles belzebuth*	Vulnerable
Goeldi's Marmoset	*Callimico goeldii*	Near Threatened
Pacarana	*Dinomys branickii*	Endangered
Giant Anteater	*Myrmecophaga tridactyla*	Vulnerable
Jaguar	*Panthera onca*	Near Threatened
Giant Armadillo	*Priodontes maximus*	Endangered
Giant Brazilian Otter	*Pteronura brasiliensis*	Endangered
Puma	*Puma concolor*	Near Threatened
Bush Dog	*Speothos venaticus*	Vulnerable
Lowland Tapir	*Tapirus terrestris*	Vulnerable

Tabla 2. Las especies mundialmente amenazadas y casi amenazadas según la Lista Roja de la UICN 2006 que han sido registradas hasta la fecha en la CCLA. Categorías de amenaza: EN = En Peligro; VU = Vulnerable; LR/nt y NT = Casi Amenazada.

Tipo de	Nombre científico	Nombre común	Categoría

organismo			de amenaza
Árbol	*Cedrela fissilis*	Cedro	EN
Árbol	*Caryocar amygdaliforme*		EN
Mamífero	*Pteronura brasiliensis*	Lobo de río	EN
Mamífero	*Dinomys branickii*	Pacarana	EN
Árbol	*Bertholletia excelsa*	Castaña	VU
Árbol	*Couratari guianensis*	Misa	VU
Árbol	*Cedrela odorata*	Cedro	VU
Árbol	*Swietenia macrophylla*	Caoba	VU
Pájaro	*Ara militaris*	Guacamayo militar	VU
Tortuga	*Podocnemis unifilis*	Taricaya	VU
Tortuga	*Geochelone denticulata*	Motelo	VU
Mamífero	*Speothos venaticus*	Perro de monte	VU
Mamífero	*Priodontes maximus*	Carachupa gigante	VU
Mamífero	*Tapirus terrestris*	Sachavaca, tapir	VU
Murciélago	*Thyroptera lavali*		VU
Árbol	*Miconia abbreviata*		LR/nt
Árbol	*Minquartia guianensis*		LR/nt
Caimán	*Melanosuchus niger*	Caimán negro	LR/cd
Pájaro	*Conothraupis speculigera*	Tangara Negra y Blanca	NT
Pájaro	*Contopus cooperi*	Pibí Boreal	NT
Pájaro	*Formicarius rufifrons*	Gallito-Hormiguero de Frente Rufa	NT
Pájaro	*Harpia harpyja*	Aguila Harpía	NT
Pájaro	*Morphnus guianensis*	Aguila Crestada	NT
Pájaro	*Nannopsittaca dachilleae*	Periquito Amazónico	NT
Pájaro	*Neochen jubata*	Ganso del Orinoco	NT
Pájaro	*Simoxenops ucayalae*	Pico-recurvo Peruano	NT
Pájaro	*Tryngites subruficollis*	Playero Acanelado	NT
Murciélago	*Artibeus concolor*		LR/nt
Murciélago	*Artibeus obscurus*		LR/nt
Murciélago	*Glyphonycteris sylvestris*		LR/nt
Murciélago	*Platyrrhinus infuscus*		LR/nt
Murciélago	*Sturnira magna*		LR/nt
Murciélago	*Vampyressa bidens*		LR/nt
Murciélago	*Vampyressa brocki*		LR/nt
Primate	*Callimico goeldii*	Mono de Goeldi	NT
Mamífero	*Myrmecophaga tridactyla*	Oso hormiguero	NT
Mamífero	*Panthera onca*	Jaguar	NT
Mamífero	*Puma concolor*	Puma	NT

Tabla 3. Las especies amenazadas a nivel nacional según el Instituto Nacional de Recursos Naturales del Perú que han sido registradas hasta la fecha en la CCLA. Categorías de amenaza: CR = En Peligro Crítico; EN = En Peligro; VU = Vulnerable; LR/nt y NT = Casi Amenazada.

Tipo de organismo	Nombre científico	Nombre común	Categoría de amenaza
Liana	*Celtis iguanaea*		CR
Pájaro	*Neochen jubata*	Ganso del Orinoco	CR
Pajaro	*Ajaia ajaja*	Espátula Rosada	EN
Pajaro	*Mycteria americana*	Manchaco	EN
Mamífero	*Pteronura brasiliensis*	Lobo de río	EN
Mamífero	*Dinomys branickii*	Pacarana	EN
Árbol	*Cedrela fissilis*	Cedro	VU
Árbol	*Cedrela odorata*	Cedro	VU
Árbol	*Manilkara bidentata ssp. bidentata*		VU
Árbol	*Swietenia macrophylla*	Caoba	VU
Pájaro	*Ara chloroptera*	Guacamayo rojo y verde	VU
Pájaro	*Ara couloni*	Guacamayo verde de cabeza celeste	VU
Pájaro	*Ara macao*	Guacamayo rojo	VU
Pájaro	*Ara militaris*	Guacamayo verde	VU
Pájaro	*Harpia harpyja*	Aguila Harpía	VU
Pájaro	*Jabiru mycteria*	Jabiru	VU
Caimán	*Melanosuchus niger*	Caimán negro	VU
Tortuga	*Podocnemis unifilis*	Taricaya	VU
Mamífero	*Ateles chamek*	Maquisapa	VU
Mamífero	*Callimico goeldii*	Mono de Goeldi	VU
Mamífero	*Myrmecophaga tridactyla*	Oso hormiguero	VU
Mamífero	*Priodontes maximus*	Carachupa gigante	VU
Mamífero	*Tapirus terrestris*	Sachavaca, tapir	VU
Liana	*Abuta grandifolia*		NT
Liana	*Banisteriopsis caapi*	Ayahuasca	NT
Árbol	*Ceiba pentandra*	Ceibo	NT
Árbol	*Clarisia biflora*	Chimicua	NT
Árbol	*Clarisia racemosa*	Mashonaste	NT
Hierba	*Mikania guaco*		NT
Caimán	*Paleosuchus trigonatus*	Lagarto enano	NT
Pájaro	*Morphnus guianensis*	Aguila Crestada	NT
Pájaro	*Formicarius rufifrons*	Gallito-Hormiguero de Frente Rufa	NT
Pájaro	*Mitu tuberosum*	Paujil	NT
Pájaro	*Pipile cumanensis*	Pava	NT
Pájaro	*Pteroglossus beauharnaesii*	Tucán Encrespado	NT
Pájaro	*Simoxenops ucayalae*	Pico-recurvo Peruano	NT
Pájaro	*Conothraupis speculigera*	Tangara Negra y Blanca	NT

Pájaro	*Nannopsittaca dachilleae*	Periquito Amazónico	NT
Mamífero	*Alouatta seniculus*	Mono aullador	NT
Mamífero	*Panthera onca*	Jaguar	NT
Mamífero	*Puma concolor*	Puma	NT

Appendix 5.
LOS AMIGOS IN NUMBERS
Last updated September 2006

History
Number of archeological artifacts found since 2000 at Los Amigos: 4
Number of archeological studies carried out to date at Los Amigos: 0

First known published map of the Los Amigos River: 1902
Number of indigenous inhabitants living at the mouth of the Los Amigos River in the 1950s: ~50
Number of indigenous inhabitants living there today: 0

First date the CICRA terrace was cleared, in recent human memory: 1974
Date the AURINSA mining camp was built on the CICRA terrace: 1982
Number of men living in that camp during the 1980s: 120

Date CICRA property was purchased by ACCA:
Date CICRA station was completed: June 2002

Date Los Amigos Conservation Concession was established: 24 July 2001
Number of years in contract of Los Amigos Conservation Concession: 40
Date CM1 station was completed: April 2003
Date CM2 station was completed: October 2003

Geography
Location of CICRA in UTM: 380500E 8610297N
Location of CICRA in decimal degrees: 12.56 S 70.10W
Location of CICRA in degrees minutes seconds: 12°34’07”S 70°05’57” W
Elevation of CICRA terrace: 268 masl
Elevation of arbitrary zero at CICRA dock: 227 masl

Location of CM1 in UTM: 383826E 8609489N
Location of CM1 in decimal degrees: 12.57 S 70.06W
Location of CM1 in degrees minutes seconds: 12°34’17”S 70°04’29”W
Elevation of CM1: 238 masl

Location of CM2 in UTM: 363960E 8623430N
Location of CM2 in decimal degrees: 12.44S 70.25W
Location of CM2 in degrees minutes seconds: 12°26’57”S 70°15’06”W
Elevation of CM2: 259 masl

Location of CM3 in UTM: 377865E 8617215N
Location of CM3 in decimal degrees: 12.50S 70.12W
Location of CM3 in degrees minutes seconds: 12°30’21”S 70°07’26”W
Elevation of CM3: 251 masl

Air distance from CICRA to Puerto Maldonado: 100 km
Air distance from CICRA to Cusco: 231 km
Air distance from CICRA to Machu Picchu: 269 km
Air distance from CICRA to closest point of the Brazilian border: 168 km

Air distance from CICRA to closest point of the Bolivian border: 138 km

Air distance from CICRA to CM1: 3.5 km
Air distance from CICRA to CM2: 21.1 km
Air distance from CM1 to CM2: 24.3 km

Air distance from CICRA to Wayqecha Biological Station: 176 km
Air distance from CICRA to Cocha Cashu Biological Station: 162 km
Air distance from CICRA to Pakitza guardpost: 146 km
Air distance from CICRA to Explorer's Inn: 92 km
Air distance from CICRA to Tambopata Research Center: 83 km
Air distance from CICRA to (formerly Cusco Amazónico): 115 km

Air distance from CICRA to Balta: 298 km NNW
Air distance from CICRA to Pucallpa: 672 km
Air distance from CICRA to Iquitos: 1,036 km
Air distance from CICRA to Jenaro Herrera: 937 km

Area of Madre de Dios department: 85,183 km^2
Area of the Los Amigos watershed: 4,415 km^2
Ranking of the Los Amigos among all watersheds in the Peruvian headwaters of the Madre de Dios, by area: 6th
Highest elevation in Los Amigos watershed: 608 masl
Lowest elevation in Los Amigos watershed: 222 masl

Area of Los Amigos Conservation Concession when established in 2001: 135,831.47 ha
Area of Los Amigos Conservation Concession following enlargement in 2005: 145,918.22 ha
Highest elevation in Los Amigos Conservation Concession: 437 masl
Lowest elevation in Los Amigos Conservation Concession: 222 masl

Area of CICRA property in 2006: 440 ha
Highest elevation on CICRA property: 297 masl
Lowest elevation on CICRA property: 224 masl

Length of the Los Amigos River: 353.4 km
Distance from the mouth of the Los Amigos River to CM2, following the river: 47 km
Distance from the mouth of the Los Amigos River to CM3, following the river: 19 km
Air distance from the mouth of the Los Amigos River to the mouth of the Amazon River: 2,600 km
Air distance from the mouth of the Los Amigos River to the Pacific Ocean: 500 km

Proportion of Madre de Dios that is below 500 m elevation: 82%

Declination at Los Amigos: 5°16'W
Time: GMT -5
Earliest sunrise (21 December): 5:09 AM
Latest sunrise (21 June): 5:56 AM
Latest sunset (21 December): 6:01 PM
Earliest sunset (21 June): 5:20 PM
Longest day of the year (21 December): 12 hours, 52 minutes

Shortest day of the year (21 June): 11 hours, 24 minutes

Climate, hydrology, and disturbances
Number of months that daily weather data has been collected at Los Amigos since 2000: 73
Number of months that 30-minute weather data has been collected at Los Amigos since 2004: 28
Number of SENAMHI (government-operated) weather stations in lowland Madre de Dios: 2

Average annual temperature in the Los Amigos clearing since 2004: 24.2°C (75.6°F)
Highest temperature recorded in the Los Amigos clearing since 2004: 37.9° C (100.2°F)
Lowest temperature recorded in the Los Amigos clearing since 2004: 11.3° C (52.3°F)
Highest temperature recorded in the Los Amigos forest since 2000: 39.0° C (102.2°F)
Lowest temperature recorded in the Los Amigos forest since 2000: 9°C (48.2°F)

Average annual rainfall at Los Amigos since 2000: 2,684 mm
Number of months per year averaging <100 mm of rain since 2001: 1
Maximum annual rainfall since 2000: 3,498 mm (2003)
Minimum annual rainfall since 2000: 2,152 mm (2005)
Maximum 24-hour rainfall since 2000: 217.6 mm
Maximum 72-hour rainfall since 2000: 240.2 mm

Probability that it will rain during a given 30-minute period in January, the rainiest month: 11%
Probability that it will rain during a given 30-minute period in August, the driest month: 2%

Average relative humidity in the CICRA clearing since September 2004: 87.6%
Minimum relative humidity in the CICRA clearing since September 2004: 29.2%

24-hour average of solar radiation in the CICRA clearing since September 2004:

Maximum width of Madre de Dios River at the CICRA dock (high water season):
Minimum width of Madre de Dios River at the CICRA dock (low water season):
Maximum depth of Madre de Dios River near Los Amigos: 15 m
High-water means of Madre de Dios River depth near Los Amigos: 7-10 m
Low-water means of Madre de Dios River depth near Los Amigos: 2-5 m
High-water velocity of Madre de Dios River near Los Amigos: 11-14 km/hour

Highest daily level of the Madre de Dios River since 2001: +5.62 m (21 January 2003)
Lowest daily level of the Madre de Dios River since 2001: -3.85 m (9 September 2005)
Difference between record high and record low: 9.47 m
Proportion of water in the Madre de Dios River that is runoff from the Andes: about half

Number of *cochas* in the Los Amigos Conservation Concession: ~44

Number of landslides in the Los Amigos Conservation Concession in 2003: 381
Average landslide size in 2003: 0.24 ha
Percentage of Los Amigos Conservation Concession covered by landslides in 2003: ~0.5%

Biology
Number of species officially recorded in Los Amigos: >3,657
Number of new species described from collections made at Los Amigos: 0
Number of world diversity records held by Los Amigos: 1

Number of globally threatened plant and animal species at Los Amigos: 15
Number of globally near-threatened plant and animal species at Los Amigos: 12

Research and training
Earliest scientific work in the Los Amigos watershed: 1980s
Number of research projects at Los Amigos before 2000: 5
Number of research projects at Los Amigos since 2000: 132
Number of researchers and assistants hosted at Los Amigos since 2000: 333
Average daily number of researchers and assistants hosted at Los Amigos in 2005: 31

Number of peer-reviewed publications including data from Los Amigos: 21
Number of doctoral theses including data from Los Amigos: 1
Number of master's theses including data from Los Amigos: 7
Number of undergraduate theses including data from Los Amigos: 3
Number of books and unpublished reports including data from Los Amigos: 144

Number of field courses hosted at Los Amigos since 2000: 17
Number of students in these field courses: >300
Proportion of those students who were from Latin America: >80%

Number of grants given to support work at Los Amigos since 2003: 90
Percentage of grants awarded to Peruvian researchers and students: 60%
Percentage of grants awarded to researchers and students from other Latin American countries: >15%

Number of hectares of permanent tree plots in the Los Amigos watershed: 11.5
Number of trees examined each month at Los Amigos for phenological data: ~2,800

Infrastructure
Number of researcher/student beds at CICRA: 61
Number of researcher/student beds at CM1:
Number of researcher/student beds at CM2: 0
Number of tent spaces at CM2: 10
Number of researcher/student beds at CM3: 0

Length of trails at CICRA: 61.4 km
Length of trails at CM1: 116.8 km
Length of trails at CM2: 1.4 km
Length of trails at CM3: 46.2 km
Length of other trails: 32 km
Summed length of trails at Los Amigos: 257.8 km

Number of permanent staff at CICRA: 13
Number of *promotores*: 8
Proportion of CICRA's operating costs that are staff-related: 50%

Number of useful plant species in the ACEER botanical garden: 62
Number of useful plant species in the CICRA clearing: 32

Internet upload speed at CICRA: 100 kbps
Internet download speed at CICRA: 256 kbps
Daily cost of CICRA internet service: $14

Dimensions of CICRA airfield: 835 x 18 m
Maximum weight of planes permitted to land there: 11,000 lbs
Height of three communications towers built in the Los Amigos watershed in 2005: 60 m

Regional
Travel time in outboard canoe from CICRA to Boca Amigos: 5 minutes
Population of Boca Amigos:
Date of establishment of Boca Amigos: 1996

Travel time in outboard canoe from CICRA to San Juan: 40 minutes
Population of San Juan:
Date of establishment of San Juan:

Number of ecotourists who visit Madre de Dios each year: 70,000
Number of ecotourists who visit Los Amigos each year: 0
Number of biological stations in Madre de Dios:

Number of texts written about the biology of Madre de Dios, 1567-2005: >2,330
Number of scientific journals published in Madre de Dios: 1
Number of universities with forestry programs in Madre de Dios: 2
Number of universities with biology programs in Madre de Dios: 0

Other
Number of days each year that the Andean range is clearly visible from CICRA: <10

Number of palm leaves required to thatch the roof of the CICRA dining hall:
Cost of purchasing those palm leaves:
Expected lifetime of the roof: 6 years

Number of times the no-alcohol policy at CICRA has been relaxed and then reinstated because of problems: 4

Number of gallons of gasoline purchased by CICRA in the 2005-2006 fiscal year: >7,000
Number of gallons used by a typical American household each year: 1,060
Proportion of CICRA gasoline that was used for boat travel between Laberinto and CICRA: 92%

Mean number of daily visits to the ACA website during August 2006: 674
Number of donations made via the ACA website during 2004, 2005 and 2006: 3, 9, 16
Mean monthly total of tips left in the CICRA tip box since July 2006: $40

Number of steps from the CICRA dock to the terrace: 251
Record number of times someone has gone down and come up the stairs in 30 min.: 8

Fastest time yet recorded from the CICRA dock platform to the top of the stairs, running:

Number of students who have completed theses about Los Amigos without ever visiting Peru: 1

Proportion of visitors to CICRA who ask the Scientific Coordinator if he still has time to do his own research: 100%
Answer to the question: Yes

Appendix 6.
PUBLIC HEALTH AT LOS AMIGOS

Los Amigos is a healthy place to live. As was the case 50 years ago for Madre de Dios in general (González del Río 1960), the most commonly reported ailments among residents of and visitors to Los Amigos since 2000 are minor conditions like colds, stomach upset, and insect bites.

Leishmaniasis is endemic to Madre de Dios and has been contracted several times at Los Amigos (see Figure 5.1). Nearly all of the cases were contracted by people who had recently done field work in the upper Los Amigos watershed (CM2 and upriver). In 2008 we recorded the first two cases of leishmaniasis apparently contracted at CICRA itself. Everyone who contracted leishmaniasis at Los Amigos has received treatment and recovered completely.

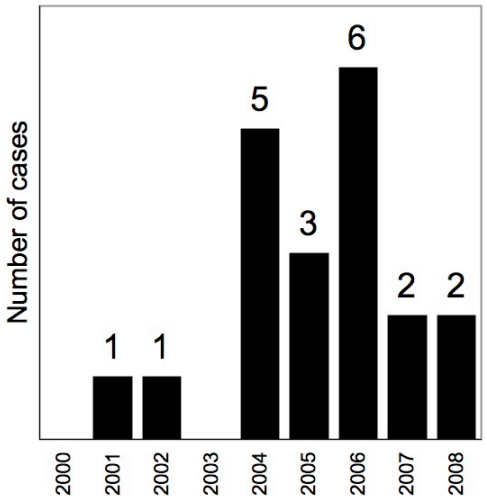

Figure 5.1. Number of leishmaniasis cases contracted in Los Amigos by staff and visitors, 2000-2008.

Stomach upset is common at Los Amigos. One obvious cause is the large number of visitors whose bodies are not yet accustomed to the South American intestinal flora. Intestinal parasites, a more serious cause of stomach upset, are commonly diagnosed in people who live and travel in rural South America, and many kinds are endemic to Madre de Dios. Most staff at Los Amigos take antiparasite medication twice a year whether or not they have been diagnosed, since parasites are often missed in lab tests. Leptospirosis, a bacterial disease contracted from dirty water and endemic in Amazonia, has been diagnosed at least once in Los Amigos. Stomach problems are more common at the station during the rainy season than during the dry season, which suggests that most illnesses are waterborne.

Malaria is endemic to Madre de Dios and several dozen cases are reported each year in Puerto Maldonado hospitals. *Vivax* is the most common type of malaria contracted in the region, but *falciparum* has also been reported as present. No one living or working at Los Amigos since 2000 has contracted malaria, and next to no one takes prophylactic medication. The highest risk of malaria contraction for visitors to Los Amigos is probably an overnight stay in Puerto Maldonado; it is worth checking that one's hotel room has good screens.