# Appendix A. The Study Sites

This appendix contains descriptions of the 46 systems which served as the principal foci of field investigations, along with notes on the composition and structure of the vegetation. Note that descriptions of the study site floras from the three regions which were examined in detail (the Cloud Forest, Chapter 3; the Chapare, Chapter 4; and, the Gran Pantanal, Chapter 5) were presented in these chapters.

## High Andean

Despite the semi-arid to arid conditions that are characteristic of the Bolivian High Andean region, various types of wetlands (*i.e.*, lakes, ponds, streams, small rivers, riparian marshes, and marshes) were common. The larger systems were often fairly accurately located on maps, and, as the paucity of woody vegetation in the Puna allowed for expansive vistas, wetlands were easily encountered during general reconnaissance. This region possessed such a large number of study sites due to both the close proximity of High Andean habitats to the my home in Cochabamba, and to the relative ease with which these systems were encountered. Eight study sites were established in the High Andean region (Table A.1): five lakes (four created or modified by impoundments, and one natural lake), two ponds, and one riparian wetland.

Table A.1 Study sites in the High Andean region (Bolivia), with elevation, approximate area of the system, approximate location, and number of species noted for each site.

| System | Elev. (m) | Approximate Area (ha) | Approximate Location | No. Spp. |
|---|---|---|---|---|
| Laguna Toro | 4420 | 2.5 | 66°23'W 17°11'S | 15 |
| Huayalmarca Pond | 4300 | 0.1 | 66°41W 17°39'S | 3 |
| Laguna Saythu Khocha | 4020 | 40 | 65°39'W 17°23'S | 7 |
| Laguna Totora Khocha | 3620 | 120 | 66°38'W 17°27'S | 20 |
| Laguna Larati | 3540 | 124 | 66°02'W 17°21'S | 25 |
| Laguna Juntutuyo | 3360 | 244 | 65°39'W 17°34'S | 7 |
| Río Candelaria | 3165 | 1 | 65°56'W 17°16'S | 31 |
| Chulichuncani Laguna | 3160 | 20 | 65°22W 17°34'S | 15 |

**Laguna Toro**

Elevation: 4420 m. Watershed: Amazon Number of species: 15
Dates visited: Sep 23, 1994; Mar 9, 1995; Dec 1, 1996

Laguna Toro, the highest elevation study site (ca. 4420 m), was an approximately 2.5 ha pond, with a maximum depth of about 3 m. The Río Khullarijoni– which was hardly more than a stream (maximum width, ca. 2.5 m) in the area around Laguna Toro– provided a year-round, low volume flow through the system. Directly upstream from where the Khullarijoni entered the system, the river took a sinuous path, forming a small marsh. The basin was bordered by steep slopes on the southern and western edges, and runoff from these slopes drained into the system.

The pond basin possessed a complex morphometry, with the southern half flat-bottomed and shallow (ca. 0.5-1.0 m), and the remainder deeper, with sharply sloped sides. The shallows were vegetated by small, submerged species. Typical species were *Crassula venezuelensis* (Crassulaceae), *Lilaeopsis macloviana* (Apiaceae), *Lilaea scilloides* (Juncaginaceae), *Isoëtes lechleri* and *I. herzogii* (Isoëtaceae), and *Pilularia americana* (Marsileaceae). *Calamagrostis eminens* (Poaceae) formed a series of hummocks in this part of the system, and other emergent herbs, such as *Schoenoplectus californicus* (Cyperaceae) and *Alopecurus aequalis* (Poaceae) were common. The deeper parts of the basin were dominated by the submerged macrophyte *Myriophyllum quitense* (Haloragaceae). Another submerged species, *Ruppia filifolia* (Ruppiaceae), was fairly common in this zone.

No rare species were observed at Laguna Toro. Nevertheless, the population of *Myriophyllum quitense* was noteworthy for possessing some unusual characteristics (see Appendix E). Laguna Toro was located in an area of low population density, and appeared to be subjected to only a small amount of anthropogenic disturbance; generally from fishing and grazing livestock (predominantly llamas).

**Huayalmarca Pond**

Elevation: 4300 m Watershed: Desaguadero Number of species: 3
Dates visited: Jun 4, 1994; Feb 25, 1995

The Huayalmarca Pond was a small (ca. 0.1 ha) pond situated downslope from the highway between Cochabamba and La Paz. The system was shallow, with a maximum depth of less than 0.75 m, nevertheless, it apparently contained water throughout the year. The pond received inputs of water from runoff draining the adjacent slopes, and from a small seep at one end of the basin, which also appeared to be wet year-round. Pond water was rich in suspended material, and water color was an opaque white.

Although the Huayalmarca Pond was very species-poor (3 spp.), it was selected as a study site because of the extreme alkalinity (pH 10.0-10.4) of the water. Despite the low species richness, aquatic vegetation filled the basin, with two submerged macrophytes, *Myriophyllum quitense* and *Stuckenia filiformis* (Potamogetonaceae) present in abundance.

No rare or noteworthy species were observed at this site. Anthropogenic disturbance appeared to be limited to the road construction, and the resultant erosion, above the site.

**Laguna Saythu Khocha**

Elevation: 4020 m. Watershed: Amazon Number of species: 10
Dates visited: Jul 2, 1994; Oct 11, 1994

Laguna Saythu Khocha was located on the eastern Cordillera near the lower limits of the Puna vegetation zone. The lake was a fairly large (ca. 40 ha), artificial system that was formed by damming the shallow end of a natural depression. The dam appeared to be of fairly recent origin (*i.e.*, within the last 5-20 years). Presumably, some type of wetland served as the "nucleus" for the system. Overflow from the system passed through a stream (unnamed on the topographic map) which flowed into the Río Talpasale. Lake water was clear and somewhat acidic (pH = 6.5). Although water levels were controlled by a floodgate, at the time of the second visit to the site (well into the dry season) water levels were about 2.5 m below the floodgate. Maximum depth of the system was not determinable.

Although Laguna Saythu Khocha was somewhat richer in species (10 spp.) than many of the high elevation lakes encountered in this study, vegetative cover was generally sparse. No emergent species were noted; rather, the flora was composed almost entirely of submerged species. Common species were *Crassula venezuelensis* (Crassulaceae), *Limosella* sp. (Scrophulariaceae), *Elodea potamogeton* (Hydrocharitaceae), *Myriophyllum quitense*, and *Isoëtes* sp. (Isoëtaceae). As noted, during the dry season water levels dropped substantially, exposing a broad band (varying from ca. 5-20 m) of relatively flat lake bottom and allowing short-lived annual herbs (primarily, *Alchemilla* sp., Rosaceae) to become established. No rare or noteworthy species were observed at this system.

A small agrarian community was located on the western side of the mountains, a few kilometers downslope from Laguna Saythu Khocha, and villagers passed by the lake on their way to harvest firewood from the forested areas (Ceja de Monte, and Cloud Forest) on the eastern side of the Cordillera. Nevertheless, other than the modifications to the original system and the control of water levels, there were no obvious indications of anthropogenic disturbance to the system.

**Laguna Totora Khocha**

Elevation: 3620 m. Watershed: Amazon Number of species: 20
Dates visited: Jun 28, 1994; Jul 2, 1994; Apr 26, 1995

Laguna Totora Khocha was a large (ca. 120 ha) lake. Previously, the lake was significantly smaller, but in 1991 construction of a dam was completed on the southern end of the system, thereby greatly increasing the system's area and depth. According to a sign posted along the edge of the lake, the system possessed a maximum depth of 18 m and a volume of 22,000,000 $m^3$. Lake water was basic (pH = 8.1), with abundant filamentous algae. Outflow from Laguna Totora Khocha formed the Río Jatun Mayu.

The vascular flora consisted primarily of submerged species. Typical species were *Crassula venezuelensis* (Crassulaceae), *Myriophyllum quitense* (Haloragaceae), *Elodea potamogeton* (Hydrocharitaceae), *Isoëtes boliviensis* (Isoëtaceae), and *Potamogeton pusillus* (Potamogetonaceae). With the exception of *Poa annua* (Poaceae), no emergent species were observed. Vascular species were generally limited to a fairly narrow band

around the perimeter of the lake, however, during the dry season, small islands were exposed as water levels dropped. These islands supported populations of diminutive herbs, many of which are typical of streams and marshes in the area and others which were of uncertain ecological affinity. Typical "island" species were *Spergula arvensis* (Caryophyllaceae), *Erodium cicutarium* (Geraniaceae), *Paspalum pygmaeum* (Poaceae), and *Cotula australis* (Rosaceae). No rare or noteworthy species were observed.

Anthropogenic disturbance appeared to be limited to modifications of the original system and the continued control of water levels. Although Laguna Totora Khocha most likely once possessed large reed beds ("totora" is Quechua for *Schoenoplectus californicus*), the construction of the dam apparently resulted in the extirpation of this species from the site.

**Laguna Larati**

Elevation: 3540 m. Watershed: Amazon Number of species: 25
Dates visited: May 29, 1994; Jul 14, 1994; May 5, 1995, Oct 5, 1995

Laguna Larati was another large (ca. 124 ha), high elevation lake that had been modified by the construction of a dam. The dam had clearly been in existence longer than dams of the other high elevation systems of anthropogenic origin (probably 30-50 years), allowing macrophytes to become well-established. At least two seasonal streams flowed into the basin and others may be present. Lake water was cloudy white, with abundant solids in suspension. Outflow from the system formed the Río Apacheta Mayu, which in the area around Laguna Larati was scarcely more than 1.5 meters wide. Species encountered in the lake basin and in the "river" just below the spillway were included in the site checklist.

Laguna Larati possessed a rich flora (25 spp.) for a high-elevation system. Submerged species were abundant along the edges of the system, occupying depths up to ca. 2.5 m. Common species were *Myriophyllum quitense* (Haloragaceae), and *Potamogeton illinoensis*, and *P. pusillus* (Potamogetonaceae). The submerged herbs *Callitriche heteropoda* (Callitrichaceae) and *Elodea potamogeton* (Hydrocharitaceae) were locally abundant below the spillway and in quiet areas along the stream banks.

Emergent species were common, with *Juncus arcticus var. andicola*, J. fuscocapitatus, and *J. pallescens* (Juncaceae), and *Polypogon interuptus* (Poaceae) representative. Two aquatic ferns were present. *Marsilea crotophora* (Marsileaceae) was abundant in the shallows and in depths up to ca. 1.2 m and *Azolla mexicana* (Salviniaceae) was common in the area beneath the spillway.

Small islands (at least some of which were seasonally submerged) were present and these supported a distinct flora. Species typical of this habitat were *Hydrocotyle ranunculoides* (Apiaceae), *Eleocharis acicularis* (Cyperaceae), *Ludwigia peploides* (Onagraceae), and *Castilleja pumila* (Scrophulariaceae). Island surfaces that were still slightly inundated at the time of the fieldwork supported dense populations of the diminutive herb *Limosella subulata* (Scrophulariaceae).

Laguna Larati was atypical for a Bolivian high Andean system. The flora possessed an extremely complex structure for a high altitude site. Life-forms noted included emergent, submerged, free-floating, rooted with floating leaves, and rooted with floating stems. Many of the species encountered at this site were not observed in other Bolivian wetlands during this study, although none were new country records. Two species noteworthy for their presence in a high altitude system were *Ludwigia peploides* and *Potamogeton illinoensis* (see Appendix E).

The land surrounding the lake was utilized for farming and grazing, and the community of Larati was large by high Andean standards (ca. 300-500 residents). Nevertheless, little anthropogenic disturbance was noted at the site, although, agricultural run-off might have had a negative impact on the system. Grazing from livestock generally appeared to be minimal. An exception was *Marsilea polycarpa*, which was grazed when the plants became easily accessible in the dry season due to subsiding water levels. A much greater threat to Laguna Larati came from the city of Cochabamba, which was located approximately 15 km from the system. In 1995, it was decided to increase the area of the lake in order to incorporate Laguna Larati into the city's municipal water supply. The proposed plan entailed raising the level of the dam by a number of meters, a modification

that clearly would negatively impact existing aquatic vegetation. Species associated with the seasonally inundated islands would be particularly vulnerable.

**Laguna Juntutuyo**

Elevation: 3360 m. Watershed: Amazon Number of species: 7
Dates visited: Sep 9, 1994; Apr 3, 1995; May 27, 1995

Laguna Juntutuyo, was a large (ca. 244 ha) lacustrine system located in a dry, high elevation valley situated between the Cochabamba valley and the Mizque valley. This system was the third largest of a complex of six large lacustrine systems; these most likely were once a single system. Water color was an opaque brown, and the water had a distinct saline taste. Maximum depth of the system was not determined, but it exceeded 3.5 meters (the length of a pole used to propel the log raft that was utilized during botanical collecting).

Despite Laguna Juntutuyo's large size, the flora was quite species-poor (7 spp.). The submerged herb *Myriophyllum quitense* (Haloragaceae) was by far the most abundant species; S*tuckenia filiformis* and *S. striata* (Potamogetonaceae) were common. Although compact, submerged species (*e.g.*, *Crassula venezuelensis*, Crassulaceae; *Elatine* spp., Elatinaceae) are frequently abundant in the shallows of high Andean lakes, no species with this life-form were noted in Laguna Juntutuyo. *Schoenoplectus californicus* (Cyperaceae) was the sole abundant emergent species. Large populations of this species were present along the edges of the basin, growing in depths of ca. 0.5-2.0 m. The free-floating fern *Azolla caroliniana* (Salviniaceae) was fairly abundant at one end of the system; this species is said to be extremely abundant, at times (A. Zabala Alvarado, pers. com). No rare or noteworthy species were observed at this system.

Laguna Juntutuyo was subjected to some anthropogenic disturbance. A number of small agrarian communities (*e.g.*, Estancia Juntutuyo, Estanica Chimpa Khocha, Estancia Juntutuyo Pampa) were located within a few kilometers of Laguna Juntutuyo. During the dry season, cattle were driven into the lake to browse, with *Myriophyllum quitense* and *Stuckenia striata* the preferred species. Additionally, *Schoenoplectus totora* was harvested for use as roofing thatch, and for building traditional Andean reed boats.

**Río Candelaria**

Elevation: 3165 m. Watershed: Amazon Number of species: 31
Dates visited: May 27, 1994; Feb 9, 1995; May 30, 1995

The Río Candelaria study site was a section of a high elevation river located on a plateau on the Cordillera Oriental, between the Cochabamba valley and the descent to the Amazon basin. The river was fed by run-off from the steep slopes bordering the area and experienced intense hydrologic pulses during periods of rain. Consequently, the river was fairly dynamic, and during the course of this study deposition and erosion changed the structure and floristic composition of some of the areas included in the study site. A section of the Río Candelaria approximately 0.5 km long (total area ca. 1.0 ha) was surveyed. This section was selected for study because it possessed a fairly complex morphology, with small strand lakes (or, more properly, "strand ponds") present in areas formerly occupied by the main channel and with marshy habitats present in low-lying adjacent areas. The main channel of the river possessed water throughout the year, however, at least some of the strand lakes and marshes were subject to dry-down during the dry season.

Río Candelaria supported a rich flora (31 spp.) for a high elevation system. Emergent species were the predominant life-form. Representative species were *Eryngium* cf. *coronatum* (Apiaceae), *Pycreus niger* (Cyperaceae), *Juncus ebracteatus* and *J. bufonius* (Juncaceae), *Polypogon viridis*, and *Deyeuxia rigescens* (Poaceae), and *Rumex conglomeratus* (Polygonaceae). *Hydrocotyle ranunculoides* (Apiaceae) was extremely abundant along the edges of the strand lakes, where it formed loosely coalesced floating mats. Submerged species were much less abundant than emergents, with *Lilaeopsis macloviana* (Apiaceae), *Callitriche* sp. (Callitrichaceae), *Crassula venezuelensis* (Crassulaceae), and *Isolepis inundata* (Cyperaceae) representative species. *Alchemilla pinnata* (Rosaceae), *Cotula australis* (Asteraceae), and *Mimulus glabratus* (Scrophulariaceae) were present along the river banks. As water levels dropped, sand bars became exposed and these supported various herbaceous species, a number of which were not observed elsewhere in the system. Representative species were *Sagina procumbens* (Caryophyllaceae), *Equisetum bogotense* (Equisetaceae), *Plantago buchtienii* (Plantaginaceae), *Poa annua* (Poaceae), and *Limosella aquatica*

(Scrophulariaceae). These areas were particularly vulnerable to erosion and deposition. The sole noteworthy species encountered at Río Candelaria was the cosmopolitan weed *Sagina procumbens* (see Appendix E).

The system appeared to experience some anthropogenic disturbance, primarily from livestock grazing in the marshes. Nevertheless, impacts from human activities were clearly small-scale relative to the hydrologic disturbances (*e.g.*, deposition of sediments, and channel migration) which were characteristic of this system.

**Chulichuncani Laguna**

Elevation: 3160 m. Watershed: Amazon Number of species: 15
Date visited: Apr 26, 1995

The Chulichuncani Laguna was an approximately 20 ha, artificial lake, situated on the slopes (the Cerro Macho Corral) above the community of Estancia Chulichuncani. The system was situated above the old highway to Santa Cruz, ca. 50 km east of the Serranía de Siberia Wetland. Although the terrestrial vegetation immediately around the laguna was Puna, Cerro Macho Corral was situated in the transition between the Valles Secos and the Cloud Forest. The system appeared to receive greater inputs of atmospheric water (precipitation and fog) than did high Andean systems in the Cordillera del Tunari.

The lake was created by damming the Río Chulichuncani. A deep basin occupied the western half of the lake. Maximum depth was not determinable, however, the dam was approximately 12-15 m tall at its highest point. The eastern half of the basin was characterized by a much more shallow topography, and depths did not exceed 2 meters. Seasonally inundated marsh was present along the south and southwestern edges of the basin. It was difficult to determine the magnitude of annual fluctuations in water level, although the presence of species such as *Crassula venezuelensis* (Crassulaceae) and *Elatine peruviana* (Elatinaceae) along the gradually sloping edges suggests that these areas are inundated throughout much of the year. Therefore, annual variations in water level most likely were not large-scale. At the time of the visit to the site (in the first few months of the dry season) the water level was just slightly below the level of the spillway.

The sides of the basin along the deeper (western) end of the system were quite steep and vegetation was scarce. The shallowly sloped, eastern portion of the basin supported a number of species, although vegetation was often sparse. Common emergents were *Juncus microcephalus* (Juncaceae), and *Agrostis perennans* and *Amphibromus scabrivalvis* (Poaceae). Small submerged species were also fairly common, with *Crassula venezuelensis* (Crassulaceae), *Elatine peruviana* (Elatinaceae), and *Limosella aquatica* (Scrophulariaceae) representative species. The seasonally inundated marshes supported an abundance of herbaceous vegetation. Common species were *Cotula mexicana*, *Gamochaeta americana*, *Gnaphalium dombeyanum*, and *Hypochoeris apargioides* (Asteraceae), *Spergula arvensis* (Caryophyllaceae), *Plantago australis* (Plantaginaceae), and *Ranunculus flagelliformis* (Ranunculaceae). The sole species of note at the Chulichuncani Laguna was *Amphibromus scabrivalvis*, an aquatic grass with lax semi-floating culms, which was common in the shallow end of the system (see Appendix E).

Anthropogenic disturbance appeared to be minimal, other than the control of water levels. Abundant livestock were noted in the area, but there were other water sources nearby and these appeared to be more heavily frequented than the Chulichuncani Laguna.

This system was worthy of more than the single visit it received, but the site's inaccessibility served as a deterrent to return visits. A particular incentive to continued fieldwork in the Chulichuncani Laguna was provided by the boiled potatoes, hard-boiled eggs, and “locoto” (*Capsicum pubescens*) that residents of the nearby community of Khewiña Pampa offered for sale along the highway. These are highly recommended as a source of comfort to researchers whose chest-waders may have recently been filled with water from a high Andean lake.

# Valles Secos

Four systems served as study sites in the Valles Secos (Table A.2): one lake, two riparian marshes, and one irrigation channel. Additionally, general collections were made from other wetlands in the Valles Secos, principally seasonal ponds, riparian habitats, and irrigation channels and ditches.

Table A.2. Study sites in the Valles Secos region (Bolivia), with elevation, approximate area of the system, approximate location, and number of species noted for each site.

| System | Elevation (m) | Approximate Area (ha) | Approximate Location | No. Spp. |
|---|---|---|---|---|
| Laguna Alalay | 2550 | 175 | 66°08'W 17°24'S | 32 |
| Río Mizque Wetland | 1970 | 0.5 | 65°18'W 17°56'S | 65 |
| Río Guadalquivir Wetland | 1800 | 0.05 | 64°44'W 21°32'S | 49 |
| Tiquipaya Irrigation Canal | 2620 | 0.02 | 66°13'W 17°21'S | 16 |

## Laguna Alalay

Elevation: 2550 m Watershed: Amazon Number of species: 33
Dates visited: Apr 6, 1994; May 25, 1994; Mar 18, 1995; Apr 1, 1995; Jan 10, 1996; Oct 3, 1996; Oct 23, 1996; Jun 24, 1997

Laguna Alalay was a large (ca. 175 ha) basin system located within the city of Cochabamba. The basin was shallow throughout; average water depth was estimated at 69.8 cm (Maldonado and Goitia 1989). Maximum depth was on the order of ca. 2.0 m. Water conditions were basic, with average measured pH ranging from 9.8-10.3 (Maldonado and Goitia 1989). Water was dark brown. Basin sediments were soft and deep, averaging 54.5 cm in areas without macrophytes and 72.7 cm in areas with macrophytes (Maldonado and Goitia 1989).

When fieldwork commenced in Laguna Alalay, vegetation was abundant throughout much of the system. Subsequent human activities, however, greatly affected the distribution of vegetation (see below). The most abundant emergent species were *Schoenoplectus californicus* and *S. americanus* (Cyperaceae), *Echinochloa crus-pavonis* (Poaceae), *Polygonum lapathifolium* and *P. punctatum* (Polygonaceae), and *Typha domingensis* (Typhaceae). Species typical of seasonally inundated habitats along the edge of the system were *Baccharis juncea, Eclipta prostrata, Pluchea sagittalis* (Asteraceae), and *Tessaria integrifolia* (Asteraceae), *Heliotropium curassavicum*

(Boraginaceae), *Pycreus niger* and *Schoenoplectus americanus* (Cyperaceae), *Chenopodium ambrosioides* (Chenopodiaceae), and *Rumex crispus* (Polygonaceae). *Tessaria integrifolia* was the sole woody species observed in the system. Following major changes to the system's hydrology (see below), *Heliotropium curassavicum* and *Chenopodium ambrosioides* were particularly abundant, dominating large-areas of the recently exposed lake bed.

Free-floating species were *Lemna gibba*, *Wolffia columbiana* and *Wolffiella oblonga* (Lemnaceae), and *Azolla caroliniana* (Salviniaceae). At times, *A. caroliniana* was extremely abundant, covering extensive areas (ca. 40-50 ha) of the system; at other times this species was inconspicuous. The sole rooted species with floating stems was *Ludwigia grandiflora* (Onagraceae), which formed small, loosely-knit floating assemblages in one part of the system. Despite the dark water and the episodic blanketing of the surface by *Azolla caroliniana*, submerged species were abundant. Submerged species were *Myriophyllum quitense* (Haloragaceae), and *Potamogeton pusillus, Stuckenia striata* and *S. pectinata* (Potamogetonaceae). In extensive areas of the system, dense populations of filamentous algae were present, although this varied seasonally (see Maldonado and Goitia 1989). No rare species were observed at Laguna Alalay, but a few species were noteworthy, either for possessing unusual characteristics or for approaching the known elevational limits of their distribution (see Appendix E).

Laguna Alalay was heavily impacted by human activities. The system served as an informal dumping ground for all manner of refuse and most likely received raw sewage from the surrounding neighborhoods. In recent years, Laguna Alalay has experienced severe perturbation. In 1995 the lake was partially drained in an attempt to install a system to facilitate the aeration of the typically stagnant, foul-smelling water. Water levels, therefore, were lower than normal during the dry season and a much larger than normal area of basin was exposed during dry down. Additionally, in 1997 the city initiated dredging the lake. A dike was constructed, bisecting the basin, water was drained from one side of the system, and the basin was deepened. The dredged portion of the system was left without water for a long period (a year or two), and was subsequently refilled. This process was then repeated for the area on the other side of the dike.

The close proximity of Laguna Alalay to my home in Bolivia facilitated numerous visits to the site. Despite this accessibility, the system's deep, mushy sediments–which were of decidedly suspicious, anthropogenic origin–and the site's powerful stench, assured that the system was visited no more often than was absolutely necessary.

**Río Mizque Wetland**

Elevation: 1970 m Watershed: Amazon Number of species: 65
Dates visited: Jan 8, 1995; Apr 6, 1995; May 28, 1995, Nov 11, 1996

The Río Mizque wetland was a riparian wetland, situated ca. 2 km south of the town of Mizque. The wetland was structurally complex, and incorporated a series of meander scrolls, intervening marshy areas, and three streams which passed through these areas on their way to the Río Mizque. The system was also hydrologically complex. Many parts were annually flooded during the rainy season when the river level rose. Some areas were only temporally inundated, however, the three streams provided year-round water to other parts of the system. One section of the wetland also received ground water from a hillside seep. Soils were variable, ranging from compacted silty sand to soft, fairly deep deposits of silt. An approximately 300 m long section of the river, including areas along both banks, was selected for study. Total study area was about 0.5 ha.

The site supported a species-rich flora (65 spp.), with slightly more than half (55.4%) of these contributed by three families: the Poaceae (14 spp.; 21.5%), Asteraceae (12 spp.; 18.5%), and Cyperaceae (10 spp.; 15.4%). Emergent species were the dominant life form. The most abundant emergents were *Pluchea sagittalis* and *Tessaria integrifolia* (Asteraceae), *Eleocharis flavescens, E. montana,* and *Pycreus bipartitus* (Cyperaceae), *Juncus microcephalus* (Juncaceae), *Echinochloa* crus-pavonis, *Imperata tenuis,* and *Paspalum distichum* (Poaceae), *Polygonum punctatum* (Polygonaceae), *Pityrogramma trifoliata* (Pteridaceae), and *Salix humboldtiana* (Salicaceae). Two emergent species, *Commelina* sp. (Commelinaceae) and *Dalea cliffortiana* (Fabaceae), were common in shallowly inundated areas along the upland edge of the system. The creeping semi-aquatic herbs *Bacopa monnieri* (Scrophulariaceae), *Mimulus glabratus* (Scrophulariaceae), and *Rorippa nasturtium-aquaticum* (Brassicaceae) were abundant along the upland edge of the system and in shallow pools. *Ludwigia peploides*

(Onagraceae) was extremely abundant in shallow pools alongside the main river channel, occurring both as a creeping herb and as a rooted macrophyte with floating stems.

Submerged species were nearly absent, with a small population of *Callitriche* sp. (Callitrichaceae) the only example of this life-form noted. Free-floating species were well-represented. The water hyacinth, *Eichhornia crassipes*, was extremely abundant, completely covering the surface of some meander scrolls. Other free-floating species were *Azolla caroliniana* and *A. filiculoides* (Salviniaceae), and *Lemna aequinoctialis* and *L. minuta* (Lemnaceae). The sole climber noted was *Mikania micrantha* (Asteraceae). Despite the rich flora relative to other Valles Secos wetlands, no rare or noteworthy species were observed.

The Río Mizque Wetland was periodically subjected to anthropogenic disturbance. At times, cows were tethered in the meander scrolls to graze. In the 1990's, a concrete bridge was built over the wetland, and was rebuilt a few years later (see below). These construction activities must have impacted the wetland; however, the largest disturbances to the wetland appeared to come from the Río Mizque itself. During the rainy season, when water velocities are high, a portion of the substantial bed load transported by the river will be spread through sections of the wetland. Additionally, the river can periodically rise far above its normal flood level and move through the study site area with great force. For example, the first bridge that was built over the wetland during the early 1990's lasted only a few years until it was destroyed by an unusually high flood. This magnitude of flood (ca. 3 m over the water's "normal" height during the rainy season) must have flooded the entire study site area.

**Río Guadalquivir Wetland**

Elevation: 1800 m Watershed: Paraná Number of species: 49
Dates visited: Dec7, 1996; Dec 9, 1996; Dec 10, 1996.

The Río Guadalquivir Wetland, another riparian wetland, was the southernmost study site. The portion of the Río Guadalquivir that was selected for study was situated in the northwestern section of the city of Tarija. Two separate areas comprised the study site. The first, located along the west bank of the Río Guadalquivir, was structurally similar to the Río Mizque Wetland. Predominant features were: 1) meander scrolls; 2) seasonally

inundated areas directly adjacent to the main river channel, with numerous, scattered pools; and, 3) small streams. The second area was located along the east bank, approximately 300 m upstream from the first. The predominant feature of this area was a shallowly inundated (ca. 0.7 m) marsh. Total area included in the study site was approximately 0.5 ha This system was quite dynamic hydrologically, as per the Río Mizque Wetland.

The flora was species-rich (49 spp.) and was dominated by emergent vegetation. The most abundant emergent species were *Gnaphalium dombeyanum* (Asteraceae), *Chenopodium ambrosioides* (Chenopodiaceae), *Juncus microcephalus* and *J. tenuis* (Juncaceae), *Luziola peruviana* and *Paspalum distichum* (Poaceae), *Polygonum* punctatum and *P. persicaria* (Polygonaceae), *Salix humboldtiana* (Salicaceae), *Typha domingensis* (Typhaceae), and *Veronica anagallis-aquatica* (Scrophulariaceae). The shrub *Baccharis salicifolia* (Asteraceae) and the herb *Acicarpha tribuloides* (Calyceraceae) were common in the transition between wetland and upland.

The sole submerged species was *Myriophyllum aquaticum* (Haloragaceae), which also possessed an erect, semi-terrestrial form in formerly inundated areas. Free floating species were *Eichhornia crassipes* (Pontederiaceae), *Spirodela intermedia* and *Lemna* sp. (Lemnaceae), and *Azolla mexicana* (Salviniaceae). *Eichhornia crassipes* was particularly abundant, at times nearly covering the surface of meander scrolls. The two noteworthy species observed at this site were *Myriophyllum aquaticum* and *Oenothera tarijensis* (see Appendix E).

Due to its location in an urban area, this system has been heavily impacted by anthropogenic activities. The edges of the wetland were used for dumping trash and construction material. Chemical pollution was probably the most significant threat to the site, as the Río Guadalquivir is said to be highly contaminated (Óscar Barrenachea, PROMETA, pers. com.).

**Irrigation Canal at Tiquipaya**

Elevation: 2620 m. Watershed: Amazon Number of species: 16
Dates visited: Apr 5, 1994; Apr 21, 1994

This study site was a section of a network of irrigation and drainage canals in the community of Tiquipaya (Cochabamba valley). Irrigation canals and ditches are common in populated areas of the Valles Secos. These frequently support hydrophytic species and species tolerant of some inundation along their edges and on channel bars. The hydrologic regime in these systems is extremely variable. Water flow is controlled by floodgates and it is not uncommon for water levels to change by a meter, or more, in a brief period. Hence, areas immediately adjacent to the canals, which spend the greatest part of the year above water, can suddenly be inundated, and at times, non-hydrophilic species can be encountered growing under water.

A stretch of canal approximately 50 m long was surveyed. No submerged or free-floating species were observed; rather the flora consisted entirely of emergent species and erect, weedy species growing under saturated conditions. The most abundant species were *Cyperus eragrostis, Eleocharis montana,* and *Schoenoplectus californicus* (Cyperaceae), *Echinochloa crus-pavonis* (Poaceae), and *Polygonum persicaria* (Polygonaceae).

In addition to their anthropogenic origin, these systems were continually heavily impacted by human activities and thus would appear to be poor candidates for the vegetation study. Nevertheless, these canals most likely functioned as corridors for the dispersal of macrophytes throughout the Valles Secos, hence their inclusion in this study.

## Cloud Forest

Six wetland systems served as the principal study sites in the Cloud Forest (Table A.3). Additional data were incorporated from general collecting in a variety of other wetlands, such as small marshes, streams, rivers, inundated roadside ditches, and vernal pools.

Table A.3. Study sites in the Cloud Forest region (Bolivia), with elevation, approximate area of the system, approximate location, and number of species noted for each site.

| System | Elev. (m) | Approximate Area (ha) | Approximate Location | No. Spp. |
|---|---|---|---|---|
| Chimpa Huata Bog | 2920 | 0.05 | 65°55'W 17°12'S | 23 |
| Incachaca Pond | 2385 | 1.00 | 65°49'W 17°15'S | 26 |
| Laguna Khonchu - East | 2620 | 0.07 | 17°09'S 65°56'W | 12 |
| Laguna Khonchu - West | 2620 | 0.09 | 17°09'S 65°56'W | 13 |
| Corani Pampa Marsh | 2470 | 0.02 | 65°58'W 17°06'S | 26 |
| Serranía de Siberia Marsh | 2800 | 0.75 | 64º45"W 17º51'S | 7 |

## Chimpa Huata Bog

Elevation: 2920 m. Watershed: Amazon Number of species: 23
Dates visited: Jul 5, 1994; Aug 26, 1994; Feb 14, 1995; May 31, 1995; Dec 7, 1995

The Chimpa Huata Bog was a small (ca. 0.05 ha) *Sphagnum* bog located on the slopes of the Cerro Chimpa Huata, directly alongside the ancient Incan roadway leading from the community of Candelaria to the community of Corani Pampa. Although small populations of *Sphagnum* spp. were often present in seeps and in protected areas alongside rivers and streams in upper montane habitats, this was one of the few systems I encountered that possessed a well-developed floating *Sphagnum* mat. The bog mat, although fairly thick, was noticeably weaker than mats of New England bogs and frequently proved incapable of supporting a person's weight.

The bog occupied a small depression at the base of a steep section of slope. The area surrounding the bog was a mixture of relatively undisturbed forest, secondary forest, and patches of open grassland, some of which were maintained by seasonal burning. Water at the site was stained a very dark brown and had a maximum depth of about 2 meters. Sediments were organic overlying clay. The site was visited under varying hydrologic conditions: during relatively dry conditions in July and August of 1994, and under wetter conditions in February, May, and December of 1995. The bog appeared to suffer little direct anthropogenic disturbance, although livestock were observed stepping through the bog mat to drink from the system.

**Incachaca Pond**

Elevation: 2385 m Watershed: Amazon Number of species: 26
Dates visited: Oct 2, 1994; Oct 30, 1994; Feb 12, 1995; Apr 2, 1995; June 7, 1995; Jul 14, 1997

The Incachaca Pond was an artificial system, with an area of ca. 1.0 ha. The system was fairly shallow throughout, with a maximum depth of about 1.2 m. Water was a transparent brown. Sediments were deep and very soft. The pond received year-round inflow through a concretized channel leading from a nearby river, with outflow occurring through a small stream at the end of the pond farthest from the inflow. The terrain above the northern edge of the system was fairly steep, and undoubtedly a significant amount of runoff drained into the pond from this area during the wetter seasons.

The Incachaca Pond was the most heavily impacted of the Cloud Forest study sites. The area surrounding the Incachaca Pond formerly supported primary cloud forest, however, in recent decades the forest has been severely fragmented by human activities. During the 1950s or thereabouts, the area surrounding the pond was logged and converted to pasture as part of a program to introduce livestock production to the region. This activity was apparently unsuccessful, and only a small number of cows and pigs are now in evidence in the area. Subsequently, the largest part of the cleared land was left fallow, and these areas developed into a shrub-scrub dominated by a weedy species of *Lepechinia* (Lamiaceae). In a later development program, a large (ca. 5-10 ha) area directly upslope from the pond was planted with *Pinus radiata*. Currently, the pond and its environs are the site of a substantial amount of recreational activity, from day visitors from the nearby (ca. 2 hours) city of Cochabamba (population 900,000) who frequent the area for hiking and fishing.

**Lagunas Khonchu East and West**

Elevation: 2620 m Watershed: Amazon Number of species: 12/13
Dates visited: Aug 31, 1994; Feb 4, 1994; Jun 1, 1995

The Lagunas Khonchu East and West were two ponds, located about 5 km downslope from the Chimpa Huata Bog and situated alongside the same trail as that system. While the name “Lagunas Khonchu” appears on a topographical map of the area, the descriptive

names “east” and “west” have been applied here to differentiate between the two systems and refer to their orientation relative to the trail.

Laguna Khonchu East was a small pond, approximately 0.07 ha in area, with a shallowly sloped basin. Laguna Khonchu West was slightly larger (ca. 0.09 ha) and was more heterogeneous, with a shallow central basin fringed by a matrix of marshy areas and small open channels at either end of the system. Maximum depth of both basins was less than 1 m. Although somewhat opaque, the water at these sites was much clearer than that of the Chimpa Huata Bog. Sediments were silt and clay. The surrounding terrestrial vegetation was relatively undisturbed primary forest, and anthropogenic disturbance at the two wetlands appeared to be minimal.

**Corani Pampa Marsh**

Elevation: 2470 m. Watershed: Amazon Number of species: 26
Dates visited: Sept 7, 1994; Apr 14, 1995; May 25, 1995

The Corani Pampa Marsh was a small streamside marsh. The marsh developed when streamflow was restricted by the installation of a culvert at the downstream end of the marsh. The marsh had a length of approximately 25 m and a maximum width of about 6 m. Depth of inundation ranged from shallowly inundated areas to a small pool greater than 1.5 m deep. Substrata were variable, ranging from firm sand and gravel areas along the edges, to deep, mushy sediments in the more permanently inundated areas.

**Serranía de Siberia Marsh**

Elevation: 2800 m Watershed: Amazon Number of species: 7
Date visited: Feb 3, 1996

The Serranía de Siberia marsh was a small *Sphagnum* dominated marsh. Although the other Cloud Forest study sites were situated on the eastern slope of the Cordillera Oriental, the Serranía de Siberia Marsh was located on the generally drier, western side of the Cordillera. Nevertheless, the area around the town of Siberia receives significant amounts of precipitation and fog during the year and undisturbed terrestrial habitats in the area typically support elfin forest with an extremely closed canopy and abundant epiphytes.

This system was situated along the “Old Highway” from Cochabamba to Santa Cruz, an unpaved road that formerly constituted the principal route between these cities. The system consisted of a small, shallow pond bordered on three sides by marshy habitat. Total area was approximately. 0.75 ha. The pond and marsh supported a variety of emergent species, particularly members of the Cyperaceae and Juncaceae. This site received a single visit in February of 1996. At this time, which was well into the rainy season, maximum depth of the pond was about 0.75 m. Despite the close proximity to the road, this system appeared to be little-disturbed. Athough a single visit to this site was insufficient for a total inventory of the flora, this system’s disjunct location, as well as the presence of a number of species not encountered elsewhere, warranted the inclusion of the Serranía de Siberia Marsh as a study site.

## The Chapare

Seven wetland systems were established as study sites in the Chapare (Table A.4), and field research was concentrated on these systems.

Table A.4. The Chapare Study Sites (Bolivia), with elevation, approximate area of the system, approximate location, and number of species noted for each site.

| Study Site Name | Elev. (m) | Approximate Area (ha) | Approximate Location | No. Spp. |
|---|---|---|---|---|
| Mariposa Wetland | 220 | 1.5 | 65°02'W 17°01'S | 49 |
| Ivirgarsama Marsh | 200 | 0.7 | 64°50'W 17°01'S | 46 |
| Senda F Wetland | 200 | 0.2 | 65°08'W 16°52'S | 19 |
| Villa Tunari Pond | 300 | 0.3 | 65°26'W 17°01'S | 11 |
| Sinahota Pond | 240 | 0.15 | 65°18'W 17°00'S | 9 |
| Valle de Sajta Curichi | 220 | 0.2 | 64°43'W 17°07'S | 6 |
| Puerto Villarroel Laguna | 200 | 30 | 64°48'W 16°49'S | 6 |

Additional collections were made from a variety of other wetlands, including inundated roadside ditches, streams, small rivers, and seasonal ponds and pools.

**Mariposa Wetland**

Elevation: 220 m Watershed: Amazon Number of species: 49
Dates visited: Nov 27, 1994; Mar 5, 1995; Jun 8, 1995; Nov 1, 1996

The Mariposa Wetland was located alongside the highway from the Chapare to Santa Cruz, approximately 1.5 km east of the community of Mariposa. The system consisted of two small (<0.3 ha) ponds fringed with a strip of marshy habitat. The ponds occupied shallow depressions (ca. 2 m deep) that were created when fill for an adjacent highway was excavated from the site. The marsh was situated between the ponds and the highway and was essentially a particularly wide (ca. 50 m) section of the "borrow canals" that typically flanked the highway and other roads in the region. Although these canals extend for many kilometers, investigations of the Mariposa "system" were limited to an approximately 200 m long section of marsh, centered on the two ponds. A small, seasonal stream delineated the western edge of the study site. Total study site area was ca. 0.8 ha.

In contrast to many similar small bodies of water in the Chapare, the ponds contained water throughout the year, suggesting that they received some subsurface water inflow. During the dry season, standing water disappeared from most areas of the marsh, and soil conditions varied from fairly dry to saturated during this period. Although this system undoubtedly received substantial inputs of runoff from adjacent uplands during the rainy season, there were no large rivers near the site. Thus, the system did not appear to receive the periodic influxes of water-borne sediment that were characteristic of many of the Chapare's aquatic habitats.

**Ivirgarsama Marsh**

Elevation: 220 m. Watershed: Amazon Number of species: 46
Dates visited: Feb 23, 1996; May 10, 1996; Oct 27, 1996

The Ivirgarsama Marsh was located alongside the unpaved road that connected the highway to Santa Cruz with the town of Puerto Villarroel. The system was composed of a small (ca. 0.2 ha), shallow pond, with an adjoining (ca. 0.5 ha) marshy area in the area between the pond and the road. Smaller sections of marsh were also present along the

other edges of the pond. A narrow stream flowed through the system, entering the pond at its southern end and discharging through the marsh at the far end of the system. As with the Mariposa Wetland, the marsh was essentially a widening of a typical roadside borrow canal, however the pond at the Ivirgarsama Marsh appeared to be of natural origin.

The Ivirgarsama Marsh was unique among the Chapare study sites because of the well-developed floating mats of vegetation that were present along the edges of the pond. Although floating mats are a characteristic feature of aquatic habitats throughout most parts of the Bolivian lowlands, they appeared to be uncommon in the Chapare.

**Senda F Marsh**

Elevation: 220 m. Watershed: Amazon Number of species: 19
Dates visited: Jun 1, 1994; Nov 11, 1994; Mar 4, 1995.

The Senda F Marsh was located alongside the unpaved road that originated in the town of Chimoré, proceeding north through a series of small communities (Comunidades Senda A-Senda F) until it reached the zone of influence of the Río Chapare. The Senda F Marsh was contiguous with the borrow canals which flanked the road. The area surveyed was approximately 80 m long with a maximum width of about 15 m on either side of the road. A small stream flowed into the southeast corner of the marsh and a number of small, fairly deep pools were present. Thus, habitat heterogeneity was much higher than was typical for the region's roadside canals. Water levels at the site fluctuated seasonally and standing water was absent from parts of the marsh during the driest portions of the year.

**Villa Tunari Pond**

Elevation: 300 m. Watershed: Amazon Number of species: 11
Dates visited: Nov 12, 1994; Mar 5, 1995; Jun 8, 1995

The Villa Tunari Pond was a small pond located alongside the Cochabamba-Santa Cruz highway, approximately 4 km east of the town of Villa Tunari. Due to its location at the start of the ascent of the Cordillera Oriental (Eastern Range) of the Andes, this system was at a slightly higher elevation (300 m) than the other Chapare sites. During the dry season, the pond basin occupied an area of approximately 0.3 ha with a maximum depth of about 2.0 m. During the rainy season, large portions of the upland areas adjacent to

the pond become shallowly inundated and the limits of the "system" were indistinct. Water levels dropped significantly during the dry season. Although the system was never observed to be entirely without standing water, it seems likely that this might occur during dry years.

**Sinahota Pond**

Elevation: 240 m Watershed: Amazon Number of species: 9
Dates visited: Nov 12, 1994; Jun 8, 1995

The Sinahota Pond was another small (approximately 0.15 ha), seasonal pond situated alongside the Cochabamba-Santa Cruz highway, ca. 2 km west of the town of Sinahota. Maximum depth during the rainy season was about 2.0 m; during the dry season the system dried out completely. The basin was fairly steep-sided and, in contrast to the Villa Tunari Pond, inundation did not appear to extend to the surrounding areas during high water stages.

**Valle de Sajta Curichi**

Elevation: 210 m. Watershed: Amazon Number of species: 6
Date visited: Mar 20, 1995

In the Bolivian lowlands, a "curichi" is a system that occupies a section of a former river channel, and which normally does not dry down completely during the dry season (Beck 1984). The Valle de Sajta Curichi consisted of two small ponds separated by a narrow (10 m) strip of land. The ponds originally were part of a river channel, most likely the nearby Río Zabala, and developed into their present form after being stranded due to channel migration. This system was said to contain water year-round, and the ponds appeared to be connected by an subterranean passage.

**Puerto Villarroel Laguna**

Elevation: 190 m. Watershed: Amazon Number of species: 6
Dates visited: Mar 19, 1995; Nov 1, 1996

The Puerto Villarroel Laguna, a large curichi, was the largest and deepest of the Chapare study sites. Despite being located in a region of "white-water' (*sensu* Sioli 1975), the water was stained dark from organic acids. Maximum depth was difficult to determine, but appeared to be at least 4 m. The lake's area was estimated using the cut and weight

method (Lind 1985) on a topographical map (scale 1:100,000). By this method, the system was found to occupy 70 ha, however during visits to the site, the area was visually estimated at about 15 ha. As a compromise, 30 ha was selected as a rough approximation of the system's size.

## Andean Piedmont

Two study sites were established in the Andean Piedmont region (Table A5). A small amount of additional fieldwork was conducted in the region, principally in seasonal ponds, riparian wetlands, and seasonally inundated grasslands.

Table A.5. Study sites in the Andean Piedmont of Santa Cruz (Bolivia), with elevation, approximate area of the system, approximate location, and number of species noted for each site.

| System | Elev. (m) | Approximate Area (ha) | Approximate Location | No. Spp. |
|---|---|---|---|---|
| Bermudez Curichi | 430 | 15.0 | 63°16'W 17°46'S | 70 |
| Viru Viru Wetland | 430 | 15.0 | 63°16'W 17°40'S | 75 |

### Bermudez Curichi

Elevation: 430 m Watershed: Amazon Number of species: 70
Dates visited: May 6, 1995; May 8, 1995; Jun 3, 1995; Nov 25, 1996; June 26, 1997; July 28, 1998

The Curichi at Bermudez was a crescent-shaped system, located in the grassy plains west of the outskirts of the city of Santa Cruz. The Bermudez Curichi occupied a section of the former channel of the Río Piray–which currently passes a kilometer, or so, to the east of the system. After the Río Piray shifted its course, the system appears to have been no more than a shallow pond. At some point, however, a dike was constructed along the low end of the basin, deepening the system appreciably. Total area of the system was about 15 ha. Inputs from rainfall and groundwater through a hillside seep at the western end of the system were sufficient to fill and maintain the basin to the level of the overflow in the dike (maximum depth ca. 2.5 m). When first visited in 1995, the Curichi was a magnificent (from a botanical point of view), rich system, however it has since been significantly altered (see below). The following description of the flora represents the system before these alterations.

The vegetation of the Bermudez Curichi was rich (71 spp.) and structurally complex. The eastern end of the system exhibited an extremely marked zonation. Moving from open water toward the upper limits of the system, the zones were: 1) deepest water dominated by submerged species; 2) shallower water dominated by rooted macrophytes with floating leaves; 3) 1-3 distinct zones dominated by different emergent herbaceous species; and, 4) a shrub-dominated zone. In many areas, the zone closest to open water was occupied by loosely coalesced floating mats of vegetation. The central portion of the Curichi was more shallowly inundated than was either end. During the rainy season, this central area was inundated to a depth of ca. 1.0 m; during the dry season standing water was scarce or absent, although the soil appeared to remain saturated. The western end of the Curichi was similar to that of the eastern end, although zonation of the vegetation was not nearly so evident.

Submerged species were *Mayaca longipes* and *M. fluviatilis* (Mayacaceae), and *Bacopa aquatica* (Scrophulariaceae). "Nymphaeaceous" species (*i.e.*, rooted macrophytes with floating leaves) were particularly well-represented. Species were *Sagittaria guayanensis* (Alismataceae), *Hydrocleys nymphoides* and *H. parviflora* (Limnocharitaceae), *Nymphoides indica* (Menyanthaceae), and *Ludwigia sedoides* (a rooted macrophyte with its upper leaves crowded toward the tip of the stem and forming floating "rosettes"). Surprisingly, no free-floating species were observed, although the free-swimming herb *Utricularia foliosa* (Lentibulariaceae) was abundant in some parts of the system. Species which formed loosely-coalesced floating mats were *Eichhornia azurea* and *P. subovata* (Pontederiaceae), and, to a lesser degree, *Hydrocotyle bonariensis* (Apiaceae).

Emergent species were particularly well-represented. The most abundant emergent herbaceous species were *Eleocharis interstincta*, *Fuirena umbellata*, and *Scleria setuloso-ciliata* (Cyperaceae), *Syngonanthus caulescens* (Eriocaulaceae), *Limnocharis flava* (Limnocharitaceae), T*halia geniculata* (Marantaceae), *Andropogon bicornis, Homolepis aturensis,* and *Panicum schwackeanum* (Poaceae), and *Polygonum ferrugineum* (Polygonaceae). Emergent shrubs and shrubby herbs were *Aeschynomene fluminensis* (Fabaceae), *Hydrolea spinosa* (Hydrophyllaceae), *Rhynchanthera grandiflora* (Melastomataceae), and *Ludwigia martii* (Onagraceae). Climbing species were not

abundant, nor diverse, and were represented by only two species *Aniseia martinicensis* and *Ipomoea regnellii* (Convolvulaceae). A number of noteworthy species were encountered in the Bermudez Curichi *Apalanthe granatensis, Bacopa aquatica, Ludwigia martii,* and *Mayaca longipes* (see Appendix E).

As noted, the Bermudez Curichi has been subjected to significant disturbance. In 1996, the owner of the land initiated a process to deepen the system by the breaching the dike, thereby draining much of the basin. A number of small, primarily seasonal pools remained, however, and these supported some of the species which had been abundant before the disturbance. Additionally, weedy hydrophilic species, such as *Torulinium odoratum* and *Kyllinga odorata* (Cyperaceae), became established around pool edges. The system remained in this condition for approximately a year, after which the dike was repaired and the basin allowed to refill. It was not apparent whether or not the basin was deepened during this process. Of note, some of the more noteworthy species, such as *Mayaca longipes* and *Bacopa aquatica*, which were not observed at the site during the "drying down period", were both abundant after the dike had been restored. Furthermore, two submerged species not observed before modifications to the system, *Cabomba furcata* (Cabombaceae) and *Apalanthe granatensis* (Hydrocharitaceae), were both common afterwards.

**Viru Viru Wetland**

Elevation: 430 m Watershed: Amazon Number of species: 75
Dates visited: Jun 4, 1995; Jan 14, 1996; May 25, 1996; Aug 2, 1996; Jun 28; 1997

The Viru Viru Wetland was a marsh located near the Santa Cruz International Airport. The wetland had an area of approximately 15 ha, and was structurally complex incorporating a variety of permanently and seasonally inundated marshy habitats, and a small (ca. 0.75 ha), but fairly deep (maximum depth > 2.5 m) pond. The system was also hydrologically complex, with some areas fed by runoff and groundwater from adjacent slopes and other sections apparently relying on rainwater as the major water input.

The Viru Viru Wetland supported a rich flora (75 spp.), with a particularly rich pteridophyte component (11 spp.). Common emergent herbaceous species were *Commelina diffusa* (Commelinaceae), *Eleocharis minima* and *E. mutata* (Cyperaceae),

*Imperata contracta*, *Leersia hexandra*, and *Luziola peruviana* (Poaceae), *Polygonum punctatum* and *P. acuminatum* (Polygonaceae), and *Acrostichum danaeifolium* and *Pityrogramma trifoliata* (Pteridaceae). Emergent shrubs and shrubby herbs were represented by *Aeschynomene sensitiva* (Fabaceae), *Hydrolea spinosa* (Hydrophyllaceae), *Hibiscus sororius* (Malvaceae), *Ludwigia peruviana* (Onagraceae), and *Piper aduncum* and *P. gaudichaudianum* (Piperaceae).

Floating mats, composed principally of either *Oxycaryum cubense* or *Typha domingensis*, were characteristic of many areas. These provided a substratum for colonization by other species, and were often sufficiently buoyant and adherent to support a person's weight. Species commonly associated with floating mats, either as secondary colonizers or growing in openings in the mat matrix, were *Hydrocotyle ranunculoides* (Apiaceae), *Begonia fischeri* (Begoniaceae), *Utricularia gibba* (Lentibulariaceae), *Erythrodes* sp. and *Xylobium* sp. (Orchidaceae), *Pityrogramma calomelanos* (Pteridaceae), and *Thelypteris interrupta* and *T. serrata* (Thelypteridaceae). Small individuals of the arborescent *Sapium glandulosum* (Euphorbiaceae) grew on *Typha* mats in one area.

Free-floating macrophytes were common and fairly diverse. Species were *Limnobium laevigatum* (Hydrocharitaceae), *Lemna aequinoctialis* and *L. valdiviana* (Lemnaceae), *Ludwigia helminthorrhiza* (Onagraceae), *Ceratopteris pteridoides* (Pteridaceae), and *Azolla mexicana* and *Salvinia minima* (Salviniaceae). Additionally, the free-floating liverwort *Ricciocarpus natans* (Ricciaceae) was locally abundant in one area. Nymphaeaceous species were poorly represented, with *Hydrocleys nymphoides* (Limnocharitaceae) the sole representative of this life-form. In contrast to the Bermudez Curichi, which supported a rich submerged flora, no submerged species were observed at the Viru Viru wetland.

Climbers were common, with Asclepiadaceae Indet., *Mikania congesta* (Asteraceae), *Ipomoea ramosissima* and *Merremia umbellata* (Convolvulaceae), *Centrosema pubescens* and *Vigna adenantha* (Fabaceae), and *Odontocarya* sp. (Menispermaceae) representative species. Common species in the seasonally inundated transition zone along the upper edge of the system were *Pycreus bipartitus* (Cyperaceae), *Teucrium*

*vesicarium* (Lamiaceae), *Ammannia latifolia* (Lythraceae), *Anagallis pumila* (Primulaceae), and *Stemodia hyptoides* (Scrophulariaceae). Despite the rich flora, the only species of note encountered at the Viru Viru Wetland was the robust emergent fern *Acrostichum danaeifolium* (see Appendix E).

Conspicuous seasonal changes in floristic composition were observed in parts of the system. During the rainy season, some areas were nearly completed covered by free-floating macrophytes. These species disappeared as water levels subsided, with the areas then supported abundant emergent herbs.

The Viru Viru Wetland was located in a fairly high population area, nevertheless, direct anthropogenic disturbance did not appear to be significant. The edges of the system were used for dumping refuse, but few impacts beyond this were noted.

## White-water Floodplain

Three study sites–two lakes, and one basin swamp–were established in the White-water Floodplain region (Table A.6). Additionally, general collections were made from other wetlands in the region, principally streams, rivers, roadside marshes, and curichis and ponds.

Table A.6. Study sites in the White-water Floodplain Region (Bolivia), with elevation, approximate area of the system, approximate location, and number of species noted for each site.

| System | Elev. (m) | Approximate Area (ha) | Approximate Location | No. Spp. |
|---|---|---|---|---|
| Riberalta Ciénaga | 170 | 150 | 66°03'W 11°02'S | 81 |
| Laguna Tumi Chuqua | 170 | 300 | 66°11'W 11°08'S | 34 |
| Laguna Suarez | 160 | 560 | 64°52'W 14°53'S | 97 |

### Riberalta Ciénaga

Elevation: 170 m Watershed: Amazon Number of species: 81
Dates visited: Oct 11-13, 1996; Jul 5, 1997

The Riberalta Ciénaga (swamp) was a large (150 ha), steep-sided basin swamp, located on the outskirts of the town of Riberalta in northern Bolivia. The system occupied a section of the former channel of the Río Beni. Rivers can be very dynamic in this region,

but the Río Beni clearly migrated long ago and there were no indications that the Ciénaga is ever flooded by overflow from the river. The Río Beni was a whitewater system, however, owing to the buildup of acids from the slow decomposition of accumulated plant matter, the Riberalta Ciénaga water was better classified as a "secondarily blackwater" system.

The flora was quite rich (81 spp). Large portions of the system support swamp forest, many parts of which appeared to be inundated year-round. Arborescent species were *Tabebuia insignis* (Bignoniaceae), *Diospyros nur* (Ebenaceae), *Hevea brasiliensis* (Euphorbiaceae), *Macrolobium acaciifolium* and *Pterocarpus santalinoides* (Fabaceae), *Hasseltia floribunda* (Flacourtiaceae), *Cariniana* sp. (Lecythidaceae), *Lueheopsis hoehnei* (Tiliaceae), and *Mauritia flexuosa* (Arecaceae). Shrubs and shrubby perennials were fairly abundant, particularly along the edge of the system, and were well-represented. Species were *Combretum lanceolatum* (Combretaceae), *Hyptis lacustris* (Lamiaceae), *Aeschynomene ciliata, A. fluminensis*, and *Mimosa schrankioides* (Fabaceae), *Hibiscus furcellatus* (Malvaceae), *Cybianthus longifolius* (Myrsinaceae), and *Ludwigia nervosa* (Onagraceae).

Floating mats occurred throughout the system, both in areas below the canopy, and in non-forested areas. *Eleocharis acutangula, Fuirena umbellata,* and *Oxycaryum cubense* (Cyperaceae) were the most common mat-forming species, with *F. umbellata* the most abundant, particularly in areas beneath the canopy. *Eichhornia azurea* (Pontederiaceae), another mat-forming species which is often abundant in Bolivian lowland aquatic habitats, was not observed in Riberalta Ciénaga, nor were any other members of the Pontederiaceae. Their exclusion was most likely due to the system's acidic conditions. Species commonly associated with floating mats were *Chromolaena laevigata, Eclipta prostrata, Enhydra anagallis*, and *Pacourina edulis* (Asteraceae), *Begonia fischeri* (Begoniaceae), *Cyperus haspan* (Cyperaceae), *Irlbachia alata* (Gentianaceae), *Sinningia sceptrum* (Gesneriaceae), *Habenaria* aff. *repens* and *H. sartor* (Orchidaceae), *Panicum grande* (Poaceae), and *Alectra aspera* (Scrophulariaceae).

Common emergent herbs were Erechtites hieracifolia (Asteraceae), Urospatha sagittifolia (Araceae), Rhynchospora corymbosa (Cyperaceae), Andropogon bicornis, Homolepis aturensis, Isachne polygonoides, and Panicum hylaeicum (Poaceae), Polygonum acuminatum (Polygonaceae), Thelypteris interrupta (Thelypteridaceae), and Xyris laxifolia (Xyridaceae). One portion of the basin was characterized by a channel and hummock topography, with the emergent fern Thelypteris serrata (Thelypteridaceae) the dominant species. The perennial herb Hypolytrum longifolium (Cyperaceae) was common in seasonally inundated areas along the system edge.

Free-floating species were Pistia stratiotes (Araceae), Limnobium laevigatum (Hydrocharitaceae), Lemna valdiviana and Wolffiella lingulata (Lemnaceae), Azolla caroliniana, Salvinia auriculata and S. minima (Salviniaceae). The free-floating liverwort, Ricciocarpus natans (Ricciaceae) was also present. No rooted macrophytes with floating leaves were observed.

Climbers were particularly diverse, with *Rhabdadenia macrostoma* (Apocynaceae), *Mikania congesta* (Asteraceae), *Combretum laxum* (Combretaceae), *Ipomoea regnellii* and *Tetralocularia pennellii* (Convolvulaceae), *Melothria pendula* (Cucurbitaceae), *Senna pendula* and *Vigna longifolia* (Fabaceae), *Odontocarya tamoides* (Menispermaceae), and *Cissus erosa* (Vitaceae) representative species. The semi-climbing sedge, *Scleria flagellum-nigrorum* (Cyperaceae) formed dense, nearly impenetrable tangles in some parts of the transition between wetland and upland.

Access to the swamp was frequently quite difficult and moving through the system was particularly trying. Therefore, many parts of the system were not investigated. Arborescent species were most likely particularly under-represented in the site checklist. A single noteworthy species, *Diospyros nur*, was observed at this system (see Appendix E).

The Riberalta Ciénaga is fringed on two sides by the town of Riberalta; however, direct human impacts to the system appeared to be minimal. Among local residents, the system was reputed to contain enormous anacondas (*e.g.*, 15 m long, with diameters greater than a meter). Fortunately, I was unable to corroborate their existence.

**Laguna Tumi Chuqua**

Elevation: 170 m Watershed: Amazon Number of species: 34
Approximate center of the system: 66°11'W 11°08'S
Dates visited: Oct 14, 1996; Jul 8, 1997

Laguna Tumi Chuqua was a large (ca. 300 ha) oxbow lake, located in the northern Departamento of Beni, approximately 40 km south of the town of Riberalta. As with the Riberalta Ciénaga, the system occupied a section of a former channel of the Río Beni. During high water stages, the Río Beni periodically breaches the uplands that separate the laguna from the current main channel. Local residents indicated that this occurs approximately every 12-15 years. During the initial site visit, the lake water possessed the crystalline green color that was characteristic of numerous lakes viewed during overflights of the region. The second visit to the site occurred during a particularly rainy year, shortly after the Río Beni had overflowed into the laguna. There were abundant sediments in suspension, and the water had much more the appearance of a "whitewater" system.

Species richness was low for an Amazonian system of this size (34 spp.), although this may be partially accounted for by the site having received only two visits. The genus *Ludwigia* was particularly well-represented, with six species.

The system contained numerous floating mats; these were generally weakly coalesced, and were not extensive. Mat-forming species were *Leersia hexandra* and *Paspalum repens* (Poaceae), and *Eichhornia crassipes* and *Pontederia rotundifolia* (Pontederiaceae). Some mats were sufficiently adherent to support secondary colonizers. These included *Cyperus surinamensis* and *Torulinium odoratum* (Cyperaceae), *Limnocharis* flava (Limnocharitaceae), *Ludwigia leptocarpa* (Onagraceae), *Phlebodium decumanum* (Polypodiaceae), *Sphenoclea zeylanica* (Sphenocleaceae), and *Thelypteris interrupta* (Thelypteridaceae).

Submerged macrophytes (*e.g.*, *Potamogeton pusillus,* Potamogetonaceae; *Najas arguta,* Najadaceae) were abundant in depths up to ca. 1.5 m during the first visit to Laguna Tumi Chuqua. During the second visit (*i.e.*, after sediment-rich water from the Río Beni had

poured into the system), however, no submerged species were encountered. Free-floating species were generally rare and were poorly represented, with *Ludwigia helminthorrhiza* (Onagraceae), and *Salvinia auriculata* and *S. minima* (Salviniaceae) the only species noted. *Nymphaea amazonum* (Nymphaeaceae) and *Ludwigia sedoides* (Onagraceae) were the sole "Nymphaeaceous" species.

Due in part to the steep basin sides, emergent species were generally not very abundant. In general, these were restricted to marshy edge habitats, and in seasonally inundated areas along the banks. Emergent herbaceous species were *Gymnocoronis spilanthoides* (Asteraceae), *Ludwigia hyssopifolia* (Onagraceae), *Dactyloctenium aegyptium* (Poaceae), *Polygonum acuminatum* (Polygonaceae), and *Lindernia crustacea* (Scrophulariaceae). Shrubs and shrubby perennials were common in marshy edge habitats, with *Mimosa xanthocentra* and *Sesbania exasperata* (Fabaceae), *Cuphea melvilla* (Lythraceae), *Hibiscus peruvianus* (Malvaceae), and *Ludwigia affinis* (Onagraceae) representative species. Climbers were abundant in a few areas, yet diversity in this life-form was low, with *Mikania congesta* (Asteraceae) and *Centrosema vexillatum* (Fabaceae) the sole species noted. Despite the relatively small flora, Laguna Tumi Chuqua possessed two noteworthy species: *Potamogeton pusillus* (Potamogetonaceae) and *Ludwigia hyssopifolia* (Onagraceae) (see Appendix E).

A small community was present along the eastern end of Laguna Tumi Chuqua. However, anthropogenic impacts to the system appeared to be minimal.

**Laguna Suarez**

Elevation: 160 m Watershed: Amazon Number of species: 97
Approximate center of the system: 64°52'W 14°53'S
Dates visited: Jun 15, 1996; Jun 17-20, 1996; Aug 4, 1996; Aug 6, 1996; Nov 18, 1996; July 1-2, 1997

Laguna Suarez was a large (ca. 600 ha) lake located in the southeastern corner of the Llanos de Moxos, the seasonally inundated savannas of the central Departamento of Beni. Laguna Suarez belongs to the class of "oriented fault lakes"– lacustrine systems with strait edges, which are oriented in a SW to NE alignment (Allenby 1988)– which characteristically occur in the Beni Basin. Despite it's large area, Laguna Suarez was

extremely shallow throughout, with maximum depths during the rainy season said to be no more than about 1.5 m. The basin contains water year-round; seasonal fluctuations in water levels appeared to small scale (ca. 0.5 m). The water was an opaque brown, and contained abundant sediments in suspension. Laguna Suarez was bordered on three sides by extensive inundated savannas, dominated by the tall emergent herb *Cyperus giganteus* (Cyperaceae). In a number of areas, more deeply inundated marshy habitats dominated by species other than *C. giganteus*, were present between the lake basin and the *C. giganteus* marsh. Additionally, small amounts of seasonally inundated gallery forest occupied a raised spit of land along the western edge of the system.

Laguna Suarez possessed a rich flora (97 spp.). Much of the basin was fringed with floating mats. The most abundant mat-forming species was *Panicum elephantipes* (Poaceae), which formed extensive mats along the northern and eastern basin edges. Most often, these were loosely coalesced, but in some areas the mats were sufficiently adherent to permit secondary colonizers to become established. Other mats were dominated by *Oxycaryum cubense* (Cyperaceae), *Eichhornia azurea, E. crassipe*s, and *Pontederia rotundifolia* (Pontederiaceae), with *Hydrocotyle ranunculoides* (Apiaceae), *Hymenachne donacifolia* and *Paspalum repens* (Poaceae) present in lesser amounts. Species associated with the mats were *Gymnocoronis spilanthoides* (Asteraceae), *Begonia fischeri* (Begoniaceae), *Cyperus haspan* and *Torulinium odoratum* (Cyperaceae), *Ludwigia leptocarpa* (Onagraceae), *Habenaria* aff. *repens* (Orchidaceae), *Andropogon bicornis* (Poaceae), *Pityrogramma calomelanos* (Pteridaceae), *and Alectra aspera* (Scrophulariaceae). Despite the shallow basin, no submerged species were noted. Likewise, rooted species with floating leaves were nearly absent, with *Ludwigia sedoides* (Onagraceae) the sole representative.

Free floating species were well-represented. Within the lake basin, these were generally restricted to small "pools" formed by openings in the floating mats, and in among the small interstices between the mat-forming species. Representative free-floating species were *Alternanthera philoxeroides* (Amaranthaceae), *Pistia stratiotes* (Araceae), *Limnobium laevigatum* (Hydrocharitaceae), *Lemna valdiviana* and *Wolffiella lingulata* (Lemnaceae), *Ludwigia helminthorrhiza* (Onagraceae), *Ceratopteris pteridoides*

(Pteridaceae), and *Azolla mexicana, Salvinia auriculata* and *S. minima* (Salviniaceae). The free-floating liverwort *Ricciocarpus natans* (Ricciaceae) was also present.

Arborescent species were fairly common. *Erythrina fusca* (Euphorbiaceae) grew in the shallows and in the adjacent marshes; *Laetia americana* (Flacourtiaceae) was occasional in the latter habitat. Other arborescent species were *Ocotea cernua* and *Nectandra amazonum* (Lauraceae) and an unidentified Fabaceae. Shrubs and shrubby perennials were abundant in many areas. Common species were *Aeschynomene fluminensis, A. sensitiva, Senna alata* and *Sesbania exasperata* (Fabaceae), *Hydrolea spinosa* (Hydrophyllaceae), *Hyptis lorentziana* (Lamiaceae), and *Rhynchanthera novemnervia* (Melastomataceae).

Climbers were abundant and particularly speciose. Representative species were *Rhabdadenia* sp. (Apocynaceae), *Sarcostemma clausum* (Asclepiadaceae), *Mikania congesta* (Asteraceae), *Aniseia martinicensis, Ipomoea rubens* and *Merremia umbellata* (Convolvulaceae), *Cayaponia citrullifolia* (Cucurbitaceae), *Vigna lasiocarpa* (Fabaceae), *Odontocarya tamoides* (Menispermaceae), *Paullinia pinnata* (Sapindaceae), and *Cissus spinosa* (Vitaceae).

Emergent herbaceous species were most abundant in marshy habitats, but were also present in the basin, most often in shallowly inundated areas that lacked floating mats. Common emergent herbs were *Echinodorus grandiflorus* subsp. *aureus* and *E. macrophyllus* subsp. *scaber* (Alismataceae), *Enhydra anagallis* (Asteraceae), *Canna glauca* (Cannaceae), *Rhynchospora* cf. *gigantea* and *R. corymbosa* (Cyperaceae), *Caperonia castaneifolia* (Euphorbiaceae), *Ludwigia decurrens* (Onagraceae), *Hymenachne amplexicaulis*, *Panicum mertensii,* and *Steinchisma hians* (Poaceae), *Polygonum acuminatum, P. ferrugineum, P. hispidum,* and *P. punctatum* (Polygonaceae), and *Thelypteris interrupta* (Thelypteridaceae). Two tall emergents, *Thalia geniculata* (Marantaceae) and *Ipomoea alba* subsp. *fistulosa* (Convolvulaceae), were frequently present in the transition between the *Cyperus giganteus* marsh and more open marshy areas.

Various species were strongly associated with shallow water along the basin edge; these increased in abundance as water levels subsided during the dry season. Representative species were *Xanthosoma* cf. *sagittifolium* (Araceae), *Cyperus imbricatus* and *Eleocharis interstincta* (Cyperaceae), *Heliconia marginata* (Heliconiaceae), *Marsilea* sp. (Marsileaceae), *Panicum dichotomiflorum* (Poaceae), and *Sphenoclea zeylanica* (Sphenocleaceae).

Some areas supported markedly different floras during different hydrologic seasons. For example, at the end of the rainy season one of the marshes adjoining the lake was covered with free-floating (principally, *Limnobium laevigatum* and *Salvinia auriculata*) and free-swimming (*Utricularia gibba*) species, intermixed with young plants of *Oxycaryum cubense*. During the dry season, this same area was dominated by the spiky-leaved emergent herb *Pacourina edulis* (Asteraceae).

Despite the rich flora at Laguna Suarez, no rare or particularly uncommon species were encountered. Laguna Suarez was subjected to low levels of anthropogenic disturbance. The system was situated about 6 km to the south of the city of Trinidad, and portions of the system were used for recreation–primarily swimming and fishing–however, the impacts from these activities appeared to be minimal. The vegetation of the lake was directly impacted by livestock, which were periodically herded into the system to graze, and by logging (selective cutting) in gallery forest along system edges.

## Chiquitanía

Seven study sites were established in the Chiquitanía region: one large pond with associated marsh, two bahías, one basin swamp, one riparian wetland, one streamside marsh, and one curichi;Table A.7).

Additionally, general collections were made from other wetlands in the region, including seasonally inundated gallery forest, streams, rivers, roadside marshes and pools, and curichis and ponds. Some particularly useful collections were made in the inundated savannas in the La Toledo and Flor de Oro areas.

Table A.7. Study sites in the Chiquitanía Region (Bolivia), with elevation, approximate area of the system, approximate location, and number of species noted for each site.

| System | Elev. (m) | Approximate Area (ha) | Approximate Location | No Spp. |
|---|---|---|---|---|
| Concepción Wetland | 485 | 10 | 62°01'W 16°08'S | 70 |
| Huanchaca Arroyo | 760 | 0.04 | 65°56'W 17°16'S | 24 |
| La Toledo Curichi | 220 | 6 | 61°8'W 14°42'S | 42 |
| Bahía Toledo | 210 | 150 | 61°07'W 14°42'S | 72 |
| Río Paraguá | 210 | 0.5 | 61°10'W 14°40'S<br>61°10'W 14°37'S | 40 |
| Cuatro Vientos Swamp | 205 | 690 | 61°11'W 14°32'S | 50 |
| Lago Caimán | 200 | 575 | 60°55'W 13°35'S | 80 |

## Concepción Wetland

Elevation: 485 m Watershed: Amazon Number of species: 70
Dates visited: Sep 6, 1995; Aug 20, 1996; Dec 4, 1996; Jun 18, 1998

The Wetland at Concepción was a small (ca. 10 ha) wetland complex, located alongside the unpaved highway leading from the town of Concepción to San Ignacio de Velasco. The system was composed of two ponds, separated by a deeply inundated (ca. 1.5-2.0 m) marsh. The wetland was bisected by a road which was raised well above water levels, and the two halves of the system were interconnected through a single culvert. Additional marshy habitat was present around the edges of both ponds. A stream passed through the system; year round flow was evident. Annual variation in water levels was on the order of 2.5 m (as judged from the high-water mark on pilings in the back pond). The ponds and deeply inundated sections of marsh contained water year round, although standing water was absent from the edges of the system during the dry season. Nevertheless, soil conditions remained moist to saturated in many edge areas.

The Concepción Wetland supported a rich flora (70 spp.). The predominant vegetation was markedly different in the two ponds. The front (adjacent to the highway) pond was dominated by large populations of the emergent herb *Pontederia cordata* subsp. *ovalis* (Pontederiaceae), which in deep water areas formed loosely-coalesced floating mats. At times, these were sufficiently buoyant and had accumulated sufficient sediment to be colonized by other species. Species associated with floating mats of *Pontederia cordata* subsp. *ovalis* were *Utricularia gibba* (Lentibulariaceae), *Habenaria* aff. *repens* (Orchidaceae), and *Polygonum meisnerianum* (Polygonaceae). The back pond was characterized by floating mats of *Eleocharis quadrangulata* (Cyperaceae), a common

mat-forming species. Species associated with floating mats of *Eleocharis acutangula* were *Echinodorus bolivianus* and *E. grandiflorus* (Alismataceae), *Erechtites hieracifolia* (Asteraceae), *Begonia fischeri* (Begoniaceae), *Pycreus lanceolatus* (Cyperaceae), *Caperonia palustris* (Euphorbiaceae), *Mayaca sellowiana* (Mayacaceae), *Pterolepis glomerata* (Melastomataceae), *Ludwigia peploides* and *L. torulosa* (Onagraceae), *Erythrodes* sp. (Orchidaceae), *Bacopa salzmanii* and *B. tweedii* (Scrophulariaceae), *Thelypteris interrupta* (Thelypteridaceae), and *Xyris laxifolia* (Xyridaceae).

Scattered arborescent species were present, and were represented by *Mauritia flexuosa* (Arecaceae), *Tabebuia insignis* (Bignoniaceae), *Sapium glandulosum* (Euphorbiaceae), *Ocotea cernua* (Lauraceae), and *Myrsine umbellata* (Myrsinaceae). The sub-arborescent herb, *Philodendron bipinnatifidum* (Araceae) was a conspicuous component, growing on small hummocks in various parts of the system. The wetland fern, *Thelypteris serrata* (Thelypteridaceae) was frequently present on the hummocks. Shrubs and shrubby perennial species were *Desmodium subsecundum* and *Mimosa* cf. *pigra* (Fabaceae), *Hydrolea spinosa* (Hydrophyllaceae), *Adenaria floribunda* (Lythraceae), *Hibiscus sororius* (Malvaceae), *Rhynchanthera novemnervia* (Melastomataceae), *Ludwigia leptocarpa* and *L. martii* (Onagraceae), and *Paullinia pinnata* (Sapindaceae).

A number of life-forms were poorly represented. Submerged species were *Cabomba furcata* (Cabombaceae) and *Mayaca sellowiana* (Mayacaceae). The latter, however, was more frequently observed growing in interstices in the *Eleocharis acutangula* mats. The sole free-floating species observed was *Pistia stratiotes* (Araceae). This species was abundant in the front half of the system, and was observed serving as the substratum for germinating seedlings of an undetermined species of Cyperaceae (the "epiphytic" pathway of floating mat formation, *sensu* Tur 1965; Tur 1969). The free-swimming macrophyte, *Utricularia gibba* (Lentibulariaceae) was abundant in both halves of the system. The sole Nymphaeaceous species was *Nymphaea amazonum* subsp. *amazonum* (Nymphaeaceae). Climbers were also poorly represented, with *Vigna longifolia* (Fabaceae) and *Smilax fluminensis* (Smilacaceae) the only species noted.

Emergent herbs were abundant, particularly along the edges of the system. Common species were *Pityrogramma calomelanos* (Adiantaceae), *Eclipta prostrata* (Asteraceae), *Canna glauca* (Cannaceae), *Carex* sp., *Cyperus haspan*, *C. meyenianus*, *Eleocharis mutata*, *Rhynchospora* cf. *scutellata*, *R. corymbosa*, *Scleria macrophylla* and *S. mitis* (Cyperaceae), *Hyptis recurvata* (Lamiaceae), *Andropogon bicornis* and *Panicum laxum* (Poaceae), *Polygonum acuminatum* and *P. punctatum* (Polygonaceae), and *Typha domingensis* (Typhaceae).

Species of note at the Concepción Wetland were *Ludwigia martii*, *Ludwigia torulosa*, and *Carex* indet. (see Appendix E). The system experienced some perturbation from human activities, principally bathing and washing of clothes. The area between the edge of the back pond and the road were periodically trimmed or grazed. Additionally, the back pond was almost certainly used at times for watering cattle.

**Huanchaca Arroyo**

Elevation: 760 m Watershed: Amazon Number of species: 24
Date visited: Aug 16, 1996

The "Huanchaca Arroyo" was a stream situated on the Serranía de Huanchaca, the massive, steep-sided plateau which forms the eastern border of Noel Kempff National Park. This plateau, known locally as the "Meseta", is approximately 150 km long with a maximum width of about 50 km (Litherland and Power 1989), and a maximum elevation of about 900 m (Killeen 1996).

The stream was generally fairly narrow (ca. 1-2 m), widening in a few areas to form small, still pools. Although the stream was most often shallow, maximum depths reached 1.5 m in a few pools. The bottom varied between sand and exposed bedrock, although some of the deeper pools possessed accumulations of sediment and organic material. Bank topography, while generally steep, was variable; at times being sufficiently low and gradual to allow the seasonal flooding of small areas adjacent to the channel. The surrounding area was open savanna with scattered trees, corresponding to Campo Limpio *sensu* Killeen (1996). An approximately 200 m section of the stream was surveyed.

The Huanchaca Arroyo possessed a rich flora (24 spp.) for such a small study area. Floristic composition varied among the different habitats. Deeper pools were dominated by the rheophytic herb *Utricularia neottioides* (Lentibulariaceae), and by the submerged form of *Sagittaria rhombifolia* (Alismataceae). The submerged herb *Mayaca fluviatilis* (Mayacaceae) and the semi-aquatic grass *Isachne polygonoides* (Poaceae) were also common in this habitat. Where the stream widened to form shallow pools, the edges characteristically contained populations of emergent species, such as *Urospatha sagittifolia* (Araceae), *Eleocharis filiculmis* (Cyperaceae), *Syngonanthus densiflorus* (Eriocaulaceae), and *Xyris* cf. *asperula* (Xyridaceae).

Steep-sided sections of the bank supported small populations of *Drosera communis* (Droseraceae), *Trichomanes hostmannianum* (Hymenophyllaceae), a rheophytic fern, an unidentified Hepaticae, and small populations of *Sphagnum* sp. Numerous wet seeps were present along the stream. Typical species in this habitat were *Genlisea guianensis*, *Utricularia amethystina*, *U. pusilla*, and *U. nana* (Lentibulariaceae), *Siphanthera foliosa* (Melastomataceae). Small, semi-aquatic ephemerals, such as *Polygala microspora* (Polygalaceae) and *Burmannia flava* (Burmanniaceae), were also present in this habitat. A few species from the Huanchaca Arroyo were particularly noteworthy: *Genlisea guianensis*, *Utricularia nana*, and *Siphanthera foliosa* (see Appendix E).The Huanchaca Arroyo was relatively inaccessible and was situated far any human settlements; hence, anthropogenic disturbance was minimal, with the largest threats to the system perhaps coming from botanists.

**La Toledo Curichi**

Elevation: 220 Watershed: Amazon Number of species: 43
Dates visited: Sep 30, 1995; Aug 10, 1996; Aug 11, 1996

The La Toledo Curichi was large, horseshoe-shaped wetland, which occupied a portion of an abandoned course of the Río Paraguá, about 0.5 km to the west of the current position of the river. The Curichi was approximately 1.6 km long, with an average width of about 40 m; total area was on the order of 6 ha. Maximum water depth during visits to the site was about 1.5 m, with an average depth of 0.75-1.0 m. Water conditions were intermediate between clear-water and secondarily black-water.

The Curichi was ringed with a narrow belt of seasonally inundated gallery forest, beyond which were large expanses of seasonally inundated savanna interspersed with narrow forested "islands". The Río Paraguá annually overflows its banks during the rainy season, flooding the surrounding savannas (Killeen 1996). Water from the Río Paraguá flowing across the savannas at the beginning of the rainy season undoubtedly carried a pulse of cations to the Curichi (*cf*. Furch *et al*. 1983). Additionally, a portion of the accumulated organic acids was probably flushed from the basin at this time.

The La Toledo Curichi was somewhat species-poor (43 species). The system was a patchwork of different "successional" stages: sections of open water alternated with areas completely covered by floating mats of vegetation. Emergent vegetation was present along system edges, and in irregular "bands" growing on sediment bars oriented transversely across the basin.

Floating mats were well-developed. Mat-forming species were *Eleocharis acutangula, Fuirena robusta*, and *Oxycaryum cubense* (Cyperaceae), and *Eichhornia azurea* (Pontederiaceae). Accumulated sediments were particularly abundant in mats dominated by *F. umbellata*. These mats were capable of supporting shrubs (*e.g.*, *Rhynchanthera novemnervia*, Melastomataceae), and small trees, such as *Tabebuia insignis* (Bignoniaceae), and *Pterocarpus santalinoides* (Fabaceae). Other species associated with floating mats were *Echinodorus bolivianus* (Alismataceae), *Erechtites hieracifolia* (Asteraceae), *Begonia fischeri* (Begoniaceae), *Torulinium odoratum* (Cyperaceae), *Ludwigia nervosa* and *L. torulosa* (Onagraceae), *Cyrtopodium paludicolum* (Orchidaceae), *Imperata brasiliensis* and *Saccharum trinii* (Poaceae), *Pityrogramma calomelanos* (Pteridaceae), *Alectra aspera* (Scrophulariaceae), *Thelypteris interrupta* (Thelypteridaceae), and *Xyris laxifolia* (Xyridaceae).

Emergent vegetation was fairly abundant. Shrubs and shrubby perennials were *Aeschynomene fluminensis* and *Mimosa pigra* (Fabaceae), *Ludwigia nervosa* (Onagraceae), and *Melochia arenosa* (Sterculiaceae). Common emergent herbs were *Thalia geniculata* (Marantaceae), *Andropogon bicornis*, *Hymenachne amplexicaulis, Isachne polygonoides*, and *Leersia hexandra* (Poaceae), and *Polygonum acuminatum*

(Polygonaceae). The climbers *Rhabdadenia pohlii* (Apocynaceae), *Aniseia martinicensis*, *Ipomoea subrevoluta*, and *Tetralocularia pennellii* (Convolvulaceae) were common along system edges and on floating mats. The sole free-floating species noted was *Salvinia auriculata* (Salviniaceae). Free-swimming species were represented by *Utricularia breviscapa* and *U. gibba* (Lentibulariaceae); both of which were common. Two Nymphaeaceous species, *Hydrocleys nymphoides* (Limnocharitaceae) and *Nymphaea amazonum* subsp. *pedersenii* (Nymphaeaceae), were fairly common in shallow water. Species of note were *Cyrtopodium paludicolum* and *Ludwigia torulosa* (see Appendix E).

In general, the La Toledo Curichi appeared to experience little anthropogenic disturbance. At times, however, the system was subjected to unintentional burning when fires set in adjoining grasslands outside the limits of Parque Noel Kempff Mercado spread to the La Toledo savannas. During fieldwork in La Toledo, one such fire burnt through the area. The fire arrived at the La Toledo Curichi, burnt across a large section of floating mat, and spreading across adjacent savanna. All of the mat's "standing vegetation" was destroyed, including the living shoots *Fuirena umbellata*, the principal mat component. The mats retained sufficient structural integrity to support a person's weight, however, and within a week new shoots of *F. umbellata* were apparent. During a return visit to this site approximately a year later, the mats had regained full vegetative growth.

**Bahía Toledo**

Elevation: 210m Watershed: Amazon Number of species: 72
Dates visited: Sep 10-13, 1995; Aug 12, 1996

Bahía Toledo was a large wetland complex formed by the divergence of the Río Paraguá into a series of channels. Three primary channels were present; these were linked by smaller side channels, forming a complex reticulate system. Downstream from Bahía Toledo, the Río Paraguá reintegrated into a single channel. The large size and complicated morphology of the Bahía made an accurate estimate of system area difficult. Based on coordinates taken from a handheld GPS, and on extrapolation from a LANDSAT image, Bahía Toledo occupied an area of ca. 150 ha.

Year-round (albeit reduced) flow occurred in much of the system; however, some of the secondary channels were transformed into "backwaters" during the dry season, when they became isolated by water levels dropping below the level of sediment dams. Additionally, some connecting waterways were most likely ephemeral during dry years. Annual variation of water levels appeared to be on the order of 1.5-2.5 meters. Water conditions were intermediate between clear- and blackwater. The system was fairly steep-sided along most of its perimeter, however, the upland areas which separated the main channels possessed a more gradual slope. Additionally, some areas between the channels were scarcely higher than the channel beds and were apparently inundated year-round. These topographical differences, in combination with variation in the amounts of sedimentation and build up of organic matter in the channels and backwaters, conferred a high degree of habitat heterogeneity to the system. The areas surrounding Bahía Toledo were essentially as described for the La Toledo Curichi. Hence, Bahía Toledo likely experienced a similar pulse of cations at the start of the rainy season.

Bahía Toledo supported a rich flora (72 spp). Furthermore, due to the system's complex morphology of this system, it is expected that many additional species that were present at the site were not encountered. Much of the system supported extensive floating mats. Principal mat-forming species were *Oxycaryum cubense* and *Eleocharis acutangula* (Cyperaceae). *Fuirena robusta* (Cyperaceae) and *Paspalum repens* (Poaceae) also contributed to mat formation, but were not nearly so abundant as the former species. *Eichhornia azurea* (Pontederiaceae) was abundant, frequently forming the outermost zone of floating mats. Species associated with floating mats were *Erechtites hieracifolia* (Asteraceae), *Begonia cucullata* (Begoniaceae), *Commelina diffusa* (Commelinaceae), *Cyperus haspan* (Cyperaceae), *Ludwigia affinis* (Onagraceae), *Cyrtopodium paludicolum*, *Erythrodes* sp., and *Habenaria* aff. *repens* (Orchidaceae), *Imperata brasiliensis* and *Isachne polygonoides* (Poaceae), *Pityrogramma calomelanos* (Pteridaceae), *Alectra aspera* and *Bacopa stricta* (Scrophulariaceae), *Thelypteris interrupta* (Thelypteridaceae), and *Xyris laxifolia* (Xyridaceae).

Arborescent species were poorly represented, with *Tabebuia insignis* ("tajibo", Bignoniaceae) and *Genipa americana* (Rubiaceae) the sole trees noted. Scattered

individuals of *Tabebuia insignis* were present on floating mats, and one area contained a small "tajibal" (a swampy area dominated by *T. insignis*). Some species, such as *Echinodorus macrophyllus* (Alismataceae), *Rhynchospora rugosa* (Cyperaceae), and *Luziola bahiensis* (Poaceae), were only observed in this habitat.

Climbers were common, and were most abundant on floating mats. Representative species were *Rhabdadenia pohlii* (Apocynaceae), *Aniseia martinicensis*, *Ipomoea carnea*, *Ipomoea subrevoluta*, *Operculina hamiltonii*, and *Tetralocularia pennellii* (Convolvulaceae), *Centrosema vexillatum*, *Senna splendida*, and *Vigna luteola* (Fabaceae), *Passiflora* sp. (Passifloraceae), and *Cissus spinosa* (Vitaceae).

Two submerged species were noted. *Najas arguta* (Najadaceae) was locally abundant in a few areas, and tended to occur in large expanses of open water, in depths up to ca. 2.0 m. *Eichhornia diversifolia* (Pontederiaceae), was also locally abundant, but occurred in areas with shallow, still water.

Free-floating species were well-represented, with *Pistia stratiotes* (Araceae), *Limnobium laevigatum* (Hydrocharitaceae), *Lemna* sp. (Lemnaceae), *Eichhornia crassipes* (Pontederiaceae), *Ceratopteris pteridoides* (Pteridaceae), and *Salvinia auriculata* (Salviniaceae). The free-floating liverwort *Ricciocarpus natans* (Ricciaceae) was also present. *Utricularia gibba* (Lentibulariaceae), was the only free-swimming species noted. *Hydrocleys nymphoides* (Limnocharitaceae) was the sole "Nymphaeaceous" species encountered.

Emergent species were uncommon along the edges of the main channels, as these were generally steep-sided, and frequently served as anchoring points for floating mats. Areas with a more gradual topography, such as the edges of the secondary channels and seasonally inundated sediment bars, and shallowly inundated marshes, supported abundant emergent species. Common shrubs and shrubby perennials were *Mimosa pellita* and *Sesbania exasperata* (Fabaceae), *Hydrolea spinosa* (Hydrophyllaceae), *Rhynchanthera novemnervia* (Melastomataceae), *Piper fuligineum* (Piperaceae), and *Ludwigia leptocarpa* and *L. nervosa* (Onagraceae). Common emergent herbs were *Echinodorus paniculatus*, and *E. subalatus* subsp. *subalatus* (Alismataceae),

*Alternanthera lanceolata* (Amaranthaceae), *Eleocharis elegans, E. filiculmis, Rhynchospora corymbosa* and *Scleria microcarpa* (Cyperaceae), *Andropogon bicornis, Hymenachne donacifolia*, and *Oryza grandiglumis* (Poaceae), and *Polygonum acuminatum* (Polygonaceae).

The system contained three species of note: *Operculina hamiltonii, Tetralocularia pennellii* and *Cyrtopodium paludicolum* (see Appendix E). In general, Bahía Toledo appeared to be subjected to little anthropogenic disturbance, other than small-scale fishing by local residents. As with the La Toledo Curichi, however, the edges of this system were perhaps vulnerable to fires in adjoining savannas.

**Río Paraguá**

Elevation: 210 m Watershed: Amazon Number of species: 41
Dates visited: Sep 13, 1995; Mar 22, 1996; Aug 13, 1996; Jun 20-21, 1996

This study site was composed of two sections of the Río Paraguá. The first was located approximately 5 km from Bahía Toledo, and incorporated the area where a blackwater stream, the Arroyo Toledo, entered the river. The second which incorporated the east bank of river adjacent to the community of Florida, was located approximately 7 km further downstream. At the first site, the "Arroyo Toledo sub-site" (61°10'W 14°40'S), an approximately 150 m long section of the Río Paraguá, and ca. 60 m of the Arroyo Toledo were surveyed. At the second site, the "Florida sub-site" (61°10'W 14°37'S), sampling was conducted over an approximately 100 m long section of the river. Total area sampled was roughly 0.5 ha.

At the Arroyo Toledo sub-site, the banks of the Río Paraguá were frequently steep, however some areas were shallow and supported scattered emergent vegetation. The main river channel possessed a strong current, however, the current was much reduced in the area directly around the mouth of the Arroyo Toledo, and floating mats were well-developed. During the two visits to the site, the Arroyo Toledo possessed a continuous flow, but this stream was said to dry down substantially during the dry season, to the point where it is reduced to a series of isolated pools. Maximum water depth in this section of the Río Paraguá was about 2.0 m during the first visit (September, 1995), and

was at least 1.0 m deeper during the subsequent visit (June, 1998). Based on the high water mark in adjacent seasonally inundated forest, maximum depth of inundation appeared to be at least three m above this.

Vegetation at the Arroyo Toledo sub-site was more species-rich and structurally complex than at the Florida sub-site. Principal mat forming species were *Oxycaryum cubense* (Cyperaceae) and *Eichhornia azurea* (Pontederiaceae). *Hydrocotyle ranunculoides* (Apiaceae) was frequently a component of the mats. Species associated with the mats were *Hibiscus sororius* (Malvaceae), *Ludwigia affinis* and *Ludwigia leptocarpa* (Onagraceae), *Habenaria* aff. *repens* (Orchidaceae), and *Pityrogramma calomelanos* (Pteridaceae). Climbers were fairly abundant on the floating mats, with *Mikania micrantha* (Asteraceae), *Ipomoea subrevoluta* (Convolvulaceae), *Cayaponia* sp. (Cucurbitaceae), and *Centrosema bifidum* and *Vigna longifolia* (Fabaceae) representative species.

Free-floating species were common in interstices of the floating mats, or in small eddies among fallen, partially submerged tree trunks. Representative species were *Pistia stratiotes* (Araceae), *Lemna valdiviana*, *Spirodela intermedia*, and *Wolffiella lingulata* (Lemnaceae), and *Azolla mexicana* and *Salvinia auriculata* (Salviniaceae). The free-floating liverwort *Ricciocarpus natans* (Ricciaceae) was also present. The sole submerged species noted was *Eichhornia diversifolia* (Pontederiaceae), which was present in shallowly inundated areas along the stream. The sole Nymphaeaceous species was *Hydrocleys parviflora* (Limnocharitaceae). Common emergent species were *Echinodorus subalatus* subsp. *subalatus* (Alismataceae), *Melanthera latifolia* (Asteraceae), *Torulinium odoratum* (Cyperaceae), *Senna pendula* (Fabaceae), *Homolepis aturensis* (Poaceae), and *Polygonum acuminatum* and *P. hispidum* (Polygonaceae).

At the Florida sub-site, the Río Paraguá was broader, and the current was reduced. The banks were generally shallow, enabling free-floating and submerged vegetation to develop. Floating mats were poorly developed in this area, although fairly large expanses were visible along the (unsampled) eastern bank. Rather, the vegetation was dominated by submerged and free-swimming species. Submerged species were *Cabomba furcata*

(Cabombaceae), *Websteria confervoides* (Cyperaceae), *Egeria najas* (Hydrocharitaceae), and *Najas arguta* (Najadaceae). The rare *Nymphaea oxypetala* (Nymphaeaceae)–an unusual member of the genus which possesses submerged leaves–was locally abundant. The free-swimming species *Utricularia breviscapa* and *U. foliosa* (Lentibulariaceae) were abundant locally.

Rare or noteworthy species encountered at the Río Paraguá were *Egeria najas*, *Nymphaea oxypetala,* and *Websteria confervoides* (see Appendix E). The Río Paraguá was subjected to a certain amount of anthropogenic disturbance. The community of Florida utilized the river for bathing and for washing clothes, and maintained areas along the banks free from floating mats to facilitate these activities. During the same general period as fieldwork, commercial fishermen working the Río Paraguá used the Arroyo Toledo as an embarkation point. Although no visible effects on the aquatic vegetation were noted, fishing clearly impacted more than the ichthyofauna as wild birds were shot and used for bait. The remains of a blue and gold Macaw beside the Arroyo Toledo were a particularly disturbing indicator of the damages effected by these activities.

**Cuatro Vientos Palm Swamp**

Elevation: 205 m Watershed: Amazon Number of species: 50
Dates visited: Oct 1. 1995; Aug 14, 1996

The Cuatro Vientos Palm Swamp was a basin swamp dominated by the palms *Mauritiella armata* and *Mauritia aculeata*. The system occupied a large, shallow basin, estimated to be roughly 690 ha in area. Water at the site was very dark brown, with abundant humic acids in suspension, and extremely low transparency, and corresponded to either blackwater or secondarily blackwater. Depth at the time of the visits to the site ranged from approximately 0.8-2.0 m, with an average depth of ca. 1.0 m. The basin contained water throughout the year; seasonal variations in water level appeared to be fairly small-scale, probably on the order of 0.5-1.0 m.

With only 51 species, Cuatro Vientos gave the appearance of being somewhat depauperate for a large lowland system. As with the Riberalta Ciénaga, however, maneuvering through the system was extremely problematic, and large areas of Cuatro Vientos were not surveyed. During the second visit to the site, more than 30 species were

noted that weren't encountered during the initial visit, therefore, it seemed probable that numerous additional species were present but not encountered.

The system was structurally heterogeneous. Basin sides were steep, and a lagg (narrow band of open water) was present along the outer edge of the basin. A substantial portion of the system was covered with floating mats of vegetation. Peat deposits beneath the mats reached 1 m, or greater (F. Mayle, pers. com). The mats were dissected by broad channels, at least some of which led to two large expanses of open water. Few emergent species appeared capable of growing in the channels. Exceptions were *Ludwigia torulosa* (Onagraceae), *Panicum schwackeanum* (Poaceae), and *Pontederia cordata* var. *lancifolia* (Pontederiaceae).

Trees were well-represented at Cuatro Vientos. *Mauritiella armata* and *Mauritia aculeata* (Arecaceae) were abundant, growing on hummocks throughout the system. In addition to these two palms, arborescent species were *Tapirira guianensis* (Anacardiaceae), *Tabebuia insignis* (Bignoniaceae), *Diospyros yomomo* (Ebenaceae), *Pterocarpus santalinoides* (Fabaceae), and *Genipa americana* (Rubiaceae). With the exception of *G. americana*, these grew on floating mats and were small in stature (ca. 2.5 m tall). *G. americana* was present in the lagg and in seasonally inundated forest surrounding the swamp, and attained heights of about 5 m.

Floating mats varied in composition, with *Fuirena* cf. *robusta* (Cyperaceae) the most abundant and *Eleocharis acutangula* (Cyperaceae) the second-most abundant mat-forming species. Mats with a large *Oxycaryum cubense* component were also present. These tended to occur adjacent to the lagg, in the (presumably) more nutrient rich water. It appeared that different mat types were often colonized by different species, however, some species appeared to be “mat generalists”. Additionally, as large sections of mats were composed of both *Fuirena* cf. *robusta* and *Eleocharis acutangula*, it was often not possible to identify species growing on these mats as favoring a particular mat type. Species encountered growing on *Eleocharis acutangula* mats were *Anthurium atropurpureum* (Araceae), *Drosera communis* (Droseraceae), *Syngonanthus caulescens* (Eriocaulaceae), *Irlbachia caerulescens* (Gentianaceae), *Lycopodium clavatum*

(Lycopodiaceae), *Mayaca fluviatilis* (Mayacaceae), *Macairea radula* (Melastomataceae), and *Pityrogramma calomelanos* (Pteridaceae). Species observed growing on *Fuirena robusta* mats were *Philodendron brevispathum* and *P. imbe* (Araceae), *Blechnum serrulatum* (Blechnaceae), *Calyptrocarya luzuliformis*, *Cyperus haspan* and *Eleocharis elegans* (Cyperaceae), *Diospyros yomomo* (Ebenaceae), *Aeschynomene fluminensis* (Fabaceae), *Utricularia tricolor* (Lentibulariaceae), *Miconia* sp. (Melastomataceae), *Alectra aspera* (Scrophulariaceae), and *Thelypteris interrupta* (Thelypteridaceae). Species commonly encountered on both *Eleocharis acutangula* and *Fuirena* cf. *robusta* mats were *Urospatha sagittifolia* (Araceae), *Rhynchospora* corymbosa (Cyperaceae), Piper *fuligineum* (Piperaceae), and *Xyris laxifolia* (Xyridaceae).

No free-floating species were observed, although the free-swimming *Utricularia gibba* (Lentibulariaceae) was present in low abundance. The sole submerged species was *Isoëtes panamensis* (Isoëtaceae). Only a few individuals of *I. panamensis* were noted; these grew in a small opening in an *Eleocharis acutangula* dominated mat. *Nymphaea gardneriana* (Nymphaeaceae), which was common in the channels, was the only rooted macrophyte with floating leaves encountered. Climbers were infrequent, and species-poor, with *Tassadia* sp. (Asclepiadaceae), and *Combretum laxum* (Combretaceae) the representatives noted. Additionally, some of the species of Araceae present at Cuatro Vientos possessed an elongated trailing life form.

Cuatro Vientos possessed a number of rare and/or noteworthy species: *Calyptrocarya luzuliformis, Cyrtopodium paludicolum, Diospyros yomomo*, which was recently described from this system (Wallnöfer 1999), *Isoëtes panamensis*, and *Ludwigia torulosa* (see Appendix E). This system appeared to suffer little anthropogenic disturbance, with almost all human activity apparently associated with scientific investigation.

**Lago Caimán**

Elevation: 200 m Watershed: Amazon Number of species: 80
Dates visited: Mar 30, 1996; Apr 5, 1996; Apr 9-10, 1996; Apr 14, 1996; Apr 18, 1996; Jun 25-26, 1998

Lago Caimán was a large (ca. 575 ha) basin system located at the base of the extreme northern end of the Serranía de Huanchaca. Although the name "Lago Caimán" suggests a lake, the system was more properly a "bahía": a lacustrine system that is seasonally connected with a river. The system occupied a section of a former course of the Río Iténez. During the rainy season, water from the river entered Lago Caimán through a narrow channel. During the highest water stages, inflow and outflow also occurred through broad sections of the seasonally inundated forest bordering Lago Caimán. The bed of the inflow channel was elevated above the low water levels of both the Río Iténez and Lago Caimán, hence, during the dry season as water levels in the river subsided, Lago Caimán became isolated from the river.

Lago Caimán was approximately 8-9 kilometers long, and had the shape of an elongated fishhook with a sinuous shank. The dimensions of the basin were quite variable, with the narrowest stretches approximately 150 m wide, and the widest areas on the order of half a kilometer. Because many parts of the basin were steep-sided in, there most likely was not a substantial fluctuation in system area between wet and dry seasons. Annual fluctuations in water level appeared to be on the order of 3 m. The system's water possessed the visual characteristics of clearwater, with a slight brown tint.

Lago Caimán was tremendously heterogeneous. Along the edge which abutted the base of the Serranía, the basin was extremely steep-sided, with little macrophyte development, other than small assemblages of wind-blown, free-floating aquatics. Other parts of the system were characterized by a more gradual topography; these frequently served as anchoring points for large expanses of floating mats. The eastern edge of the basin possessed an irregular profile, with various small "bays". At times, floating mats were sufficiently large to span the mouths of these bays, thereby transforming them into isolated backwaters (*remansas*). Differences in water movement throughout the system,

also contributed to habitat heterogeneity, with the areas of the strongest current possessing distinctive floras.

Lago Caimán possessed a rich flora (80 spp.). Submerged species were very well-represented with *Cabomba* cf. *furcata* (Cabombaceae), *Websteria confervoides* (Cyperaceae), *Egeria najas* (Hydrocharitaceae), *Mayaca longipes* and *M. sellowiana* (Mayacaceae), *Najas arguta* (Najadaceae), *Eichhornia diversifolia* (Pontederiaceae), and *Limnophila perdiemensis* Ritter sp. nov. (Scrophulariaceae). The submerged form of *Ludwigia inclinata* (Onagraceae) was abundant around the mouth of the channel that connected Lago Caimán with the Río Iténez.

Numerous free-floating species were present. Representative species were *Pistia stratiotes* (Araceae), *Limnobium laevigatum* (Hydrocharitaceae), *Lemna aequinoctialis* (Lemnaceae), *Ceratopteris pteridoides* (Pteridaceae), and *Azolla microphylla*, *Salvinia auriculata* and *S. minima* (Salviniaceae). The free-floating liverwort, *Ricciocarpus natans* (Ricciaceae), was also present, and floating clusters of the moss cf. *Vesicularia* sp. (Hypnaceae), were occasionally observed. Free-swimming species were common, and well-represented with *Utricularia breviscapa, U. foliosa*, *U. gibba*, and *U. hydrocarpa* (Lentibulariaceae).

Much of the system was characterized by the presence of large, well-developed floating mats. Principal mat forming species were *Eleocharis acutangula* and *Oxycaryum cubense* (Cyperaceae). In a few areas, *Leersia hexandra* (Poaceae) formed weakly-coalesced floating mats. Outer edges of the floating mats were frequently formed by *Eichhornia azurea*. At times, *Floscopa glabrata* (Commelinaceae), *Isachne polygonoides* (Poaceae), *Polygonum acuminatum* (Polygonaceae), and *Pontederia rotundifolia* (Pontederiaceae) also occupied the outermost zone. Species associated with floating mats were *Erechtites hieracifolia* and *Gymnocoronis spilanthoides* (Asteraceae), *Cyperus haspan*, *Pycreus unioloides* and *Torulinium odoratum* (Cyperaceae), *Syngonanthus caulescens* (Eriocaulaceae), *Aeschynomene fluminensis* (Fabaceae), *Hydrolea spinosa* (Hydrophyllaceae), *Utricularia tricolor* (Lentibulariaceae), *Cuphea melvilla* (Lythraceae), *Hibiscus sororius* (Malvaceae), *Ludwigia nervosa* and *L.*

*leptocarpa* (Onagraceae), *Cyrtopodium paludicolum* (Orchidaceae), *Pityrogramma calomelanos* (Pteridaceae), *Diodia multiflora* (Rubiaceae), *Alectra aspera* (Scrophulariaceae), and *Xyris laxifolia* (Xyridaceae). The shrub *Rhynchanthera novemnervia* (Melastomataceae) was common on floating mats, and frequently formed a distinct zone a few meters from the edge. Additionally, a few small individuals of the arborescent *Macrolobium acacifolium* (Fabaceae), were growing in conjunction with the mats. It could not be determined whether these were actually supported by the mats, or whether they were rooted in the basin and merely surrounded by mat.

Climbers were common along system edges and on floating mats. Representative species were *Sarcostemma clausum* (Asclepiadaceae), *Mikania micrantha* (Asteraceae), *Ipomoea regnellii*, *I. subrevoluta*, and *Operculina hamiltonii* (Convolvulaceae), *Pseudocyclanthera australis* (Cucurbitaceae), *Vigna peduncularis* and *V. longifolia* (Fabaceae), and *Cissus* sp. (Vitaceae). *Pseudocyclanthera australis* was particularly abundant, covering large areas along island edges, where water levels had subsided.

Emergent species were generally uncommon, although in a few areas they were fairly abundant. Representative species were *Justicia laevilinguis* (Acanthaceae), *Echinodorus grisebachii* and *E. tenellus* (Alismataceae), *Scleria melaleuca* (Cyperaceae), *Caperonia castaneifolia* (Euphorbiaceae), *Hymenachne amplexicaulis, Oryza grandiglumis,* and *Panicum pilosum* (Poaceae), and *Pontederia cordata* var. *ovalis* (Pontederiaceae). The shrub *Senna aculeata* (Fabaceae), was locally abundant around the mouth of the inflow channel, growing in fairly deep (ca. 2.0 m) water, with a strong current. *Oryza grandiglumis* was also abundant in this area.

Noteworthy species present at Lago Caimán were Cyrtopodium paludicolum, Egeria najas, Floscopa glabrata, Limnophila perdiemensis Ritter, sp. nov., Nymphaea jamesoniana, Operculina hamiltonii, and Websteria confervoides (see Appendix E). Lago Caimán was fairly isolated, and access to the system was well-hidden, nevertheless, local fishermen and hunters were familiar with the system and made occasional use of it, although anthropogenic impact appeared to be minimal.

# Gran Pantanal

Five study sites were established in the Bolivian portion of the Gran Pantanal: four large lacustrine systems and one riparian marsh (Table A.8). The four lacustrine study sites are said to be remnants of much larger "pluvial" lakes (Por 1995), and are interconnected by either the Río Paraguay, or through channels that connect with the river. Three of these lakes, Lagunas Uberaba, La Gaiba and Mandioré, are said to also receive inputs from the overflow of the Río Cuiaba system (Por 1995).

Table A.8. Study sites in the Bolivian Gran Pantanal region, with elevation, approximate area of the system, approximate location, and number of species noted for each site.

| System | Elev (m) | Approximate Area (ha) | Approximate Location | No. Spp. |
|---|---|---|---|---|
| Laguna Uberaba | 90 | 30000 | 57°44'W 17°34'S | 66 |
| Laguna La Gaiba | 90 | 10500 | 57°46'W 17°48'S | 61 |
| Laguna Mandioré | 90 | 25000 | 57°34'W 18°17'S | 63 |
| Laguna Cáceres | 90 | 3500 | 57°46'W 18°57'S | 124 |
| Puesto Gonzalo | 90 | 2 | 57°47"W 17°40'S | 38 |

## Laguna Uberaba

Elevation: 90 m. Watershed: Paraná Number of species: 66
Approximate center of the system: 57°44'W 17°34'S
Dates visited: Jul 10-11, 1998

Laguna Uberaba, the northernmost of the Gran Pantanal study sites, was once thought by the Spanish Conquistadors to be an inland sea: the “Sea of the Xaraes” (Por 1995). The lake is situated in both Brazil and Bolivia, with approximately 60% occurring in Bolivian territory (Justiniano M. 1998). The area of Laguna Uberaba has been variously estimated as being from 91 $km^2$ (Justiniano M. 1998) to 400 $km^2$ (Por 1995). The basin appeared to be fairly shallow throughout, with a maximum depth of perhaps 3 m at the time of fieldwork.

Most areas along the edges of the system supported either well developed floating mats of vegetation or fairly dense populations of emergent species. The edges of the lake possessed a few areas of marshy habitat, with these almost always associated with inflowing streams. In one area, however, a large back-swamp had formed behind a low “dike” of highly sedimented floating mat that, having come to rest as water levels

subsided, served to isolate this swamp from the main body of the lake. This habitat was inundated to a depth of about 1 m, and was dominated by emergent shrubs, herbs, and climbers. A few small, scattered islands were present in the lake, and at least one of these contained a well-developed marsh along one edge.

**Laguna La Gaiba**

Elevation: 90 m Watershed: Paraná Number of species: 61
Approximate center of the system: 57°46'W 17°48'S
Dates visited: Jul 9, 1998; Jul 13-14, 1998

Laguna La Gaiba was located at the southern end of the Río Pedro II, a river which connected this system with Laguna Uberaba. Laguna La Gaiba was situated in both Brazil and Bolivia, with approximately 60% occurring in Bolivian territory (Justiniano M. 1998)). Laguna La Gaiba is said to cover 105 square kilometers during high water, diminishing to 55 square kilometers during the dry season (Por, 1995), and large areas of the system are said to be less than 1 m deep (Por, 1995). At the southern end of the system, a small cove, "Bahía Preseverancia", was separated from the main body of the lake by an narrow spit of land. This cove was much more protected from wave and wind action than were the other parts of the system.

**Laguna Mandioré**

Elevation: 90 m Watershed: Paraná Number of species: 63
Approximate center of the system: 57°34'W 18°17'S
Dates visited: Jul 15-17, 1998

Laguna Mandioré was located almost entirely within Bolivian territory. Various estimates place the seasonal fluctuations in area of this system at between 89 and 200 $km^2$ (Por, 1995), or between 80 and 300 $km^2$ (Justiniano M. 1998). Laguna Mandioré was connected to the río Paraguay by a navigable channel, which flowed southward from the lake. Another channel flowed from the Río Paraguay to the northeastern corner of the lake, but this was said to be non-navigable and flow may have been seasonal.

Laguna Mandioré possessed greater habitat heterogeneity than did Lagunas Uberaba and La Gaiba. A raised spit of land partially separated the southern end of the system from the main body of the lake, forming a large, somewhat-protected cove. A few small

streams entered the lake along its western edge; at the time of fieldwork, flow was negligible and floating vegetation covered much of the water's surface. In some sections of the streams, small marshes occupied the transition zone between stream edge and upland. The area around the mouth of the outflow channel had a particularly complex morphology, with a series of small channels anastomosing along the main channel. Additionally, a back-swamp was present along one section of the northwestern edge of the basin. Water in this habitat was about 1 m deep and was stained very dark brown.

**Laguna Cáceres**

Elevation: 90 m Watershed: Paraná Number of species: 124
Approximate center of the system: 57°46'W 18°57'S
Dates visited: Jul 14-15, 1997; Jul 18-20, 1998

Laguna Cáceres, the southernmost of Gran Pantanal study sites, was located entirely within Bolivian territory. The system had an area of approximately 35 $km^2$ (3,500 ha). Laguna Cáceres was the sole Pantanal study site situated near any appreciable human populations, with the communities of Puerto Suárez and Puerto Qiharro–where the Bolivian Navy maintained a port–located along its southern edge. Additionally, the city of Corumbá (Brazil) was situated approximately 15 km east of the lake. Activities associated with these population centers, in particular shipping, had some effect on the aquatic vegetation. For example, crewmen from a lumber barge were observed using a smaller boat to remove sections of floating mat to maintain an navigable channel between an access road and open water.

Although the other Gran Pantanal lacustrine study sites were all "overflow lakes" (Por 1995), Laguna Cáceres was one of a series of deeper lakes which are thought to be of karstic origin (Por 1995). These are said to be characterized by smaller scale fluctuations in water level (Por 1995), however, local lore has it that Laguna Cáceres dried out completely at one point during the 1930's. Likewise, Por (1995) noted that during a particularly dry year (1994) Laguna Jacadigo, another deep lake, also dried down completely.

Laguna Cáceres was the most heterogenous of the Gran Pantanal study sites. Two rivers, the Río Pimiento and Río Sicurí, flowed into the lake. Upstream from the lake's basin

these were sinuous and were flanked by a series of braided side channels. Overflow from these rivers during high water stages flooded large parts of the adjacent floodplains, forming what appeared (from images) to be complex and potentially interesting marshlands. Unfortunately, at the time of both visits to this system (July 1997, 1998), the mouth of the Río Pimiento was completely blocked by mats of floating vegetation, and it was not possible to access these areas. The main channel of the Río Sicurí was also blocked with floating mats at various points, however, it did prove possible to clear pathways through these, enabling sampling to be conducted for a few km upriver. Outflow from the lake was through the Tamengo canal, which connected Laguna Cáceres with the Río Paraguay.

**Puesto Gonzalo**

Elevation: 90 m. Watershed: Paraná Number of species: 38
Approximate center of the collecting area: 57°47"W 17°40'S
Date visited: Jul 12, 1998

Puesto Gonzalo was an outpost of the Bolivian Navy, situated along a side channel of the Río Pedro II. The two ends of this channel were said to be connected with the Río Pedro II during high water stages, and water conditions are said to be lotic at this time. At the time of the fieldwork, the sole connection with the main body of the river was through a small lateral channel, and water conditions were lentic. Total area surveyed was approximately 2 ha.

In general, Puesto Gonzalo lacked the substantial populations of emergent woody and herbaceous species characteristic of the lacustrine study sites, however, a few emergent herbs were present. In most areas, channel edges contained floating mats of vegetation. At times, small openings were present in the mats and these supported either submerged species (*e.g. Cabomba furcata*) or rooted macrophytes with floating leaves (*e.g. Nymphaea* spp.). The area between the floating mats and non-inundated uplands was shallowly inundated at the time of the fieldwork, and supported dense populations of free-floating herbaceous macrophytes.

# Outlying Sites

## Laguna Volcan

Elevation: 1150 m. Watershed: Amazon Number of species: 39
Approximate center of the collecting area: 63°39'W 18°08' S
Dates visited: Feb 4, 1996; Jul 17, 1996; Jun 29, 1997

Laguna Volcan was a montane pond (elev. 1150 m) situated in a small saddle in the eastern Andean foothills. Bolivian vegetation maps (Killeen *et al*. 1993; Ribera *et al*. 1994) depict the general area of Laguna Volcan as falling within the transition between the southern (Bosque Tucumano-Bolivian) and northern (Bosque Montano Húmedo) wet montane forest types. As in the Bosque Montano Húmedo, wetlands appear to be uncommon in the Bosque Tucumano-Boliviano. For example, in the account of the RAP (Rapid Assessment Protocol) survey of this vegetation type (Schulenberg and Awbrey 1998) references to wetlands were limited to streams.

The system occupied a natural basin, but the basin had been deepened by the creation of a low earthen dike at it's shallow most end. A billboard at the base of the road leading to Laguna Volcan marked the area of the system at 7.0 ha, but I estimated the area as closer to 3.0 ha. Inputs of water to the system appeared to be limited to runoff and groundflow from adjacent slopes. Pond water was stained a dark brown, yet fairly transparent. Maximum depth was on the order of 3.5-4.0 m. A few marshy areas adjoined the pond basin. One of these contained a spongy, floating mat dominated by *Cyperus papyrus* (Cyperaceae) and *Typha domingensis* (Typhaceae). The emergent sedge, *Schoenoplectus californicus* (Cyperaceae), was the most abundant species in other marshy habitats.

Much of the basin was dominated by submerged vegetation. Three species, *Potamogeton gayii* and *P. illinoensis* (Potamogetonaceae), and *Najas guadalupensis* (Najadaceae), were noted; all were abundant. The submerged alga, cf. *Nitella* sp. (Characeae), was also common. Submerged species grew to depths of about 2.0-2.5 m.

Two species of rooted macrophytes with floating leaves, *Nymphoides verrucosa* (Menyanthaceae) and *Nymphaea lingulata* (Nymphaeaceae), were common in the basin.

A few free-floating species were present. *Lemna valdiviana* (Lemnaceae) and *Limnobium laevigatum* (Hydrocharitaceae) were both common. *Spirodela intermedia* (Lemnaceae) was also present, but only a single frond was noted.

Emergent vegetation was well-represented with: Hygrophila costata (Acanthaceae), Echinodorus bolivianus and E. paniculatus (Alismataceae), Acmella brachyglossa (Asteraceae), Cyperus haspan, Rhynchospora gigantea, Schoenoplectus californicus, and Torulinium odoratum (Cyperaceae), Hydrolea cf. elatior (Hydrophyllaceae), and Leersia hexandra (Poaceae). Species which occupied the shallows, increasing in abundance as water levels dropped were Echinodorus bolivianus and E. paniculatus (Alismataceae), Drymaria glandulosa (Caryophyllaceae), Commelina diffusa (Commelinaceae), Eleocharis minima, (Cyperaceae), Ludwigia leptocarpa and L. octovalvis (Onagraceae), Polygonum meisnerianum (Polygonaceae), and Bacopa salzmannii (Scrophulariaceae).

Species associated with the Typha domingensis/Cyperus giganteus mat were Hydrocotyle verticillata (Apiaceae), Begonia cucullata (Begoniaceae), Carex sp. and Cyperus surinamensis (Cyperaceae), Polygonum acuminatum, P. hispidum, and Polygonum punctatum (Polygonaceae), and Physalis sp. (Solanaceae).

Woody species were poorly represented, although the shrub *Ludwigia peruviana* (Onagraceae) was abundant along one edge of the system. Two poorly represented taxonomic groups were the Pteridophytes (with no species noted), and grasses, which had a single representative (*Leersia hexandra*).

Laguna Volcan was the sole wetland encountered in the Bosque Tucumano-Boliviano, other than a few, essentially unvegetated streams. Therefore, it is unclear whether or not the flora was representative of other wetlands in this vegetation type. Moreover, Laguna Volcan was located near the borders of two other primary vegetation types, the Bosque Serrano Chaqueño and the Bosque Semideciduo Chiquitano (Killeen *et al*. 1993), and elements from these were undoubtedly present.

Noteworthy species encountered at Laguna Volcan were *Carex* sp., *Echinodorus bolivianus* and *E. paniculatus*, *Hydrocotyle verticillata*, *Nymphaea lingulata*, *Nymphoides verrucosa*, and *Potamogeton gayii* (see Appendix E). Formerly, anthropogenic impacts appeared to be small-scale. The system was used for recreation by tourists from the nearby (ca. 40 km) city of Santa Cruz, with these activities generally limited to boating and fishing. Recently, however, residential development was initiated in the areas immediately surrounding Laguna Volcan. At the time of the last visit to the site (June, 1997) the road which led to this area had been extended to the pond. It is uncertain how many structures are planned, but erosion from clearing the slopes and nutrient inputs from sewage almost certainly will pose threats to the system.

**Yolosa Wetland**

Elevation: 1150 m Watershed: Amazon Number of species: 38
Approximate center of the collecting area: 16°16'04"S 67°44'14"W
Dates visited: Feb 26, 1995; May 21, 1995; May 18, 1996; July 29, 1996

The Yolosa Wetland was composed of a series of riverside and streamside marshy habitats associated with the Río San Juan, in the area around the town of Yolosa. Approximately 100 m of the river were surveyed. Included within the study site were two distinct areas: 1) a small stream which flowed out of the Río San Juan, passed through a culvert under a highway, and re-entered the river; and, 2) seasonally inundated areas along the banks of the river. The total area surveyed was approximately 0.05 ha.

The Yolosa Wetland flora was fairly species-rich (38 spp.), and was composed almost entirely of herbaceous species. Exceptions were the small tree, *Tessaria integrifolia* (Asteraceae) and the shrub *Ludwigia peruviana* (Onagraceae), both of which grew along the upper edges of the system, and the climber, *Mikania* sp. (Asteraceae), which was abundant in the stream and associated marshy areas. The spreading herb *Heteranthera reniformis* (Pontederiaceae) was locally abundant in one broad, shallow area, where it formed a very loosely-coalesced, more or less floating assemblage. The remainder of the flora was composed of emergent herbs, the most abundant of which were *Eclipta prostrata* (Asteraceae), *Drymaria glandulosa* (Caryophyllaceae), *Cyperus iria*, *C. luzulae*, *C. prolixus*, *Eleocharis montana*, and *Kyllinga odorata* (Cyperaceae), *Ludwigia*

*octovalvis* (Onagraceae), *Chloris radiata, Echinochloa colona, Eleusine indica, Melinis minutiflora* and *Pennisetum purpureum* (Poaceae) *Polygonum hydropiperoides* (Polygonaceae), and *Pityrogramma calomelanos* (Pteridaceae).

No species of note were encountered at the Yolosa wetland; rather, the flora was composed almost entirely of common weedy species. Of note, however, was the population of the endemic "rockweed", *Apinagia boliviana* (Podostemaceae), which was encountered in the Río Coroico, a few kilometers below the point where the Río San Juan entered this system (see Appendix E).

The Yolosa Wetland was significantly impacted by human activities. All manners of refuse were deposited along the edges of the system, and the upper portions of the stream were commonly used for washing clothes. Additionally, Yolosa was the site of a police checkpoint, and the buses that passed through this area on their way to and from La Paz were often required to stop at the checkpoint for extended periods. Consequently, the portion of the stream nearest the road was frequently called into service as a public bathroom. How these activities may have impacted the flora is not certain, but it can be stated unequivocally that they served to minimize botanical reconnaissance in this part of the system.

**Laguna Yaguacua**

Elevation: 920 m Watershed: Paraná Number of species: 10
Approximate center of the collecting area: 20°26'S 63°27'W
Date visited: Nov 24, 1996

Laguna Yaguacua was located in Serranía de Aguarague–a low range which comprises the first foothills of the Andes–at an elevation of 920 m. The system had an area of about 30 ha, and was shallow throughout, with a maximum depth (near the end of the dry season) of about 1.0 m. Water was a cloudy brown.

The vegetation was dominated by herbaceous species. An exception was the arborescent *Salix Humboldtiana* (Salicaceae), numerous individuals of which were present along the edge the system and along a seasonally inundated spit of land which intruded into the basin. Many species were sterile at the time of the visit, hence, species which could

normally be easily identified (*e.g.*, *Schoenoplectus californicus*) were given only provisional determinations. Emergent species (listed in approximate order of decreasing abundance) were *Thalia* sp. (Marantaceae), *Polygonum paraguayense* (Polygonaceae), *Eleocharis macrostachya* (Cyperaceae), cf. *Schoenoplectus californicus* (Cyperaceae), *Eclipta prostrata* (Asteraceae), cf. *Echinodorus* (Alismataceae) and *Cleome hassleriana* (Capparidaceae). *Lemna aequinoctialis* (Lemnaceae) was the sole free-floating species. No true submerged species were present, but young plants of *Ludwigia peploides* (Onagraceae) had the aspect of *Callitriche*, with most of the plant submerged, and leaves crowded toward the tip of the plant and floating on the water's surface. The lack of submerged species was surprising, since two other shallow ponds in the same general area supported fairly dense populations of *Stuckenia striata* (Potamogetonaceae).

Anthropogenic disturbance appeared to be limited to grazing by cattle, which ranged freely in the area. No rare or noteworthy species were present, at least as could be determined from the numerous sterile species. Nevertheless, as fieldwork at this site represented conditions during a single hydrologic stage, the composition and structure of the vegetation during the rainy season is expected to be significantly different. At the time of the visit, a striking feature of the system was the presence of 20-30 flamingos (presumably, the Andean flamingo, *Phoenicopterus andinus*).

**Cristalmayu Wetland**

Elevation: 640 m. Watershed: Amazon Number of species: 12
Approximate center of the collecting area: 65°38'W 17°00'S
Dates visited: Oct 30, 1994; May 14, 1995; Jun 7, 1995

The Cristalmayu Wetland consisted of a small artificial pond, formed by damming a stream which passed through the basin. The pond was situated in a notch at the base of two hills. A poorly constructed road ran above the pond and a large amount of material from the eroding hillside was washed into the pond during the (prolonged) rainy season. Basin sediments were soft and deep. Total area of the system was approximately 0.5 ha.

The Cristalmayu Wetland was the lowest montane study site. Due to the steep topography, few bodies of standing water were encountered in the lower Andean slopes,

and the rivers and streams draining these slopes were generally fast moving, and supported few macrophytes.

The stream passed through thick forest and was heavily shaded in the areas immediately above and below the pond. No vascular species were observed in the stream in the immediate vicinity of the pond, but a small population of *Heteranthera rotundifolia* (Pontederiaceae) was noted where the stream crossed a highway (ca. 0.3 km below the pond). Small marshy areas were present around the mouth of the stream, and in a few additional areas along the edge of the pond basin. These contained the greatest portion of the wetland vegetation at the site. Species noted in these habitats were *Justicia comata* (Acanthaceae), *Hydrocotyle leucocephala* (Apiaceae), *Drymaria glandulosa* (Caryophyllaceae), *Commelina diffusa* (Commelinaceae), *Cyperus luzulae*, *Scleria melaleuca*, and *Torulinium odoratum* (Cyperaceae), *Hymenachne donacifolia*, *Panicum polygonatum*, and *P. stoloniferum* (Poaceae), *Pennisetum purpureum* (Poaceae), and *Ludwigia affinis* (Onagraceae). *Pennisetum purpureum* (Poaceae), was common along the edge of the pond, and extended over open water by means of floating culms. No submerged, or free-floating species were observed at the site.

No noteworthy species were encountered at the Cristalmayu Wetland. The system was heavily impacted by human activities. By the time of the second visit, the streamside marsh had been modified by the deposition of sand and gravel from roadside erosion above the pond, and the species previously observed in this habitat were no longer evident. Because of heavy erosion upslope from the system, the future prognosis for the Cristalmayu pond is poor.