

## Appendix B. Extra-Bolivian Regional and National Wetland Floras

In addition to the sources listed below, regional and country floras were augmented by species distributions noted from taxonomic treatments, from herbarium specimens viewed at BOLV, LPB, MO, and USZ, and from distribution data obtained from queries of two online databases: the Flora Mesoamericana checklist (Davidse *et al.* 1999; <http://mobot.mobot.org>), and the Missouri Botanical Garden database TROPICOS (<http://mobot.mobot.org>).

### Argentina

#### Río Paraná Delta Region

A number of references pertaining to wetlands in the southern Río Paraná region were available. The following were entered in their entirety:

- Burkart, A. 1957. Ojeado sinóptica sobre la vegetación del Delta del Río Paraná. *Darwiniana* 11: 457-561.
- Cabrera, A. L. and H. A. Fabrís. 1948. Plantas Acuáticas de la Provincia de Buenos Aires *In: Publ. Tec. Min. Hac. Econ. Prev. Cont. Ser. D.A.G.I.* 5.
- Menalled, F. D. and J. M. Adámoli. 1995. A quantitative phytogeographic analysis of species richness in forest communities of the Parana River Delta, Argentina. *Vegetatio* 120: 81-90.

Additional wetland species were noted from the following sources. Although the complete species lists from these volumes were not incorporated into the database, each volume was reviewed for the presence of species already included in the “Wetland Species Database” and for additional species whose descriptions suggested that they were strongly associated with wetland habitats.

- Burkart, A., ed. 1974. Flora Ilustrada de Entre Ríos (Argentina). Parte VI: Dicotiledoneas Metaclamideas (Gamopétalas), B. Rubiales a Campanuales (incluso Compuestas). Instituto Nacional de Tecnología Agropecuaria, Buenos Aires, Argentina.

——— 1978. Flora Ilustrada de Entre Ríos (Argentina). Parte V : Dicotiledoneas Metaclamideas (Gamopétalas), A. Primulales a Plantaginales. Instituto Nacional de Tecnología Agropecuaria, Buenos Aires, Argentina.

Troncoso de B., N. S. and N. M. Bacigalupa eds. 1987. Flora Ilustrada de Entre Ríos (Argentina). Parte III: Dicotiledóneas Arquiclamídeas, A. Salicales a Rosales (Incluso Leguminosas). Instituto Nacional de Tecnología Agropecuaria, Buenos Aires, Argentina.

## **Brazil**

### **Central Amazonia**

The wetland flora of Central Amazonia was represented by the following sources:

Howard-Williams, C. and W. J. Junk. 1977. The chemical composition of central Amazonian aquatic macrophytes with special reference to their role in the ecosystem. *Arch. Hydrobiol.* 79: 446-464.

Junk, W. J. 1983. Ecology of Swamps on the Middle Amazon. pp. 269-294. *In:* Ecosystems of the World 4B. Mires: Swamp, Bog, Fen and Moor. Gore, A. J. P., ed. Elsevier, Amsterdam, The Netherlands.

——— 1986. Aquatic plants of the Amazon system. pp. 319-337. *In:* The Ecology of River Systems. Davies, W. B., ed. Dr. W. Junk Publishers, Dordrecht, The Netherlands.

——— 1989. Flood tolerance and tree distribution in central Amazonian floodplains. pp. 47-64. *In:* Tropical Forests. Botanical Dynamics, Speciation and Diversity. Haynes, R. R., Holm-Nielsen, L. B. and Balslev, H., eds. Academic Press, London.

——— and M. T. F. Piedade. 1993. Herbaceous plants of the Amazon floodplain near Manaus: species diversity and adaptations to the flood pulse. *Amazoniana* 7: 467-484.

Keel, S. H. K. and G. T. Prance. 1979. Studies on the vegetation of a white-sand black-water igapó (Río Negro, Brazil). *Acta Amaz.* 9: 645-655.

Worbes, M. 1997. The forest ecosystem of the floodplain. pp. 223-265. *In:* The Central Amazon Floodplain. Junk, W. J. (ed.) . Springer-Verlag, Berlin, Heidelberg.

### **Gran Pantanal de Mato Grosso**

The following sources were used to identify wetland species in the Gran Pantanal and to compile a regional flora. Additional species were from data provided by Vali Pott (personal communication).

- Conceição, C. d. A. and J. E. de Paula. 1986. Contribuição para o conhecimento da flora do Pantanal Mato-Grossense e sua relação com a fauna e o homem. pp. 107-130. *In: Anais 1º Simpósio Recursos Naturais e Sócio-Econômico do Pantanal*. EMBRAPA-CPAP, Corumbá, Brasil.
- Heckman, C. W. 1998. *The Pantanal of Pocone - Biota and Ecology in the Northern Section of the World's Largest Pristine Wetland*. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Por, F. D. 1995. *The Pantanal of Mato Grosso (Brazil)*. Kluwer Academic Publishers, Dordrecht.
- Pott, A. and V. J. Pott 1997. *Plants of Pantanal*. EMBRAPA-SPI, Corumbá, Brasil.
- Pott, V. J. 1998. A família Nymphaeaceae no Pantanal, Mato Grosso e Mato Grosso do Sul, Brasil. *Acta. Bot. Bras.* 12: 183-194.
- . S. C. de Almeida Rego and A. Pott. 1986. Plantas uliginosas e aquáticas de Pantanal arenoso. 6. EMBRAPA, CPAP, Corumbá, Brasil.
- . N. C. Bueno, R. A. C. Pereira, S. M. De Salis and N. L. Vieira. 1989. Distribuição de macrófitas aquáticas numa lagoa na fazenda Nhumirim, Nhecolândia, Pantanal, MS. *Acta. Bot. Bras.* 3: 153-168.
- . N. C. Bueno and M. Pereira da Silva. 1992. Levantamento florístico e fitossociológico de macrófitas aquáticas em lagoas da Fazenda Leque, Pantanal, MS. *Anais 8º Cong. SBSP* : 91-99.
- and A. Pott. 1997. Checklist do macrófitas aquáticas do Pantanal, Brasil. *Acta. Bot. Bras.* 11: 215-227.
- Prado, A. L., do, C. W. Heckman and F. R. Martins. 1994. The seasonal succession of biotic communities in wetlands of the tropical wet-and-dry climatic zone: II. The aquatic macrophyte vegetation in the Pantanal of Mato Grosso, Brazil. *Int. Rev. Gesamten. Hydrobiol.* 79: 569-589.

## **Other Brazil**

Additional Brazilian wetland species were ascribed from:

- Brandão, M., J. P. Laca-Buendia and M. L. Gavilanes. 1989. Plantas palustres e aquáticas que se comportam como invasoras, no estado de Minas Gerais. *Acta. Bot. Bras.* 2 (1) supl. Anais do XXXIX Congresso Nacional de Botânico: 255-265.
- Klinge, H., W. J. Junk and C. J. Revilla. 1990. Status and distribution of forested wetlands in tropical South America. *For. Ecol. Manag.* 33/34: 81-101.
- Pires, J. M. and G. Prance. 1985. The vegetation types of the Brazilian Amazon. pp. 109-145. *In: Key Environments: Amazonia.* Prance, G. T. and Lovejoy, T. E. eds. Pergamon Press, Oxford, England.

No comprehensive checklist of the flora of Brazil was encountered. Therefore, a provisional Brazilian flora was approximated by combining the preceding sources with the following general checklists:

Espécies Arbóreas da Estação Ecológica dos Caetetus. Estação Ecológica dos Caetetus Gália/Alvinândia, SP. Base de Dados Tropical.  
<http://www.bdt.org.br/mata.atlantica/flora/caetetus/listagalia>. Date Accessed: September 12, 2000.

Floristics and Economic Botany of Acre, Brazil. New York Botanical Garden and Universidade Federal do Acre. <http://www.nybg.org/bsci/acre/title.html> (Date Accessed: June 27, 2000)

Listagem de Espécies da Flora do Cerrado. Espécies da flora de Cerrado do Estado de São Paulo. Base de Dados Tropical.  
<http://www.bdt.org.br/cerrado/flora/sp/especies>. Date Accessed: September 12, 2000.

Mata da Esperança. New York Botanical Garden:  
<http://www.nybg.org/bsci/res/bahia/ME-chkl.html> (Date Accessed: 6/27/2000)

Monte Pascoal National Park. New York Botanical Garden:  
<http://www.nybg.org/bsci/res/bahia/MP-chkl.html> (Date Accessed: 6/27/2000)

Serra Grande forest/Serra do Condurú State Park. New York Botanical Garden:  
<http://www.nybg.org/bsci/res/bahia/SG-chkl.html> (Date Accessed: 6/27/2000)

Una Biological Reserve. New York Botanical Garden:  
<http://www.nybg.org/bsci/res/bahia/Checkli1.html> (Date Accessed:  
6/27/2000)

## **Colombia**

No comprehensive checklist of the flora of Colombia was encountered. Sufficient references were available, however, to allow the compilation of a national checklist of wetland species. The checklist of Colombian macrophytes provided by Profesor Udo Schmidt-Munn was a particularly critical resource. Sources were as follows:

Rangel, O. and J. Aguirre. 1983. Comunidades acuáticas altoandinas - I: Vegetación sumergida y de ribera en el Lago de Tota, Boyacá, Colombia. *Caldasia* 13: 719-742.

———. and ———. 1986. La vegetación de la cuenca del Lago de Tota (Boyacá). *Caldasia* 15: 263-311.

Sanabria, M. J. and A. De Wilde. 1998. Humedales del Departamento del Quindío. Inventario preliminar. (doc. intern.). Corporación Autónoma Regional del Quindío. CRQ, Armenia, Colombia.

Schmidt-Mumm, U. 2000. Macrófitos Acuáticos y Palustres de Colombia. Unpublished checklist. Date created: March 19, 2000.

## **Costa Rica**

The following sources were used in the ascription of Costa Rican wetland species:

Bumby, M. J. 1982. A survey of aquatic macrophytes and chemical qualities of nineteen locations in Costa Rica. *Brenesia* 19/20: 487-535.

Crow, G. E. and D. I. Rivera. 1986. Aquatic vascular plants of Palo Verde National Park, Costa Rica. *Uniciencia* 3: 71-78.

———. D. I. Rivera and C. Charpentier. 1987. Aquatic vascular plants of two Costa Rican ponds. *Selbyana* 10: 31-35.

Gómez, L. D. 1984. Las Plantas Acuáticas y Anfibias de Costa Rica y Centroamérica. Editorial Universidad Estatal A Distancia, San José, Costa Rica.

The complete Costa Rican flora was represented by:

Grayum, M., B. Hammel and N. Zamora. 1987 to present. Species list for the Manual to the Plants of Costa Rica. Database maintained at INBio. Access Date: Sep. 3, 1999. (<http://www.inbio.ac.cr/bims/PLANTAE.html>).

This checklist was obtained from the authors as a text file, and was converted to a database.

## **Ecuador**

The following sources were used to identify Ecuadorian wetland species:

Bravo-Velásquez, E. and H. Balslev. 1985. Dinámica y adaptaciones de las plantas vasculares de dos ciénegas tropicales en Ecuador. Reports from the Botanical Institute, University of Aarhus 11: 1-50.

Briones, E. E., A. Flachier, J. Gómez, D. Tirira, H. Medina, I. Jaramillo and C. Chiriboga 1997. Inventario de Humedales del Ecuador. Primera Parte: Humedales Lénticos de las Provincias de Esmeraldas y Manabí. EcoCiencia/INEFAN/Convención de Ramsar, Quito, Ecuador.

The complete Ecuadorean flora was represented by:

Jørgensen, P. M. and S. León-Yáñez (eds.). 1999. Catalogue of the Vascular Plants of Ecuador. Monographs in Systematic Botany from the Missouri Botanical Garden, St. Louis, Missouri.

The checklist was obtained from the authors as a text file, and was converted to a database. Data pertaining to species habitat, elevational range and geographical range were obtained by querying the "Catalogue of the Vascular Plants of Ecuador" (<http://www.mobot.org/MOBOT/research/ecuador/welcome.htm>) at the Missouri Botanical Garden website. A program was written to direct the computer to automatically submit queries to the website and to transfer query results to the database of Ecuadorian species (Dates accessed: August 20-25, 2000).

## **El Salvador**

Due to insufficient data, it was not possible to compile a complete national checklist for El Salvador. Information from the following published accounts of Salvadorian wetlands was used in the ascription of wetland species:

- Armitage, K. B. 1957. Lagos de la Planicie Costera de El Salvador. *Comun. Inst. Trop. Invest. Ci. Univ. El Salvador* 6: 5-8.
- 1958. Lagos Volcánicos de El Salvador. *Comun. Inst. Trop. Invest. Ci. Univ. El Salvador* 7: 39-48.
- and N. C. Fassett. 1971. Aquatic plants of El Salvador. *Arch. Hydrobiol.* 69: 234-255.
- Loetschert, W. 1954. La Laguna de Alegría. *Comun. Inst. Trop. Invest. Ci. Univ. El Salvador* 3: 173-175.

## **The Guianas**

French Guiana, British Guyana, and Suriname, the three countries which constitute “the Guianas”, were treated as a single OGU. Although this region possesses a rich wetland flora, no reports of Guianan wetlands were encountered, other than references in various taxonomic treatments. Therefore, additional Guianan wetland species were distinguished by a query of the exsiccatae in the Biological Diversity of the Guianas Database (performed by Tom Hollowell, of the Department of Botany at the Smithsonian Institution, Washington, DC) using the following terms: Like “\*bog\*” Or Like “\*wetland\*” Or Like “\*marsh\*” Or Like “\*fen\*” Or Like “\*swamp\*” Or Like “\*seep\*” Or Like “\*flooded\*”.

The complete flora of the Guianas was represented by:

- Boggan, H., V. Funk, C. Kelloff, M. Hoff, G. Cremers and C. Feuillet 1997. Checklist of the Plants of the Guianas. The Biological Diversity of the Guianas Program, Dept. of Botany, National Museum of Natural History, Washington, DC.

The checklist was acquired in database format from the Biological Diversity of the Guianas project, National Museum of Natural History, Washington, DC. (Access Date: February 2, 2000).

## Mexico

No comprehensive checklist of the flora of Mexico was available. Checklists for various state and regional floras, however, were encountered on the World Wide Web. These, along with species lists from a number of published studies of Mexican wetlands, were downloaded and incorporated into a database. Additional species records from the Flora Mesoamerican database (Davidse *et al.* 1999) were combined with these sources.

Although this checklist was undoubtedly an incomplete representation of the country's flora, it contained over 10,000 species. As many of the studies used in compiling the list were of wetland habitats, it seems probable that a significant portion of the country's wetland species were represented. Sources were:

- Bonilla-Barbosa, J. R. and A. Novelo R. 1995. Manual de Identificación de Plantas Acuáticas del Parque Nacional Lagunas de Zempoala, México. Instituto de Biología, Universidad Nacional Autónoma de México, México, D. F., México.
- Breedlove, D. E. 1986. Listados Florísticos de México II: Flora de Chiapas. Instituto de Biología, Universidad Nacional Autónoma de México. Access Date: Nov. 21, 1999. (<http://www.ibiologia.unam.mx/publicaciones/lfl4.html>).
- Cowan, C. P. 1983. Listados Florísticos de México I: Flora de Tabasco. Instituto de Biología, Universidad Nacional Autónoma de México. Access Date: Aug. 8, 1999. (<http://www.ibiologia.unam.mx/publicaciones/lfl1.html>).
- Dávila Aranda, P., J. L. Villasenor Ríos, R. Medina Lemos, A. Ramírez Roa, A. Salinas Tovar, J. Sánchez-Ken and P. Tenorio Lezama. 1993. Listados Florísticos de México X: Flora del Valle de Tehuacán-Cuicatlan. Instituto de Biología, Universidad Nacional Autónoma de México. Access Date: Nov. 23, 1999. (<http://www.ibiologia.unam.mx/publicaciones/lfl10.html>).
- López-Hernández, E. 1993. Aspectos de la vegetación de los Pantanos de Centla, Tabasco, México. *Universidad y Ciencia* 10: 43-56.



- Lot, A., A. Novelo R. and P. Ramírez-García. 1986. Listados Florísticos de México V. Angiospermas Acuáticas Mexicanas 1. Instituto de Biología, Universidad Nacional Autónoma de México. Access Date: Sep. 20, 1999. (<http://www.ibiologia.unam.mx/publicaciones/lfl5.html>).
- and A. Novelo R. 1988. Vegetación y flora acuática del Lago de Pátzcuaro, Michoacán, México. *Southw. Natur.* 33: 167-175.
- A. Novelo Retana, M. Olvera García and P. Ramírez-García 1999. Catálogo de Angiospermas Acuáticas de México. Hidrófitas estrictas emergentes, sumergidas y flotantes. Instituto de Biología. Universidad Nacional Autónoma de México, México, D. F.
- Ramírez-García, P. and A. Novelo R. 1984. La vegetación acuática vascular de seis lagos-cráter del estado de Puebla, México. *Bot. Soc. Bot. México* 46: 75-88.
- Rojas, J. and A. Novelo R. 1995. Flora y vegetación del Lago de Cuitzeo, Michoacán, México. *Act. Bot. Mex.* 31: 1-17.
- Sousa S., M. and E. F. Cabrera C. 1983. Listados Florísticos de México II: Flora de Quintana Roo. Instituto de Biología, Universidad Nacional Autónoma de México. Access Date: Nov. 19, 1999. (<http://www.ibiologia.unam.mx/publicaciones/lfl2.html>).
- Tellez Valdes, O. and E. F. Cabrera Cano. 1987. Listados Florísticos de México VI: Florula de la Isla de Cozumel, Q.R. Instituto de Biología, Universidad Nacional Autónoma de México. Access Date: Nov. 24, 1999. (<http://www.ibiologia.unam.mx/publicaciones/lfl6.html>).
- . G. Flores Franco, A. Martínez Rodríguez, R. E. González Flores, G. Segura Hernández, R. Ramírez Rodríguez, A. Domínguez Mariani and I. Calzada. 1995. Listados Florísticos de México XII. Flora de la Reserva Ecológica Sierra de San Juan, Nayarit, México. Instituto de Biología, Universidad Nacional Autónoma de México. Access Date: Nov. 22, 1999. (<http://www.ibiologia.unam.mx/publicaciones/lfl12.html>).

## **Panama**

The Panamanian flora was represented by:

- D'Arcy, W. G. 1987. Flora of Panama. Missouri Botanical Garden. Access Date: Aug. 7, 1999. (<http://mobot.mobot.org/Pick/Search/index/panamaa.html>.)

As this checklist included only flowering plants, the presence and absence of wetland pteridophytes in Panama were determined from: 1) online queries of the Flora

Mesoamerican database (Davidse *et al.* 1999; <http://mobot.mobot.org>); 2) exsiccatae listed in TROPICOS; 3) specimens encountered in herbaria; and, 4) species distributions from the literature.

No reports of Panamanian wetlands were encountered. Nevertheless, as numerous accounts of wetlands and wetland species in countries near Panama (*i.e.*, countries in Central America and northern South America) were incorporated into the Wetland Species Database it seems likely that the greatest part of the Panamanian wetland flora was accounted for. Additionally, Gómez (1984) listed various wetland species known for Panama, and this information was also incorporated into the compiled Panamanian wetland flora.

### **Paraguay**

The following sources were used in the ascription of wetland species, and for compiling a representative wetland flora for Paraguay:

Galán de Mera, A. and G. Navarro. 1992. Comunidades vegetales acuáticas del Paraguay occidental. *Caldasia* 17: 35-46.

Mereles, F., R. Degen and N. López de Kochalca. 1992. Humedales en el Paraguay: breve reseña de su vegetación. *Amazoniana* 12: 305-316.

Wolf, A. 1990. Vegetationskundliche Beobachtungen en Flachwasserseen nahe der Mündung des Río Ypané, Paraguay. *Amazoniana* 11: 167-184.

### **Peru**

The following sources were used in the ascription of Peruvian wetland species:

Cano, A., B. León and K. R. Young. 1993. Plantas vasculares de los Pantanos de Villa, Lima. pp. 177-208. *In: Las Plantas Vasculares en las Aguas Continentales del Perú.* Kahn, F., León, B. and Young, K. R., eds. IFEA (Instituto Francés de Estudios Andinos), Lima, Perú.

Galán de Mera, A. 1989. Notas florísticas sobre el litoral y los Andes del Perú (Departamento de Lima). *Lazaroa* 11: 193-196.

Kahn, F., B. León and K. R. Young, eds. 1993. *Las Plantas Vasculares en las Aguas Continentales del Perú*. IFEA (Instituto Francés de Estudios Andinos), Lima, Peru.

Kalliola, R., J. Salo, M. Puhakka and M. Rajasilta. 1991. New site formation and colonizing vegetation in primary succession on the western Amazon floodplains. *J. Ecol.* 79: 877-901.

León, B., A. Cano and K. R. Young. 1995. *La flora vascular de los Pantanos de Villa, Lima, Perú: adiciones y guía para las especies comunes*. *Publ. Mus. Hist. Nat. UNMSM (B)* 38: 1-39.

The complete Peruvian flora was represented by:

Brako, L. and J. L. Zarucchi 1993. *Catalogue of the Flowering Plants and Gymnosperms of Peru*. Missouri Botanical Garden, St. Louis, Missouri.

The checklist was downloaded from the Missouri Botanical Garden website (<http://www.mobot.org/MOBOT/Research/peru.html>; Access date: August 20, 1999) and converted to database format. This file contained the complete range of data (i.e., life-form, principal habitat, elevational range) contained in the published checklist. Thus, it was possible to produce “regional” checklists (i.e., the Lowland Amazonian Peru OGU) by querying the database.

As pteridophytes were not included in Brako and Zarucchi's (1993) checklist, the presence and absence of wetland pteridophytes in Peru were determined from: 1) exsiccatae listed in TROPICOS; 2) online queries of the Flora Mesoamerican database (Davidse *et al.* 1999; <http://mobot.mobot.org>); 3) specimens encountered in herbaria; and, 4) monographs and other literature.

### **United States and Associated Territories**

The 1996 National List of Vascular Plant Species That Occur in Wetlands (Reed 1996) was downloaded as a text file and converted to a database. This checklist enumerated the wetland status for 7437 species from the United States *sl.* and catalogued the status for each species in 11 regions from the Continental United States (Northeast, Southeast, North Plains, North Central, Central Plains, South Plains, Southwest, Inter-mountain, Northwest, California, and Alaska), and for associated territories in the Caribbean (Puerto

Rica and the U.S. Virgin Islands) and Pacific regions (the Hawaiian Islands, American Samoa, the Federated States of Micronesia, Guam, the Marshall Islands, the Northern Mariana Islands, Palau, and U.S. Minor Outlying Islands).

Of the 7000+ species included in the checklist, 3284 were selected here as being “wetland species”. Of these, 2034 were characterized as “Obligate Wetland Species” (OBL), *i.e.*, those that, under natural conditions, almost always occur in wetlands (Reed 1996). The remaining 1250 species were those that possessed a national status of “Facultative Wetland Species” (FACW), *i.e.*, those that usually occur in wetlands (estimated probability 67%-99%, Reed 1996). In most cases, species that had a “mixed” national status indicating both wetland and upland affinities (*i.e.*, FACU, FACW) were not considered as wetland species. Thirty-four species had a mixed national status that indicated that each was an obligate wetland species in part of its range (*i.e.*, FACU, OBL), and these were treated as wetland species. To allow comparisons on the sub-regional level, the presence and absence of wetland species from various states were ascertained by downloading state checklists from the National Plant Data Center website (USDA & NRCS 1997) and incorporating this information into the database.

The complete flora of the United States and associated territories was obtained by downloading the PLANTS National Database checklist (USDA, NRCS 1997. The PLANTS database. (<http://plants.usda.gov>). National Plant Data Center, Baton Rouge, LA. (Downloaded July 9, 2000). The checklist was downloaded as a text file and was converted to a database.

### **Venezuela**

The following sources were used to compile a representative wetland flora for the country:

Aristeguieta, L. 1968. Consideraciones sobre la flora de los Morichales Llaneros al norte del Orinoco. *Acta Bot. Venez.* 3: 19-38.

- Colonnello, G., S. Castroviejo and G. López. 1986. Comunidades vegetales asociadas al río Orinoco en el Sur de Monagas y Anzoátegui (Venezuela). Mem. Soc. Ci. Nat. La Salle 46: 127-165.
- Ramía, M. 1974. Plantas de las sabanas llaneras. Monte Avila Editores, Caracas, Venezuela.
- Velásquez, J. 1994. Plantas Acuáticas Vasculares de Venezuela. Universidad Central de Venezuela, Consejo de Desarrollo Científico y Humanístico, Caracas.

## Appendix C. The Bolivian Regions

In addition to species lists compiled from my field research, wetland floras for the Bolivian regions were augmented by the work of other researchers whenever possible. In some cases (*e.g.*, the White-water floodplain region), data from these sources equaled or exceeded data from my fieldwork. In addition to data taken from studies of specific wetlands, regional checklists were augmented by specimens listed in the general literature (*e.g.*, monographs and local floras and florulas) that could be confidently ascribed to a that region.

The Missouri Botanical Garden's database TROPICOS also served to augment the regional checklists. Data from TROPICOS were obtained by querying the database for the exsiccatae collected from each of Bolivia's nine Departamentos. The selected records (ca. 61,000) were subsequently apportioned to the proper region. As with any database, a portion of the records from TROPICOS contained errors from incorrectly entered data. Errors in locality data were located by exporting the records to a spreadsheet and performing a series of sequential sortings. In this way, specimen records with outlying locations (*i.e.*, latitudes or longitudes) or improperly recorded political divisions (*e.g.*, Provincias which did not correspond to the Departamento for which they were listed) were identified. Whenever possible, incorrect data for these records were emended, but when it was not possible to make corrections the record was discarded.

In the following sections, the eight Bolivian regions considered in floristic comparisons are described and sources used in compiling the regional wetland floras are listed.

### **High Andean**

The High Andean "region" incorporates territory from the country's three major watersheds (Desaguadero, Amazon, and Paraná). In Bolivia, the greatest portion of high Andean (Puna) vegetation occurs within one large contiguous region (the "Altiplano" and adjacent peaks), with outlying high Andean ecosystems occurring on high elevation habitats in the Cordillera Central ("central range") and the Cordillera Oriental ("eastern range") of the Andes (*i.e.*, the montane peaks situated above the Valles Secos).

The Altiplano, which has a mean elevation of 3800 m (Solomon 1989), is an extensive interior basin bounded by the Cordillera Occidental (“western range”) and the Cordillera Central. The Altiplano and bordering montane slopes comprise the Desaguadero watershed, which is essentially a closed watershed. High-elevation habitats from the mountain peaks above the Valles Secos (Dry Interandean Valleys) are characterized by alpine vegetation similar to that of the Altiplano (Solomon 1989), and these habitats have been grouped with the high-altitude sites from the Río Desaguadero watershed. The greatest part of these belong to the Amazon watershed, although the southern sections of the mountains drain to the Río Paraná system. With a single exception (Huayalmarca Pond Desaguadero watershed) the High-Andean study sites were all situated within the Amazon watershed. Auxiliary collections, however, were made from other high-elevation wetlands in the Desaguadero watershed in the areas around the city of La Paz and Lago Titicaca. Additional botanical reconnaissance was conducted in high-elevation habitats of the Paraná watershed, but no study sites were established in this area.

The High Andean region is characterized by low (<500 mm) average annual precipitation and by an annual average temperature of less than 10°C. (Killeen *et al.* 1993). The vegetation of the High-Andean zone is termed *puna*; an association which extends southwards into Chile and Argentina and northwards into Peru (Solomon 1989). In Bolivia, puna formations occur between elevations of 2550-4800 m (Killeen *et al.* 1993). The puna is characteristically dominated by graminoids and herbaceous dicotyledons (Killeen *et al.* 1993), although a variety of shrubs and short trees are also often present.

Sources used to augment the checklist for the High Andean region were:

Estenssoro C., E. S. 1991. Los bofedales de la cuenca alta del valle de La Paz. pp. 109-116. *In: Historia Natural de un Valle en Los Andes: La Paz.* Forno, E. and Baudoin, M., eds. Instituto de Ecología, Universidad Mayor de San Andrés, La Paz, Bolivia.

Franken, M. 1991. Plantas Acuáticas. pp. 511-520. *In: Historia Natural de un Valle en Los Andes: La Paz.* Forno, E. and Baudoin, M., eds. Instituto de Ecología, Universidad Mayor de San Andrés, La Paz, Bolivia.

Lara, R. R. and A. L. Cazas. 1996. Caracterización ambiental de las vegas altoandinas en Los Lipez - Potosí. *Revista Boliviano de Ecología* 1: 60-68.

Pestalozzi Schmid, H.-U. A. 1998. Flora ilustrada Altoandina: la relación entre hombre, planta y medio ambiente en el Ayllu Majasaya Mujlli (Prov. Tapacará, Depto. Cochabamba, Bolivia). Herbario Forestal "Martín Cárdenas", Herbario Nacional de Bolivia, Cochabamba and La Paz, Bolivia.

Raynal-Roques, A. 1991. Las Plantas Superiores. pp. 233-239. *In*: El Lago Titicaca: Síntesis del Conocimiento Limnológico Actual. Dejoux, C. and Iltis, A., eds. ORSTOM, La Paz, Bolivia.

Siebert, P. v. and X. Menhofer. 1992. Die Vegetation des Wohngebietes der Kallawaya und des Hochlandes von Ulla-Ulla in den bolivianischen Anden. Teil I. *Phytocoenologia* 20: 289-438.

### **Cloud Forest**

A description of the Bolivian Cloud Forest region is presented in Chapter 3. No published accounts of wetlands in the Cloud Forest were encountered; hence, the region's species checklist was compiled almost entirely from my fieldwork in the region, with a few species added from TROPICOS specimens and from the taxonomic literature.

### **Valles Secos**

"Valles Secos" is the name given to the series of tablelands, peaks and valleys which occupy portions of the Central and Eastern Ranges (Cordillera Central and Cordillera Oriental) of the Andes. In the Andes south of about 18° the orientation of the mountains changes to a nearly north-south alignment, the mountains are lower, orographic precipitation is lessened, and there is a shift in weather patterns (Solomon 1989). This results in the Valles Secos being in rainshadow, with the region having a dry season of at least six to eight month duration (Killeen *et al.* 1993). The terrestrial vegetation is a matrix of xerophytic thorn woodland, thorn scrub, and dry forest (Killeen *et al.* 1993). The Valles Secos have been inhabited since pre-Incan times, and now face a number of serious problems, such as erosion, desertification, loss of vegetative cover, and lack of water during the prolonged dry season (Navarro *et al.* 1996).

Although aquatic habitats do not constitute a large portion of the Valles Secos, lakes and ponds are not uncommon, and the edges of streams and rivers frequently contain marshy habitats. These range in size from tens of square meters to a few hectares (and possibly



much larger). The sole published floristic account of a Valles Secos wetland that I encountered was Cadima's (1989) study of Laguna Alalay. This system was also one of my study sites. Cadima listed three species for Laguna Alalay that I did not encounter, but I felt that the identity of these was questionable. No voucher specimens were cited; hence, I was unable to satisfactorily resolve the questions I had regarding their identity. These species, therefore, were not added to the regional checklist.

### **Chapare**

A description of the Chapare region is presented in Chapter 4. Sources used to augment the checklist for the Chapare region were:

Jiménez, A. M. 1984. Flora de Cochabamba. Imprenta Los Huerfanos, Santa Cruz de la Sierra, Bolivia.

Maldonado, M., E. Goitia, F. Acosta, M. Cadima and D. Castellon. 1996. Caracterización limnológica de lagunas en la llanura aluvial del río Ichilo (Cochabamba). Rev. Bol. de Ecol. 1: 30-38.

### **Andean Piedmont**

The Andean Piedmont region is a small (ca. 4500 km<sup>2</sup>) region situated along the area at the base of the Andes directly east of the Chapare. As defined here, this region comprises the lowland portions of the areas around the city of Santa Cruz (the Provincias of Sarah, Santiesteban, Warnes, and Ibanez). Elevations are somewhat higher than the Chapare, with a minimum of ca. 400 m. For this study, a maximum elevation of 600 m was chosen as the upper limit for the region.

In contrast to the Chapare, which is situated in an "inside corner" of the Andes, the Andean Piedmont region is located in an "outside corner", formed as the orientation of the mountains changes from an approximately eastern to a southern bearing. Hence, the eastern portion of the Andean Piedmont region is situated in the transition between the mountains and the vast plains which extend from south-central Bolivia southwards through Paraguay and Argentina. Because of its position in the transition between the humid forests of Amazonia and the dry forests of the Chiquitanía and the Chaco, the

Andean Piedmont region supports a matrix of terrestrial vegetation types (Killeen *et al.* 1993).

As with the Chapare, annual precipitation varies significantly over a fairly short distance, ranging from ca. 2400 mm yr<sup>-1</sup> at the town of Yacapaní near the western limits of the region to 1300 mm yr<sup>-1</sup> in the area around the city of Santa Cruz (Servicio Nacional de Meteorología e Hidrología, La Paz). Isohyets shown in a map prepared by Roche and Rocha (1985) suggest that the eastern portion of the region is even drier, reaching about 900 mm yr<sup>-1</sup> in the area south of the city of Santa Cruz.

Sources used to augment the checklist for the Andean Piedmont region were:

Foster, R. C. 1946. Studies in the Flora of Bolivia, -- I. Contributions From The Gray Herbarium Of Harvard University, No. CLXI : 3-18.

——— 1948. Studies in the Flora of Bolivia, II. Contributions From The Gray Herbarium Of Harvard University, No. CLXVI : 28-43.

——— 1965. Studies in the flora of Bolivia, III. Cyperaceae, Part 1. *Rhodora* 67: 97-138.

——— 1966. Studies in the flora of Bolivia, IV. Gramineae. *Rhodora* 68: 97-120; 233-358.

### **White-water Floodplain**

Northern and northeastern Bolivia, is characterized by an extensive plain, cut-through by a network of rivers which drain the eastern slope of the Andes. In this study, the greatest part of this plain was treated as the “White-water Floodplain” region. As defined here, this region corresponds roughly to the area extending from near the base of the Andes northwards to the country’s borders with Peru and Brazil, and is composed of the Departamentos of Beni and Pando, and most of the lowland portions of the Departamentos of La Paz and Cochabamba. The name “white-water” refers to the highly turbid rivers which drain the Andes, as per the classification of Amazonian water types presented by Sioli (1975).

The floodplain varies from 150-250 meters in elevation, with areas of local relief located near the base of the mountains (Killeen *et al.* 1993). Annual precipitation is variable,

with rainfall generally decreasing northwards. Mean annual precipitation from seven meteorological stations ranged from 1800 mm at Riberalta (yearly totals: 975-2430 mm) to about 2200 mm at Rurrenabaque (yearly totals: 1155-3512 mm; Servicio Nacional de Meteorología e Hidrología, La Paz). Based on records for precipitation in the adjacent Chapare region— where mean annual precipitation can reach at least 6000 mm (Moraes and Beck 1992)—the southernmost portions of the White-water Floodplain undoubtedly experience annual rainfall of greater than 3,000 mm. Average annual temperature is on the order of 25°C (Killeen *et al.* 1993).

Large areas of the floodplain contain wetland ecosystems. Allenby (1988) estimated that this region (excluding the Pando) contained roughly 250,000 km<sup>2</sup> of “swampland”. Included in this region are the “Llanos de Mojos”, an extensive complex of seasonally flooded savanna, which covers approximately 100,000 km<sup>2</sup> (Haase and Beck 1989) and which constitutes the largest area of seasonally inundated savanna (“sabanas hiperestacionales”) in the Amazon basin (Hanagarth 1993). Lacustrine systems are plentiful, with many characteristically containing one or more straight edge (*i.e.*, the “aligned, rectangular lakes of the Beni Basin” *sensu* Allenby 1988).

Sources used to augment the checklist for the White-water Floodplain region were:

Beck, S. G. 1984. Comunidades vegetales de las sabanas inundadas en el NE de Bolivia. *Phytocoenologia* 12: 321-350.

Haase, R. 1989. Plant communities of a savanna in northern Bolivia I. Seasonally flooded grassland, and gallery forest. *Phytocoenologia* 18: 55-81.

——— 1990. Plant communities of a savanna in northern Bolivia II. Palm swamps, dry grassland, and shrubland. *Phytocoenologia* 18: 343-370.

——— and S. G. Beck. 1989. Structure and composition of savanna vegetation in northern Bolivia: A preliminary report. *Brittonia* 41: 80-100.

Hanagarth, W. 1993. Acerca de la Geoecología de las Sabanas del Beni en el Nordeste de Bolivia. Instituto de Ecología - Bolivia, La Paz.

Helme, N. A. and L. Kruger. 1995. Preliminary Field Report. The Bolivian Pampas de Heath - An International Conservation Priority for Neotropical Savannas. Proposed Madidi National Park, Dpto. La Paz, Prov. Iturrealde,

## Chiquitanía

The Chiquitanía is a large (ca. 170,000 km<sup>2</sup>, Killeen 1990) region in eastern lowland Bolivia. The Chiquitanía occupies the extreme western edge of the Brazilian shield (Killeen 1990) and is composed of the provinces of Velasco, Chiquitos, and Ñuflo de Chavez. The region experiences a pronounced dry season (ca. 5 months, Killeen 1990) during the austral winter. Precise meteorological data are lacking for the region, however, mean annual precipitation from two weather stations (Concepción and San Ignacio de Velasco) ranged from about 1150-1250 mm, with yearly totals ranging from 700-1600 mm (Servicio Nacional de Meteorología e Hidrología, La Paz). Conditions are progressively wetter toward the northeast, with mean annual precipitation in the Parque Nacional Noel Kempff Mercado area estimated at between 1400-1500 mm (Killeen and Schulenberg 1999). Mean annual temperatures are around 25°-26°C, with highs of 38° and lows of 3°C recorded for Concepción (Killeen and Schulenberg 1999).

The central portion of eastern Bolivia is essentially a zone of climatic transition between the wet conditions of the Amazon basin and the drier climate of southern South America. The terrestrial vegetation in this area reflects a gradual change from the evergreen forest of Amazonia to the dry forest of the Chaco, and has been delineated as “Bosque Semideciduo Chiquitano” (Killeen *et al.*, 1993). The Chiquitanía possesses a variable topography (ca. 300-1,240 m), and is characterized by a mixture of forest, savanna, savanna wetlands, and vegetated rock outcroppings and is considered to be a part of the Cerrado biogeographic region (Killeen *et al.*, 1993). No wetland complex on the scale of the Llanos de Mojos is present in Chiquitanía, nevertheless, wetlands are fairly common throughout the region.

Sources used to augment the checklist for the Chiquitanía region were:

Killeen, T. J. 1990. The grasses of Chiquitanía, Santa Cruz, Bolivia. *Ann. Missouri Bot. Gard.* 77: 125-201.

——— and M. Nee. 1991. Catálogo de las plantas sabaneras de Concepción, Depto. de Santa Cruz, Bolivia. *Ecol. Bolivia* 17: 53-71.

—— and T. S. Schulenberg eds. 1999. A Biological Assessment of the Parque Nacional Noel Kempff Mercado, Bolivia. RAP Working Paper 10. Conservation International, Washington, DC.

### **Gran Pantanal**

The Gran Pantanal region is described in Chapter 5. Sources used to augment the checklist for the Gran Pantanal region were:

Frey, R. 1995. Flora and vegetation of "Las Piedritas" and the margin of Laguna Cáceres, Puerto Suárez, Bolivian Pantanal. *Bull. Torrey Bot. Club* 122: 314-319.

Halloy, S. 1997. Áreas Protegidas Pantanal de Otuquis y San Matías. Ministerio de Desarrollo Sostenible y Medio Ambiente, Santa Cruz, Bolivia.

### **Additional Sources Incorporated Into The Bolivian Wetland Species Database**

Species listed in the following two reports for the Reserva de Vida Silvestre Ríos Blancos y Negros were incorporated in the wetland species database. This reserve is situated in the transition zone between the White-water floodplain and the Chiquitanía, therefore, I was unable to confidently ascribe species listed for the Reserva to either region.

Navarro, G. 1992. Informe: Sectorización Ecológica Previa de la Reserva Memoria y Mapa de Unidades Ambientales. Proyecto de Protección Ríos Blanco y Negro. Departamento de Botánica, Universidad Complutense, Madrid, Spain.

—— 1993. Informe: Tipificación de Ambientes Acuáticos y Clasificación de la Vegetación de la "Reserva de Vida Silvestre Ríos Blanco y Negro". Proyecto de Protección Ríos Blanco y Negro. Departamento de Botánica, Universidad Complutense, Madrid, Spain.