

Colombian Páramo Vegetation Database (CPVD) – the database on high Andean *páramo* vegetation in Colombia

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Abstract: The Colombian Páramo Vegetation Database (CPVD; GIVD ID SA-CO-001) originates from the rush of phytosociological studies developed during the second half of the last century. The efforts of Spanish, Dutch and Colombian botanists have allowed almost the entire territory of the country where this natural region (*páramo*) is present to be covered. The database currently has records of approximately 1,000 plots representing at least 327 different physiognomic types such as shrubs, *Espeletia* stem rosettes and bunchgrasses established in localities of the three Andean Cordilleras and in the Caribbean massifs, Sierra Nevada de Santa Marta and Serranía de Perijá. The Eastern Cordillera, which is the most explored mountain range, contains the highest diversity and richness in vegetation types. The construction of the database has allowed us to start the delimitation and syntaxonomical classification of vegetation units, as can be seen in the most recent phytosociological treatments of the *páramo* vegetation of the Western Cordillera and the massifs of the Caribbean region. The database provides information for programs on conservation of associated flora and fauna species and restoration – recovery of vegetation types under imminent risk due to habitat loss. Also relevant are its applications in spatial delimitation of conservation reserves, development of thematic cartography, and precise definition of altitudinal limits of the *páramo* region for land use purposes.

Keywords: Andes; biodiversity; phytosociology.

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Introduction

The establishment of the vegetation characterization in Colombia, including the *páramo* region, has its historical origins in the contributions of Caldas and von Humboldt (van der Hammen & Rangel-Churio 1997), actions extraordinarily boosted by Cuatrecasas-Arumí's contributions (Cuatrecasas-Arumí 1934), who described under geobotanical criteria several types of stem rosettes: *Espeletietum hartwegianae-Calamagrostiosum*, *Hypericetosum* and *Sphagnosum* (Central Cordillera), and *Espeletietum argenteae-Calamagrostiosum* (Eastern Cordillera), and also by the studies associated with 'The Quaternary of Colombia' program lead by Prof. Dr. Thomas van der Hammen (van der Hammen & González 1960, van der Hammen 1973).

Among the most relevant contemporary contributions are those of Lozano-Contreras & Schnetter (1976), Cleef (1981), Sturm & Rangel-Churio (1985), Rangel-Churio & Franco-Roselli (1985), Franco-Roselli et al. (1986), Duque-Nivia

& Rangel-Churio (1989), Sánchez-Montaño & Rangel-Churio (1990) and Salamanca-Villegas (1991). The 'Studies on Tropical Andean Ecosystems' program (ECOANDES) allowed the characterization of the *páramo* vegetation of Central (Salamanca-Villegas et al. 2003) and Western and Eastern Cordilleras (Cleef et al. 2005, Cleef et al. 2008). The evaluation of the isolated Caribbean massifs such as Sierra Nevada de Santa Marta and Serranía de Perijá was carried out by Cleef & Rangel-Churio (1984) and Rangel-Churio & Arellano-Peña (2007b). The abundant information from different sources has been gathered in the database, including precise physical and biotic aspects such as plot size, elevation and detailed inventory of plant species. Data related to geographical locations and the taxonomic identity of floristic elements are currently being updated (Pinto-Zárate & Rangel-Churio 2010a), and the validation of the phytosociological nomenclature is being addressed. The first results based on this database for Western *Cordillera* and the Caribbean massifs were

published by Pinto-Zárate & Rangel-Churio (2010b, c).

Characteristics of the Colombian *páramo*

The *páramo* region in Colombia includes the extensive zones that crown the mountains, extended between the continuous upper limit of the middle mountain forest vegetation and the lower limit of the snow line. In most locations the soils have a thick layer of organic matter. The climate is very contrasting with cold humid nights and very sunny days, occasionally with intense radiation. According to annual rainfall, they can be classified as pluvial (above 4,000 mm), super-humid (4,000-3,000 mm), humid (3,000-1,800 mm), semi-humid (1,800-1,200 mm) and dry (below 1,200 mm) (Rangel-Churio 2000c). Three life zones have been considered for the *páramo* region, showing physical and biotic characteristics clearly defined (Cuatrecasas-Arumí 1958, Cleef 1981, Rangel-Churio 1991, 2000b, Lut-

eyn 1999, Salamanca-Villegas et al. 2003): *subpáramo*, grass *páramo* and *superpáramo*. The *subpáramo* ('lower páramo', 'shrub páramo'), from 3,200 (3,100) to 3,500 (3,600) m a.s.l., has a predominance of shrubby vegetation

types. The grass *páramo* ('middle páramo', 'páramo properly said', 'proper páramo'), from 3,500 (3,600) to 4,100 m.a.s.l., is dominated by *Espeletia* stem rosettes and bunchgrasses. The *superpáramo* ('upper páramo'), from 4,100 m

a.s.l. to the lower snow line, shows a very characteristic discontinuity of meadow vegetation and an elevated amount of bare soil.

| GIVD Database ID: SA-CO-001 | | Last update: 2012-07-11 |
|---|--|--------------------------|
| Colombian Páramo Vegetation Database (CPVD) | | |
| Scope: The Colombian Páramo Vegetation Database (CPVD) summarizes the main floristic and environmental information about relevés of zonal, azonal and extra-zonal vegetation from Colombian high mountain (from (2500) 3000 to 4500 m.a.s.l.). It includes plots done by several researchers during the last four decades along the most important mountain massifs of the country: Eastern, Central and Western cordilleras, and massifs from Caribbean region. | | |
| Status: emerging | Period: 1973-2006 | |
| Database manager(s): Jesús Orlando Rangel-Churio (jorangelc@gmail.com); Jairo Humberto Pinto-Zárate (jhpintoz@unal.edu.co) | | |
| Owner: Jesús Orlando Rangel-Churio | | |
| Web address: [NA] | | |
| Availability: not yet available | Online upload: no | Online search: no |
| Database format(s): Excel | Export format(s): Excel | |
| Publication: [NA] | | |
| Plot type(s): normal plots | Plot-size range: 1-100 m ² | |
| Non-overlapping plots: 800 | Estimate of existing plots: 1,500 | Completeness: 53% |
| Total plot observations: 800 | Number of sources: 45 | Valid taxa: 1,500 |
| Countries: CO: 100.0% | | |
| Forest: [NA] — Non-forest: [NA] | | |
| Guilds: all vascular plants: 100%; bryophytes (terricolous or aquatic): 100%; lichens (terricolous or aquatic): 100%; non-terricolous taxa (epiphytic, saxicolous, lignicolous): 100% | | |
| Environmental data: altitude: 95%; slope aspect: 30%; slope inclination: 90%; soil depth: 5%; surface cover other than plants (open soil, litter, bare rock etc.): 95%; soil pH: 10%; other soil attributes: 20%; land use categories: 30% | | |
| Performance measure(s): cover: 100%; number of individuals: 40%; measurements like diameter or height of trees: 15% | | |
| Geographic localisation: GPS coordinates (precision 25 m or less): 10%; point coordinates less precise than GPS, up to 1 km: 60%; small grid (not coarser than 10 km): 10%; political units or only on a coarser scale (>10 km): 20% | | |
| Sampling periods: 1970-1979: 25.0%; 1980-1989: 50.0%; 1990-1999: 15.0%; 2000-2009: 10.0% | | |
| Information as of 2012-07-20; further details and future updates available from http://www.givd.info/ID/SA-CO-001 | | |

According to the physiognomy, the zonal vegetation types include dwarf forests with a tree stratum of 8 to 10 m high dominated by one or two species, such as the forests of *Escallonia myrtilloides*, *Hesperomeles ferruginea*, and those of *Polylepis sericea* and *P. quadrijuga*. Scrubs with woody elements below 5 m high are generally dominated by species of *Asteraceae* (*Diplostephium*, *Baccharis*, *Ageratina*, *Gynoxys*), *Hypericum* (*Hypericaceae-Clusiaceae*) and *Arcytophyllum* (*Rubiaceae*). Grasslands and bunchgrasses are dominated by species of *Poaceae* of genera like *Calamagrostis*, *Agrostis* and *Festuca*, and low bamboo communities (*chuscales*) by *Chusquea tessellata*. Stem rosettes (*frailejonales*) are dominated by species of *Espeletiinae* (*Espeletia*, *Espeletiopsis*), and the meadows with a ground stratum by species of genera like *Lachemilla*, *Acaena* (*Rosaceae*), *Draba* (*Brassicaceae*) and *Azorella* (*Apiaceae*). Azonal communities include vascular cushions with *Distichia muscoides*

(*Juncaceae*), *Plantago rigida* (*Plantaginaceae*) and *Werneria* (*Asteraceae*), and reed swamps with species of *Carex* and *Rhynchospora* (*Cyperaceae*), as well as riparian and submerged or emergent vegetation types in lakes and ponds (Plate A, B, C). Rangel-Churio (2000b) recorded 327 plant communities for the entire Colombian páramo region, with predominance of scrubs. Most of them are concentrated in the grass páramo (146), followed by the *subpáramo* (112) and then the *superpáramo* (69).

Geographical scope of the study and the database

Rangel-Churio (2000b) mentioned almost 1252 páramo locations in Colombia, distributed from 3000 m a.s.l. up to 4600 m a.s.l. in the three Andean cordilleras (Eastern, Central and Western) and in locations such as the Macizo Colombiano, the Nudo de Los Pastos and the Caribbean

massifs, Sierra Nevada de Santa Marta and Serranía de Perijá, between 1° and 11° North latitude and 72° and 78° West longitude. About the Eastern Cordillera, the database includes locations of the departments of Arauca, Boyacá, Cundinamarca, Meta, Norte de Santander and Santander, bounded by the Páramo de Romeral to the North, the Sierra Nevada del Cocuy to the East, and the Sumapaz Natural National Park (PNN) to the Southwest. This information was compiled and initially homogenized by Hernández-Roa (2002) and Pinto-Zárate (2005). About the Central Cordillera, the database includes localities of the departments of Caldas, Cauca, Huila, Risaralda, Quindío and Tolima, with reference to Los Nevados PNN and Nevado del Huila PNN. The information about Macizo Colombiano and Nudo de Los Pastos, particularly related to the volcanoes Azufral, Bordoncillo, Chiles, Cumbal, Galeras and Puracé in the departments of Cauca and Nariño, come from several local phytosociological treatments (Duque-

Nivia & Rangel-Churio 1989, Rangel-Churio & Ariza-Niño 2000). The phytosociological synthesis of páramo vegetation of Western Cordillera and Caribbean

massifs was recently presented by Pinto-Zárate & Rangel-Churio (2010b, 2010c). The final treatment for the other Cordilleras is in preparation. The distribution of

the main páramo localities registered in the database is shown in Figure 1.

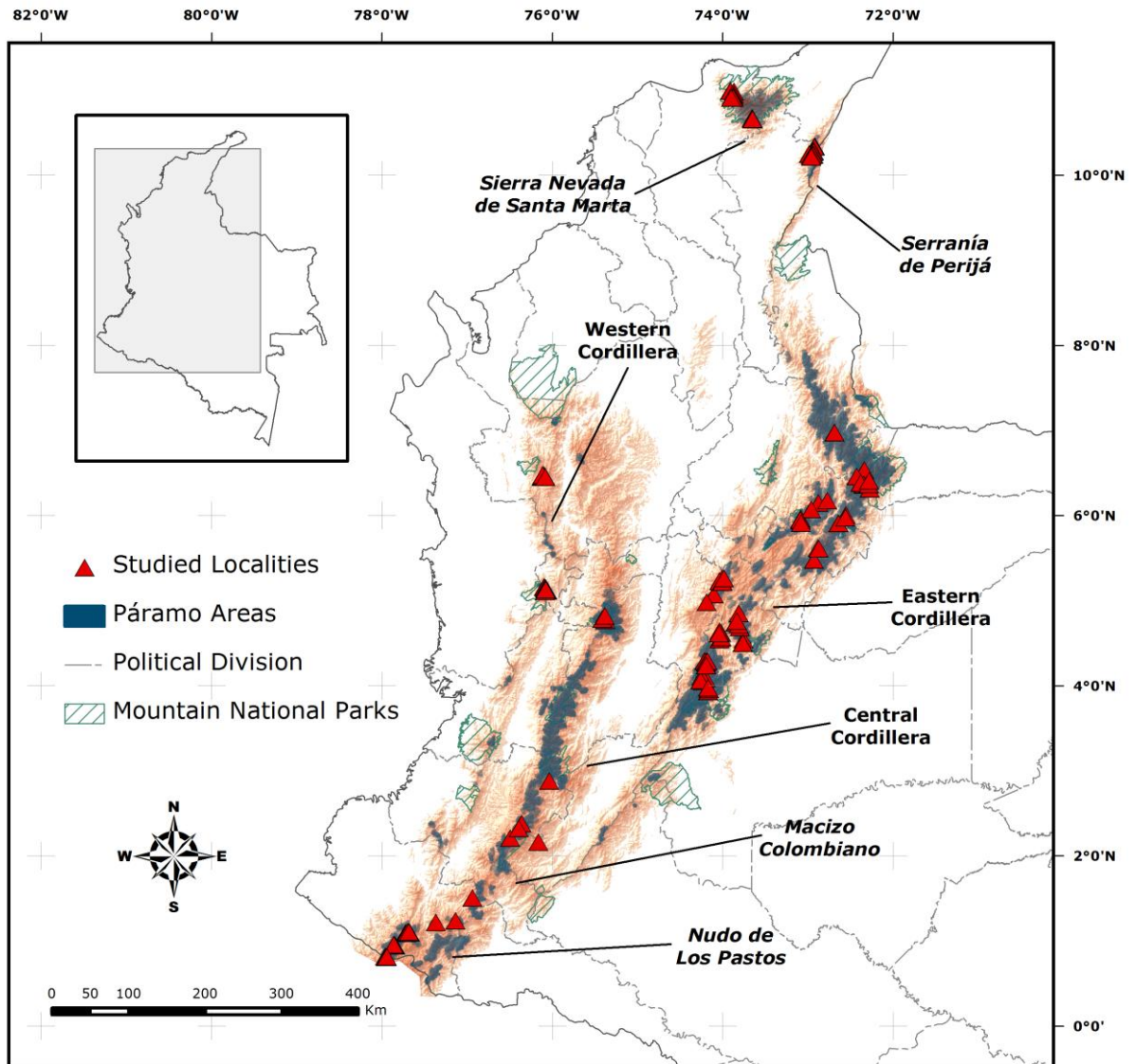


Fig. 1: Distribution of the high mountain localities included in the Colombian Páramo Vegetation Database (CPVD). Páramo areas: Rodríguez-Eraso et al. (2004), Morales-Rivas et al. (2007). Digital Elevation Model: NASA SRTM-90 m, 2000-02 (>1,000 m.a.s.l.) (GLCF 2004). Geographic coordinates, datum Bogotá.

Methodology

Vegetation research in Colombia brings together the floristic approach of the classical Sigmatis school (Braun-Blanquet 1979), followed by botanists and biologists who carried out exhaustive inventories of all species present in a given area, and the structural approach of forestry schools, which pays more attention to the inventory of arboreal and sub-arboreal species (Rangel-Churio &

Velásquez 1997). The vegetation plots or relevés are sampled in bounded surfaces. In the case of the páramo vegetation, according to their appearance or physiognomic aspect they may vary between 1 and 50 m² for shrubby and herbaceous communities (exceptionally large areas), and for dwarf forests between 100 and 250 m². The formulation of Rangel-Churio & Lozano-Contreras (1986) is followed to differentiate strata, taking into account the following height intervals of

the individuals: (**r**): ground (<0.3 m); (**h**): herbaceous (0.3–1.49 m); (**ar**): shrubby (1.5–4.9 m); (**A**): sub-arboreal or of small trees (5–11.9 m). The plant cover or vertical projection of the aerial portion of individuals on the ground surface is estimated in square meters (m²) and is subsequently converted to a percentage of the sampled area. The cover (%) of each species in a stratum is the sum of the cover of its individuals. The number of individuals is an absolute number based

on the field plots. In the case of relevés where there are measurements of diameter at breast height (DBH), the basal area (BA) of each individual tree was calculated as follows: $BA = (\pi / 4) DBH^2$.

In the definition of the floristic composition patterns which characterize the different phytocoenoses, automated methods such as TWINSPLAN (McCune & Mefford 1999) were applied to identify the main separation trends among the sets of quadrats. The preliminary syntaxonomic units were differentiated, estimating the species fidelity according to the Szafer & Pawlowsky scale (Braun-Blanquet 1979). Recently this procedure has been complemented with statistical fidelity measures (phi coefficient) according to the proposal of Chytrý et al. (2002). Such procedures were implemented using the JUICE software, version 7.0 (Tichý 2002). The final phytosociological scheme follows the recommendations of the International Code of Phytosociological Nomenclature (Weber et al. 2000, Izco & del Arco 2003).

Features of the database

The Colombian Páramo Vegetation Database was developed with the purpose of gathering the main results of the last four decades of research on high Andean mountain vegetation in Colombia. This created for the first time an integrated information system covering diverse

aspects relating to the phytosociological knowledge. Some of the most relevant issues are: geographical and altitudinal distribution of the *relevés*; taxonomic identity, relative cover and conservation status of each one of their floristic components (species); structural and environmental properties of the vegetation; literature sources; and hierarchical position in the syntaxonomical proposals developed by different authors (Box 1).

The information has been collected from different original sources, including field notes, internal reports, herbarium specimen labels, partial databases and published works, and integrated into a Microsoft Excel data matrix. The vegetation plots were sampled between 1970 and 2006 by several researchers along the main Colombian mountain ranges (Fig. 1). Most of the sampling was carried out during the 1980s (ca. 50%). Approximately 800 relevés have been completely or almost completely computerized and georeferenced, representing 53% of the ca. 1500 quadrats estimated for the biome in the country. An exhaustive standardization procedure has been developed to ensure the quality of the data. A large number of floras and monographs have been consulted in order to confirm the botanical identity of the floristic elements and to update the taxonomic names. These focused on Colombia (Churchill & Linares-Castillo 1995, Uribe-Meléndez & Gradstein 1998, Aguirre-Ceballos 2008a,

b), the local mountain massifs (Rangel-Churio & Jaramillo-Mejía 1984, Sipman 1984, van Reenen et al. 1984, Carbonó & Lozano-Contreras 1997, Parra et al. 2002, Rivera-Díaz & Fernández-Alonso 2003, Calderón-Sáenz 2005, Rangel-Churio et al. 2005, Avendaño & Aguirre-Ceballos 2007, Rivera-Díaz 2007), the páramo biome (Luteyn 1999, Linares-Castillo et al. 2000, Murillo 2000, Rangel-Churio et al. 2000, Sipman et al. 2000, Uribe-Meléndez & Rangel-Churio 2000, Briceño & Morillo 2002, 2006, Rangel-Churio & Sánchez 2005, Sklenář et al. 2005, Vargas & Gómez-Hoyos 2005), or specific taxonomic groups (Smith et al. 2006, Stančík & Peterson 2007, APG 2009, among others). Online plant checklists and databases were also helpful throughout this task (Hassler & Swale 2001, USDA 2001, 2010, SI 2003, IPNI 2004, Luteyn & Pedraza-Peñalosa 2007, BayScience Foundation 2010, CABI 2010, ICN 2010, MBG 2010a, b, NYBG 2010, RBG Kew & MBG 2011).

We are currently working to develop an online relational database which will be made available to the public. We expect this tool will be useful for researchers, environmental authorities, decision makers and other people involved in the conservation and sustainable use of mountain natural resources in Colombia and Latin America.

Box 1: Basic vegetation-plot information provided in the database SA-CO-001.

Relevé information: Relevé ID / Author / Date / Area (m²) / Number of species

Taxonomic information: Record ID / Cover: percentage – quantitative scale / Main taxonomic group: angiosperms – ferns and lycophytes – mosses – liverworts – lichens / Family / Genera / Specific epithet / Accepted species / Intraspecific ranks / Author citation / Original name recorded / Endemism / IUCN-CITES status / Collection number / Sources

Structural information: Physiognomy / Height / Strata cover (%): ground – cushions – herbaceous – shrubby – arboreal – epiphytes / Components cover (%): total – vascular – woody – grasses – bryophytes – lichens

Geographical information: Locality ID / Mountain range or massif: Eastern, Central or Western Cordilleras, Sierra Nevada de Santa Marta, Serranía de Perijá, Macizo Colombiano, Nudo de Los Pastos / Páramo name / Political division: department – municipality - district / Locality description / Elevation / Life zone / Geographic coordinates (Lat-Long): exact – approximate

Environmental information: Vegetation zonality / Disturbance / Slope / Exposition / Substrate attributes: classification – texture – depth – acidity – soil bases – other elements (C, N, Al) – other properties / Water depth (aquatic and semi-aquatic environments)

Syntaxonomical information: Syntaxon ID / Correct name: principal ranks – supplementary ranks / Author citation / Synonyms – Corresponding names / Previous classifications / Non-syntaxonomic proposals

Vegetation references: Source ID / Author / Year / Relevé table / Page / Complete reference

* Information recorded from primary and secondary sources (when available)

Application of the knowledge generated from the database

Case study: The páramo vegetation of Colombian Western Cordillera and the Caribbean massifs

The zonal páramo vegetation from Colombian Western Cordillera is represented in 28 syntaxonomic units (Box 2). These include fourteen associations, five subassociations, five alliances and three orders integrated in a single zonal and extrazonal vegetation class for the páramo region of Frontino and the Tamamá National Natural Park (*Pentacalio vaccinioidis-Calamagrostietea effusae*). Among the plant associations, there were considered: two types of shrubs of *Pentacalia vaccinioides* with *Diplostephium rosmarinifolium* and *Aragoa occidentalis*; three types of bamboo-shrubs of *Chusquea tessellata*, *Monnina salicifolia* and species of *Diplostephium*; four types of stem rosettes-bunchgrasses and shrubs-rosettes of *Espeletia hartwegiana* and *E. frontinoensis*; one type of dwarf shrubs of *Loricaria complanata* and *Diplostephium rupestre*; one of shrubby bunchgrasses of *Calamagrostis effusa* with *Loricaria colombiana*; two types of grasses-sedges of *Rhynchospora aristata*, *Carex bonplandii* and *Calamagrostis effusa*; and one of bunchgrasses of *Calamagrostis effusa* with *Arcytophyllum muticum* (Pinto-Zárate & Rangel-Churio 2010c).

In the case of the páramos from northern Colombia, Sierra Nevada de Santa Marta and Serranía de Perijá, the plant formations are summarized in 28 zonal units gathered in fifteen associations, six subassociations, five alliances, one order and one class (*Stevio lucidae-Calamagrostietea effusae*), complemented by five associations and one subassociation of azonal vegetation (Pinto-Zárate & Rangel-Churio 2010b). Regarding dry communities from the southern slope of the Sierra Nevada de Santa Marta (*Obtegomerio caerulescentis-Lachemillion polylepidis*), two shrubby bunchgrasses of *Calamagrostis effusa* and *Festuca* cf. *sanctae-martae* were identified, and one association of arboreal stem rosettes of *Libanothamnus occultus*. Another seven associations with dominant matrices of *Calamagrostis effusa* and *C. intermedia* tussocks were described from dry southern areas of the Serranía de Perijá (*Hyperico magdalenici-Calamagrostietalia effusae*), including low scrubs and stem rosettes of *Arcytophyllum nitidum*, *Espeletia*

perijaensis and species of *Hypericum* and *Bejaria*, herbaceous vegetation of *Lourteigia stoechadifolia* and *Orthrosanthus chimboracensis*, and bunchgrasses of *Muhlenbergia angustata* (Box 3) (Pinto-Zárate & Rangel-Churio 2010b).

The wet environments of the north-western slope of the Sierra Nevada de Santa Marta include two associations of open and dense bunchgrasses of *Calamagrostis* cf. *effusa* with low shrubs and herbaceous or creeping elements such as *Ranunculus spaniophyllus*, *Perissocoleum purdiei* and rosettes of *Draba cheiranthoides*, plenty of bryophytes (*Ranunculo spaniophylli-Calamagrostion effusae*). On the northern side of the Serranía de Perijá there were identified three associations of bamboo shrubs of *Chusquea tessellata* in combination with tussocks of *Calamagrostis intermedia*, stem rosettes of *Espeletia perijaensis* and low shrubs of *Arcytophyllum nitidum*, *Hypericum strictum* and *Pernettya prostrata* (*Hyperico stricti-Chusqueion tessellatae*) (Box 3) (Pinto-Zárate & Rangel-Churio 2010b).

The azonal vegetation units (Box 4) include several types of dry arboreal stem rosettes of *Libanothamnus divisorienis*, wet sparse shrubs of *Lachemilla polylepis*, shrubby meadows with cushions of *Xyris columbiana* and low bushes of *Hypericum magdalenicum*, ground rosettes and meadows of *Werneria pygmaea* and *Acaena cylindristachya*, and vascular cushions of *Azorella crenata* (Pinto-Zárate & Rangel-Churio 2010b).

Other applications of the database

In terms of plant species (alpha diversity) and communities (beta diversity), the high Andean mountain region of Colombia is recognized as the most diverse in the biogeographical area (Luteyn 1999, Rangel-Churio 2006). The information gathered in the database has been helpful to assess the conservation status and the main threats to species and vegetation types established in the páramos. Rangel-Churio (2000a) considered that at least 69 (21%) of the 327 plant communities documented until 2000 in the páramo region are at imminent risk due to habitat degradation. The most affected vegetation types are shrubs (27 types) and stem rosettes (10 types), while the strongest disturbance effects are expressed particularly in the subpáramo. *Orchidaceae*, *Asteraceae* and *Bromeliaceae* are among

the plant families with the highest number of endangered species. The differentiation of relevés and vegetation types according to their physiognomy is also useful to evaluate the conservation status of páramo areas by geographical locations; generally the dominance of shrubby communities in the best preserved areas of Colombian páramo is clear (Rangel-Churio 2006, Arellano-Peña & Rangel-Churio 2008).

Based on the phytosociological treatment of the páramo vegetation of the Serranía de Perijá, Rangel-Churio & Arellano-Peña (2007a) developed detailed distribution maps which constitute the basic input to characterize and spatialize the ecosystems. The database information has also been applied in wildlife conservation programs, such as the protection of birds associated with *Polylepis sericea* and *P. quadrijuga* forests (*coloraditos*), two arboreal species found up to 4100 m.a.s.l. Their relictual populations provide habitat for several species of birds which depend on them for refuge, breeding zone and food supply (Rangel-Churio & Arellano-Peña 2010).

Final considerations

The consolidation of the database on páramo vegetation will make it easier to obtain a clear definition of the different vegetation types and their geographical distribution ranges across the national territory. The database is therefore an essential tool in the definition of the natural limit of the páramo region in Colombia. This procedure is necessary for all the ecological land use plans, the regulation of mining resources exploitation, and for conservation programs focused on the preservation of natural areas of this key region, critical to ensure water supply for the huge population of the country settled in middle and low mountain areas.

The detailed information of the relevés is fundamental for assessing the conservation status and the health of páramo wild populations and ecosystems. The vegetation database and its phytosociological characterization will allow us to elaborate an appropriate thematic cartography, facilitating the comparison of the spatial distribution of species, populations and communities at local and regional scales throughout the biogeographical páramo region, from the Central American mountains of Costa Rica to the foothills of the Bolivian Amazonian slopes.

Box 2: Syntaxonomical scheme accepted for the páramo vegetation of the Colombian Western Cordillera, according to the proposal of Pinto-Zárate & Rangel-Churio (2010c).

- Pentacalio vaccinioidis*-*Calamagrostietea effusae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Cortaderio nitidae*-*Baccharitetalia macranthae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Calamagrostio effusae*-*Rhynchosporion aristatae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Geranio sibbaldiioidis*-*Rhynchosporium aristatae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Rhynchosporo aristatae*-*Caricetum bonplandii* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Diplostephio schultzi*-*Chusqueion tessellatae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Rhynchosporo aristatae*-*Monninetum salicifoliae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Cortaderio nitidae*-*Chusqueetum tessellatae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Alliancia *Incertae Sedis*
- Diplostephio rosmarinifolii*-*Gaiadendretum punctati* Rangel, Cleef & Salamanca in Cleef, Rangel, Salamanca, C. Ariza & van Reenen 2005 em. J. Pinto & Rangel 2010
- Loricario complanatae*-*Calamagrostietalia effusae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Diplostephio rupestris*-*Chusqueion tessellatae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Diplostephio rupestris*-*Loricarietum complanatae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Diplostephio*-*Loricarietum oreoboletosum cleefii* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Diplostephio*-*Loricarietum sphagnetosum magellanicum* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Diplostephio cinerascens*-*Chusqueetum tessellatae* Cleef, Rangel & Salamanca in Cleef, Rangel, Salamanca, C. Ariza & van Reenen 2005 em. J. Pinto & Rangel 2010
- Diplostephio*-*Chusqueetum gaultherietosum anastomosantis* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Diplostephio*-*Chusqueetum diplostephietosum schultzi* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Diplostephio*-*Chusqueetum calamagrostietosum effusae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Alliancia *Incertae Sedis*
- Sphagno magellanicum*-*Calamagrostietum effusae* Cleef, Rangel & Salamanca in Cleef, Rangel, Salamanca, C. Ariza & van Reenen 2005 em. J. Pinto & Rangel 2010
- Halenio foliosae*-*Baccharitetalia tricuneatae* Rangel, D. Sánchez & C. Ariza 1999 em. J. Pinto & Rangel 2010
- Aragoo occidentalis*-*Espeletion frontinoensis* Rangel, D. Sánchez & C. Ariza 1999 em. J. Pinto & Rangel 2010
- Hieracio adenocephali*-*Espeletietum frontinoensis* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Blechno loxensis*-*Espeletietum frontinoensis* Rangel, D. Sánchez & C. Ariza 1999 em. J. Pinto & Rangel 2010
- Halenio foliosae*-*Calamagrostion effusae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Espeletio frontinoensis*-*Calamagrostietum effusae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Hyperico juniperini*-*Pentacalietum vaccinioidis* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Arcytophylo mutici*-*Calamagrostietum effusae* Rangel & J. Pinto in J. Pinto & Rangel 2010
- Alliancia *Incertae Sedis*
- Oreobolo venezuelensis*-*Achyroclinetum alatae* Rangel, D. Sánchez & C. Ariza 1999



Plate: Vegetation types featured by the vegetation-plot database GIVD SA-CO-001.

A: Colombia: Antioquia, Páramo de Frontino, transition between high Andean forest and páramo, 3,600 m a.s.l. **A:** Elfin forest of *Polylepis quadrijuga*. **B:** Stem rosettes of *Espeletia frontinoensis*. **C:** High Andean forest of *Miconia* cf. *jahnii* and *Myrsine parvifolia* (Photo: L.N. Parra).

B: Colombia: Cesar, Serranía de Perijá, grass páramo, 3,600 m a.s.l. Dry arboreal stem rosettes of *Libanothamnus divisoriensis* (*Holodisco argentei-Libanothamnetum divisoriensis*) (Photo: J.O. Rangel-Churio).



C: Colombia: Caldas-Tolima, Los Nevados PNN, low *superpáramo*, 4,290 m a.s.l. Dwarf scrubs of *Loricaria colombiana* (Photo: J.H. Pinto-Zárate).



Box 3: Syntaxonomical scheme accepted for the zonal páramo vegetation of the massifs from Northern Colombia (Sierra Nevada de Santa Marta, Serranía de Perijá), according to the proposal of Pinto-Zárate & Rangel-Churio (2010b).

Dry formations

Stevio lucidae-Calamagrostietea effusae Rangel & Arellano ex J. Pinto & Rangel 2010

Hyperico magdalenici-Calamagrostietalia effusae Rangel & J. Pinto in J. Pinto & Rangel 2010

Hyperico baccharoidis-Calamagrostion effusae Rangel & Arellano ex J. Pinto & Rangel 2010

Bejario resinosae-Hypericetum magdalenici Rangel & J. Pinto in J. Pinto & Rangel 2010

Bejario nanae-Calamagrostietum effusae Rangel & J. Pinto in J. Pinto & Rangel 2010

Bejario-Calamagrostietum gaiadendretosum punctati Rangel & J. Pinto in J. Pinto & Rangel 2010

Bejario-Calamagrostietum espeletietosum perijaensis Rangel & J. Pinto in J. Pinto & Rangel 2010

Gaylussacio buxifoliae-Arcytophyllum nitidi Rangel & J. Pinto in J. Pinto & Rangel 2010

Lourteigio stoechadifoliae-Calamagrostion effusae Rangel & J. Pinto in J. Pinto & Rangel 2010

Calamagrostio effusae-Espeletietum perijaensis Rangel & J. Pinto in J. Pinto & Rangel 2010

Calamagrostio intermediae-Lourteigietum stoechadifoliae Rangel & J. Pinto in J. Pinto & Rangel 2010

Calamagrostio effusae-Orthrosanthetum chimboracensis Rangel & J. Pinto in J. Pinto & Rangel 2010

Lourteigio stoechadifoliae-Muhlenbergietum angustatae Rangel & J. Pinto in J. Pinto & Rangel 2010

Ordo Incertae Sedis

Obtegomerio caerulescentis-Lachemillion polylepidis Rangel & J. Pinto in J. Pinto & Rangel 2010

Valeriano karstenii-Libanothamnetum occulti Rangel & J. Pinto in J. Pinto & Rangel 2010

Arcytophylo nitidi-Festucetum sanctae-martae Rangel & J. Pinto in J. Pinto & Rangel 2010

Laennecio schiedeanae-Calamagrostietum effusae Rangel & J. Pinto in J. Pinto & Rangel 2010

Wet formations

Classis – Ordo Incertae Sedis

Ranunculo spaniophylli-Calamagrostion effusae Rangel & J. Pinto in J. Pinto & Rangel 2010

Drabo cheiranthoidis-Calamagrostietum effusae Cleef & Rangel 1984

Drabo-Calamagrostietum erigerontetosum raphaelis Cleef & Rangel 1984

Drabo-Calamagrostietum oligandretosum chrysocomatis Cleef & Rangel 1984

Perissocoeleo purdiei-Calamagrostietum effusae Cleef & Rangel 1984

Classis – Ordo Incertae Sedis

Hyperico stricti-Chusqueion tessellatae Rangel & Arellano ex J. Pinto & Rangel 2010

Espeletio perijaensis-Chusqueetum tessellatae Rangel & Arellano ex J. Pinto & Rangel 2010

Espeletio-Chusqueetum aetosum leucanthae Rangel & J. Pinto in J. Pinto & Rangel 2010

Espeletio-Chusqueetum perissocoeleetosum phylloidei Rangel & J. Pinto in J. Pinto & Rangel 2010

Arcytophylo nitidi-Calamagrostietum intermediae Rangel & Arellano ex J. Pinto & Rangel 2010

Geranio holosericei-Chusqueetum tessellatae Rangel & J. Pinto in J. Pinto & Rangel 2010

Box 4: Syntaxonomical scheme accepted for the azonal páramo vegetation of the massifs from Northern Colombia (Sierra Nevada de Santa Marta, Serranía de Perijá), according to the proposal of Pinto-Zárte & Rangel-Churio (2010b).

Plantagini rigidae-Distichietea muscoidis Rivas-Martínez & Tovar 1982

Oritrophio limnophili-Wernerietalia pygmaeae Cleef 1981

Wernerion crasso-pygmaeae Cleef 1981

Oritrophio limnophili-Wernerietum pygmaeae Cleef 1981 *em.* Cleef & Rangel 1984

Oritrophio-Wernerietum typicum Cleef 1981 *em.* Cleef & Rangel 1984

Classis – Ordo – Alianza *Incertae Sedis*

Holodisco argentei-Libanothamnetum divisoriensis Rangel & J. Pinto *in* J. Pinto & Rangel 2010

Lachemilletum polylepidis Cleef & Rangel *ex* J. Pinto & Rangel 2010

Hyperico magdalenici-Xyridetum columbianae Rangel & J. Pinto *in* J. Pinto & Rangel 2010

Acaenetum cylindristachyae Cleef, Rangel & van der Hammen *in* Cleef & Rangel 1984

Azorelletum crenatae Cleef & Rangel 1984

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