THE VEGETATION OF THE BAHÍA HONDA REGION (VERAGUAS, PANAMA)

Alicia Ibáñez

&

Santiago Castroviejo

The vegetation of the Soná peninsula has been included in numerous vegetation maps of Panama and Central America, but never in any detail due to the fact that no delimitation or typification of plant formations has been made (Holdridge & Budowski, 1956; Holdridge & Budowski, 1959; Bennett, 1968; Dodson & Gentry, 1978; Murphy & Lugo, 1995). Recently (2000), under the "Mesoamerican Biological Corridor" Project (PNUD-CCAD), a map of the current vegetation of Panama was drawn up. This was done based on the interpretation of satellite images (Landsat TM) and using the categories for vegetation types proposed by UNESCO (Mueller-Dombois & Ellenberg, 1974). According to this physionomy-based classification system, most of the vegetation of the Bahía Honda area was assigned to a "semi-deciduous lowland forest subjected to significant human intervention". Various grades of "productive systems with significant natural woody vegetation" in previously used lands, and "mangrove forests" were also limited within our area of interest (CBMAP, 2000).

Holdridge's system for classifying vegetation is the most widely used in Central America (Holdridge, 1979). This system uses the mean temperature, rainfall and potential evapotranspiration to classify the natural vegetation according to a logarithmic and isogonal arrangement of the three aforementioned parameters, which forms hexagons corresponding to each "life-

zone" (Holdridge, 1979). According to the vegetation map based on this system (Holdridge & Budowski, 1959), most of the Bahía Honda region comes within one life-zone, “tropical wet forest”. On the uplands of the Cordillera south of the geological fault we can also find “premontane rain forest" and towards the SE, "premontane wet forest" and "tropical moist forest". These last two are the same life-zones recognized by the authors for the island of Coiba. According to this classification, the type of forest in Bahía Honda is more humid than any on Coiba, due to a higher rainfall on the mainland (Holdridge & Budowski, 1959). This contradicts the earlier description by CBMAP (2000) which attributed a dryer type of forest to the Bahía Honda area.

Following our observations, and not taking into account any data on the climate, most of the region under study would be covered (before the intense deforestation to which it was submitted in the past) in "evergreen moist or wet forest", similar to that which now almost completely covers Coiba island. The extended belief that on western Pacific Panama grows a type of dry deciduous forest is, generally speaking, incorrect. Probably this can only be said of the forests of SE Azuero Peninsula and the western part of Panama Bay, where the rainfall is considerably less than elsewhere in the country (McKay, 2000; Peckham, 2002). The high rainfall in our study area is more in accordance with forests of the "moist" or even "wet" type. However, on the island of Canales de Tierra and on the continental coastal border, a large amount of deciduous species are to be found, especially at the end of the dry season, due to the adverse environmental conditions on these rocky borders. On most of the coast this situation is aggravated by deforestation and the periodical burning of the surrounding vegetation.

Vegetation Studies

Several plant communities or formations, either natural or man-induced under different stages of recovery, appear in the area under study. In order to describe on a large scale the vegetation cover of these areas, the best instrument nowadays is the analyses of satellite images.

The colour patterns in the satellite images are created by local differences in the way the ground cover reflects the sunlight. This depends on physical characteristics such as structure of the vegetation, colour of the leaves, surface water, bare ground, etc. (Chuvieco, 2000). When two areas in the same image appear in different colours, we can assume that there is a difference in the ground cover. However, without an actual sighting of the terrain, we can not know for a certainty the reason for the difference (Tuomisto, 1998).

For a first interpretation of the current vegetation in the Bahía Honda area, we analysed satellite images of southern Veraguas. We were seeking to obtain images which discern the greatest differences in colour (reflectance patterns) which can show floristic and structural differences of the different vegetation types. We were able to interpret the colour patterns observed by combining a detailed study of these images with data taken in the field in the areas visited, as well as from the permanent plots. For this first approximation, we were most interested in recognizing and locating mature forest areas, which are the remnants of the original forest cover, and also in providing a hypothesis to explain the differences in colour we observed.

With the idea of maximising the available information of these differential reflectances, any number of more or less complex digital treatments can be made (such as combinations of bands in “false colour composite images”, transformations and combinations of bands by means of Principal Components Analysis, indexes of vegetation, etc., or else supervised or unsupervised classifications). However, simple procedures like spectral enhancement of the images, show more significant differences in the vegetation than the more complicated digital classification (Tuomisto, 1998). Therefore, it is possible to see that the forest is not homogeneous but a mosaic of different colours, each representing different vegetation structure, floristic composition, soils, etc.

For our study of the vegetation of Bahía Honda, we analysed an image obtained by the sensor TM of the satellite Landsat 4 (Path 13, Row 55) on the 27th of February, 1990. Although of fairly good quality it does have some cloudiness in the centre and NE part. However, most of our area of study can be seen clearly. Following Tuomisto's recommendations (Tuomisto, 1998), we obtained "false colour composite images" with three wave-lengths. After, we submitted them to contrast, brightness and tone enhancement, until achieving

the one which differentiates the most colours. We used the superposition of the TM3, TM4 and TM5 bands to which we assigned the blue, green and red channels respectively (Fig. 2 - Chapter 1, Fig. 1 – this Chapter). We made up another composition with the bands TM7, TM5, and TM4 from our 1990 image to compare with a different “false colour composite” of the area, created from an image from Landsat 7 – ETM + (Path 14, Row 55) of 23rd February, 2000. A copy of this composite was lent by the department of Physical Geography and Regional Geographic Analysis of the University of Sevilla (Spain). A comparison of both images allows an evaluation of the vegetation changes (mostly of the mature forest cover) occurred in the 10 years elapsed between them.

We obtained the composite images with the GIS program, Idrisi 32 and used the Adobe Photoshop 5.5 program for the final treatment (enhancement). We took GPS readings and notes on the vegetation (height, density and most abundant species) at certain sampling points all through our field trips. The colour patterns obtained in the images were contrasted in the field with the real vegetation on numerous occasions.

In the Soná peninsula image (Fig. 2 - Chapter 1), obtained after the composition of the bands TM3, TM4 and TM5, and which we submitted to hardly any enhancement, the eastern and northern areas are seen to be completely deforested (pink colour), while the Bahía Honda region presents the last forest remnants of the whole area (scrub and tree vegetation in green colour). In another view of the same image (Fig. 1), this time enhanced, we can see the woodland formations more clearly, both mature forests as well as advanced secondary ones, in green colour. The remaining areas, which appear in reds, pinks and violets, are either barren of arboreal vegetation or else this is just incipient (rastrojos or scrub vegetation). In this case, the forest cover is undergoing a natural regeneration process. The mangrove zones are dark green and their texture is softer than the other forests. Clouds appear white and their shadows are black.

In Figure 2 we have an amplification of the same image, showing the island of Canales de Tierra and its surroundings, in which we have enhanced other colours. The plot locations are also shown (P1 and P2). From the sampling and our observations in the field, we can deduce that the colour patterns in the image seem to reflect changes in the vegetation's structure. Thus, the mature forests or

the late secondary ones -with an old forest structure- appear in red, as in the area where plot P1 is found. Incipient secondary forests are in green as well as the low arboreal formations undergoing regeneration and made up mostly of pioneer species with a low and uniform canopy. Open areas and very low scrub vegetation are blue. In Figures 4 and 5 forests are in red and scrub and open land in bluish shades. We see that the surface of the mature forests in the Bahía Honda region has not changed significantly over the last 10 years. However, there has been a reduction in the size of the old forests in the SE part. These remnants need to be studied and urgently protected as they are in danger from burning and logging.

Vegetation Types

Briefly and in accordance with the local terminology, the vegetation formations present in the area, are the following:

NATURAL VEGETATION:

• **Mangroves**: Woody formations that can occupy large areas, growing at the mouth and estuaries of the major rivers, and are flooded on a daily basis by the tides. There are large extensions of these woods in our study area. *Rhizophora mangle* (*Rhizophoraceae*) "red mangrove", predominate in formations of different heights (1 m to 30 m).They usually form the arboreal strip closest to the water. Other frequent species are: *Pelliciera rhizophorae* (*Pelliceraceae*) "mangle piñuelo", *Avicennia germinans (Verbenaceae*) "black mangrove" and *Laguncularia racemosa* (*Combretacaeae*) "white mangrove". Other species which are commonly associated with mangroves are *Conocarpus erectus* (*Combretaceae*) "button mangrove", *Rhabdadenia biflora* (*Apocynaceae*) and *Muellera moniliformis* (*Fabaceae*). Mangrove groves form on beaches and breakwaters, especially those of "red mangrove". Figure 1 shows the wide expanse of the mangroves, in dark green, at the mouth of the larger rivers such as Limón, Salmonete, Seco, Managua or Mona in Pixvae, etc. (Photos:1-7, 8-6, 8-72, 8-74, 1-1, 1-3, 8-100, 4-87, 4-75).

• **“Sangrillo” Swamp Forests**: These are almost monodominat formations of "sangrillo", *Pterocarpus officinalis*. This is a large tree of the legume family (*Fabaceae*) which can grow up to 30 m. These are typical forests of areas which are periodically flooded by fresh water and usually appear inside mangroves, on the banks of rivers near the mouth. Other species which are associated with the "sangrillo" and also adapted to this periodical flooding are *Prioria copaifera* (*Fabaceae*) "cativo" and *Mora oleifera* (*Fabaceae*) "alcornoque". Both of these are huge trees and the latter has enormous buttresses. *Zigia longifolia* (*Fabaceae*) "guabo de río", *Guapira costaricana* (*Nyctaginaceae*), *Cassipourea elliptica* (*Rhizophoraceae*), etc. are all typical undergrowth trees common to these formations. The ground is mostly bare although some species also adapted to flooded environments such as *Dieffenbachia* sp. (*Araceae*), *Aechmea magdalenaae* (*Bromeliaceae*) or the large fern *Acrostichum aureum* can be found growing here. One of the most impressive "sangrillo" swamp forests in the area is the so-called "Magic Forest" on the banks of the río Limón. Another smaller formation is on one side of the Laboratorio beach on the island of Canales de Tierra (Photos:1-4, -5,1-6,5-66, 2-46, 2-51, 6-84, 2-30).

• **Beach Vegetation**. Low height vegetation formation, typical of beaches on sandy ground. Trees and shrubs characteristic of this habitat are to be found, such as *Taliparitiparitiliaceus*, accepted synonym for the well-known *Hibiscus permambucensis,* (*Malvaceae*), *Terminalia catapa* (*Combretaceae*) "almond tree", *Cocos nucifera* (*Arecacee*) "coconut-palm", *Pachira sessilis* (*Bombacaceae*) "yuco", *Pachira quinata* (*Bombacaceae*) "cedro espino", *Amphitecna latifolia* (*Bignoniaceae*) "calabazuelo", *Ximenia americana* (*Olacaceae*), *Hippomane mancinella* (*Euphorbiaceae*) "manzanillo", *Dalbergia brownei* (*Fabaceae*), *Chrysobalanus icaco* (*Chrysobalanaceae*) "icaco", *Conocarpus erecta* (*Combretaceae*), *Caesalpinia crista* (*Fabaceae*), etc. Some trailing species such as *Canavalia rosea* (*Fabaceae*), *Ipomea sp*. (*Convolvulaceae*) and *Sphageticola trilobata* (*Asteraceae*) grow at the edge of the beach in many places. We find this vegetation type over all the beaches of the area, both on sandy and stony ones, as in: Playa Limón or Playa de los Luchos on the island of Canales de Tierra (Photos: 7-39,8-99,4-76,3-67).

• **Coastline Vegetation**. In this case we refer to the deciduous vegetation of the coastline, occurring on rocky areas with usually steep slopes. The dominant tree and shrub species are *Bursera simaruba* (*Burseraceae*), *Plumeria rubra* (*Apocynaceae*), *Tabebuia rosea*, (*Bignoniaceae*), *Pachira quinata* (*Bombacaceae*), *Pachira sessilis* (*Bombacaceae*), *Pseudobombax septenatum* (*Bombacaceae*), *Stemmadenia grandiflora* (*Apocynaceae*), *Calycophyllum candidissimum* (*Rubiaceae*), *Swarzia simplex* (*Fabaceae*), *Alibertia edulis* (*Rubiaceae*), *Clusia rosea* (*Clusiaceae*) and the herbaceous or bromeliads, *Begonia sp*. (*Begoniaceae*), *Pitcairnia megasepala* (*Bromeliaceae*) and *Kohleria spicata* (*Gesneriaceae*). Deciduous species are widely abundant on the island of Canales de Tierra and on the continental coastline especially towards the end of the dry season, as we have remarked earlier. This is a drier type of forest than that which covers most of the territory. The steep slopes, where soil accumulation is scarce, and the dryness of the summer season determine the dominance of those species well adapted to this environment. In this zone, the effect produced by a shortage of water and the presence of species which adapt to extreme conditions is enhanced by deforestation and burning (Photos: 5-60, 5-77, 4-83, 6-66, 6-67).

• **“Cativo” Forests**. These are forests made up almost exclusively of the "cativo" tree, a species of legume, *Prioria copaifera* (*Fabaceae*), which can reach heights of up to 50 m. These formations occupy the plains or flat zones that become waterlogged by fresh water during the rainy season (May-December). We know of a “cativo forest” near the río Luis, where some logging had taken place shortly before our visit in January 2002. The "cativo" tree is of great economic importance as a logging species, that is why this kind of forests in Panama have been almost depleted. Fortunately, this particular cattival has recently been acquired as part of the reserve which should mean that in a few years it will recuperate (Photos:7-38, 8-3).

• **Mature Forests**. Mixed tropical forests are generally very difficult to study and characterize due to their high floristic diversity and the impossibility of identifying the dominant species, if there are any, before having identified all individuals

(Condit *& al*.,1992). Another trait of this type of forest is that, in spite of the apparent homogeneity of the vegetation, there is actually a great variation in the floristic composition and structure between one area and another, regardless or not of their proximity -the so-called -diversity- (Ruokolainen *& al*.,1994). These differences are the result of numerous ecological and biogeographical processes which take place on different time and space scales.

In the Bahía Honda region we can find the last remnants of the primary forests (or at least areas where little alteration has occurred) that used to cover the whole region before deforestation. As we have said before, these are wet, evergreen forests with a continuous, dense canopy reaching an average height of 20-30 m and the tallest of around 40-50 m. The most abundant tree species of this region are *Calophyllum longifolium* (*Clusiaceae*) "maria", *Manilkara staminodella* (*Sapotaceae*) "níspero'", although this species has been cut down for lumber almost everywhere, *Anacardium excelsum* (*Anacardiaceae*) "espave", *Buchenavia capitata* (*Combretaceae*) "amarillo", *Parinari chocoensis* (*Chrysobalanaceae*) "azulillo", *Carapa guianensis* (*Meliaceae*) "tangaré", *Virola sebifera* (*Myristicaceae*) "boga", *Licania hypoleuca* (*Chrysobalancaceae*), *Tetragastris panamensis* (*Burseraceae*) "secuaro", *Brosimum alicastrum* (*Moraceae*), etc. A few examples of trees and shrubs frequently found in the understorey are *Faramea occidentalis* (*Rubiaceae*), *Marila laxiflora* (*Clusiaceae*), several *Psychotria* spp. (*Rubiaceae*) and several *Melastomataceae*. In the wetter areas, such as the bottom of the valleys, the understorey contains abundant dwarf palms and *Cyclanthaceae* such as *Cyclanthus bipartitus* and *Carludovica palamata*, as well as species of *Heliconia* sp., *Costus* sp. etc. The epiphytes are also abundant, as are the *Bromeliaceae* of the genus *Tillandsia* and numerous fern and orchid species.

We can find well conserved examples of these forests in the continental area of Playa de Juana and Cativito, as well as very humid ones at the head of the río Seco, S of the Cordillera, which are practically intact due to their inaccessibility. Large specimens of *Sloanea ternifolia* (*Elaeocarpaceae*) dominate here, as well as a great number of species in the families *Moraceae* and *Sapotaceae*.

Two research plots have been installed in the area (see further on) to describe in detail some of these forests. Characterization studies by means of

plots or transects are essential for getting top know the floristic composition of these tropical mixed forests. The forest on the northern part of the island of Canales de Tierra, facing Playa Limón, where we have placed plot P1, can be considered a mature or little altered forest (see the description further on). (Photos: 8-93, 8-7, 8-21, 8-20).

HUMAN DISTURBED VEGETATION:

• **Secondary Forests.** These can originate either from a partial recovery of previously open areas which have overcome the scrub or "rastrojo" phase and have developed a woodland cover, or from a degraded mature forest recovering from an alteration caused by human intervention. Usually, after 10-15 years of neglect, an area which has been used for grazing or agriculture starts to be an incipient secondary forest, of a height of 5-10 m., wherein the dominant species are, in this region, *Trichospermum galeotti* (*Tiliaceae*), *Ochroma pyramidale* (*Bombacaeae*), *Cecropia* spp. (*Cecropiaceae*), *Schefflera morotoni* (*Araliaceae*), *Spondias mombin* (*Anacardiaceae*), *Apeiba tibourbou* (*Tiliaceae*), etc. We found this type of forest in the area of the Jeringuita beach, in Punta Mona, wide expanses of the interior of the island of Canales de Tierra, etc. Species such as *Vochysia ferruginea* (*Vochysiaceae*) "maya", abundant on Canales de Tierra Island, form a canopy of 20-30 m, and make up an advanced secondary forest which we can call mature. Other species common to these mature secondary forests are *Hyeronima alchorneoides* (*Euphorbiaceae*) "zapatero", *Trichospermum galeotti* (*Tiliaceae*), *Miconia poeppigi* (*Melastomataceae*), *Inga* spp. (*Fabaceae*), *Couratari guianensis* (*Lecythidaceae*), etc. This is the most common forest in the region of Bahía Honda. El Edén is a good example of a secondary forest in an advanced state of recovery which we have studied intensively using a research plot (see further on) (Photos: 1-8, 8-10).

• **Scrub Vegetation or "Rastrojo"**. This vegetation type together with the secondary forests, are the principal vegetal cover of the area. "Rastrojo" proliferates in areas that were broken up in the past for cultivation or grazing. Once these activities are abandoned, pioneer species start the recovery process.

These are very dense woody formations dominated by scrub and lianoid species which adapt well to degraded soils. The most frequent species are *Byrsonima crassifolia* (*Malphigiaceae*), *Miconia argentea* (*Melastomataceae*), *Davilla kunthii* (*Dilleniaceae*), *Cecropia* spp. (*Cecropiaceae*), *Cornutia microcalycina* (*Verbenaceae*), *Apeiba tibourbou* (*Tiliaceae*), *Xylopia frutescens* (*Annonaceae*), *Cordia spinescens* (*Boraginaceae*), *Cochlospermum vitifolium* (*Cochlospermaceae*), *Tibouchina bipenicellata* (*Melastomataceae*), *Isertia haenckeana* (*Rubiaceae*), *Lippia oxyphyllaria* (*Verbenaceae*), etc. as well as a great number of species in the families *Asteraceae* and *Melastomataceae*. The floristic composition of this scrub vegetation is generally characterized by one or very few dominant species, which vary greatly from one zone to another, according to the period of abandonment, as well as other factors such as the frequency of fires. We can find examples of this type of vegetation on Canales de Tierra Island -on the track from Playa de los Luchos towards the northwestern part of the island, in the vicinity of the Laboratory, in the area of the "large *Ceiba* with the flag"- and on the mainland around Playa del Sol, on the path from El Edén to Playa Limón and in the Jeringuita and Caoba areas, etc. (Photos: 4-18, 2-30, 8-22, 8-29, 8-53, 8-54, 7-43, 2-10, 8-39).

• **Pastureland or "Potreros".** These are areas which have been broken up for pasture and cattle grazing, that cover most of the flat zones such as the alluvial plains of the rivers Salmonete, Pixvae, etc., as well as the slopes where the vegetation is burned at the end of the dry season. Numerous species of grasses and sedges such as *Rynchospora nervosa* or *R. cephalotes* and weeds like *Aeschynomene americana* (*Fabaceae*), *Desmodium* spp. (*Fabaceae*), *Hyptis capitata* (*Lamiaceae*), *Phyllanthus urinaria* (*Euphorbiaceae*), etc. are the dominant species. Species adapted to temporary waterlogged conditions were found in the most humid locations. These are *Eleocharis* sp. (*Cyperaceae*), *Limnocharis laforestii* (*Limnocharitaceae*), *Ludwigia octovalvis* (*Onagraceae*), etc. There are still left a few large specimens of trees like *Ceiba pentandra* (*Bombacaceae*) or *Terminalia oblonga* (*Combretaceae*), the remains of the old forests of these alluvial plains. Where the pasture land has been abandoned, a number of scrub species invade the pastures; among the pioneer species are: *Senna reticulata (Fabaceae)*, *Senna hayesiana (Fabaceae), Byrsonima*

crassifolia (Malpighiaceae), Davilla kunthii (Dilleniaceae), etc. (Photos: 1-11, 1-13, 8-5, 8-12).

• **Abandoned Orchards, Open Areas**. In the past these areas supported human habitation and maintain more or less in a naturalized state the following fruit trees: *Mangifera indica* (*Anacardiaceae*) "mango", *Citrus x aurantium* (*Rutaceae*) "limonero", *Syzyngium jambos* (*Myrtaceae*) "pomarosa", *Syzyngium malaccense* (*Myrtaceae*) "marañón curaçao", *Artocarpus atilis (Moraceae)* "fruta de pan", *Persea americana (Lauraceae)* "aguacate", *Crescentia cujete* (*Bignoniaceae*) "calabazo" or in some cases plantations of oil-palms, *Elaeis oleifera* (*Arecaceae*) as on the Canales de Tierra Island -el Guabo beach- or in the vicinity of the laboratory in Playa Limón, etc.

BIBLIOGRAPHIC REFERENCES

Bennett, C.F.J. (1968). *Human influences on the zoogeography of Panama*. Ibero-Americana **51**: 1-112.

CBMAP (2000). *Mapa de vegetación de Panamá*, Corredor Biológico Mesoamericano del Atlántico Panameño (CBMAP). Louis Berger International, Inc.

Chuvieco, E. (2000). *Fundamentos de Teledetección espacial*. Ediciones RIALP, S.A. Alcalá. Madrid.

Condit, R., S.P. Hubbell & R.B. Foster (1992). *Short-term dynamics of a neotropical forest*. Bioscience **42**(11): 822-828.

Dodson, C.H. & A.H. Gentry (1978). *Flora of the Rio Palenque Science Center*. Selbyana **4**: 1-6.

Holdridge, L.R. (1979). *Ecología basada en zonas de vida*. Instituto Interamericano de Ciencias Agrícolas. San José. Costa Rica.

Holdridge, L.R. & G. Budowski (1956). *Report of an Ecological Survey of the Republic of Panama*. Caribbean Forester **17**: 92-110.

Holdridge, L.R. & G. Budowski (1959). *Mapa ecológico de Panamá*. Instituto Interamericano de Ciencias Agrícolas, O. E. A. San José.

McKay, A. (2000). *Climas de Panamá*, Mapa presentado en la Primera Conferencia Internacional sobre Biodiversidad en Mesoamérica. Panamá del 7 al 11 de agosto de 2000. Autoridad Nacional del Ambiente. ANAM. Panamá.

Mueller-Dombois, D. & H. Ellenberg (1974). *Aims and methods of vegetation ecology*. Wiley, New York.

Murphy, P.G. & A.E. Lugo (1995). *Dry forests of Central America and the Caribbean.* In: *Seasonally Dry Tropical Forests*. S. H. Bullock, H. A. Mooney & E. Medina (Eds.). Cambridge University Press.

Peckham, G.H. (2002). *Rehabilitation of Dry Tropical Forest Ecosystems in Degraded Agropastoral Landscapes: Azuero Península, Panamá*. ATB Annual Meeting, Panamá City, Republic of Panamá.

Ruokolainen, K., H. Tuomisto, R. Ríos, A. Torres & M. García (1994). *Comparación florística de doce parcelas en bosque de tierra firme en la Amazonia peruana*. Acta Amazônica **24**: 31-48.

Tuomisto, H. (1998). *What satellite imagery and large-scale field studies can tell about biodiversity patterns in amazonian forests*. Annals of the Missouri Botanical Garden **85**: 48-62.