OROGRAPHIC INFLUENCES ON VEGETATION AND BIOPROSPECTING POTENTIAL AT THE CONFLUENCE OF THE BAYAMO, GUAMÁ AND GUISA RIVERS

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This paper is part of a plan to develop the Peña Prieta Institute to bio-prospect on family land between the Bayamo and the Guamá Rivers in the rain forests of the Sierra Maestra of old Oriente Province. These are the lands originally held by seven times wounded Mambí Colonel Don Benjamín Ramírez. On this land many desperate struggles took place during the Cuban Wars of Independence, and various conflicts of the Cuban Republican era, including the actions during the sad 1912 "Guerra de los Negros" and resistance against Batista in 1933-34 and 1957-58 (L. Daley manuscript in preparation).

The objective here is to begin to inventory the level of deforestation, erosion and manmade change such as dams. We start by examining the complex orography of the area (Woodring and Davies, 1944; Marrero, 1981; Borhidi, 1991); to do this we compare the old 1940s aerial photographs and 2001 satellite imagery.

OROGRAPHY AT THE CONFLUENCE OF THE BAYAMO, GUAMÁ AND GUISA RIVERS

Local vegetation (Borhidi, 1991) and even animal species are partially dependent on the rock substrate below where they live since all vegetation depends on the minerals in and the nature of the soil. In mountains, in the absence of active volcanoes, the mineral matrices of soils arise from the underlying or adjacent overlooking orography. The orography of this region is well described (Woodring and Davies, 1944; Borhidi, 1991; Marrero, 1981 and previous editions).

Geologically, part of this area appears to be the uplifted caldera of a long extinct submarine volcano, in which the northern wall has been broken by the hydro-dynamic action of eons of heavy rainfall. The southern wall contains the highest waterfall in Cuba, which pours into the now broken caldera. This is the so-called El Salto, or La Chorrera de Guamá (Enamorado 1917, Marrero, 1981), the highest waterfall in Cuba. A long ridge, perhaps the remains of a second sister volcanic cone, extends to the southeast (including lots 8 and 9 of Los Números).

When this land was beneath the sea, a thick calcareous layer rich in manganese and other minerals was deposited over the volcanic rock. After emergence from the sea, large remnants of this layer, now eroded to karst by rainwater still remain, and have significant value for mining purposes (Woodring and Davies, 1944). Unlike other areas of rain forest in the world (e.g., Shoumatoff, 1978, pp. 19-21), this richness in minerals brings about the promise of rainforest renewal. Traces of 19th Century and earlier coffee plantings were visible in the 1950s, lost among the re-growth of tall trees (personal observation circa 1954). Thus, apparently this would not be the first time that the rainforest came back here.

The erosion of this calcareous layer, gave place to caves, and small sinkholes, providing varied ecological niches. These niches combined with the rich and

fertile rock and soil substrates of the area to support much and varied flora and as well as diverse invertebrate, bird and reptilian fauna. Cuba is notorious poor in mammalian species; however, almiquí sightings have been reported near here and the jutía is/was common (see below).

This area is part of what is considered to be in the "cradle of Cuban flora, and together with the western Hispaniola, the most prominent centre of speciation in the Antilles" (Borhidi, 1991). This is also true for a good number of vertebrate and invertebrate animal species (e.g., for lepidoptera, de Zayas and Alayo, 1956; Johnson and Coates, 1999; Smith et al., 1994).

Development of bio-diversity in this area has come about over very long periods due to the consequence of successive sea level changes resulting from world wide glaciation and de-glaciation causing island isolation and reunification, climate change (e.g. Jackson et al., 1990) and to the complex effects of "continental drift" on the Antilles (Johnson and Coats, 1999). Thus, this is an area of great interest for conservation and bio-prospecting (Daley, 1997, 2000).

Information pertinent to the flora of the area can be found in a number of sources (de la Maza and Roig, 1914; Freres Marie-Victorin and Leon, 1942-1944; Fors, 1956 Alain, (Liogier, E.E., Hermano Alain) 1962; Little and Wadsworth, 1964; Robineau, 1990; Borhidi, 1991; Mabberley, 1993; Areces-Mallea, 2001). Descriptions of pertinent fauna include (Walker et al., 1964; Sepland and Schwartz,1974; Ottenwalder, 1985, 1991; Rodríguez, 1991; Schwartz and Hedges, 1991; Estrada and Hedges, 1996; Schwartz, 1997; Silva Lee, 1996; Garrido and Kirkconnel, 2000). Information is also available from multiple sources on the web (e.g., U.S. Department of the Interior cited below) and various older volumes (e.g., Zayas, 1914; Enamorado, 1917); here the author also uses first hand information and correspondence with various other scientists.

It is important to develop the medically and agriculturally significant bio-prospecting potential of Cuba. A single medicinal product can produce gross incomes of millions or even billions. One can expect that the need for new antibiotics and cancer drugs will rapidly accelerate these endeavors as this century progresses. Currently, even traditional products such as ginkgo metabolites, are in much demand and command large markets.

My laboratory's relatively recent and unexpected discovery of Taxol® in hazelnut trees (Hoffman, et al., 1998) shows how little we know about even the most common plants in the United States. The potential for bioactive substances among the mostly unexplored flora of Cuba is highly promising (Daley, 1997, 2000).

Cuban flora and fauna diverges considerably from the surrounding continent. And bio-prospecting is not new to Cuba, since as far back as the 18th century (e.g., Guaiac, Guayacán Santo, an antisyphilitic preparation from *Guaiacum sanctum* (Parke, Davis & Co., 1890)), the Island has been a source of medicinal products. Since these products are often unique and locality and species limited, similar projects throughout the world will not compete directly but help diversify the markets for such products.

In the 1940s, most of the high areas and much of the lower lands were forested (Woodring and Davies, 1944, and private correspondence of General Calixto García-Iñiguez Enamorado). However, even then the pressures, often politically motivated (Enamorado correspondence), to allow cut and slash agriculture were growing.

During the last forty years, Cuba has been subjected to widespread rapidly implemented projects. Almost universally these projects—much like the blighted ground nut project that the British labor government started in Africa at the end of WWII—have failed. The lessons learned would indicate that to be successful such projects require extensive planning and research, careful administration, and contingency-based flexible supervision. It is also clear the private sector has a far superior record of success in such matters. Well thought out pilot plans are essential. This is part of such a pilot plan.

Recent imagery shows that the massive dam on the Bayamo and Guisa River, and the smaller dam on the

lower canyon of the Guisa River have changed the local environment a great deal.

Personally I feel great sorrow at the destruction of the residence, library, and accompanying coffee processing structures, built with life savings of grandfather (Brigadier General, Cuban War of Independence Army, Calixto García-Iñiguez Enamorado). However, I will report the following with as much objectivity as I can muster.

These dams are presumed, from their satellite images, to be either of concrete or of concrete-covered rammed earth. Questions arise as to their safety in such a tectonically unstable area. Severe earthquakes have been reported in the Bayamo area with frequency over the centuries in: 1551, 1624 and 1766. These earthquake, termed "espantosos," were powerful enough that each in turn destroyed the city of Bayamo's main church, San Salvador de Bayamo (Ortega Alvarez, 1999). The city of Bayamo is on the Cauto Plains, approximately 15 miles north west of, and below, these dam sites. Tectonic shifting continues. As a child (late 1940s early 1950s), I still remember the mild trembling of the earthquakes of that area, and that my elders did not find it remarkable.

The Bayamo River is known also for its massive floods during hurricanes and wet seasons. The famous flood of September 1616 destroyed all the ships that once docked on the river (Ortega Alvarez, 1999). When we lived in Entre Ríos, I recall so very clearly how ton or more sized boulders came crashing down the bed of the then-unbound river, making the rocks of the valley resound to their passage. During the 1960s, there was also massive flooding and great landslides in the area.

Reforestation is urgently needed to alleviate the erosion shown in imagery since the silt gravel deltas at the upper part of the reservoirs is witness to considerable erosion. The disastrous effect of these dams on the underground waters of the Cauto Plain has been described (Díaz-Briquets and Pérez-López, 2000).

It would seem, from the imagery used here (available on request) that one can divide the area into a number of zones based upon its orography:

1. The peninsula created out of Grandfather's land, "Entre Ríos," is mainly thin soil pastures over old volcanic lava flows (laja). The original vegetation included some karstic forest but mainly lowland seasonal rain forest. Trees still survive in these areas, probably mostly *Guazuma ulmifolia* or guásima; hopefully the royal palms (*Roystonea*) and the various other trees *Ceiba pentandra, Mammea Americana, Swietenia mahogoni, Anacardium occidentale* and others have persisted among the guava (*Psidum guajava*), guinea grass (*Panicum maxima* an introduced, and also bioactive, species) and thorn bushes. Perhaps the associated polychromatic, the great speciation (Lincoln et al., 1986) of arboreal land snails that once contributed to the very numerous, excellent and perhaps lost collection of Rev. Galofre at the Escolapios de Guanabacoa collection, are still extant. One would not expect the tree species previously present on the flood plain, such as *Samanea saman* to have survived. However, some individual trees of locally adapted germplasm may have survived both above and below the dam and reservoir. That is if reports of the massive scavenging of all available wood prove less harmful or less extensive than is at present believed. The larger animal species to be sought as replacements for this area include the Cuban freshwater crocodile (*Crocodrylus rhombifera*) once seen frequently at the Guamá River ford, "Paso de Caimanes" (e.g., Rosita García- Iñiguez personal communication); and if necessary, the various species of jutía (*Capromys* spp.) and the great (to 21 feet long, Sepland, and Schwartz, 1974; 15 to 18 feet apparently from personal war experience by Zayas (20-22 feet citing Oviedo), 1914) Cuban rainbow boa, majá de Santamaría (*Epicrates angulifer*).
2. The Los Llanos Plateau, a heavily karstic (eroded marine lime stone) area, very difficult to traverse and not easily worked for crops, seems to have retained much partial forest cover. This once was, and perhaps still is, the land of the jutía and the Cuban boa. I have some hope that this area still retained much of its plant species diversity (e.g., Borhidi, 1991).

3. The Canyon areas of the Guamá and Arroyón Rivers seems to be eroded and abandoned. This area is a jumble of alluvial, karstic and ancient volcanic soils. This is the bottom of what seems to have been the original caldera of an ancient volcano and also the area into which the high waterfall, the Salto de Guamá, drops to give origin to the Arroyón stream (a tributary of the Guamá River). Long ago in this area I observed what appeared to be an example of the small race of mute Taíno-domesticated *sato* dogs (see Schwartz, 1997). It is hoped that on the cliffs there is sufficient vegetation that can be used to re-seed and re-establish the original forest

4. The Ridge of the Números, previously known as La Mambisa. This area constitutes the walls of the putative ancient volcano. Much of the precipitation is gathered by a large crag called "La Peña Prieta." This great rock, when the area was completely forested, gave origin to at least seven streams. This area can be thought of as consisting of a semicircular remnant of crater rim plus ridge with a high branching sister ridge to the southeast. This geologically very complex, richly bio-diverse, area, climbs through karstic forest, through submontane rain forest to reach the wet montane rainforest (see Borhidi, 1991). This area in the early 1950s was still alive to the howls of the wild dogs (which seem to be derived from the larger domestic dogs of pre-Taíno peoples, see Schwartz, 1997; and Rouse, 1992). In this area there have been reported tentative sightings of the Ivory billed wood pecker (*Campephilus principalis*) and the almiquí (*Solenodon cubanus*) (Barbour, 1944 and personal observations.) The almiquí is one of only a few mammals that are venomous; thus examination of its toxins is likely to be of scientific and possibly biomedical interest. Imagery of this area shows, among what appears to be abandoned or semi-abandoned coffee plantings, what seem to be massive landslides, and also remnants of original forest on the steeper slopes and precipices. Given its steepness, heavy rainfall and the tectonic instability of the regions, it is critical to restore this area first.

MATERIALS AND METHODS

The imagery was obtained from Space Imaging of Thornton, Colorado. The geographic location was Cuba, north slope Sierra Maestra mainly between Bayamo and Guama rivers, south west of town of Guisa. The geographic limiting coordinates were:

Upper Left Latitude:	North 20 degrees 13 minutes
Upper Left Longitude:	West 76 degrees 36 minutes
Lower Right Latitude:	North 20 degrees 05 minutes
Lower Right Longitude:	West 76 degrees 25 minutes

A sample of images was chosen from those with less cloud cover acquired in the Spring of 2001. The resampling interval was 5 m.

The sample was received in the form of a "pdf" file, and processed in Adobe PhotoShop (Adobe Systems Incorporated, Salinas California) to divide up and sharpen the images and equalize their histograms. Cultivated areas at lower elevations were used as internal standards. These images, far too detailed for hard copy, are available by request.

SUMMARY

The complex orography of the area between the Guamá, Guisa, and Bayamo Rivers has given rise to a species-rich, ecologically and geologically complex region. Satellite imagery indicates that the area seems to be in bad, but not irremediable, shape and has been subject to considerable manmade disturbance during dam building and forest cutting that have caused much erosion during the last forty years. However, I conclude, since unlike parts of the Amazon the area of interest here has a mineral rich substrate, that this valuable land can be restored to its original pristine "rain forest" condition.

Thus, if prompt remedial steps are taken soon, this area may still become a source of valuable scientific and perhaps even medically important materials. Hopefully, ecology, esthetics and history of the area with allow for tourism to help the economics of the area, and diminish the social, and political pressures that allow "cut and slash" agriculture. In addition and perhaps most importantly from a human view, given the unstable tectonic nature of the region, it is

urgent that the region be completely restored to forest to ameliorate sedimentation deposits and consequential disastrous flooding in the probable case that these dams rupture, when a severe earthquake strikes again.

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