

# The Inter-American Highway and Human Disturbance of Páramo Vegetation in Costa Rica

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## ABSTRACT

Written descriptions and photographs were examined to determine how the construction of the Inter-American Highway across the Cordillera de Talamanca, Costa Rica, in the 1940s affected the vegetation of the Buenavista páramo. Travelers' accounts from the period 1890-1937 mention human-set fires and the grazing of pigs and cattle along the rough trail that predated the highway, and describe vegetation that seems to differ little from that present today. Repeat photo pairs of scenes photographed in 1949 and 1957 and re-photographed in 1985 supplement the spotty aerial photo coverage available for the region. Both sources show recent clearing under electrical transmission lines, but reveal few other changes in páramo composition or timberline position. Fires and light cattle grazing occur today in the Buenavista páramo, but the intensity of disturbance may have been greater prior to the completion of the highway. The same road that led to massive environmental degradation in the Talamanca oak forests may have somewhat reduced disturbance in the higher páramos by speeding travelers' journeys through the region.

## INTRODUCTION

Modification of the world's plant cover by humans began in prehistory, and few areas of the world support vegetation not disturbed now, or in the past, by cultural activities. In Latin America, human-induced vegetation change has occurred for at least ten thousand years, as the result of hunting, burning, clearing, livestock grazing, agriculture, logging, and the introduction of alien plants and animals (Bennett 1975, 215-233). These changes in vegetation have long attracted research attention, and a rich literature exists on contemporary and early human impacts on Latin American vegetation.<sup>1</sup>

A theme often highlighted in discussions of recent vegetation change in Latin America is the impact of roads on vegetation patterns (Budowski 1970; Parsons 1976). As observed by the Mexican economist Edmundo Flores (quoted in Parsons 1976, 123), roads "give value to previously worthless land by making it accessible and incorporating it within the market area." Settlers follow on the heels of road construction crews, eager to carve farmlands and pastures from the newly accessible land (Parsons 1976, 123; Fearnside and Ferreira 1984). The result is often a rapid transformation of roadside vegetation and increasing environmental disturbance throughout the region. If the new road passes through areas ill-suited for agriculture (Parsons 1976, 123), or if other factors conspire to limit settlers' ability to make a living in the region (Smith 1982), clearings may soon be abandoned. However, recovery of the native vegetation may be severely retarded, leading to long-lasting environmental degradation (Budowski 1970).

This study is concerned with the impact of a twisting, two-lane road through the mountains of southern Costa Rica. The road, a section of the Inter-American Highway, was constructed with U.S. assistance in the 1940s and links the populous Meseta Central of Costa Rica with the settlement of San Isidro in the Valle del General along the lower Pacific coast (Figure 1). This stretch of the highway crosses the northwestern end of the Cordillera de Talamanca, a rugged granitic mountain range that is one of the highest and least-settled mountain ranges in Central America. The crest of the Talamanca range traverses a series of peaks and massifs that includes Cerro Chirrip6 (3,819 m), the highest peak in the country, and the slightly lower peak of Cerro Buenavista (3,491 m), along the Inter-American Highway route (Figure 1). Both highland areas and a number of other massifs and isolated peaks reach above timberline, and support bamboo- and shrub-dominated vegetation referred to as páramo. Their steep and deeply dissected flanks support dense montane oak forests.

The construction of the Inter-American Highway across the Buenavista massif opened the northwestern part of the Cordillera de Talamanca to [end p. 13] intensified human exploitation. The effects of highway construction have been well-documented in the montane oak forests, where the improved access provided by the new road led to extensive forest clearance for timber, charcoal production, and the establishment of cattle pastures (Schubel 1980). The possible impact of the highway on páramo shrublands found at higher elevations has not been investigated. The more general theme of contemporary and past human influence on vegetation patterns has, however, attracted attention. Hartshorn (1983, 144, 146) has suggested that human-set fires have lowered treeline along the Inter-American Highway, resulting in a spread of páramo vegetation. Janzen (1973a, 678; 1983, 330) holds that even the highest peaks supported some type of low montane rainforest, rather than páramo, before they were subjected to clearing, burning, and livestock grazing.

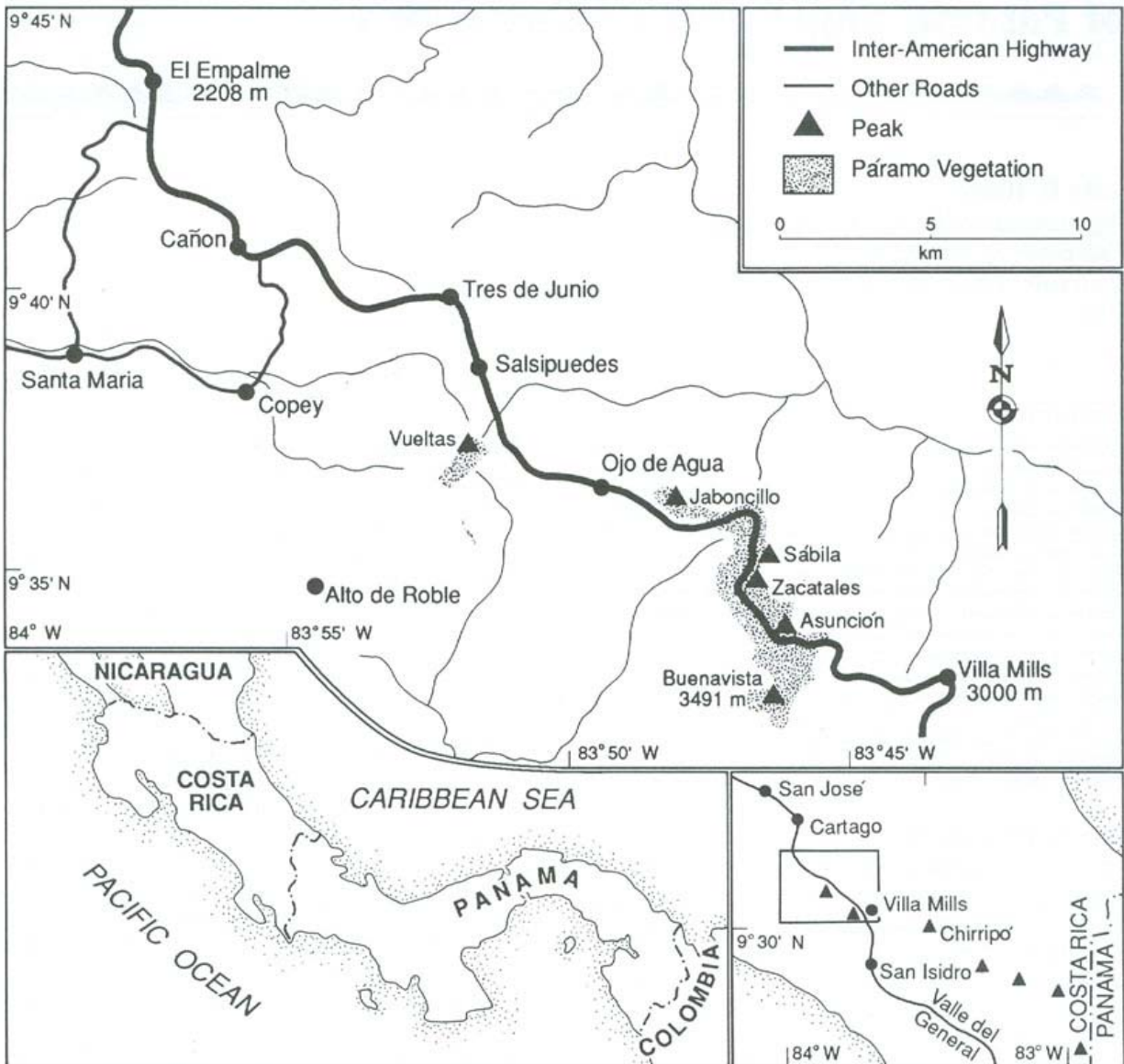


Fig. 1. The Buenavista páramo and the Inter-American Highway route across the northwestern end of the Cordillera de Talamanca. The heavy line in the inset map of southern Costa Rica indicates the crest of the range.

This paper describes historical evidence relating to pre- and post-highway anthropogenic impacts on the vegetation of the Buenavista páramo. The re-photographing of scenes originally photographed in the 1940s and 1950s provides useful information for assessing recent vegetation history, and five photographic pairs are reproduced [end p. 14] here. Repeat photography has proven a valuable tool for assessing changes (or lack of changes) in vegetation (Gibbins and Heady 1964; Rogers 1980; Byers 1987) and other natural and cultural features of the environment (Vale 1989). But, with the exception of two studies that included scenes of northwestern Sonora, Mexico (Hastings and Turner 1965; Bahre and Bradbury 1978), and the recent work by Veblen and Lorenz (1988) in northern Patagonia, repeat photography has received little attention in Latin America. It has not been used previously in Costa Rica.

#### ENVIRONMENTAL SETTING

The uplifted granitic batholith that forms the backbone of the Cordillera de Talamanca is mantled in the Buenavista highlands by basalt and pyroclastic debris (Weyl 1957, 16). Soils are generally acidic, with pH values as low as 4.0, and rich in organic matter (Harris 1971, 198). Meteorological data from a station near the summit of Cerro Buenavista (station elevation 3,475 m) show a mean annual temperature (1970-79) of 7.6° C and average annual precipitation (1971-84) of just over 2,500 mm (Instituto Costarricense de Electricidad, n.d.). Nearly 90 percent of the annual rainfall total falls during the May to November wet season.

Clouds characteristically enshroud the Buenavista highlands, and high atmospheric humidity moderates the dry season. This is particularly true in the montane oak forests, where the trees appear to generate a significant amount of moisture through cloud sweep. Plants growing above the forest limit also intercept atmospheric moisture, but for days or weeks during the dry season the condensation belt lies below

timberline. These cloud-free intervals of dry weather in the highlands are associated with the trade wind inversion and strong atmospheric subsidence (Dohrenwend 1972). Grasses, sedges, and some perennial herbs die back during these periods, and ground litter dries out, providing the fuel for fires. Fuel buildup is favored by the continuously low temperatures, which retard decomposer activity and hence the rate of litter breakdown (Janzen 1973b, 121).

The vegetation of the Buenavista massif has been described by Weber (1959). The most characteristic species is the dwarf bamboo, *Swallenochloa subtessellata*, which often occurs in nearly monospecific stands (Janzen 1983, 330). Several small-leaved, evergreen shrubs occur intermixed with the bamboo, among which the families Hypericaceae, Compositae, and Ericaceae are particularly prominent. Grasses, sedges, and herbaceous dicots --many of Andean affinity--dominate the herbaceous cover.

The montane forests that replace the páramo at lower elevations are dominated by the oak, *Quercus costaricensis*. The upper forest limit in the Buenavista highlands ranges in elevation from about 3,150 to 3,200 m. In some areas, oak forest 20-30 m high gives way to 1-3 m high bamboo- and shrub-dominated páramo along an abrupt boundary. Elsewhere a broad transitional zone dominated by large shrubs and small trees other than oak is apparent.

### **THE CAMINO DE CALDERON AND EARLY DESCRIPTIONS OF THE BUENAVISTA MASSIF**

Agricultural settlement of the lower slopes of the Buenavista massif began in the 1860s with the establishment of Santa María de Dota and Copey (fig. 1), but it was not until the 1880s that the upper slopes became accessible. In 1861, the Costa Rican Congress offered a reward for the best plan for a trail between Cartago and the new agricultural settlements in the Valle del General that would accommodate pack animals. Several adventurers began exploring possible routes across the highlands in hopes of claiming the prize. The victor was Don Pedro Calderón, who with his son-in-law Juan López opened what became known as the Camino de Calderón between 1883 and 1885 (Ureña 1941, 495-496; Sandner 1961, 12). Calderón's rough trail followed existing paths along the lower slopes of the cordillera between the settlements of Santa María and Copey. From Copey the road proceeded south to a point known as the Alto de Roble, then cut east to join the continental divide at Cerro Vueltas. After passing Cerro Vueltas the trail followed the crest of the range along the approximate route of today's Inter-American Highway before descending into the Valle del General.

Following the completion of Calderón's trail the government constructed a series of shelters along the route to protect travelers. These were poorly maintained, and provided little refuge from the cold and rain. The many fatalities that resulted from exhaustion and hypothermia within the Buenavista highlands (Congreso Constitucional 1931, 1; Sandner 1961, 12; Skutch 1971, 62), led to its popular designation as the Cerro de La Muerte or "Mountain of Death."

The earliest known description of a journey across the new route is that of the naturalist Henri Pittier, who crossed the Buenavista summit in 1890 (Pittier 1891). Pittier and his associate Adolphe Tonduz collected more than 80 species of vascular plants in the vicinity of Cerro Buenavista, some of which are mentioned by Tonduz (1893) in a companion report. Pittier's description of [end p. 15] the summit vegetation, though vague, establishes that at the time of his visit, the higher peaks were not forested, but were covered by extensive *zacatales* or grasslands (Pittier 1891, 32). The dwarf bamboo *Swallenochloa subtessellata* was not specifically cited, but in a later volume (Pittier 1978 [1908], 84), Pittier described the bamboo as forming extensive chaparrales or shrublands in the "high páramos of Buena Vista and the Cerro de la Muerte," where it constituted an important forage for pack animals. In this case Cerro de la Muerte refers to the peak of Cerro Zacatales, the highest point along Calderón's route (Sandner 1961, 12), whereas Buena Vista designates the slightly higher summit of Cerro Buenavista, which was visible from the road but not traversed by it.

Pittier's account of his journey across the Buenavista massif indicates that by the late 1800s the upper slopes of the cordillera had been settled only in the vicinity of Cerro Vueltas. The Vueltas area was unoccupied at the time Pittier passed by, but attempts had been made previously to establish cattle grazing there. These attempts apparently failed due to the harsh climate and the loss of stock to wild animals (Pittier 1891, 32; Leiva 1908, 3001).

There is no mention of human-set fires in Pittier's description of the vegetation, but the naturalist's observations near timberline (Pittier 1891, 27, 28) are suggestive of burning. Pittier found to his surprise that the forests near timberline on both sides of the massif were composed of well-formed, but entirely dead trees. Pittier speculated that the trees represented a formerly higher timberline that had been lowered by climatic cooling, or by a progressive downslope impoverishment of the soils owing to the continuously high rainfall. An alternative explanation, not mentioned by Pittier, is that the trees had been killed by fire. If burning had occurred recently, Pittier surely would have noticed evidence. But decomposition proceeds very slowly in the Buenavista highlands (Janzen 1973b, 121; Horn 1989, 107), and Pittier may have been looking at trees that died decades earlier. Subsequent regrowth of the understory vegetation and the colonization of charred trunks and branches by mosses and liverworts may have obscured evidence of fires.

Pittier's description of his journey across the massif and other accounts from the early twentieth century (Leiva 1908; Congreso Constitucional 1931) document the hardships endured when crossing along Calderón's rough trail. The same journey that can today be completed in three or four hours by car or bus took three or four days using the old route, and horses were more often led or pulled than ridden across. Despite the difficulties of the trail, stockmen in San Isidro and adjacent areas of the Valle del General drove both cattle and pigs over the summit to take advantage of the higher prices that could be obtained in the Meseta Central. The potential profits were apparently high enough to offset the loss of animals that would wander off or die during the arduous trip (Franck and Lanks 1940, 220; Skutch 1971, 61).

The most detailed account of human disturbance of the vegetation along Calderón's route is that provided by the naturalist Alexander Skutch, who crossed the Buenavista massif on foot in 1936. His description of the journey, published several decades later (Skutch 1971) documents the accidental or deliberate setting of fires by stockmen and travelers. Describing the vegetation below timberline on the southeastern slope of the massif, Skutch (1971, 60) explained that "In many places along this lofty ridge, the trees had been scarred or killed by fires, which consumed the dry undergrowth and left the ground black and charred." Farther upslope, Skutch encountered other burns:

I climbed out of the forest into the páramo that covered the open summit of the Mountain of Death. Here dwarf bamboos ([*Swallemochloa*] *subtessellata*) and low bushes with dark, compact foliage gradually replaced the trees of the lower slopes. The ground was softly carpeted with a thick, peaty layer of dead vegetation, which at this season was so dry that in many spots it smoldered with fires that had evidently been set on purpose by travelers. . . . Over large areas that had already been burned, the ground was covered with gray, powdery ash, into which I sank to my shoe tops (Skutch 1971, 60).

To Skutch the cumulative impact of these fires was readily apparent: Here and there a half-burned trunk, lying where only shrubs and grasses were now to be found, was proof that small trees had once grown higher on this mountain. All the fires burning along the trail, and signs of earlier fires, helped to explain their disappearance (Skutch 1971, 64).

### **THE COMING OF THE INTER-AMERICAN HIGHWAY**

The construction of the Inter-American Highway in the 1940s led to increased human activity in the Buenavista highlands, particularly in the oak forests below timberline. Newly accessible areas along the highway were settled by agriculturalists from the Meseta Central, who exploited the oaks [end p. 16] for timber and charcoal production, and cleared and burned large areas for cattle pasture (Schubel 1980). El Empalme, Tres de Junio, Ojo de Agua, and a number of other small settlements developed along the road (Figure 1).

The section of highway through the Buenavista páramo was officially opened to vehicular traffic in 1946 (Sandner 1961, 2). Three years later the botanist Hugh Iltis took advantage of the new road to collect herbarium specimens near Cerro Buenavista. At that time the highway was unpaved, and the region was still very isolated. According to Iltis (1985), in 1949 "there was no such thing as a grocery store, a telephone, or even traffic beyond a truck or two a day." The growing importance of the highway brought some changes. The highway workers' barracks built just below timberline on the southeastern slope of the Buenavista massif became the locus for a dispersed settlement, known first as Millsville (after the Ralph E. Mills construction company), and later as Villa Mills. Here today's travelers can make use of a public telephone, and purchase provisions, a meal, or even a bed for the night.

But settlement and economic activity within the higher páramo region remain limited. There is only one residence above treeline, a house adjacent to the Channel 7 television transmitter atop Cerro Buenavista, where the transmitter operator lives. A few head of cattle are occasionally grazed on the high peaks, but the overall impact at present appears minimal. Around Christmas, mosses are occasionally gathered within the páramo for use in holiday decorations.

### **POST-HIGHWAY VEGETATION HISTORY: CLUES FROM REPEAT PHOTOGRAPHY**

The available written descriptions and photographs suggest that, at the time of highway construction, the uppermost slopes of the Buenavista massif supported low, shrub- or grass-dominated vegetation, not forest. Did the increased accessibility of the Buenavista páramo result in greater human disturbance, as was the case in the oak forests found at lower elevations? Has the páramo vegetation changed as a consequence?

Written descriptions and field evidence document continuing human disturbance, including fires, throughout the Buenavista páramo from the 1950s to the present (Horn 1986, 29-31). Field surveys within recent burn sites in the Buenavista páramo have revealed short-term changes in species composition following burning (Williamson et al. 1986; Horn 1989). However, no information is available on longer-term changes in páramo composition or on the dynamics of the forest/páramo transition. Full assessment of the impact of highway construction on the composition and extent of the Buenavista páramo awaits further field study, but in the meantime repeat photography provides important clues.

In 1984 a small collection of photographs taken in the Buenavista massif during the 1940s and 1950s was assembled by requesting photographs from early visitors (Iltis photos) or copying them from publications. Nine old photographs were obtained, of which five could be relocated and re-photographed in the field. Additional photo pairs would be desirable but are limited by the availability and quality of early photographs.

Scenes were re-photographed in early 1985 using a single lens reflex camera with a 50 mm lens. The camera set-up did not allow exact duplication of the original photographs, which were taken using lenses of different focal length. However, darkroom manipulation of both the original and recent prints has produced pairs of near-identical views that are suitable for the present study. In re-photographing the scenes no attempt was made to exactly duplicate light levels, cloud cover, or time of year, although both the old and new photographs were taken during the dry season.

The first photo pair (Figures 2a and 2b) was taken on the south slope of Cerro Asunción, looking towards the peaks of the Buenavista group. The bamboo *Swallemochloa subtessellata* dominates the vegetation in the scene photographed by Hugh Iltis in 1949, as it does in the 1985 scene. Aside from the paving of the Inter-American Highway, few changes are evident between 1949 and 1985.

Figures 3a and 3b depict the upper forest limit on the lower east slope of Cerro Asunción. The older view was photographed by Hugh Iltis in 1949, from the roadbed of the recently completed Inter-American Highway. An abrupt transition between oak forest and bamboo-dominated páramo is apparent on both photographs. Páramo vegetation in the foreground is less dense in the 1949 view, perhaps because of clearing along the roadbed. Electrical transmission lines in the recent photograph were installed in 1984.

Figure 4a is a photograph of Cerro Jaboncillo taken by the botanist Hans Weber in 1957. The trail visible in the photograph is the old, pre-highway route across the summit. Bamboo dominates the area, with shrubs more important on rock outcrops along the crest. The 1985 version (Figure 4b) shows little overall change in vegetation. The old trail has been widened; it is now a jeep trail providing access to electrical transmission towers installed in the early 1980s (background) and an older set [end p. 17]



Fig. 2. (a) The Inter-American Highway and peaks of the Buenavista group, as photographed by Hugh Iltis from the upper south slope of Cerro Asunción in 1949. (b) The same view in 1985.



Fig. 3. (a) The upper limit of oak forest on the lower east slope of Cerro Asunción, as photographed from the Inter-American Highway by Hugh Iltis in 1949. (b) The same scene in 1985.



Fig. 4. (a) Cerro Jaboncillo, as photographed by Hans Weber in 1957. Source: Weber, 1959. (b) Cerro Jaboncillo in 1985.

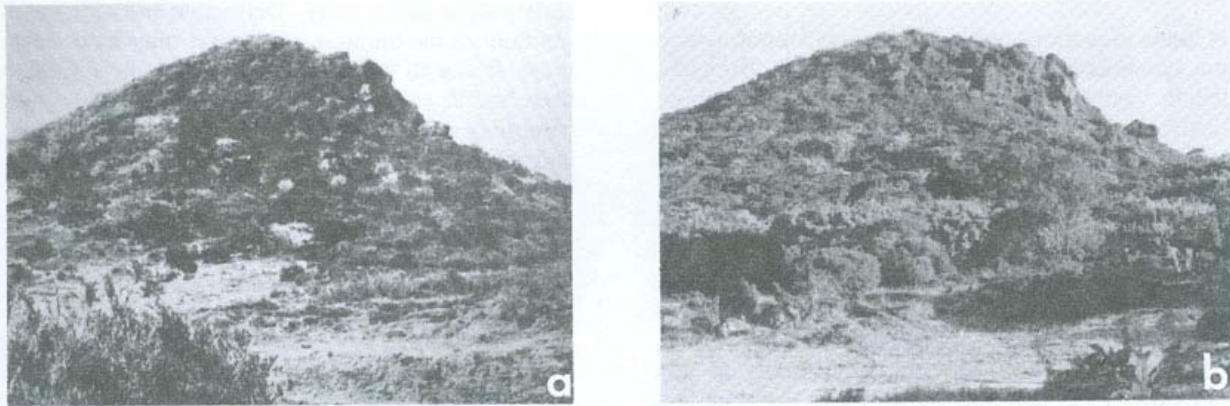


Fig. 5. (a) The upper south slope of Cerro Asunción, as photographed by Hans Weber in 1957. Source: Weber, 1959. (b) Cerro Asunción in 1985.

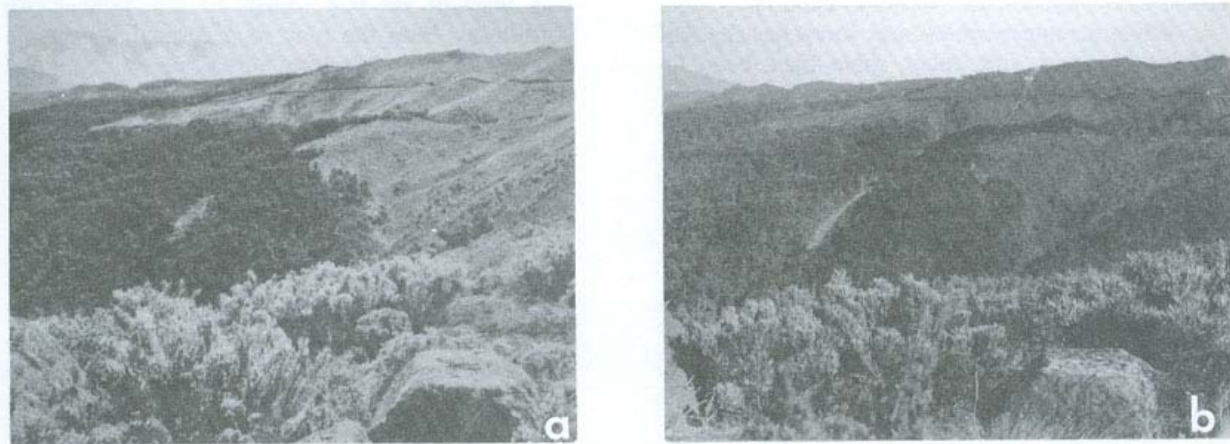


Fig. 6. (a) Hans Weber's 1957 photograph of the Inter-American Highway and the distribution of oak forest and páramo in the Buenavista highlands. The photograph was taken from the summit of Cerro Sábila, looking southeastward. Source: Weber, 1959. (b) The same scene as it appeared in 1985.

of towers and lines installed in the early 1970s (foreground). The Inter-American Highway skirts this peak and is not visible in the photograph.

Figure 5a shows the upper south slope of Cerro Asunción, as photographed by Weber in 1957. In 1985 (fig. 5b) the vegetation appeared slightly denser, although differences in contrast and shadows make close comparison of the photographs difficult. In 1985 the slope pictured was dominated by evergreen shrubs, particularly *Hypericum irazuense* and *Vaccinium consanguineum*; lighter patches are clumps of the bamboo *Swallemochloa subtessellata*. The older photograph suggests a similar composition thirty years earlier.

The final photo pair (Figure 6a and 6b) depicts the view from Cerro Sábila, looking southeastward towards the Inter-American Highway. The older photograph was taken in 1957 by Hans Weber. A sharp transition between oak forest and bamboo-dominated páramo is evident in both photographs. The 1985 version of the scene reveals clearing of both páramo and oak forest in connection with two sets of electrical transmission lines and associated jeep access roads. However, few if any changes are apparent in the upper elevational limit of oak forest. The slopes visible on the right side of the photograph, and the highway roadbed, today support larger woody plants (large shrubs or small trees) than they did in 1957.

#### DISCUSSION AND CONCLUSIONS

The relative stability of páramo species composition and extent suggested by the comparative photographs stands in marked contrast to the situation [end p. 19] at lower elevations in the Buenavista massif, where the construction of the Inter-American Highway led to vast and enduring changes in the roadside landscape. The impression of stability is reinforced by the limited aerial photo coverage available for the massif, which reveals no significant changes in the upper limit of continuous forest between 1941 and 1985,<sup>2</sup> despite the much improved access provided by the highway. Janzen (1973a, 678; 1983, 330) may be correct in his belief that the Buenavista peaks once supported low forest, rather than páramo. But the summit region was not forested at the time of highway construction, or sixty years earlier when Calderón's

trail was completed. If human disturbance has converted forest to scrub in the Buenavista highlands, this conversion predates the twentieth century.

While the upper limit of oak forest has changed little in the past fifty years, there have been local depressions in the upper elevational limit of scattered trees other than oak. On the south slope of Cerro Zacatales, for example, there are fire-killed individuals of *Escallonia poasana* and *Arctostaphylos sp.* up to 5 m high. These large woody plants were alive when the first aerial survey of the region was made in 1941, but were killed by successive fires in subsequent decades. If these plants are considered to be trees, their fire-induced mortality supports Hartshorn's (1983, 144, 146) suggestion that treeline in the Buenavista highlands has been lowered by burning.

Cutting may have also brought about local shifts in treeline position. During field surveys in 1984-85, little evidence of cutting was seen outside of the newly cleared electrical transmission corridors, but during the 1970s Janzen (1984) observed large cut stumps extending halfway up the slopes of Cerro Asuncion.

The cumulative impact of recent (post-highway) anthropogenic disturbances in the Buenavista páramo is difficult to assess. Fire, clearing, and grazing have left their mark on the roadside vegetation, but the construction of the Inter-American Highway may have in some ways reduced anthropogenic disturbance. Consider, for example, human-set fires. Several fires have occurred in the Buenavista páramo since the completion of the highway, but burning may actually be less common today than it was during the pre-highway period. Field surveys in 1985 revealed only two burn sites, both less than 0.2 ha, that were less than about eight years old; later visits revealed no evidence of burning between 1985 and January 1989. If Skutch's description of the situation in the 1930s is typical, fire-free intervals of this duration may have been uncommon in the early part of this century. Deliberate and accidental ignition of the summit vegetation may have been more frequent when travelers spent days (rather than hours) crossing the massif, when they made campfires and cook fires and slept in the páramo, and when cattle and pigs walked, rather than rode, to market.

The construction of the Inter-American Highway through the Buenavista páramo may represent an exception to the oft-cited relationship between roads and environmental destruction. In lowland Central America, the Amazon basin, and elsewhere in Latin America and in other developing regions, road building generally leads to widespread disturbance of the roadside environment and clearing of the original vegetation. This was certainly true for that part of the Inter-American Highway that cuts through the oak forests of the Talamanca cordillera. Here the new road opened a valuable resource to more intensive human exploitation, and the result was massive deforestation and the development of settlements along the highway route. People spent more time in the region, and had a greater impact on the vegetation, after the highway was in place.

Above timberline the effect was different. The Inter-American Highway opened the Buenavista páramo to potentially greater human impacts, but the area has never been perceived as having much value and highway construction seems not to have much altered land use. The most important consequence of the highway may be that people can now move into and out of the region more rapidly. By speeding traveler's journeys through the páramo the highway may actually have reduced human disturbance in the region.

#### ACKNOWLEDGMENTS

Fieldwork was supported by the Institute of International Education, the Association of American Geographers, and the Center for Latin American Studies of the University of California, Berkeley. The Instituto Geográfico Nacional in San José, Costa Rica, kindly provided darkroom facilities and access to aerial photograph collections, and Hugh Itlis generously shared photographs and notes from a 1949 visit to the Buenavista paramo. I thank Conrad Bahre and two anonymous reviewers for their comments on the manuscript.

#### NOTES

1. No comprehensive bibliography or review of this literature exists, but several key papers are cited in Bennett (1975, 315-316) and Flenley (1979, 118-121).
2. The 1941 photographs were taken by the U.S. Public Roads Administration in connection [end p. 20]with the first Inter-American Highway survey. The 1984 photographs were taken by the Northwest Canadian Survey Company, Inc. for the Instituto Geográfico Nacional with the cooperation of the Inter-American Development Bank. In 1985 both sets were available for examination at the Instituto Geográfico Nacional in San José, Costa Rica.

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## **RESUMEN**

Se examinaron descripciones escritas y fotografías para determinar cómo fue influenciada el páramo Buenavista con la construcción de la Carretera Interamericana al través de la Cordillera de Talamanca, Costa Rica, en los 1940s. Informes de viajeros del período 1890-1937 mencionan el pastoreo de cerdos y ganado a lo largo de la vereda que existía antes de la construcción de la carretera. y describen vegetación que parece difirirse poco de la vegetación que existe hoy. Parejas de fotos de paisajes fotografiados originalmente en 1949 y 1957 Y re-fotografiados en 1985 suplen la cubierta incompleta de fotos aéreas disponibles para la región. Ambas fuentes muestran desmontes recientes bajo las líneas de transmisión eléctricas, pero revelan pocos otros cambios en la composición del páramo o en la posición del límite del bosque. Fuegos y pastoreo limitado ocurren hoy en el páramo Buenavista. pero la magnitud del disturbio pudo haber sido de mayor intensidad antes de la realización de la carretera. La misma carretera que resultó en gran degradación ambiental en los bosques de roble de la Cordillera de Talamanca posiblemente ha reducido un poco las perturbaciones humanas en los páramos superiores porque la misma permite ahora cruzar la región más rápido. [end p. 22]