The Isabela Fire: Galapagos Islands[1]

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RESUMEN

Entre los meses de marzo y mayo de 1985 varios incendios ocurrieron en la Isla Isabela, la mayor de las islas del Archipiélago de las Galápagos. El primero de estos incendios comenzó en una zona agrícola el 28 de febrero y el segundo comenzó el 3 de marzo en el Parque Nacional Galápagos. Desde el 14 de marzo, personal capacitado para combatir incendios forestales del Servicio Forestal Ecuatoriano (DINAF), miembro del Ejército Ecuatoriano y asesores de la AID combatieron estos incendios.

Las actividades asociadas al control de los incendios fueron: el establecimiento de una "brecha de tractor" durante el período del 14 al 20 de marzo con la intención de proteger los territorios de Puerto Villamil y Santo Tomás.

Posteriormente rodear el incendio del Parque Nacional y la llegada a la Isla de un destacamento de ingenieros del ejército ecuatoriano, junto con cuatro tractores adicionales, dos helicópteros y otros materiales de apoyo. Con la ayuda de estos combatientes se extendió la "brecha de Tractor" de una manera eficiente y agresiva, y así se rodeó el incendio en el Parque Nacional. A partir del 11 de mayo los incendios fueron controlados pero no extinguidos.

En junio, la Estación de Charles Darwin patrocinó una expedición para evaluar las consecuencias ambientales y económicas causadas por los incendios. Las conclusiones fueron las siguientes:

1) Los fuegos en las zonas agrícolas causaron pérdidas económicas reducidas (principalmente pérdida de cercas).

2) A pesar de que las porciones superiores de muchos árboles y arbustos fueron severamente dañadas, en la mayoría de las especies se observó retoño.

3) El horizonte A del suelo fue destruido en grandes extensiones del Parque Nacional debido al consumo de materia orgánica. El material residual, constituido principalmente por tephra, quedó suelto y expuesto a saturarse de agua.

4) El efecto del fuego sobre la fauna silvestre no pudo ser evaluado con presición; sin embargo el control oportuno del fuego permitió proteger los habitats naturales de las tortugas (los galápagos) asegurando que ninguno de estos animales muriera.

5) El ecosistema de la Isla Isabela está condicionado a la presencia periódica de fuegos. Este hecho se infiere debido a que los principales representantes de la flora endémica tienen la capacidad de retoñar, especialmente el helecho arborescente *Cyathea weatherbyana*. Otros factores que apoyaron esta conclusión fueron: una elevada cantidad de carbón enterrado en suelos no afectado por el fuego, y los insectos que han coevolucionado con especies de árboles nativas y endémicas muestran una tendencia a colonizar estas especies de árboles dañados por el fuego en vez de especies introducidas.

INTRODUCTION

Several fires on the island of Isabela, the largest of the Galapagos Islands, attracted international attention from March through May, 1985, especially among people and organizations involved in environmental concerns. Rumors flew about destruction of habitat, loss of wildlife and even helicopter airlifts of the giant land tortoises. In actual fact, though the main fire was large by any standard, and at one time did threaten two colonies of tortoises, it caused little economic damage or harm to endemic wildlife. Accordingly, our aim is to review the Isabela fire and analyze possible environmental impacts of the event.

Background

The outbreak of the fires was preceded by an eight-month drought in which no rain had fallen anywhere in Galapagos. Compounding the drought conditions was a buildup of fuel caused previously by the El Niño shift. The first fire on Isabela Island started on February 28, 1985, in the Santo Tomás agricultural area; a second fire was detected on March 3 in Galapagos National Park land (Fig. 1). Local people were conscripted to fight the first fire from March 1 to March 5. The second fire burned unchecked in the fern-sedge zone found on the upper flanks of the Sierra Negra volcano.

On Monday evening, March 4, a timely rain fell, and while it did not extinguish either fire, it slowed their progress. It was clear that if mop-up operations were not executed immediately the fires would take off again. The remaining hot spots should have been immediately extinguished, but this was not done as the Isabela residents believed the danger was over. It was not. By March 8, the beneficial effects of the rain were offset by resumption of low humidities, in-

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creasing temperatures and return of steady winds. The long-standing drought was thus renewed and, with the winds picking up, a fire-front approximately 8 km long spread out along the southeastern and southern flanks of the Sierra Negra volcano. Similarly, a dozen renewed spot fires blazed fiercely in the agricultural area

On March 12, an Ecuadorian forester with fire training and AID's technical advisor in forest protection overflew the fire and noted that it was out of control. They returned to Quito and prepared a list of required tools and supplies, as well as a plan for a cooperative fire suppression effort between the Ecuadorian Forest Service (DINAF) and Ecuadorian military personnel. On March 14 the first contingent of fire fighters, including three DINAF foresters who were trained in fire suppression activities in the U.S., and a detachment of Ecuadorian special forces were dispatched to Galapagos.

The fundamental strategy, usually observed in any fire, was to first contain the fires and thus prevent their spread ("control"), and second, to systematically extinguish all hot spots ("mop-up"). The control phase was to be accomplished principally by construction of tractor lines around the fires; on an emergency basis, or in difficult terrain, construction of fire lines with hand tools also was anticipated.

Suppression activities in the National Park can be divided into three activity periods:

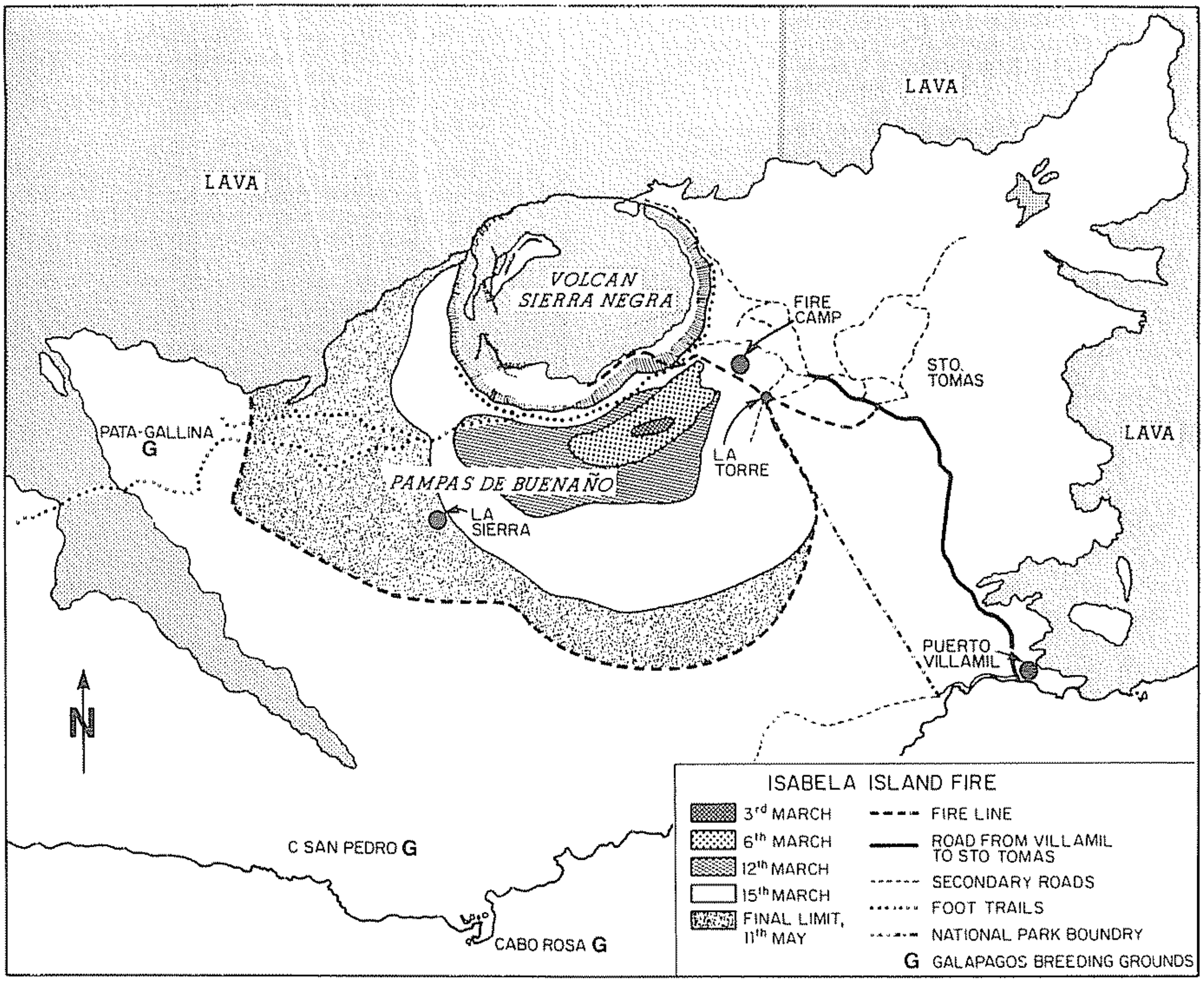

Fig 1 A section of southern Isabela Island, the largest of the Galápagos Islands, and a approximate history of the Galápagos National Park fire that began in March and was controlled on 11 May 1985

1. **14-20 March.** During this phase of the operation a base camp was established about four km south from the end of the road that climbed the southeastern flank of the Sierra Negra volcano. A tractor line, already begun by Park Service personnel, was containing the northeastern corner of the fire. This line was continued in its predominantly northeasterly direction until it merged with the principal north-south road from Puerto Villamil to the Volcano. In this manner, this fire break plus the road became a safety line that protected the agricultural and populated zone of the island (see Fig. 1). The tractor was then brought back to a point called "La Torre" and there joined battle directly with the fire again. The tractor pushed the line in a southerly direction by working along the edge of the fire ("direct attack") followed by personnel with shovels, backpack pumps, McLeods, and Pulaskis (specialized fire fighting tools sent by the U.S. Forest Service). These fire fighters worked on a 24-hour basis to prevent fires from crossing the tractor line. On occasions, however, the wind would briefly change its predominant southeast-northwest direction, and fires would jump across the fire line. This would result in sudden evacuation of personnel and equipment to safety areas constructed at intervals along the tractor line. Then the tractor and personnel would abandon the original line and construct new lines around the spot fires. Once the work routine between fire fighters and tractor operators was established, steps were taken to burn out fuels between the tractor line and the main fire. In practice, this action significantly reduced the amount of fuel available to the advancing fire; thus the occurrence of spot fires across the fire lines virtually disappeared. By 20 March the fire line had prevented any further easterly extension of the fire; the tractors had turned in a southwesterly direction and were rapidly cutting off the south flank of the fire (Fig. 1).

Another significant event took place in the vicinity of the Sierra Negra volcano and within the crater itself. A separate fire that extended southward from the volcano crater burned rapidly eastward, threatening to bypass the original fire line and the road, neither of which reached the volcano's rim. If this were to happen, the fire then would spread eastward into the agricultural area of Santo Tomás. At the same time, the vegetation within the crater caught fire and burned along the inner rim of the crater in an easterly direction; this fire also threatened to climb back up over the crater's rim and descend into Santo Tomás. With hand tools, and on a 24-hour basis, crews composed of military and Park Service personnel, together with a U.S. Peace Corps volunteer, built several kilometers of fire line around these blazes and stopped the advance of the fire. Working within the crater was particularly hazardous, as the fire fighters had to descend almost vertical slopes and build fire lines down these inclines —an extremely dangerous situation with the fire nearby.

2. **23 March.** On this date, Admiral Santiago Coral, Chief of the Ecuadorian Joint Chiefs of Staff, called a meeting of key fire suppression personnel aboard the Ecuadorian naval ship Hualcopo. This meeting represented the major turning point in control and mop-up of the Isabela fire. During this meeting, DINAF's forester in charge of the fire presented a fire status report, a subsequent action plan prepared by his civilian and military staff, and a list of needs.

The plan outlined the following basic strategy:

a. Building a tractor line along the southern flank of the fire as rapidly as possible in order to protect the coastal Galapagos tortoise habitas (*galapagueros*) of Cabo Rosa and San Pedro (Fig. 1);

b. tying this line into a north-south lava flow about 10 km west of the southwestern corner of the fire —an action to completely protect the *galapagueros* and;

c. building the tractor line along the western flank of the fire that would tie into the northern lave field (Fig. 1) —an action that would enclose and thus control the fire completely.

Efficient and timely completion of this plan would require additional tractors, better communication equipment and helicopters. After a brief discussion of this plan and other logistical matters, Adm. Coral accepted the strategy and promised the equipment needed within two to four days. In addition, he ordered the recently arrived Ecuadorian Army Corps of Engineers detachment to the fire. These personnel, together with all equipment requested, arrived at the fire within the four-day period.

3. **24 March-11 May.** During this period the engineers essentially took over fire control activities as outlined in the basic strategy. Despite personal hardships and difficult logistical problems (e.g., it took a supply truck 7 hours to drive from Puerto Villamil 15 km to the army camp), they efficiently and relentlessly finished constructing the tractor line along the southern boundary of the fire. At that point they were to continue the tractor line in a westerly direction in order to merge with the lava flow (Fig. 1). At the same time they were to construct a northwesterly line that eventually would turn north and thus enclose the entire National Park fire. They only completed the last project. Having accomplished this goal, they left the island together with all their equipment

on May 11. Although the fire was not controlled, extinguishing it was left to the return of wet weather.

The Santo Tomás fire in the agricultural area included many small fires ranging in size from 1-25 ha. Eventually fire lines were constructed around these fires and mop-up procedures began in earnest with assistance from a U.S. Forest Service advisor who arrived in late March. However, he was later transferred to the National Park fire, and many of the Santo Tomás fires were never liquidated.

In June the Charles Darwin Research Station sponsored a field trip to assess the environmental consequences of the fire. On that trip, between 12-23 June, the fires of Isabela were still burning, though under control. It is true that the spectacular burning fronts that had stretched for some 20 km along the southern and westerns edges were gone. However, isolated fires in the central part of the burn (the area of "Pampas del Buen Año") smoldered in organic material of the soils' A horizon. These latent fires were not evident during the early morning and late afternoon fogs, but when mid-day skies cleared, relative humidities dropped and winds increased, smoke from these fires became evident and localized blazes emerged.

As expected, spot fires also were noted in the Santo Tomás agricultural zone. These fires were isolated events and they were burning in buried organic material; they continued to smolder even though there were drizzles and occasional heavy rains. As it happened, heavy rains did begin all over the island during the first week of July, and by July 12 there were no fires left on the island.

Impacts

The INGALA* representative of Puerto Villamil conducted a damage survey of Santo Tomás which showed that about 262 ha were burned, of which 197 ha were brushlands, 37 ha of grassland, 19 ha of coffee and 9 ha of bananas. The burned area represented about 4% of the total agriculture area (some 6,450 ha). The greatest financial loss was attributed to lost fences (wire, posts, staples, etc.) as some 18 130 m were damaged by either the fire **per se** or fire fighting activities.

Satellite images showed that about 14 500 ha of National Park lands burned. However, within this area there are many unburned areas (islands) that range in size from a few ha to over 200 ha. While forests on the southern flank of the fire have few such islands, forests of the western flank have many. Large quantities of unburned fuels remain.

The National Park fire started on the upper slopes of the Sierra Negra volcano, about 7 km east of the "Pampas del Buen Año". The fire quickly charged uphill and westward in response to topographic profile, light fuels, and easterly winds. Once these fuels were consumed, the fire slowly but inexorably moved down slope (termed a "backing fire") and also expanded westward into very inaccessible areas. This backing fire on the eastern and southern flanks of the volcano systematically consumed light and regular surface fuels* as well as organic matter within the soil. However, there were seldom sufficient concentrations of medium and heavy fuels that, when ignited, would have provided energy for severe convection columns that could have carried sparks aloft or that could have ignited the aerial fuels (Table 1, "La Torre" area). For this reason, few tree crowns burned when the fire backed into the jaboncillo (*Sapindus saponaria*), *Trema micanthra*, and pega-pega (*Pisonia floribunda*) forests; when isolated crowns did burn, they lacked fuel continuity to spread.

In contrast to the fire's eastern and southern flanks, the fire on the western flank burned with the wind and quickly blazed down the western slopes of the volcano and into the guayabo (*Psidium guajava*), guayabillo (*P. galapageium*), pega-pega, lechosa (*Scalesia cordata*) and espino (*Zanthoxylum fagara*) forests of the dry plains west of "La Sierra". The fire of this area was wind-driven and spot fires were common as medium and heavy fuels burned along the way; as a result, the heat killed many trees. The greater fire intensity of the western flank is demonstrated by the extreme reduction of medium and heavy fuels in this area after the burn (Table 1); these two fuel classes profoundly influence fire intensity.

Because of sub-surface fuel consumption on the eastern and southern fronts, the roots of practically all trees of these areas were killed or severely wounded (the "La Torre" area of Table 1). For this reason it was difficult to find trees with surviving stems and crowns. In fact, not a single guayabo without a dead top was found in any of the line transects, but about 5% of the jaboncillos apparently were undamaged, 2% of the pega-pega, and less than 1% of the *Trema*. On the other hand, as the western

* Instituto Nacional Galápagos; the governmental entity that manages the financial, agricultural, developmental and technical aspects of the Galapagos islands.

* Fuels are classified as light, regular, medium, and heavy; light = 5 mm in diameter (grass, fern stems, leaves, etc.); regular = 5-25 mm (twigs, small stems, mostly brush and the like); medium = 25-75 mm (branches); heavy = greater than 75 mm (trunks, stumps, large branches, logs, etc.).

Table 1. A comparison between unburned and burned transects* in two forested areas of Isabela Island: one site, a "La Torre" was guayabo-fern type, the other site, "La Sierra" was guayabillo-lechoso-espino type.

Transect	Site	Fuel Quantity per Class (pieces/transect)			
		Light	Regular	Medium	Heavy
Unburned	"La Torre"	2 282	2 202	32	109
	"La Sierra"	1 210	710	195	401
Burned and	"La Torre"	604	330	28	99
Identifiable	"La Sierra"	218	126	39	215

* Fuels were sampled in unburned transects on the side of the fire line away from the fire, and in burned transects on the other side of the line. Fuel quantities were calculated from data collected from eight 201.2 m x 20.2 m transects on 16 June 1985 in "La Torre" and 20 June 1985 in "La Sierra."

flank of the fire consisted of a myriad of spot fires, only trees within these spots had dead stems and crowns.

Although the existing guayabo trees in the burn were seemingly dead, it appears that guayabo will recover its former sites quickly, as the species is a prolific stem, root crown and lateral root sprouter. Guayabos top-killed during a June 1984 fire near the "La Sierra" area already had resprouted and, moreover, doubled their basal area through root sprouting. Stem sprouts were also noted among the guayabillos, pega-pega, aguacates, jaboncillos, espinos, and *Trema*.

In the short time since the fire took place, the dead and heavily damaged trees already were infested by ambrosia beetles (*Platypus*-like and *Xyleborus*-like scolytids). The most heavily infested trees were the jaboncillos, followed by guayabillo, pega-pega and *Trema*. The least attacked species were aguacate and guayabo. Although several endemic cerambycid species have been reported from Isabela, only a single larva was discovered.

From experience with a previous fire on the island of Santa Cruz, Dr. Tjitte De Vries (personal communication 1985) feels that the burned areas will be rapidly colonized by pioneering herbs, sedges, grasses and ferns. He found that the most conspicuous pioneers were *Pteridium aquilinum*, *Equisetum* sp., *Commelina* sp., and *Oxalis* sp.; within 18 months most of the affected areas should be revegetated. However, it may be more than 10-15 years before successional dynamics serve to reestablish preburn floral associations. In contrast, the forested areas will need 20-100 years before mature trees, especially the ubiquitous and endemic guayabillo, repopulate the burned areas.

The A soil horizons were destroyed over large areas where the fire systematically burned down the slopes of Sierra Negra volcano. In doing so, most of the organic material that held the soil particles together was consumed. The residual material thus was loose and often water-soaked as the porous tephra absorbed moisture. Most likely, redevelopment of the A horizons will parallel plant succession dynamics.

Overall, we suspect that the Isabela Island range and forest ecosystem is one conditioned by periodic fires. Support of this notion would be as follow:

1. The principal endemic flora are resprouters.

2. The highly endemic tree ferns (*Cyathea weatherbyana*), although severely burned and blackened, generally survived the fire; new fiddles were rapidly deploying beneath charred meristematic zones.

3. There was a substantial amount of buried charcoal fragments beneath clumps of unburned vegetation.

4. Immediately after trees endemic to Isabela or to the Galapagos Islands were charred, ambrosia beetles (Scolytidae) located and attacked these trees; exotic trees, such as guayabo and aguacate, were only slightly colonized by scolytids. These observations point to the tight ecological fit between the scolytids and their fire-damaged native hosts.

Reseña de libros

SHKOLNIK, M. YA. 1984. Trace Elements in Plants (Development in Crop Science (6) Elsevier, Amsterdam. 463 p.

Pocas áreas de la fisiologia vegetal han avanzado tanto en los últimos años como la del papel de los elementos menores en los procesos metabólicos de las plantas, especificamente en el estudio de las enzimas

Nadie mejor que M. YA. SHKOLNIK para escribir una revisión sobre este tema. El autor es del Komarov Botanical Institute, de la Academia de Ciencias de la USSR, Leningrado. Hace treinta años escribió una monografía sobre el papel de los elementos menores en la vida de las plantas y la agricultura. A ese trabajo se suman varias decenas de otras publicaciones sobre el mismo tema. Adicionalmente y debido a la nacionalidad del autor, este libro informa sobre muchos de los descubrimientos de investigadores rusos y soviéticos, poco conocidos en occidente.

Otra característica importante del libro es que no solo cubre el papel de los elementos menores en la fisiologia de las plantas, sino que también se hace énfasis en los aspectos botánicos de los elementos menores. Así contiene capitulos sobre el rol de los elementos menores en la taxonomia, la fitocenologia, la anatomia y la organización estructural de las células vegetales, la embiologia y la genética. También trata los elementos menores en relación con la evolución del metabolismo de las plantas en la biosfera y la ecologia geoquimica

En cuanto al rol netamente fisiológico se tocan las enzimas con activadores metálicos y también los aspectos a nivel de biologia molecular. Esto incluye los mecanismos de transferencia genética y energética, el control del metabolismo, la estructura y la función de los nitocondrios, cloroplastos, ribosomas y membranas celulares.

El libro está escrito en inglés y está documentado con una lista muy extensa de citas bibliográficas, las cuales cubren literatura de todas partes del mundo, haciendo en esta forma una de las revisiones más completas que puedan tenerse.

Es una lástima que no cuente con un buen índice de materias que podría haber ampliado muchísimo su uso y su utilidad

Aunque tiene varias ilustraciones, gráficas y tablas no es muy rico en este sentido, pero tiene suficientes figuras para cumplir los propósitos ilustrativos del texto. Las fotografias tienen poca nitidez.

El libro forma parte de las serie Desarrollos en la Ciencia de los Cultivos (Developments in Crop Science) de la cual es el número seis. Lo edita y distribuye Elsevier Science Publishers Co., Inc., P.O. Box 1663, Grand Central Station, New York, NY 10165, USA.

Resumiéndolo, se trata de una excelente revisión que pone al lector al día en los últimos avances logrados y el estado del conocimiento del papel de los elementos menores en la vida de las plantas. Constituye un valioso aporte y un instrumento indispensable para expertos e investigadores en agronomía, horticultura, ecologia, biologia y ciencias ambientales.

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