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# Coral Reefs: Volcanic Impacts

## ECOLOGICAL IMPACTS OF THE MONTSERRAT VOLCANO: A PICTORIAL ACCOUNT OF ITS EFFECTS ON LAND AND SEA LIFE

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As biologists, our work in Montserrat has led us to explore not only the marine environment but also the unspoiled terrestrial habitats. These include the coastal mangroves, semi-desert vegetation in the north, and especially the cloud forest currently affected by volcanic impacts. When we first visited Montserrat in late 1994, Chances Peak had some of the finest cloud forest in the Caribbean region *(image 1)*.

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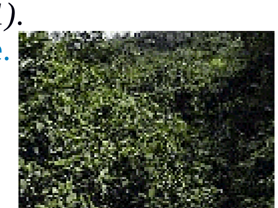

Cloud forest on South Soufriere Hills prior to volcanic activity

On one of our first visits we hiked the mountain to see the stunning cloud forest at the summit. At that time, Chances Peak cloud forest harbored a high diversity of plant life, including a rich display of tree ferns. and insects, lizards, birds, and bats. On our very first hike, we saw the famed and endemic Montserrat oriole perched on a tree about halfway up the mountain. On that same hike, Heliconia was abundant, and the beautiful black and yellow *Heliconius* butterflies guided our path through the mid-elevations *(image 2)*.

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By January 1996, our helicopter and hiking surveys of the volcano and coastline indicated that vegetation loss from acid rain, gases, heat, and dust on the top of Chances Peak and surrounding area was severe *(images 3 - left, and 4 - right)*.

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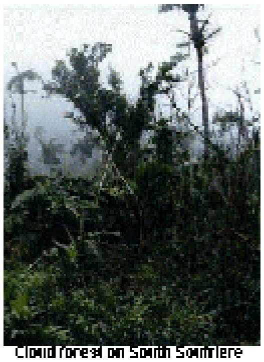

Cloud forest on South Soufriere Hills (Chances Peak) prior to volcanic activity

[illegible]

The cloud forest had disappeared. Tree ferns were dead, and the *Heliconius* butterflies had all but disappeared from the crater area. Vegetation was gradually dying further down the mountain, and during the next few months of 1996 we watched much of the mountainous vegetation in the Gages valley area turn brown and die. This pattern has continued. On the east side, the lush forests of the Tar River Valley were degraded from ash and gases, and finally destroyed by pyroclastic flows *(images 5 - left, 6 - center, and 7 - right)*.
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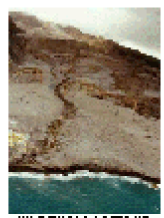

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One of the factors leading to vegetation death is acid rain, from volcanic sulfur. We are frequently asked about acid rain, and below we have included a brief explanation of the phenomenon and how it affects Montserrat's terrestrial life.
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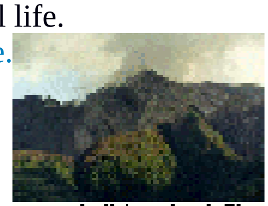

[illegible]

Volcanoes emit sulfurous gases, most of us know that from the characteristic smell, (*image 8, above*). In nature, sulfur is released into the atmosphere in three ways, through the formation of sea-spray aerosols, anaerobic respiration by bacteria--e.g. in tidal marshes, and by volcanoes. More recently combustion of fossil fuels has greatly increased the amount of sulfur in the atmosphere, with major consequences for northern forests and lakes. On a global scale the amount sulfur from active volcanoes is minor compared to other sources. On a local scale the impacts from volcanic sulfur emissions have important consequences for plant and animal life. Acid rain is formed when hydrogen sulfide and sulfur dioxide in the atmosphere undergo a complex set of chemical reactions, and eventually combine with water to produce sulfuric acid. It is these acid droplets that are known as acid rain, and they damage plant and animal life. Acid rain affects plants directly by breaking down lipids in the foliage, and by damaging membranes which can lead to plant death. Indirectly acid rain increases leaching of some nutrients and renders other nutrients unavailable for uptake by plants. Vegetation damaged by acid rain shows the characteristic browning that we have observed in Montserrat (*image 9*).

Click on these thumbnail images to see full size image.

The effect of acid rain on terrestrial and aquatic environments is determined by the acidity of the precipitation and by the geology of the soils and rocks of the area. Different types of soils and rocks have different abilities to neutralize or buffer the acid. Certain types of soils and their associated water ecosystems are particularly sensitive to acid rain because of their low buffering abilities. In general volcanic rocks, and thin topsoils have poor buffering abilities.

Acidity is measured on the pH scale. A pH value of 7.0 is neutral, and anything less than 7.0 is acidic. (The lower the number the more concentrated the acid). The pH scale is logarithmic, which means that the difference between a pH of 6 and a pH of 5 is a ten-fold difference. The ecosystem of a lake is severely affected when the pH falls below 5.0. At this level, fish, invertebrates, and plankton die. In January 1996 we measured the pH of the lake at the top of Chances Peak (where the mermaid with the golden comb resides) at 2.0 (i.e. 1,000 times more acidic than a pH of 5.0) (*image 10*).

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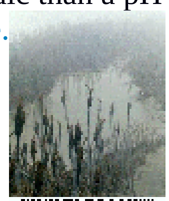

Lakes and streams near Farrells measured about 1.5 at the same time (i.e. approximately 5000 time more acidic than a pH of 5.0). We do not know if there are any important biological consequences of these low pH values for the area. However, the streams and lakes away from the crater area are highly unlikely to be affected by acid rain, as they are too distant.

In contrast to our first hikes up Chances Peak, by early 1996 we recorded almost no animal life close to the summit of the volcano, with one notable exception. To our surprise, we found hummingbirds flying within 300m of Chances Peak. The birds that we saw were settling territory disputes. Hummingbirds feed on nectar, and will defend food territories. We cannot imagine what food resources are left to defend, because most of the plant life is dead.

We have been making regular trips to monitor the Bamboo forest, home of the Montserrat oriole. To date, the forest is still in existence, but the plant life is frequently covered in ash (*image 11, below left*). The close proximity of the volcano to the bamboo forest (*image 12, below right*) means that a major collapse of the Galways Wall is likely to result in ash clouds that will severely damage the bamboo forest ecosystem including the associated animal life including the Montserrat Oriole.

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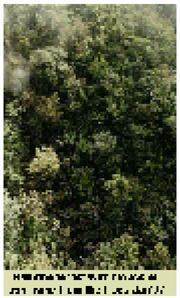

**How long will it take the cloud forest to recover?**

Nature is resilient and natural disturbances are part of the life cycle of all ecosystems. Today, even in the most impacted zones, small green shoots continue to sprout, but these do not survive. Continued volcanic activity and erosion prevent reforestation. Sustained recovery will not take place until volcanic activity greatly reduces or stops. Once this happens, a natural recovery process called succession will begin to take place. Recovery of the forest will start in two ways, seeds in the seed bank will start to germinate, and new seeds will blow in from surrounding areas. The rate of recovery will depend, in part, on the availability of seeds which in turn depends on the proximity of other forest species, and the availability of animals (e.g. birds) to disperse seeds. Presently there is cloud forest in the Center Hills and this may act as a source of new seeds for South Soufriere Hills. The recovery process follows a successional pathway, whereby early species (called pioneers) colonize the soil and make it suitable for other forest species. Early pioneer species must be able to tolerate high light intensities and high temperatures (because there is no longer any forest to provide shade). They must also be good dispersers, and able to arrive at a new site. Seed dispersal by bats and birds is very important in the recovery of tropical forests. Species such as *Cecropia* are early pioneers, they are light tolerant, and their seeds are dispersed by a variety birds and bats-- 76 species of birds feed on *Cecropia*. Other pioneer species have seeds that are long-lived in the soil, and that can survive a wide variety of soil environments. High light levels, and high temperatures often stimulate the germination of these seeds. (e.g. *Heliocarpus*). *Heliconia*, (the name means sun-loving) and some palm species will colonize large disturbed areas. Once these pioneer species have established, their shade often prevents other members of the same species from germinating and surviving. Thus new shade tolerant species can now establish, e.g. the understory palm *Crysophilia*, and many arid plants (these are the plants that do well in dim light and high moisture such as swiss cheese plants *Monstera*, *(see image 9, above) Philodentron* and wild tobacco) and trees. Thus the forest begins to increase in diversity. Tropical forests tend to recover faster than their temperate counterparts. Studies in Puerto Rico showed that some forests recover from hurricane destruction in about 40 years. However full recovery of a large landscape that had been completely denuded of forest species i s likely take considerably longer.

Because of the total loss in vegetation near the crater summit, erosion has become a severe problem, and with each rain storm more soil is lost from the mountainsides. The soil and any debris accumulated along the way, flows into the ghauts and eventually to the ocean. Vegetation on all sides of the volcano (e.g. north of Gages Wall) has been lost, and as a result a range of watersheds are indirectly impacted by the volcano through increased runoff, e.g. Belham river valley. We have observed plumes of sediment entering the ocean at Tar River, White River, Gingoes, New Beach, Fort Ghaut. These plumes are often severe and dramatic. In January and February, 1996, sediment load was heavy at Whites River, and each liter of water entering the ocean at contained from 130g to 150g dry weight of sediment. Water flowed into the ocean at a rate of 1.5m/sec (*image 13*).

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Generally the sediment settled out of the water column within 300 m from shore. However, on occasions the plume entering Fort Ghaut extended as far as Bransby Point. The sediment entering through Belham river flows south over the reefs off Garibaldi Bluff. The north side of the island had no sediment input. This is an arid, semi-desert area that is unaffected by the volcano. Visual analysis of the sediments indicated that sediment on the reefs and substrate from Garibaldi Bluff to Radio Antilles was mainly a fine grain sediment of terrigenous origin, and similar to soil sediment. However, it was not possible to determine the age of the sediment or how long it had been in the ocean. By contrast the sediment from the more northern areas (Rendezvous Bay) was composed of coarse sand grains and showed little terrigenous influence.

## VOLCANIC IMPACTS ON THE CORAL REEFS

The volcano is affecting the coral reefs between the east and southwest of the island. At the most extreme, we have observed reefs being buried by sediment and ash loads. On other reefs, we have documented sedimentation (*image 14, below left*), coral bleaching, increased disease, and the disintegration of large sponges. During recent data collection at Garibaldi Bluff (*image 15, photoquadrat sampling, below right*), all of the giant sponges (*Xestospongia*) were covered in sediment, some up to 1cm deep.

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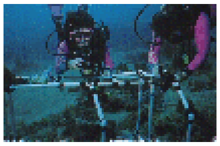

All of the sponges had bleached white spots which were beginning to disintegrate. Between February and April 1996 six individual sponges severely disintegrated. By comparison, at sites unaffected by the volcano e.g., Rendezvous Bay, none of the sponges showed signs of bleaching or disintegration. Shortly after a series of large ash plumes fell on Garibaldi Reef, we observed that, over parts of the reefs, large areas (approx. 5m x5m) were covered in a sediment, and that a thin algal film (probably *Wranglia*) was growing on the sediment and trapping it in place. The marine life under the sediment had already started to bleach and disintegrate. Further, visual observations of the alga *Dictyota* at the same time showed that many specimens were tattered compared to *Dictyota* specimens at Rendezvous Bay. At Garibaldi Bluff in February 1996, 64% of all *Agaricia* (a plate coral) coral colonies were bleached ( N=50). Visual examination of *Meandrina* colonies indicated that 40% of colonies were overgrown by algae (s.e. =29.72 N=20). We did not find any evidence of disease (black band or white band) on any of the colonies at Garibaldi Bluff.

## UPDATE

We are continuing monitoring the impacts of volcanic activity on the reefs. In February 1997 we recorded increased degradation of the reefs in the south of the island. We have, for the first time, recorded diseased corals at Garibaldi. We will update the impacts on this page as information continues to become available.

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