The Greening of Green Mountain, Ascension Island.

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1. Introduction

For over three hundred years after its discovery in 1501, Ascension Island, in the middle of the Atlantic Ocean, remained arid and barren with little greenery. But in the nineteenth century, people settled on this remote spot. They soon began an experiment that created a luxuriant mosaic of temperate and tropical vegetation on the island's highest peak, Green Mountain, which rises some 859 m (2817 feet) above sea level. Today, this artificial ecosystem towers above dry lowlands that are the enduring reminders of Ascension's pre-settlement past. The man who formulated the plan to turn one of the most desolate islands in the world into a lush landscape was Sir Joseph Hooker, Charles Darwin's closest friend and the premier botanist of the Victorian era. So, how did such a transformation come about?

Ascension Island is very geographically isolated. Its tiny landmass (**Fig. 1**), about thirteen and a half kilometers long by eight wide, lies just south of the equator (7°57'S, 14°22'W), 2200 km to the east of Brazil and 3200 km west of Angola. The island of St. Helena sits some 1200 km to the southeast.

Ascension was originally uninhabited and considered by early sailors to be little more than an inhospitable heap of cinder cones. The remarks of Peter Mundy, a Cornish merchant who passed Ascension in 1634, are fairly typical: "there is not so much as fresh water upon it, very bare, and nothing to be had there"[1]. Eventually, mariners realized that Ascension was a nesting site for green turtles, which became a regular source of food for travelers on their way to the East Indies in the 1700s and 1800s. Today, much of the coastal landscape remains barren and covered in rubbly lava flows (**Fig.2**). Traversing volcanic fragments, or clinker, is like walking on broken porcelain. For early visitors, who were used to greener landscapes, Ascension's clinker, volcanic ash, and reddish hues must have seemed like another planet. Indeed, some have compared Ascension's surface to Mars. Despite the surrounding ocean, most of the island, under a relentless tropical sun, is a parched desert.

Fig. 1. Map of Ascension Island: drawing will be supplied by editors.

Fig. 2: Parts of Ascension Island are as barren today as they appeared to the first explorers. This view is towards South East Bay and Letterbox peninsula. In the foreground are jagged, so-called "a'a" lavas (Photo: DCC).

The starkness of Ascension results from its young geologic age and sparse rainfall. The island emerged from the ocean one million years ago and represents the tip of an undersea volcano growing on a hot spot on the western flank of the mid-Atlantic ridge[2]. Some pristine, unweathered lavas suggest that volcanism may have occurred within the last 1000 years[3]. Because of the young geologic age, few plants or animals have had time to arrive on wind or ocean currents and evolve into new species. When sailors first visited, the only obvious traces of greenery were grass and small ferns on the windward side of Green Mountain, where a little moisture was gathered. In pre-human times, the total number of plants was probably around 25 to 30, of which ten were endemic[a]: two grasses, two shrubs, and six ferns[4]. Today's verdant foliage on Green Mountain of 200-300 species is overwhelmingly artificial[5].

The arrival of people altered the landscape in planned and unplanned ways. Portuguese discoverers of Ascension Island introduced goats that ran wild, fed off the scant vegetation, and victualed their ships. But even bigger changes came after the British settled in 1815. In that year, Napoleon Bonaparte was imprisoned on St. Helena after his defeat at Waterloo. Given Napoleon's previous escape from the Mediterranean island of Elba, the British thought it prudent to establish a garrison on Ascension in case friends of Napoleon tried to stage his comeback. A permanent settlement meant solving the problem of a lack of drinking water and fresh vegetables.

2. The greening of the mountain

[a] *Native species* are those that were not introduced by humans. *Indigenous* species are native species that can be found elsewhere in the world, whereas *endemic* species are native species found only in a specific location, such as Ascension Island.

Fig. 3. Breakneck Valley, where William Dampier discovered a spring in 1701. At that time, the valley would have been treeless with little vegetation. The concrete catchment in the upper right was built in the late nineteenth century to collect rainwater. It was the island's main water supply until the 1960s. (Photo: DCC)

Before Ascension was settled, various travelers described a land largely devoid of vegetation. But Green Mountain was never a blank canvas. On a repeat visit in 1656, Peter Mundy noted that "the tops of the high mountains in the middle appeared somewhat green, there being a kind of rushes and spicy [spiky] grass"[1]. Then, in a limited survey in 1698, James Cuninghame described five plant species[6].

Freshwater was also discovered. In 1701, HMS *Roebuck* sank in Clarence Bay[7]. The captain was the circumnavigator and privateer, William Dampier. According to contemporary accounts, the shipwrecked crew found a spring by following goats up Green Mountain[8]. 'Dampier's Drip' is the name given to a spring on the northeast side of Green Mountain, but in error. Dampier described "continual fogs" near his spring, and he alluded to an area facing southeast. Mist is typical in Breakneck Valley (**Fig. 3**), which has a spring and a side facing into the southeasterly winds. So Breakneck is believed to be Dampier's actual spring location. In the nineteenth century, along with new greenery that was added, a concrete water catchment was built there (**Fig. 3**).

A Swedish clergyman, Peter Osbeck, who visited in 1752, complained that Ascension "would be more tolerable if there were only some trees"[9]—the idea that later galvanized Hooker. Osbeck reported scrawny goats feeding on endemic Ascension Spurge and he identified the same plants as Cuninghame. Later, in 1775, Georg Forster, on Captain Cook's *Resolution* saw goats eating purslane, ferns and grass on Green Mountain. Forster was the first person to suggest reshaping the landscape[10]: "I am almost persuaded that with a little trouble, Ascension might shortly be made fit for the residence of men. The introduction of furze…and other plants which thrive best in a parched soil, and are not likely to be attacked by rats or goats,

would soon have the same effect as at St. Helena. The moisture attracted from the atmosphere by the high mountains…would then no longer be evaporated by the violent action of the sun, but collect into rivulets, and gradually supply the whole island…grasses would everywhere cover the surface of the ground, and annually increase the stratum of mould, till it could be planted with more useful vegetables."

Fig. 4. UPPER: A drawing published in 1835 by Capt. Henry Brandreth entitled "From Mountain Road", showing cinder cones on barren plains beneath Green Mountain[11]. LOWER: A photo from a similar altitude in 2012 showing vegetation on the mountain itself and on the plains below. (Photo: DCC).

The British marines that arrived in 1815 established a garden on Green Mountain using imported plants on a plateau of cultivable soil at about 600 meters (2000 feet) altitude. Above this height, there was only a thin veneer of soil sitting on lava or pumice. However, from 1817, Green Mountain Farm spread from the garden and was able to supply the island's population with fruit and vegetables.

Darwin admired "the active industry" on Green Mountain when he visited in 1836, where "the English nation would have thought of making the island of Ascension a productive spot"[12]. But he also lamented that the island was "destitute of trees". At the time, there was a pervasive view, supported by Darwin, that 'unproductive' land in the British empire should be transformed to support people[13].

Not long after Darwin's visit, Joseph Hooker instigated such a wholesale alteration of Green Mountain at the invitation of the British Admiralty. Hooker was well versed with Darwin's journal, having slept with the journal proofs under his pillow before his own travels[14]. After Hooker went to Ascension in 1843, he, like Darwin, was struck by the difference with St. Helena, where the governor, Alexander Beatson, promoted reforestation. Hooker's advice to the navy involved a four-point strategy: establishing trees on Green Mountain to increase rainfall, clothing steep slopes with vegetation to protect soil, planting dry-adapted shrubs in lowlands, and introducing a wide variety of crops[15]. From 1847 through 1850, Kew Gardens dispatched 330 plants to Ascension, "mostly trees and shrubs calculated to bear exposure to the sea-breezes and the most powerful winds, and the success of these has been beyond all expectation, affording shelter and protection where none could have been obtained before"[16]. Further consignments of seeds and plants from London and the Botanic Gardens at Cape Town continued in the following decades. In fact, about 5000 trees were planted in the 1860s-1870s[15].

The effect was striking. When Joseph Hooker visited, there was only one tree on Ascension[17]. Then, by 1865, "there were thickets of upwards of forty kinds of trees, besides numerous shrubs and fruit-trees"[17]. However, many exotics, such as orange trees, failed in the long run, and only the fit survived, leaving a potpourri of plants from all over the world[18] (**Fig. 4**).

The extent to which the new vegetation caused an increase in rainfall can't be quantified because we lack suitable 'before and after' rainfall records. But curiously, there are anecdotal reports of greater precipitation before Hooker's scheme, when cultivation first began. Caroline Power, who visited in 1834, reported, "in the last three years a considerable change in the climate has been perceived. For months together, I have been told by several who have been resident from 3 to 7 years, as well as by Captain Bate[b], not a cloud would pass over the heavens, nor a drop of water fall; but since the land on the mountain has been so much cultivated, a gradual increase of rain has taken place—seldom more than a day passes over now without a shower or mist on the mountain; and during the first ten days we were here constant little showers fell"[11]. Despite uncertainty about long-term rainfall trends, today's vegetation above 600 m clearly prevents direct run-off of moisture on wet days.

The modern flora of Green Mountain can be divided into three zones[4,15] (**Fig. 5**). A dry zone below 330 m has patches of grass, dry-adapted shrubs, and small thorny mesquite or tree tobacco (*Nicotiana*). From 330-630 m, there is more complete coverage including grasses, prickly pear, and trees such as juniper, she-oak (*Causarina*), and acacia. Above, 660 m, a mist zone is completely vegetated, including areas of dense trees and bushes, interspersed with some grassy slopes. The variety of plants includes banana, ginger, juniper, raspberry, coffee, ferns, fig trees, Cape Yews, and Norfolk Island pines. At the summit, there is the only open body of freshwater on Ascension, the Dew Pond, replete with blue water lilies (**Fig. 6**). Sheltered by tall bamboo, the Dew Pond is remarkably still, wet and cool–seemingly a world away from the oppressive heat of the lowlands.

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[b]William Bate was the commandant on the island from 1828 until his death from flu in 1838. It was Bates who named the main settlement Georgetown in 1829 after King George IV.

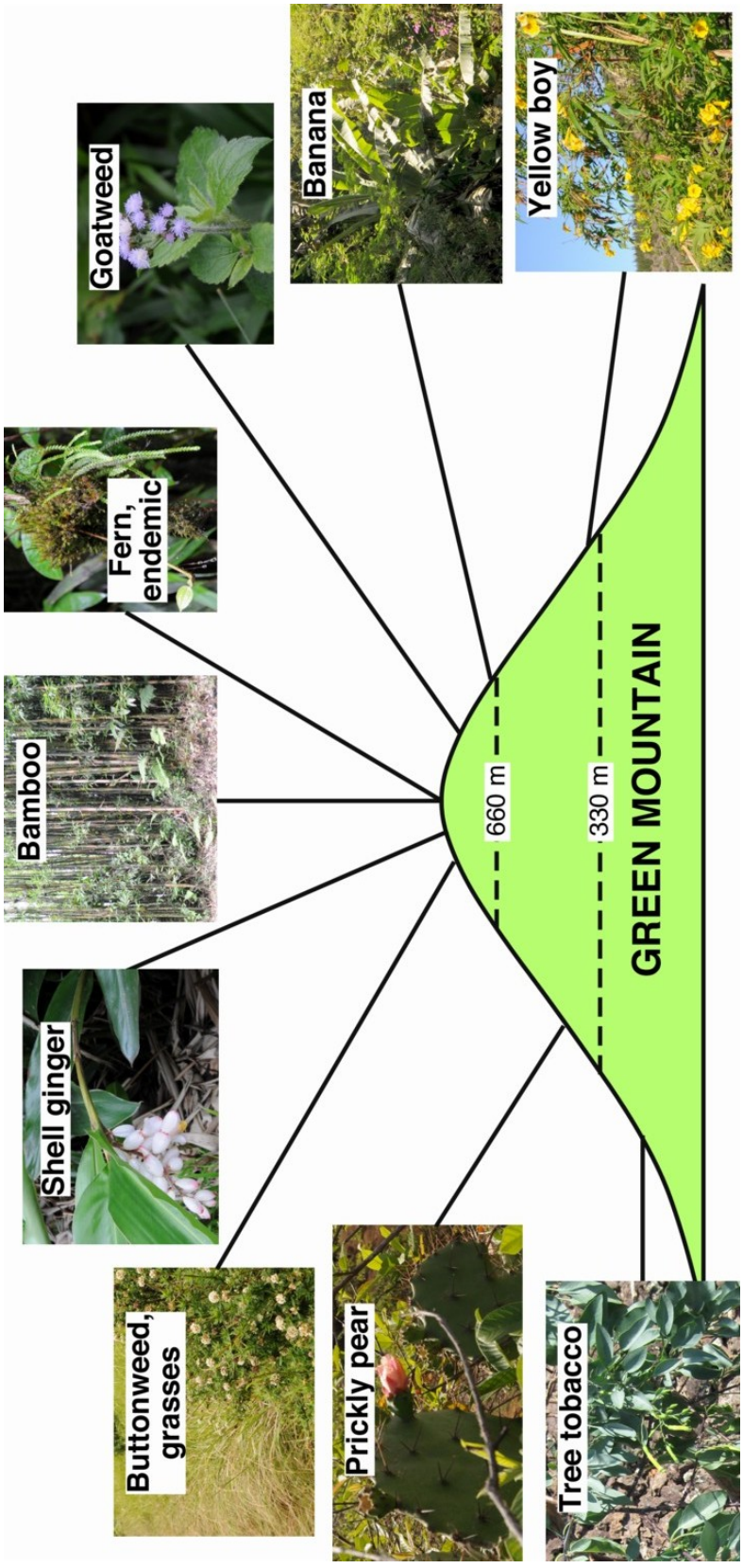

Fig. 5. Schematic diagram showing pictures of a few of the plants that are now found on Green Mountain within three different vegetation zones defined by altitude (see text). (Photos: DCC).

Fig. 6. The Dew Pond at the summit of Green Mountain. It now exists where once there was a scantily vegetated, windswept landscape, which Darwin compared to "the worse parts of the Welsh mountains". (Photo: Euan Nisbet).

3. Terraforming, aesthetics and conservation of endemic species

'Terraformed' Green Mountain is an environmentalist's quandary. On the one hand, it has great aesthetic charm. It is also typically 7°C cooler than the lowlands, providing an escape to the countryside for tourists and residents. In 1926, A. C. H. Rice, extolled its virtues: "Here lovely walks wind round the heights…How glorious is the heavenly air up here! How cool and clean after the dusty dried-up lava

pandemonium below!"[19]. On the other hand, the introduction of alien species has endangered endemic plants. Before people arrived, the island's ecology was in early development and the possibility of studying such a stage of evolution is lost. So, there is a tension between remaking the landscape for people and conserving native species.

The 'terraforming' once served a vital purpose to supply freshwater and food to Ascension's population, but its does not any more. Freshwater now comes from desalination plants, while the farm ceased operations in the 1990s. Food is imported by sea or air. So, the current greenness of Green Mountain has other purposes: a recreational area that was declared a national park in 2005, and a natural habitat, in climatic terms, for conserving native plants and animals.

Hooker came to regret that he ignored the impact on native species: "The consequences to the native vegetation of the peak will, I fear, be fatal, and especially to the rich carpet of ferns that clothed the top of the mountain when I visited it"[20]. Out of the ten endemic species, three are extinct. In more recent years, non-native plants, such as a thorny Mexican mesquite, have even spread in the lowlands. Mesquite was introduced as an ornamental plant in the 1960s, but gastronomically indiscriminate feral donkeys have since spread its seeds.

The consensus amongst ecologists is to try to preserve endemic species in pockets of habitat and nurseries, while enjoying the aesthetics of Green Mountain. The ecologist Herbert Prins argues that Ascension is a classic example for "post-modernistic nature" being "a fact of life"[21]. Prins believes that while there is a duty to prevent extinction, "the answer may be found in re-locating such threatened species". This can take the form of managed plots on Green Mountain, which is similar to conservation approaches elsewhere[22]. On the other hand, Prins argues for a balance with human interests because "aesthetic concerns…give satisfaction, spirituality or delight (and even tourist revenues) to us"[21].

4. Does Green Mountain mean that we can green other landscapes?

Global net deforestation has averaged 5.2 million hectares per year from 2000-2010 (the size of Costa Rica disappearing annually)[23], so the rapid creation of a functioning ecosystem on Green Mountain provides hope of one day reversing such negative global trends. However, any optimism must be tempered by the knowledge that Green Mountain has some especially favorable circumstances for Hooker's experiment. Ascension has persistent southeasterly trade winds. Mist forms when the moisture-laden air ascends Green Mountain and cools. Today, vegetation on the summit catches the mist and drips constantly. So, a plant system like that on Green Mountain cannot be transferred to any arid location. However, Hooker's principles of planting trees on highlands to increase rainfall, using vegetation to protect soils, and planting dry-adapted shrubs in lowlands, are general enough to apply to many places in the world[c]. A famous example of the association between forests and freshwater was demonstrated by forest clearance during the nineteenth century in the Tijuca mountains next to Rio de Janiero, which ruined Rio's watershed. The Brazilian government was forced to appropriate the land and reforest[24]. Today, Tijuca is the world's largest urban forest, a beautiful escape from Rio's hustle and bustle, and a

[c]Nowadays, we would be more mindful of soil balance and plant-insect relationships. Bee introductions to Ascension in 1827, 1834-35, and possibly later, all failed.[5] Pollination occurs today through crawling insects, flies, and wasps.

haven for species endemic to what remains of Brazil's Atlantic Forest.

There is ecological debate about the success of the strange mixture of species that co-exists on Green Mountain. Some collections of plants might be considered transplanted assemblages that co-evolved elsewhere[25]. But other species might have bucked the standard theory that complexity emerges only through co-evolution. In the alternative of *ecological fitting*, some species fit within the local ecology by chance and establish a colony despite a lack of co-evolutionary history[26].

Irrespective of disputes in biology, the success of Green Mountain's ecosystem must give some insight into transforming environments elsewhere. The positive lesson is that further study of Green Mountain might help inform strategies to green some deserts or other barren locations in the world. The caveat is that we must be mindful of the physical constraints, such as meteorology, and the need to conserve endemic flora or fauna that may otherwise vanish.

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