

The Dead Trees of Ilha da Trindade¹

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Out in the South Atlantic some 1,500 kilometers east by north from Rio de Janeiro, a volcano top called Trindade juts above the sea (Fig. 1). Though it is scarcely a seventh the size of Manhattan, the isle does not want for wonders. It has crags, a cascade, and a columnar volcanic plug eighty stories high; a Sugarloaf to rival Rio's; a great natural tunnel through which the surf thunders; a rabble of raucous seabirds; and rustling myriads of garish red and yellow land crabs (1). But ringed with rocks and days by boat from Brazil's mainland, Trindade is not suited or situated for sightseers. A naval force of forty now shares the island with the noddies and the petrels. Before, there were prisoners for a time (2), and pirates it is said, and castaways of course. Sailing ships shunned Trindade's ironbound shore unless they lacked water for drinking or wood for the stoves. There was wood aplenty, too, for the steep slopes (Fig. 2) bore thousands of trees, by all accounts trees of one kind only. Before 1821, however, something or some event had killed them—killed them all—leaving a weird landscape of standing corpses. It was, in the words of one who saw it, "a forest of desolation, as if nature had at some particular moment ceased to vegetate."

That is what we knew or thought we knew when the question of the trees' identity brought us, a botanist and an ornithologist, together. One of us had gone to Trindade to study birds (3), had seen what is left of the forest of desolation, scattered logs and bits of wood weathering away, and had brought back a sack of samples. For some of the birds, the passing of the island's forest was no small thing. Alive or dead the trees held eggs and young away from preying crabs and, where thick-strewn, made a barrier between birds and people (Figs. 3-5). The island's birds are far fewer now than they were fifty years ago (4), and the loss of the trees must be one reason for it. When we turned our attention to the trees, works on Trindade were ascribing them to *Caesalpinia*, a genus in the legume family, but the basis for the ascription was obscure. Moreover, spare-time carvers at the naval station had said that the wood does not look and feel like bona fide *Caesalpinia* wood. Hence the botanist's role: to learn whether Trindade's logs really are remains of *Caesalpinia* trees. That question, seemingly a simple one, would bring an avalanche of others, and looking for the answers would take us down paths seldom trod by those who study plants or animals.

Smithsonian researchers usually go to experts in the Forest Service for help with puzzling woods, because identification, even of common cabinet woods, is best done by those with day-to-day practice. But exposing a wrong identification can be easy enough. One starts by cutting three carefully oriented slices from the doubtful wood: a

¹ Presented to the Philadelphia Botanical Club, April 22, 1982.

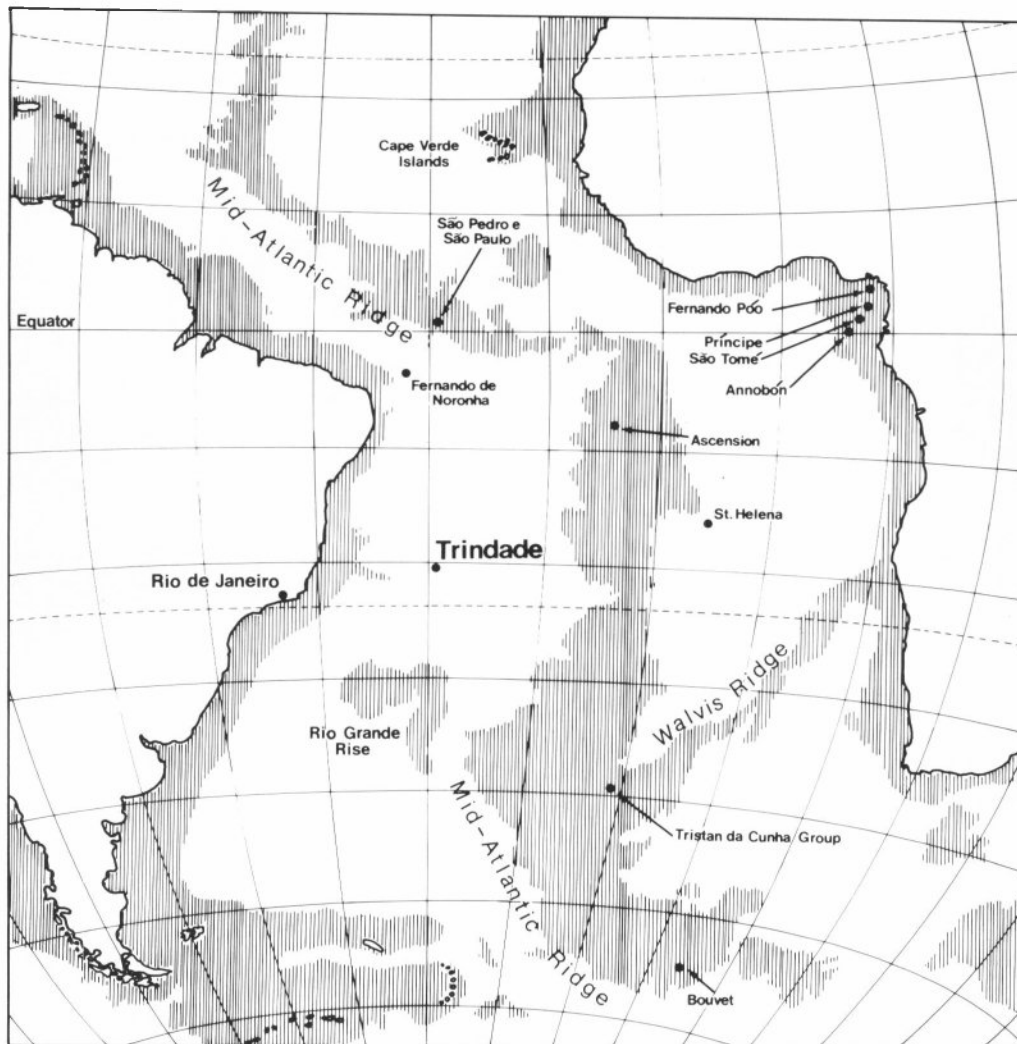


FIG. 1. Islands of the South Atlantic.

slice that is a cross section with respect to the dead tree's trunk, another that is longitudinal and radial, and a third that is longitudinal and perpendicular to the radial slice (5). The slices must be thin enough to pass light, because the goal is to match them microscopically with three similarly oriented slices from a vouchered sample—a piece of wood collected with a flowering or fruiting branch to vouch for its identity. When we put slices from a Trindade sample beside slices from vouchered *Caesalpinia* woods we found they did not match: the Trindade trees were not caesalpinias. We then took a closer look at what had been written about Trindade and discovered other ideas as to the trees' identity. Four authors had put forward, with differing levels of doubt or decision, four other genera in four plant families. In time we found that all were wrong.

We now had several questions to deal with. Of course we wanted to know what kind of trees grew on Trindade. To that end we had to ask whether any early visitor to the island had made a drawing or had pressed and preserved a leafy branch while the trees



FIG. 2. Trindade's slopes as they are today, from a Kodachrome by S. L. Olson.

still lived. And how did they come to be called *Caesalpinia*? And when did they die? And why?

SETTLERS BUT NO SPECIMENS

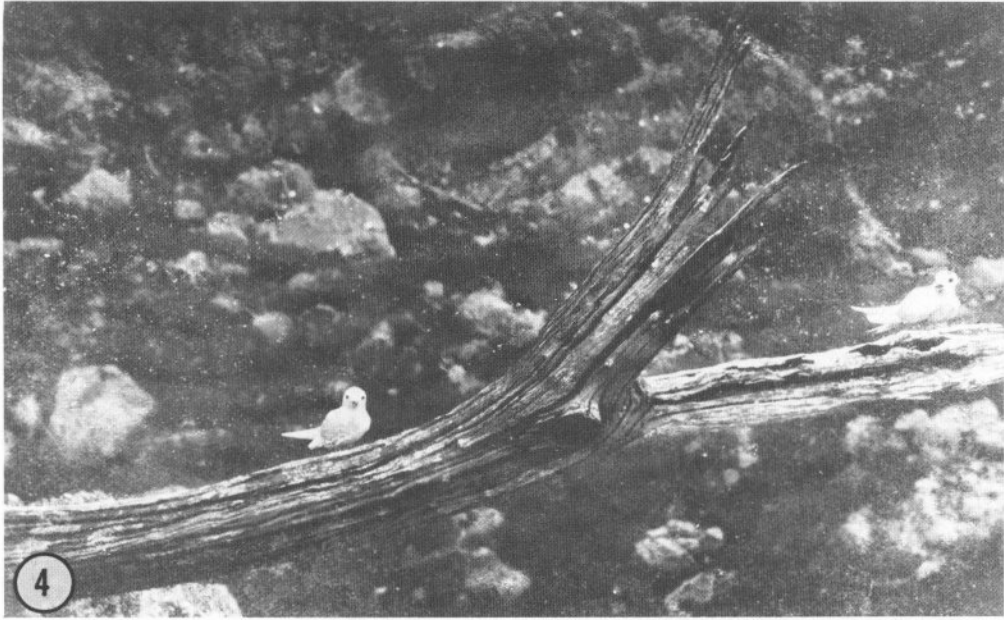
Looking for an early collection led us nowhere. It seems no visitor took a specimen or sketched one before the trees died. The first exploration on record was in April, 1700, when a British pink, the *Paramore*, Edmond Halley of comet fame commanding, landed a boat five days running. Captain Halley was a topnotch scientist, but he cared more for planets than for plants, and the *Paramore* was out to study the earth's magnetism not its vegetation. Halley's journal (6) says he drew Trindade's outline, plotted its position, and claimed it for his king, also that he "went up to the topp of the Island and found it very Steep and Laborious to ascend it." It says not a word about trees.

The Portuguese were rival claimants to Trindade, as their armadas had passed it almost two hundred years ahead of Halley. They did not really look it over, however, before 1756. In the fall of that year and again in the first months of 1757 an exploring party left the mainland to map the island, sound its waters, and see what it had to offer. Trees were not to be ignored: the governor of Rio de Janeiro had ordered that the group include a carpenter versed in New World woods and their uses. Though the explorers brought back a diary and a map, both seem to have vanished. E. M. Peixoto's massive monograph on Trindade's documents (7) does not have them, nor does it say where they are. From letters dealing with the exploration, we judge that the explorers carried home no collections and no drawings save the map. And they likely put a low value on the island, for Lisbon let it be till George Johnstone tried to take it.

The Johnstone affair was brought on by an extraordinary train of events (8). Commodore Johnstone was a bellicose schemer and sometime Member of Parliament whose



FIG. 3. Dead trees, with nest just right of center, as seen by the *Discovery* expedition, 1901. Courtesy of the Royal Society, London.



FIGS. 4 and 5. Trindade's trees as M. J. Nicoll saw them in 1905. Birds are red-footed boobies (Fig. 5) and white tern. Copied from Nicoll's *Three Voyages of a Naturalist*.

command had come as a political plum. In 1781, when Britain was at war with us, with France, with Spain, and newly with the Netherlands, the King's Secretary of State for the Southern Department sent Johnstone and his ships to the Cape of Good Hope. Johnstone's job was to grab the Cape from the Dutch before French reinforcements could get there, for both sides saw it as a vital link in the sea route to the Asian colonies. But the commodore let an enemy squadron catch him, scatter his ships, and beat him to

the goal. Having thus jeopardized Britain's hold on India, he needed a gain of some kind to blunt the reproof that awaited him at home. The course he hit upon was to start a colony on tiny Trindade and tout it as a new jewel for the British crown.

He chose Captain Philip D'Auvergne, a Jerseyman, to place the first settlement, fortify it, and make it flourish. Embarking on what a biographer (9) has rightly called a fool's errand, D'Auvergne did his brave best. Trouble began when a gale broke up the young captain's vessel six days after he dropped anchor at Trindade. The ships that had escorted him could have taken him and his settlers away when they left for other tasks, but D'Auvergne turned down the offer (10). With his wrecked sloop's guns planted on the island's heights and maize planted on the flatter spots, he held to his mission. He did not know the mission would maroon him for a year. The King's court did not accept the colony quickly, as Johnstone had hoped, but called a committee to ponder it and in time said no. When the India-bound *Bristol* finally came for them, the settlers surely shed no tears of sadness, but it is hard to tell just how badly they had suffered during the delay. Reminiscing for the *Naval Chronicle* years later, D'Auvergne recalled three months of surviving on seafowl (11). Brazilians who came to Trindade on his heels, however, harvested some of his corn (12).

Johnstone's "colony" lasted not quite 15 months—from October, 1781, to the final days of 1782—but it led to a longer occupation. A fortnight after D'Auvergne's band, 29 island-weary souls all told, left Trindade with the *Bristol* and her convoy, a force arrived from Rio with instructions to put them off (13). The commodore had been in Portugal and had bragged about his new jewel, whereupon Lisbon had complained to London and had resolved to replace the thriving colony with one of its own. Needing no new quarrels, Great Britain had yielded. (This recognition of Portugal's rights took on new worth in the 1890s when Britain tried to take Trindade again, this time as a telegraph station. Brazil, a separate land by then, pressed the old Portuguese claim and got the isle for good.) The newcomers soon learned they had been hoodwinked—that Trindade's rugged surface made it unfit for farming or for anything else they could think of. What hardscrabble tilling could be done here and there would not feed a settlement, and the island's peaty soil was prone to burn. Nevertheless, the force was not soon recalled. Following royal orders, 150 men stayed to keep Trindade out of alien hands. Brazil's viceroys would groan repeatedly about the cost of halfyearly supply ships before Lisbon at last closed down the garrison, long since reduced to 88, in 1795 (14).

Trindade was aswarm with people, as desert islands go, in the 1780s and the early 1790s. Still it seems no one drew a tree or saved a branch (15). D'Auvergne, for all his mettle, lets us down here. During his distinguished later life as military governor of Jersey, he owned 72 books on botany and took the *Botanical Magazine* (16). He could draw, too. Before he joined Johnstone's squadron he had sketched crustaceans and other invertebrates for the Phipps arctic voyage (17). After landing on Trindade he had made, under orders, a map (Fig. 6) that is still a joy to look at (18). Why then did he not leave us a relic or a record of the trees? Well, the D'Auvergne of 1781 and '82 was at least a little lazy. We have this from the journal of his superior, Captain Thomas Pasley, who, acting for Johnstone, escorted D'Auvergne's vessel to Trindade and oversaw the founding of the settlement. Before giving the Jerseyman a good mark for sticking with the mission, its pages twice denounce him as a dawdler (19).

When the Portuguese posted their garrison, no botanist or zoologist had yet set foot on the island, but the time of the great collecting expedition had come. The first such to touch Trindade was French. In October, 1785, the *Boussole* and the *Astrolabe* arrived

A
TOPOGRAPHICAL PLAN
 OF THE ISLE
TRINIDAD,

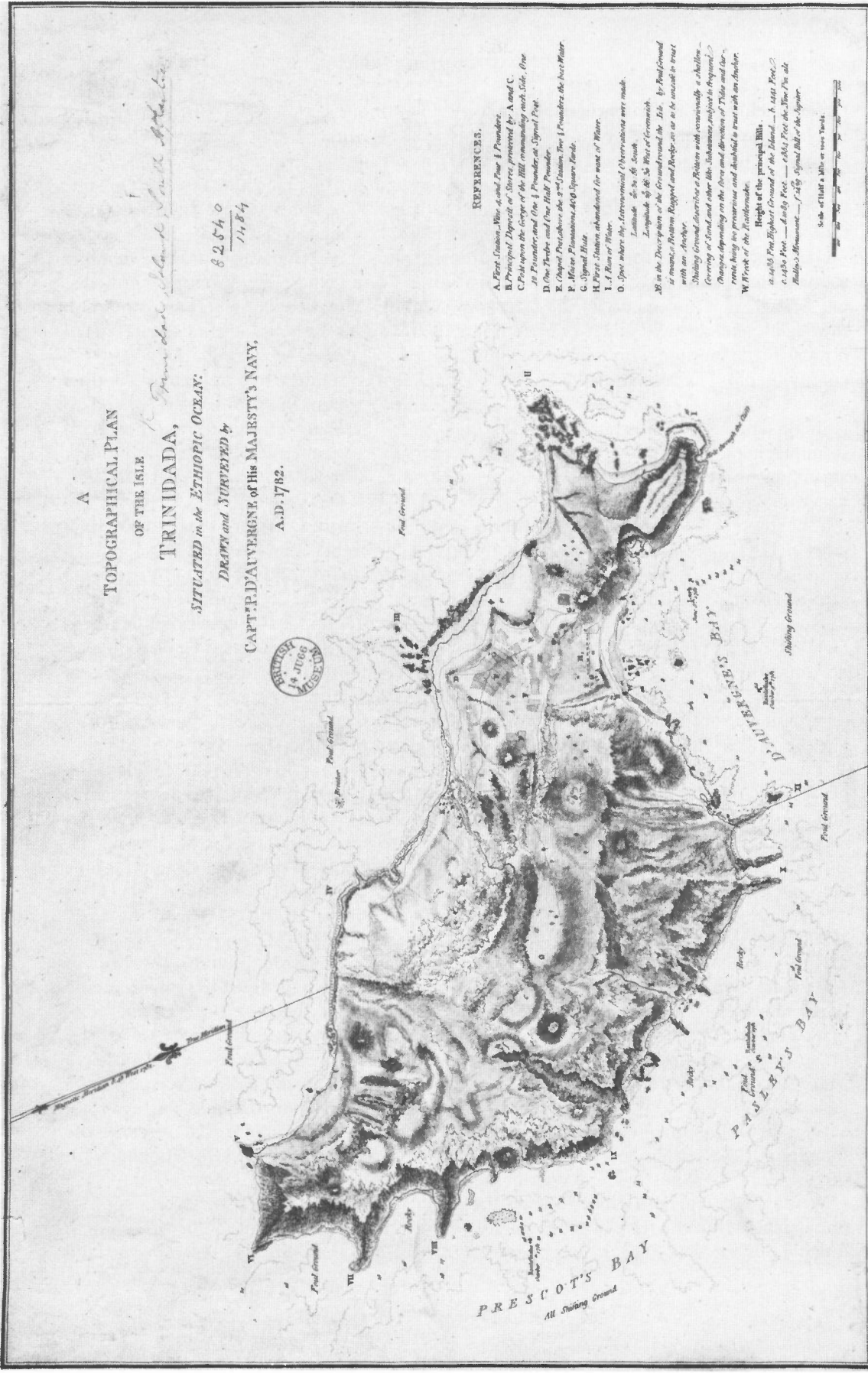
SITUATED in the ETHIOPIC OCEAN:

DRAWN and SURVEYED by
CAPT'D'AUVERGNE of His MAJESTY'S NAVY,

A.D. 1782.



Trinidad Island, South America
 82540
 11854



REFERENCES.

- A. First Landing Place, and One of the Principal Deposits of Sugar, produced by A and C.
- C. Hills upon the Edge of the Hill, commanding each Side, One of the Principal Deposits of Sugar.
- D. One of the Hills, and One of the Hills, produced by the Hills.
- E. One of the Hills, and One of the Hills, produced by the Hills.
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- U. One of the Hills, and One of the Hills, produced by the Hills.
- V. One of the Hills, and One of the Hills, produced by the Hills.
- W. One of the Hills, and One of the Hills, produced by the Hills.

Height of the principal Hills.
 a. 1433 Feet. Highest Ground of the Island. — b. 1241 Feet. —
 c. 1240 Feet. — d. 1241 Feet. — e. 1241 Feet. — f. 1241 Feet. —
 g. 1241 Feet. — h. 1241 Feet. — i. 1241 Feet. — j. 1241 Feet. —
 k. 1241 Feet. — l. 1241 Feet. — m. 1241 Feet. — n. 1241 Feet. —
 o. 1241 Feet. — p. 1241 Feet. — q. 1241 Feet. — r. 1241 Feet. —
 s. 1241 Feet. — t. 1241 Feet. — u. 1241 Feet. — v. 1241 Feet. —
 w. 1241 Feet. — x. 1241 Feet. — y. 1241 Feet. — z. 1241 Feet.

Fig. 6. D' Auvergne's map of Trinidad, courtesy of the British Library.

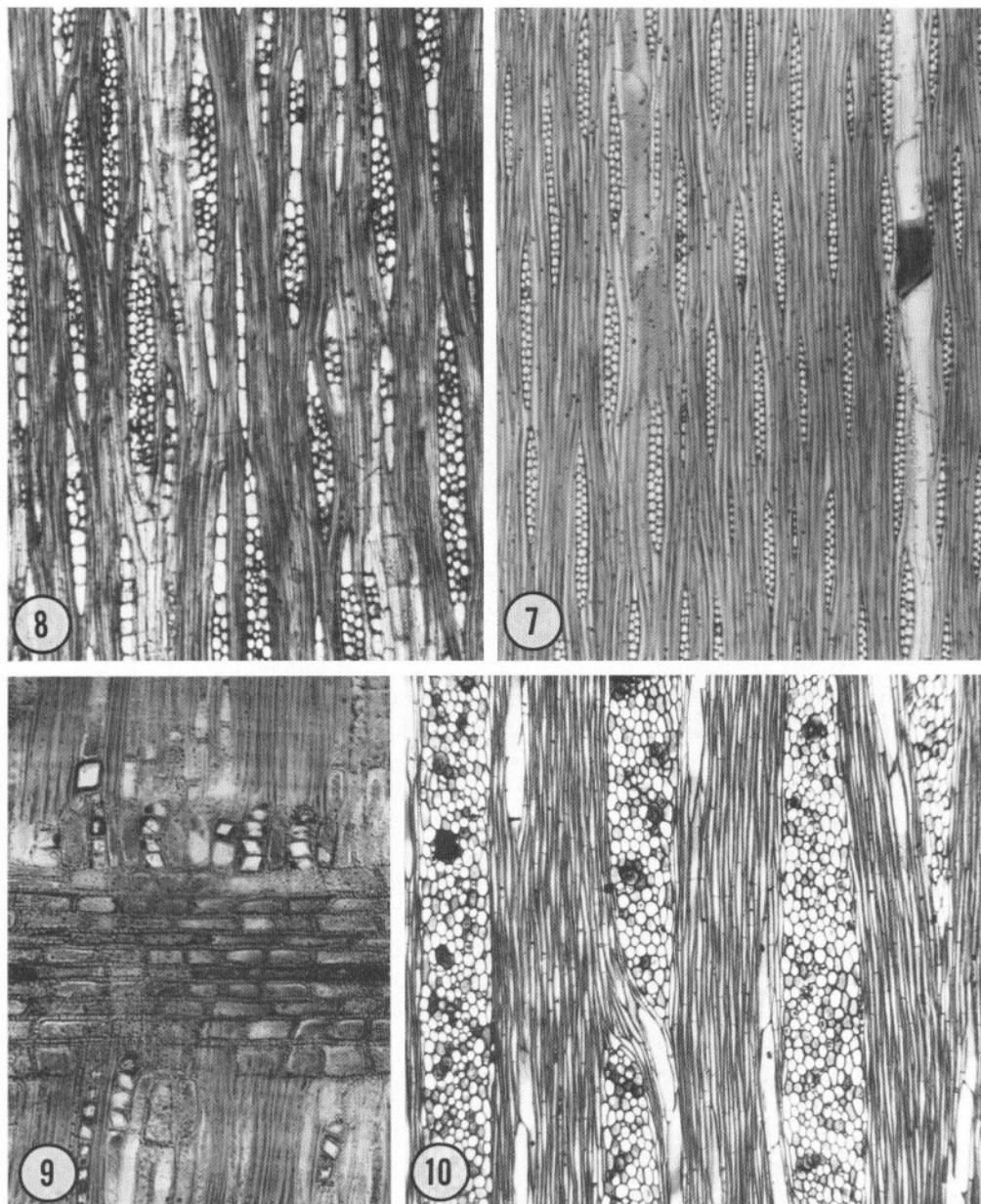
with two botanists and an artist on board and J. F. de G. de la Pérouse in charge, outward bound on a doomed "voyage round the world." Though the voyage came to grief near the Solomons some two and a half years later, collections and records returned from ports of call. Alas, collections from Trindade were not among these, because, as La Pérouse explained in his journal, the garrison's commandant had turned the landing party away just after it landed. "This officer was in such dread of our discovering the sorry state of his government," wrote La Pérouse, "that he would not even let M. de la Martinière and Father Receveur leave the shore to look for plants" (20).

French explorers came to Trindade again in 1826 when a new *Astrolabe* under Jules Dumont d'Urville set out to follow La Pérouse's path, finish his mission, and learn what had happened to him. Again, there was a plant collector on board. This time, however, there was no landing because the sea was too violent (21). As it happens, Dumont d'Urville's collector could not have gotten what we needed even if he had gone ashore, for we know from a novel that Trindade's trees were already dead. Yes, from a novel. We will explain that after we tell how we found out what trees they were.

TELLING THE TREE BY ITS WOOD

Lacking a pressed specimen, we had to work toward identification with microscopic features of the wood, with post-mortem descriptions of the trees, and with whatever clues could be taken from the island's setting. We were uneasily aware, too, that the trees could have been unique to Trindade—an endemic species now forever gone. If so, it might be impossible to match their remains with a wood from somewhere else. *Caesalpinia* woods are a bad match because, among other things, the rays are not right. Rays are the ribbons of shorter, softer cells that run spoke-like through a transected trunk. Magnified *Caesalpinia* rays have a uniform look. Most are of the same thickness, and all their cells are procumbent, lying with long axes in line with the ray's length (Fig. 7). The Trindade wood, on the other hand, has rays of different thicknesses with upright cells among the procumbent cells (Fig. 8). Secondary cross walls subdivide some of the upright cells into infracellular chambers, and each chamber encloses a crystal (Fig. 9). This is the kind of rare feature a wood identifier looks for to strike off lots of possibilities at once and keep a search within bounds. For example, Trindade's dead trees can not be *Acacia*, as ornithologist M. J. Nicoll suggested in 1908 (4), or any other legume for that matter, because members of the legume family do not have crystals in chambered upright ray cells. The same goes for *Rapanea*, a genus of the myrsine family to which a 1950 article (22) assigns the dead trees; a *Rapanea*'s rays are also much too broad (Fig. 10). Clearly, later is not better in this business, for a 1964 book (23) calls the dead trees *Pisonia*, and that is the queerest attribution of the lot. Woods of the four-o'clock family, to which *Pisonia* belongs, tend to be light and flimsy owing to an oddity: regions of thin-walled phloem cells are "included" within the rigid xylem, breaking up the continuity of the wood tissue. In contrast, Trindade's wood is hard and heavy, with no included phloem. A glance at a cut surface, or just hefting a piece, is enough to rule out *Pisonia*.

It was not so easy to rule out *Eugenia*, the oldest attribution on record. The English war correspondent and travel author E. F. Knight published this one in a book about a quest for buried gold. Knight had sailed to Trindade at the end of 1889 with nine "gentlemen adventurers" to dig for pirates' treasure, had taken home a log, and had



FIGS. 7-10. Wood rays in radial (Fig. 9) and tangential section. 7. *Caesalpinia echinata*, US wood collection no. 2542. Ray cells all procumbent. $\times 80$. 8. Trindade deadwood collected by Olson in 1976, USw 41482. Rays made up of upright and procumbent cells. $\times 80$. 9. Trindade deadwood collected by Knight in 1890. Crystals in chambered upright cells along ray's margins and in some axial parenchyma cells. $\times 135$. 10. *Rapanea guianensis*, USw 8942. Rays huge and without upright cells. $\times 40$. Photos by V. Krantz.

sent a piece of the log to Kew Gardens where anatomist L. A. Boodle had looked at it (24). Working without a microtome, the present-day biologist's precise slicer, Boodle could do wonders with a razor and a hand lens. His opinion on the Trindade trees—probably the myrtle family, possibly *Eugenia*—was the best that could be had, and it was a reasonable one. The wood does have the look and feel of a *Eugenia* wood, and there are points of similarity in the more obvious cellular features. By dint of their fleshy, bird-eaten fruits, some of the eugenias are widespread on tropical islands: that is another fact that fits (25). To be sure, we could not find a *Eugenia* wood with crystals in upright ray cells. There are eugenias, however, with upright files of crystals elsewhere in the wood. We could not make a good match with respect to the distribution of the thin-walled cells called xylem parenchyma, either, but there are hundreds of species of *Eugenia*, and no one has looked at all their woods. We had to allow that there could be a *Eugenia* somewhere with a wood like the Trindade wood. Furthermore, Boodle's opinion was so worded that we could not discount it without combing the whole myrtle family for a look-alike, which was out of the question. This would have been the end of the track had we not had help.

We could have gone to our friends in the U.S. Forest Service for help, but no one knows all the world's woods, and Brazil has its own experts. An answer to our letters came first from Calvino Mainieri, who was, before his death late in 1980 (26), Brazil's pre-eminent identifier of woods. Mainieri said he did not think any Brazilian anatomist had yet looked at the remains of Trindade's trees. Could we send a sample of the so-called *Caesalpinia*? Of course we could, and almost by return mail we got a new and true identification: Trindade's trees belonged to *Colubrina*.

The quick response was startling. Mainieri's way with woods was well known, but Brazil's woody species are so many and so diverse that we had not expected same-day service. Three weeks later we had the same answer, *Colubrina* in the buckthorn family, from a second anatomist, Armando de Mattos Filho, who sent along a piece of Trindade deadwood from the collections of the Jardim Botânico in Rio (27). The Jardim's wood was just like our samples. Then the Kew anatomists sent a bit of the log that yachtman Knight took home in 1890. It, too, was just like ours. At least one thing we had read at the outset was correct. The dead trees were of one kind.

CONFIRMATION FROM THE HERBARIUM

With a little cutting and comparing we saw for ourselves that the trees were some kind of *Colubrina*. Now we needed to know something about the species of *Colubrina*. Not that we hoped to carry the identification down to the species level; wood anatomy can not often do that. We did hope to learn the ranges of the species and to find out whether any one of them occurs on the Brazilian coast nearest to Trindade. To do that we would have to look into a recent taxonomic treatment of *Colubrina*. We were in luck: there was one. Marshall Johnston of the University of Texas had put *Colubrina* in order in 1971 (28), and the Smithsonian's botany library had his work.

Taxonomists are the oft-times undervalued heroes of biology who sort out the species, tell us their traits, map their ranges, and untangle their nomenclatural snarls. A scientist of another stripe can know the worth of all that only when he or she has run into a roadblock, then gone to a good taxonomic treatment and found what is needed to carry on. Professor Johnston's work gave us what we wanted and more. There are 31 species of *Colubrina* in the world and Brazil's southeastern coast has two of them. One of these is made up of thorny little trees that do not fit the descriptions of Trindade's dead trees.

The other, *Colubrina glandulosa*, fits nicely. To be exact, southeastern Brazil's populations of *Colubrina glandulosa* belong to an infraspecific variant, *C. glandulosa* variety *reitzii* (Fig. 11). Johnston's work told us that collectors have taken specimens of this variety in the state of Rio de Janeiro, in five other states on Brazil's mainland, and on Ilha da Trindade.

On Trindade? The herbarium case where colubrinas are kept is 27 strides from our botany library. The fat folder marked *Colubrina glandulosa* holds three dozen specimens, and, sure enough, two were taken on Trindade. Their labels show that they came to the Smithsonian from research centers in Paris and Rio through routine sharing of duplicates. One was taken in 1959, the other in 1961 (29); both are from Trindade's peaks. The herbarium sheets also carry Marshall Johnston's labels endorsing their identity. So Trindade's trees did not all die. A few persisted, or came back from seeds, on the island's upper reaches. And there were pressed specimens close at hand all the while we looked for one.

Suddenly our mystery trees seemed almost commonplace. Colubrinas are found in most warm parts of the world. Some species, with seeds that float for weeks in salt water and still germinate, are able colonizers of seaside sites (30). There are shrubby colubrinas in our southwestern states and tree colubrinas in tropical Florida. Hawaiians have one that is something of a vine. Puerto Ricans call one of theirs mabí and make a tasty beverage from its bark. Brazil's foresters plant *C. glandulosa* var. *reitzii*, which they know as *saguaraji* or *sobraji*, for its fast growth and cut it for its rot-resistant wood. (The old logs lying on Trindade's slopes demonstrate its durability.) Variable in size and shape, trees of this kind can reach anywhere from three meters to 20 meters or more, and they grow straight in planted forests. On Trindade they were 10 meters tall; some or all had twisted trunks.

How was it that no one thought to link the colubrinas on the peaks with the lifeless forest on the slopes? Even the more casual visitors had seen clumps of small trees or shrubs at the island's top. Some of the old reports were based on sightings at a distance that did not let the visitor tell true trees from tree ferns. (Trindade still has tree ferns and once teemed with them.) Others, however, made it plain that the visitor had climbed a peak for a closer look at what was growing there. And E. F. Knight, who stayed three months and explored the island thoroughly, searched the summit for live trees of a size and shape to match the dead ones before concluding that there were none. When collectors came at last, they recognized *Rapanea* and *Pisonia* among the highland plants, and authors eager for identification then put these names to the dead trees without proof. There was no reason, really, to think of *Colubrina* if one had the dead trees tagged already as rapaneas, as pisonias, or—to recall the common error—as caesalpinias.

HOW THE TREES WERE WRONGLY NAMED

The mischief-makers in the *Caesalpinia* matter were George R. M. Murray and Robert Cushman Murphy. Keeper of the Department of Botany in the British Museum (Natural History) from 1895 to 1905, Murray was also a scientific director of the National Antarctic Expedition, which took him to Trindade in 1901. A year later the *Geographical Journal* carried his account of collecting there and with it these words. "I scraped some freshwater algae from stones in the bed of the stream. . . . Two lichens were fairly abundant on the stones and on the trunks of the numerous dead trees described by Mr. Knight from this and other valleys. These trunks (*Caesalpinia* sp.)



FIG. 11. *Colubrina glandulosa* var. *reitzii*, drawn by A. Tangerini from a specimen (J. Becker 28) taken on Trindade. Stamens and hood-like petals are in the same radii, a family trait. Smallness of flowers and fruits, lack of bright color doubtless made it easy for early visitors to give Trindade's trees scant heed.

have plainly been dead for many years, and are bleached white, and for a great part covered with lichens. The wood is a hard red wood, and, from the abundance of the trunks, they must represent a considerable forest, now vanished from the island" (31). It puzzled us when we found this, the first ascription to *Caesalpinia*, because Murray was an authority on marine algae, and algologists do not ordinarily count the identification of tropical woods among their skills. We guessed Murray had shown a specimen to an anatomist, but an exchange of letters with his department drew a blank. The current keeper told us there is no such specimen among the museum's collections; he said further that Murray's words suggest to him a casual observation unaccompanied by a collection (32). Why, then, did Murray ignore the earlier view that the trees were of the myrtle family? Surely he knew about it, for his article referred more than once to Knight's book, where that opinion had appeared. Could it be that he thought poorly of Boodle, whose opinion it was? Not likely, because he had named an alga *Boodlea* "in honour of my friend Mr. Leonard Boodle" (33). The key to the puzzle may lie in the worsening mental condition (poor concentration was a symptom) that led Murray to leave science at age 46 (34). In any case, the American ornithologist Murphy took up the error in 1915 without saying where he got it: "But the most striking element in the vegetation of Trinidad is its great groves of dead trees of the genus *Caesalpinia*" (35).

The red heartwood of Trindade's trees helped to keep the *Caesalpinia* story going. As all Brazilian children learn in school, Brazil was named for the dyewood trees that brought its first settlers. We now know those trees as a kind of *Caesalpinia*, but "brazil" and "brazilwood," *pau-brasil* in Portuguese, are centuries older than Linnean nomenclature. Before America's discovery European traders had called red dyewoods from the Orient brazil—that could mean the dye, the wood, or the tree—and the name crossed the Atlantic when explorers found red dyewoods in the New World. Portuguese settlements of the 1520s were little more than camps for the cutting and the caching of these woods. At first brazil could be any of a half dozen dyewoods, but the better dyewood tree from Pernambuco became in time "the true brazil" (36). This one *pau-brasil*, *Caesalpinia echinata*, has been Brazil's national tree by law since December 7, 1978 (37). Over the years, however, usage had become so loose in some parts that *pau-brasil* could mean any tree with reddish wood, whether or not it would yield a dye. A visitor to Trindade who had known that usage would have called the dead trees *pau-brasil*, and a botanically naive writer might then have looked that up and made it *Caesalpinia*. Naive or not, Murphy did use *Caesalpinia* and brazilwood interchangeably when he wrote about Trindade again in 1936 (38), and the added air of authenticity made the error that much harder to dislodge.

The same loose usage troubled Brazil's timber trade till 1960, when the Institute for Technological Research in São Paulo put out a work with photomicrographs to set things straight (39). Its author: Calvino Mainieri. It gave microscopic features for separating *Caesalpinia* woods from other red woods called *pau-brasil*, and *Colubrina glandulosa* var. *reitzii* was one of them. Coming on that publication only after we had learned from Mainieri what our "*Caesalpinia*" was, we recalled the swift unriddling with a smile. His work of 1960 held the answer for the taking, though he had not known when he wrote it of Trindade's long-dead trees.

TIME OF DEATH

Long dead, certainly, but dead how long? We can be sure the trees died before 1821 because they were dead when Captain Frederick Marryat saw them. Marryat wrote the

desolate forest's description (a bit of which is in our opening paragraph) into *The Naval Officer*. Published in 1829, this was the first of Marryat's twenty-odd novels, and it lightly fictionalized his own ample adventures (40). Many events are real and places are truly portrayed. One of the successful British writers of his time, Marryat grew famous enough to draw a parody from Bret Harte, important enough in retrospect to draw homage from Joseph Conrad and an essay from Virginia Woolf (41). It means more to us that he was a keen observer with a bent for scientific inquiry. Examples: Marryat gave formal taxonomic standing to two mollusks that experts still treat as good taxa (42), and his *Life and Letters* (43) contains "Anecdotes of Wounded Men" that a medical man might have written. Those who went to Trindade after him vouched for his depiction of the island. He did, however, tamper with the time. *The Naval Officer* took its hero to Trindade—with a Yankee prisoner—while our War of 1812 was on. The real Marryat had stopped there on his way to St. Helena, where he was to help guard Napoleon through the erstwhile emperor's last days. Marryat's private log, now in Britain's National Maritime Museum, says he went ashore "to procure water and to examine the Island" on January 9, 1821.

If Marryat was not the first to see the dead trees, he was, it seems, the first to write about them. In 1817 survivors of the *Jeune Sophie* took refuge on Trindade when their ship caught fire at sea. A Brazilian newspaper ran the story of their rescue, but apparently the news account (44) had nothing for the naturalist. 1817 also brought edition two of Horsburgh's *India Directory*, the East India Company's sailing guide. The *Directory*'s claim that "there are trees about 12 or 18 inches diameter" on Trindade was at best an overestimate, perhaps an outright error, and Horsburgh did not tell where (or when) he got it. On the chance that a logbook would give better information, we wrote to British sailing archives to ask about the vessels Horsburgh said had watered at Trindade. The obliging archivists who rummaged through the records for us turned up nothing on the trees (45).

The trees were not dead in 1781: that we know from Captain Pasley's journal. Sailing round Trindade on June 5, Pasley saw "a pleasant appearance of Verdure near the Shore, and the little Valleys and sides of the mountains cloathed with Wood," adding, "it makes a most picturesque appearance." Landing later with D'Auvergne to put the infant colony in place, he "found the island covered with Wood, the Soil uncommonly Rich, and several Excellent springs of Water in the Woods which were all absorbed by the sponginess of the Soil ere they reached the Sea." It is clear enough that Pasley saw a greenwood rather than a scene of desolation.

It is clear, too, that the trees had not died when D'Auvergne departed, because a map made by the Portuguese who took his place shows tree-clad terrain (46). But the leader of the garrison soon deemed these woodlands worthless. He wrote back to Rio that the forest was inconsequential, the trees slender, low, and crooked. He could not find one fit, he said, to function as a flagpole (47). This report, dated a month after the takeover, already has the sour tone that would run through all the garrison's papers: time and again they stress the island's *total inutilidade* while saying nothing further on the trees. From this we take it that the trees lived through the 12-year occupation: Brazil's viceroys were not loath to list the island's shortcomings, and a dead forest would have been grist to their mill. For much the same reason we think the trees stayed green through 1803, when the New England sealer Amasa Delano toured Trindade. Delano filled his *Narrative of Voyages and Travels* (48) with lively glimpses of other places but offered bland details about Trindade. On Trindade's trees he said only that "Wood may be cut on the mountain just above the first landing place." He likely would have told his readers of it had he seen the melancholy sight that Marryat saw.

Marryat's description holds a hint that the forest died not too many years before he looked at it in 1821. The picture that emerges from the passage in *The Naval Officer* is one of trees still standing where they grew. Most had fallen when Robert McCormick, a medical officer with the Ross Antarctic Expedition, saw them in 1839. They were then "scattered around in wild confusion, here and there one fixed in the soil in an erect position" (49). With this we have said all we can about the time of death: the trees likely lived beyond 1803, and the upright trunks of Marryat's account suggest a death-year more toward 1821. It could have been 1816. That will be of interest when we guess what killed the trees.

DEATH'S CAUSE: GUESSES GALORE

We might have sought a clue to cause of death from another island with a *Colubrina* forest—if there were such. Though colubrinas of the Trindade kind tend to grow in clusters on the mainland, they never covered any island but Trindade. The closest match may have been one of Florida's keys, where a hundred years ago a different *Colubrina* formed a dense forest. At any rate, that is what Charles Sprague Sargent's 1884 *Report on the Forests of North America* says. Sargent got the story from plant collector A. H. Curtiss, and with it came specimens of *C. elliptica* from "Umbrella Key" (the Smithsonian's herbarium has one of them). Floridians have used that name for more than one island, but the state has history-minded librarians who could help us get the right one: Curtiss took the specimen from the high key now called Windley Key (50). We have talked with skeptics who know Windley well and doubt it ever had enough colubrinas to make a forest. Whatever their numbers were, Windley's colubrinas are no more. Development did them in and hurricanes helped. But Trindade's desolation can not be blamed on bulldozers—or on high winds either if the trees still stood when Marryat saw them—so we must look to other causes.

Guesses at the cause of death began with Marryat, who looked for signs of soil erosion around the roots, and, finding none, decided that the trees had died for one of two reasons. The likelier one, he thought, was a "sudden and continued eruption of sulphuric effluvia from the volcano." If not that, "by some unusually heavy gale of wind or hurricane, the trees had been drenched with salt water to their roots." The second guess tells us that he saw the trees still standing as they grew. Had they been down, he would have skipped the salt water and let the gale of wind uproot them. The water story will not work, for, as E. F. Knight pointed out, there were dead trees on the mountains way beyond the reach of any waves. Knight favored a volcanic cause, but that will not work either, because Trindade the volcano has been quiet for millenia (51). And fire was not the cause of death. To be sure, the Trindade of an earlier time did have a tindery substrate. Portuguese settlers learned this in 1783 when the soil burst into flame for no known reason and kept on burning till they stopped it with a dammed-up stream (52). Those who left the isle in 1795 would have let such a fire burn: Brazil's outgoing viceroy had written his successor in 1789 that he would rather raze Trindade to make it more useless than spend more money to defend it (53). Nevertheless, we can be sure soil fires did not spread widely enough to kill all the trees, for Marryat found afterward "no want of rich earth for nourishment of the roots." We can count crown fires out, too. Some of the logs do have fire-blackened parts, but charring must have taken place after death. Had Marryat seen a fire-charred forest he would not have guessed that gases or a gale had killed the trees.

Trindade has had free-roaming hogs and goats—infamous for what they do to

vegetation—off and on since Edmond Halley set some loose in 1700. Those brought in by settlers of the 1780s must have stripped the isle of many smaller plants, and the settlers' doings doubtless added to the devastation. There were still wild hogs and goats on Trindade in 1821, when Marryat noted the lack of undergrowth within the dead forest. Clearly, hungry goats kept the colubrinias from replacing themselves, and in that sense their coming brought the forest to an end. But goats could hardly have killed the older trees, nor could hogs have done so without baring roots to Marryat's scrutiny.

More than one of Trindade's visitors said the forest looked as if a plague had struck it, and perhaps one had. A fungus disease or insect infestation, started by a chance British or Portuguese introduction, could have passed through all the island's valleys in short order. This happened on Bermuda, a much larger area than Trindade, when scale insects brought in by accident in 1943 or thereabouts killed nine-tenths of the native cedars in ten years (54). The likelihood of an exotic pest's coming to Trindade was highest when Johnstone sent D'Auvergne to make a jewel of it. Captain Pasley's *Jupiter* went along from St. Helena as "a perfect Noah's Ark," bearing barnyard beasts and "all kinds of Trees to Plant and Grasses of every kind—Seeds both Cape and European without number and without name—Water Cresses, Sorrel, Water Dock, Purceland, Will'd Mint, Time—and the Lord knows what" (55). Though the Portuguese did not have Johnstone's Noah-impulse, their chance to loose a plague lasted longer. If a plague is to blame—that is, if *Colubrina glandulosa* var. *reitzii* succumbs easily to a pest of some kind—the weakness may show up where these trees serve for reforestation. As far as we know, mainland plantations have not yet had a pest problem.

A NEW NOTION

So far no one has proposed that Trindade's trees died of old age, but that is less absurd than it may seem. With goats eating all the undergrowth, the forest was bound to become geriatric. Marryat saw "thousands and thousands of trees . . . each of them about thirty feet high," and all seemed to have died simultaneously. His observations bring to mind the widespread death of ohia-lehua (*Metrosideros collina*) on the island of Hawaii. Foresters who first surveyed ohia dieback from the air thought it was the work of a newly brought in fungus, and they feared the native forest would be gone in 20 years. A thorough search, however, turned up no fungus or insect that could be the primary cause. Among those who have studied this puzzle most deeply are University of Hawaii botanist Dieter Mueller-Dombois and his students. Observing that dieback hits only the mature trees, Mueller-Dombois puts the blame on age and on normal ups and downs in growth conditions (56). In a poorly drained area, a root-flooding wet spell that is tolerable to young ohias can kill the old ones quickly, and a drier spell can kill the oldsters where the runoff is rapid: Mueller-Dombois's study areas include dieback sites of both kinds. After a dieback, young ohias grow with greater vigor. "The dieback thus has become a successful mechanism," Mueller-Dombois says, "to maintain an essentially shade-intolerant pioneer species as the structure-forming dominant in the course of primary succession." That sounds a lot like *Colubrina*.

If Hawaii's dieback is the right model for Trindade's desolation (57), a dry spell must have been the cause of death. Rainfall runs readily enough from the island's mountainsides, and the annual average may have been near the trees' lower limit to begin with. On the mainland, colubrinias grow where sun is bright and rain abundant (58). The *Flora Illustrada* of Santa Catarina, a Brazilian coastal state, has a map of *Colubrina* sites, which we compared with a map of Santa Catarina's rainfall distribution (59), and we

found all the sites get at least 1,300 millimeters a year. Trindade's weather station, set near sea level, now receives 800 millimeters or so (60). With green slopes to aid cloud formation, the valleys would have got more rain than that, but we doubt their wetness ever matched the wetness of the mainland's *Colubrina* stands.

To fit the ohia model, Trindade's colubrinias need not have had a drastic drop in rainfall: one of the drier stretches in an ordinary set of fluctuations would have been enough. As it happens, though, we have cause to conjecture that something extraordinary brought an extra dry spell. We said the death-year could have been 1816. That was "the year without a summer" in New England, with June snows and August frost in that region and bouts of record-breaking bad weather in parts of Europe, too (61). This nasty weather came a year after the eruption of Indonesia's Mount Tambora, the biggest blast of any kind in written history. Tambora discharged 100 cubic kilometers of debris (62), some of which stayed aloft, where, months later, it could still turn a part of the sun's heat away from the earth's surface. Murray Mitchell, a climatologist with the National Oceanic and Atmospheric Administration, explained in answer to our queries what this might have done to Trindade. As Tambora lies below the meteorological equator, its dust and droplets could have changed the weather in parts of the world's southern half as readily as in the north. Cooler surface waters near Trindade would have made for smaller shower clouds above the island and for reduced rainfall when the clouds dropped their moisture on the slopes.

The Tambora tale requires some heavy hedging. There are no long-range records to show that weather really cooled anywhere in lower latitudes—north or south—in 1816. Furthermore, there are those who doubt Tambora caused the year without a summer, and they give good reasons for their doubts (63). One counterargument: Volcanic dust-and-droplet veils do not have to keep solar radiation from the earth; much of it can scatter forward from the motes and reach the earth's surface indirectly. And temperatures reached record lows at some European and American weather stations, but not others. Why, the doubters ask, would a world-wide veil make bad weather only here and there? And if volcanic matter did make the bad weather, it may have come from more than one volcano, for there were other big blowups within a few years of Tambora's. To make things even more uncertain, temperatures seem to have been lower than usual in many places from 1810 to 1820, a decade that also had a low sunspot count. Thus, Tambora could have been just a help to a cooling trend starting from the sun. For all that, we like the thought that a pyrotechnic drama on the earth's other side could have finished off Trindade's forest. If it is not true, it is too good a lie to go untold.

To return to firmer ground: A dry spell for any reason suits our notion of the forest's death. Then, as now, Trindade's sometimes cloud-cloaked peaks were wetter than the valleys; consequently, colubrinias on the mountaintops could carry on when others perished. But keeping wet was not enough. Survivors had to keep away from goats as well; that is, their offspring had to do so. Maybe the beasts passed up a seedling now and then because, on the peaks, the colubrinias grew with woody plants of other kinds, some not tasty to a goat. Or perhaps the scant rewards a goat could get from browsing near the summit made roaming to the top a rare event. Anyhow it happened, we are grateful that the browsers missed a few and let us put away the *Caesalpinia* story with precision. That story started with a botanist and a bird man. It is fitting we should join to set it right (64).

NOTES AND REFERENCES

1. G. F. Simmons's "Sindbads of science," *National Geographic* 52:1-75 (1927), and R. H. Rockwell's "Southward through the doldrums," *Natural History* 32:424-436 (1932), have pictures taken on Trindade. See also Edward Wilson's lovely painting of Trindade before sunrise in his *Diary of the Discovery Expedition to the Antarctic Regions, 1901-1904*, Ann Savours, Ed. (Humanities Press, New York, 1967).
2. Rockwell (1), p. 434.
3. Aided by a grant from the National Geographic Society, Olson was on Trindade from December 18, 1975 to February 10, 1976. See his "Natural history of vertebrates on the Brazilian islands of the mid South Atlantic," *National Geographic Society Research Reports* 13:481-492 (1981).
4. For comments on the numbers and the tameness of Trindade's birds, see Rockwell (1) and M. J. Nicoll, *Three Voyages of a Naturalist* (Witherby, London, 1908). Both show photographs of birds on dead trees; see also the photo in (31), p. 431.
5. For more on wood and the way it is identified, see F. W. Jane, *The Structure of Wood*, ed. 2 revised by K. Wilson and D. J. B. White (Adam & Charles Black, London, 1970).
6. N. J. W. Thrower, Ed., *The Three Voyages of Edmond Halley in the Paramore, 1698-1701* (Hakluyt Society, ser. 2, vol. 156 and 157, London, 1981).
7. E. M. Peixoto, *Ilha da Trindade: Memoria Historica (Publicações do Arquivo Nacional vol. 28, xv + 667 p., Rio de Janeiro, 1932)*.
8. G. Rutherford, "Sidelights on Commodore Johnstone's expedition to the Cape," *Mariner's Mirror* 28:189-212, 290-308 (1942). V. T. Harlow, *The Foaming of the Second British Empire, 1763-1793*, vol. 1, *Discovery and Revolution* (Longmans, Green & Co., London, 1952). See p. 107-125, "The sea-route to India."
9. G. R. Balleine's *The Tragedy of Phillippe d'Auvergne, Vice-Admiral in the Royal Navy and Last Duke of Bouillon* (Phillimore, Chichester, 1973), tells of D'Auvergne's mission to Trindade and of his adventures before and after that. Britain's main link with French royalist guerillas during the Napoleonic wars, D'Auvergne was also heir by adoption to a rich duchy, but his attempts to claim it brought him to a destitute end.
10. T. Pasley, *Private Sea Joarnals, 1778-1782*, R. M. S. Pasley, Ed. (Dent, London & Toronto, 1931). D'Auvergne's decision is in the entry covering October 23-31, 1781.
11. Anonymous, "Biographical memoir of Philip d'Auvergne, Duke of Bouillon, Commodore in His Majesty's Service, &c. &c.," *Naval Chronicle* 13:169-191 (1805). Published to answer a detractor, this sketch seems to have got most of its information from its subject.
12. Peixoto (7), p. 418.
13. Balleine (9) wrongly has the *Bristol* come by accident. Her captain's report to the Admiralty makes it clear that she went to Trindade for the settlers (James Burney's in-letter of April 17, 1783, Public Record Office, London, file ADM 1/1504). Furthermore, the force from Rio carried orders right from London telling D'Auvergne and his group to leave without a struggle; see Peixoto (7), p. 37.
14. Peixoto (7), p. 470.
15. The leader of the troops from Rio was told early on to get "tudo o que pertence à Historia Natural": Peixoto (7), p. 403; Lobo (27), p. 118. But this was one order among many. If he did take specimens, nothing is known of them: P. de Assis Ribeiro, "Expedição à Ilha da Trindade," *Revista Brasileira de Geografia* 13:293-314 (1951), p. 304.
16. Balleine (9), p. 105.
17. C. J. Phipps (2nd Baron Mulgrave), *A Voyage towards the North Pole Undertaken by His Majesty's Command, 1773* (J. Nourse, London, 1774). The biographical sketch of 1805 (11) says D'Auvergne did the first drawings for all of Phipps's plates.
18. First published in 1787 and again with Pasley's *Journals* (10).
19. Pasley's (10) entries for September 27 and October 11, 1781.
20. "Cet officier était dans une telle crainte qu'on ne s'aperçût du misérable état de son gouvernement, qu'il ne voulut jamais permettre à M. de la Martinière et au père Receveur de s'éloigner du rivage pour herboriser." *Voyage de La Péroase aatoar du Monde*, L. A. Milet-Mureau, Ed. (Imprimerie de la République, Paris, 1797), vol. 2, entry for October 18, 1785. Lola Higuera of Madrid's Museo Naval told us after we had done our text that a Spanish voyage round the world stopped at Trindade, too: the

- Descubierta* and the *Atrevida*, under Alessandro Malaspina, paused to plot the isle's position on September 5 and 6, 1789, but no one went ashore.
21. J. Dumont d'Urville, *Voyage de la Corvette l'Astrolabe, Exécuté par Ordre du Roi, pendant les Années 1826-1827-1828-1829. Histoire du Voyage*, vol. 1 (Tastu, Paris, 1830). See p. 68-71 for Trindade.
 22. J. R. Andrade Ramos, "Expedição à Ilha da Trindade," *Revista da Escola de Minas* 15(6):5-14 (1950).
 23. L. de Castro Soares, "As ilhas oceânicas," p. 341-378 in *Brasil, a Terra e o Homem*, vol. 1, A. de Azevedo, Ed. (Companhia Editora Nacional, São Paulo, 1964). For Trindade's trees, p. 361.
 24. We used a 1934 printing of Knight's *Cruise of the "Alerte" in Search of Treasure* (Wm. Farquahar Payson, New York) and a 1914 printing of his *Cruise of the "Falcon"* (Longmans, London), wherein Knight told of an earlier, briefer visit to Trindade and showed an artist's rendering of the dead forest. From entries in *The National Union Catalog* we judge these works first came out in 1890 and 1884, respectively. For more on Knight, see his *Reminiscences* (Hutchinson, London, 1923). Knight did not say who at Kew had identified his wood; we learned that from C. R. Metcalfe of Kew's Jodrell Laboratory.
 25. Accordingly, H. N. Ridley repeated the assignment of Trindade's trees to *Eugenia* on p. 683 of his *Dispersal of Plants throughout the World* (Reeve, Ashford, 1930).
 26. International Association of Wood Anatomists, *IWA Bulletin* 2:51 (1981).
 27. The Jardim sent a collector to Trindade as early as World War I, when Brazilian forces occupied the isle. See B. Lobo, "Conferencia sobre a Ilha da Trindade," *Archivos do Museu Nacional do Rio de Janeiro* 22:107-158 (1919).
 28. M. C. Johnston, "Revision of *Colubrina* (Rhamnaceae)," *Brittonia* 23:2-53 (1971).
 29. J. Becker 28 from Museum National d'Histoire Naturelle, H. P. Veloso 387 from Instituto Oswaldo Cruz.
 30. S. Carlquist, "The biota of long-distance dispersal. III. Loss of dispersability in the Hawaiian flora," *Brittonia* 18:310-335 (1966).
 31. G. Murray, "The voyage southward of the *Discovery*. II. From Madeira to the Cape," *Geographical Journal* 19:423-435 (1902). Murray's first thought was that the trees might be ebony: *Wilson's Diary* (1), p. 52.
 32. We thank Keeper J. F. M. Cannon and his colleague J. Lewis for the prompt and thoughtful answer.
 33. G. Murray, "On *Boodlea*, a new genus of Siphonocladaceae," *Journal of the Linnean Society, Botany* 25:243-245; pl. 49 (1889).
 34. J. Britten, "George Robert Milne Murray (1858-1911)," *Journal of Botany, British and Foreign* 50:73-75 (1912).
 35. R. C. Murphy, "The bird life of Trinidad Islet," *Auk* 32:332-348 (1915).
 36. J. H. Holland, "Brazil-wood," *Royal Botanic Gardens, Kew. Bulletin of Miscellaneous Information* 9:209-225 (1916). See also (39).
 37. Law no. 6.607: J. H. Kirkbride, Universidade de Brasília, kindly sent a copy.
 38. R. C. Murphy, *Oceanic Birds of South America* (American Museum, New York, 1936), vol. 1, p. 173.
 39. C. Mainieri, *Estudo Macro e Microscópico de Madeiras Conhecidas por Pau Brasil* (Instituto de Pesquisas Tecnológicas Publicação no. 612, São Paulo, 1960).
 40. We read an edition titled *Frank Mildmay* (Macmillan, New York, 1897). The name of the novel's hero rose from subtitle to title in versions printed after 1834 or thereabouts. For more on Marryat, start with M.-P. Gautier's *Captain Frederick Marryat, l'Homme et l'Oeuvre* (Didier, Paris, 1973). There are three biographies in English, but the French one, being newest, has the fullest reading list.
 41. B. Harte, "Mr. Midshipman Breezy, a naval officer," in Harte's *Condensed Novels* (Literature House/Gregg Press, Upper Saddle River, 1969). J. Conrad, *Notes on Life & Letters* (Dent, London & Toronto, 1921). "Tales of the sea," p. 73-78, is Conrad's homage to Marryat and to James Fenimore Cooper. V. Woolf, *The Captain's Death Bed and Other Essays* (Hogarth, London, 1950).
 42. F. Marryat, "Descriptions of two new shells," *Transactions of the Linnean Society of London* 12:338-339; tab. 10 (1818). Smithsonian malacologist J. Rosewater told us how the taxa fared.
 43. Florence Marryat, *Life and Letters of Captain Marryat*, 2 vol. (Bentley, London, 1872).
 44. Summarized by P. T. X. de Brito in "Memoria historica e geographica da Ilha da Trindade," *Revista Trimensal do Instituto Historico, Geographico e Ethnographico do Brasil* 40(2):249-275; 5 pl. (1877).
 45. We thank M. R. Edwards, Public Record Office; R. W. Jones, Post Office Archives; R. J. B. Knight, National Maritime Museum; M. Meaden, India Office Records.
 46. Peixoto (7), following p. 4. Four views of Trindade drawn when the map was made also seem to show forested slopes. See Brito's (44) final plate.
 47. Peixoto (7), p. 414.

48. Printed by E. G. House for the author, Boston, 1817; reprinted by Praeger, 1970. See p. 424–425.
49. R. McCormick, *Voyages of Discovery in Arctic and Antarctic Seas* (Sampson Low, Marston, Searle & Rivington, London, 1884), vol. 1, p. 24.
50. The Coast and Geodetic Survey map of 1856 and the 1870 census of Monroe County and the Keys use "Umbrella Key" for what is now Windley. Finding that out was not easy. For help with the "digging," we thank Karen Achor, G. N. Avery, C. M. Brookfield, Bill Ford, Wright Langley, Nixon Smiley, W. L. Stern, Alexander Sprunt, Dan Ward, H. S. Zim, and especially librarians Betty Bruce, Key West, and Becky Smith, Miami.
51. F. F. M. de Almeida, *Geologia e Petrologia da Ilha da Trindade*, Departamento Nacional da Produção Mineral, Divisão de Geologia e Mineralogia, Monografia 18 (1961).
52. Peixoto (7), p. 422.
53. Peixoto (7), p. 428.
54. D. Challinor and D. B. Wingate, "The struggle for survival of the Bermuda cedar," *Biological Conservation* 3:220–222 (1972). C. Nolan, "Loss of a treescape—a report from Bermuda," *Quarterly Journal of Forestry* 74:165–176 (1980).
55. Pasley (10), entry for September 27, 1781.
56. D. Mueller-Dombois, "The 'ōhi'a dieback phenomenon in the Hawaiian rain forest," p. 153–161 in *The Recovery Process in Damaged Ecosystems*, J. Cairns, Jr., Ed. (Ann Arbor Science, Ann Arbor, 1980).
57. A. Cronquist pointed out to us that the model works better if Trindade's trees were short-lived, that is, if trees big enough to escape goats were bound to go overage within the thirty years or so between the 1780s and the 1810s. We have seen no figures on trees on the Trindade kind. As a rule among trees of the tropics, though, fast-growing pioneers do have short lives: P. W. Richards, *The Tropical Rain Forest* (Cambridge University Press, 1952).
58. R. M. Klein's ecological remarks in M. C. Johnston and M. A. de Freitas Soares, *Flora Ilustrada Catarinense: Ramnáceas* (Itajaí, 1972).
59. Departamento Estadual de Geografia e Cartografia, *Atlas Geográfico de Santa Catarina* (I. B. G. E., Conselho Nacional de Geografia, Directório Regional de Santa Catarina, 1958).
60. S. Serebrenick, unpublished: see Castro Soares (23), p. 362.
61. H. Stommel and E. Stommel, "The year without a summer," *Scientific American* 240(6):176–186 (1979).
62. T. Simkin, L. Siebert, L. McClelland, D. Bridge, C. Newhall, and J. H. Latter, *Volcanoes of the World* (Hutchinson Ross, Stroudsburg, 1981). See also W. A. Petroeschevsky, "A contribution to the knowledge of the Gunung Tambora (Sumbawa)," *Tijdschrift van het Koninklijk Nederlandsch Aardrijkskundig Genootschap* 66:688–703 (1949).
63. H. E. Landsberg and J. M. Albert, "The summer of 1816 and volcanism," *Weatherwise* 27:63–66 (1974). S. Self and M. R. Rampino, letter, *Scientific American* 241(4): 10 (1979).
64. Earlier writings on Trindade have drawn on British or Brazilian sources, not both. We could use both because we had help: Ann Shirley, National Maritime Museum, put us onto Balleine's book (9), and Max Justo Guedes, Serviço de Documentação Geral da Marinha, gave us Peixoto (7). Some others who helped are named in the text and in the foregoing notes. We also thank Manoel Cardozo, David Cutler, M. C. Johnston, Philip Lundeberg, Regis Miller, Carmen A. Pérez, M. R. Rampino, T. Simkin, Lyman Smith, Norman Thrower, Wilcomb Washburn, S. Yankowski.