Part II

What are Novel Ecosystems?

Chapter 2

CASE STUDY: HOLE-IN-THE-DONUT, EVERGLADES

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In the early 1900s, farmers in South Florida, USA, found an isolated area of wetlands (Fig. 2.1, upper panel) that had a sufficiently long dry season and deep enough soils to make vegetable farming worthwhile. Farmers liked the isolation of the site, removed as it was from the pest loads of surrounding fields. Furthermore, the risk of crop lost to frost was very much reduced in this warmest of continental US climates. This area, which later came to be known as the Hole-in-the-Donut, covered several thousand hectares. Farming there greatly expanded in two bursts following initial colonization. One expansion was triggered by the completion of a road to the nearest town in 1915; the second came after World War II when crawler tractors and heavy plows capable of crushing limestone and mixing it with the thin layer of marl soil on its surface created a deeper, better-aerated soil. This rock plowing of nearly 2400 hectares, plus the original area of deeper soils, together made commercial agriculture a lucrative enterprise on some 4000 hectares.

In 1947 Everglades National Park was inaugurated, and today more than 370,000 hectares of land lie within its boundaries. The park completely surrounded the agricultural lands, giving rise to the sobriquet Hole-in-the-Donut: the doughnut was the park and the hole the farmland. Not surprisingly, the accouterments of intensive agriculture (fertilizers, aerial application of pesticides, heavy equipment) were not welcomed by the park. Under threat of condemnation, the farmers sold their lands to the government in the early 1970s. At that point it was still a donut, but the hole was now abandoned soil, much of it rock-plowed, to which fertilizer had been applied for decades. Every weed in South Florida found it to be a great place to grow.

Schinus terebinthifolius (Brazilian pepper or Christmas berry) is an alien tree species that has been present in South Florida as an ornamental since the mid-1800s, but was so inconspicuous in the wild that it went unmentioned in major ecological surveys conducted in the 1940s and 1950s. It proved, however, to be exceptionally well suited to the former agricultural lands in the Hole-in-the-Donut, forming long-lived thickets of tangled stems that were almost impenetrable (Fig. 2.1, lower panel). By the late 1970s, park biologists realized that in buying out the farmers, they had traded one problem for another. *Schinus* not only transformed the viewscape from wet prairie to woodland, but it began to invade adjacent unplowed ecosystems (especially pine-dominated rocklands) despite attempts to exclude it with prescribed fire.

At that time I was invited to conduct research in the Hole-in-the-Donut with the objective of helping the park staff contain *Schinus* and consider ways to restore the Hole-in-the-Donut to some semblance of its former self. My colleagues and I worked in the Hole-in-the-Donut for four years, and the more we learned about the environment and about *Schinus*, the more intractable the problem seemed. *Schinus* is obligately

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Figure 2.1 Upper panel: native wet prairie vegetation growing on shallow marl overlying pitted limestone (inset). Lower panel: following rock plowing and subsequent cessation of agriculture, a novel forest dominated by the invasive introduced tree (*Schinus terebinthefolius*) but containing many other species, both native and introduced, developed on the rock-plowed soils (inset). This anthrosol is well aerated, supports mycorrhizae, contains residual phosphorus and has developed a surface horizon high in organic matter.

mycorrhizal, thus able to take advantage of the deep well-aerated anthrosol; it was pollinated by native insects and dispersed by native birds and mammals; and its southern hemisphere reproductive phenology landed it in a regeneration niche six months out of phase with native competitors. In short, *Schinus* was right at home in the Hole-in-the-Donut and, unlike farmers, the threat of condemnation did not faze it.

Post-agriculture vegetation in the Hole-in-the-Donut was undeniably lush, and the plant life fueled substantial animal life. Clouds of tree swallows gorged on vast quantities of fruits off the native wax myrtle bushes that formed monospecific stands in some places. Raccoons were extremely abundant and, in fact, were important long-distance dispersers of *Schinus* seed. Deer were sighted frequently. Although this was at a time when the number of surviving Florida panthers was at its nadir (in the low 20s), panther sightings were not uncommon in the Hole-in-the-Donut. Whether this was due to the abundance of food (raccoons, deer, etc.), as was common lore around the Research Center (but unsubstantiated by data), or whether it was due to great visibility on two long lightly traveled, elevated farm roads that ran east–west for miles and were the highest ground around, is unknown. But there were frequent panther sightings: that is certain. The Hole-in-the-Donut now supported a truly novel ecosystem composed of a mix of plant species including many aliens; it housed abundant bird and mammal life, not to mention mosquitoes in clouds so thick that we bought military-strength DEET by the case; and it occupied an anthrosol later conferred its own Soil Series name by the US Department of Agriculture.

Toward the end of my research tenure in the park, I was asked to participate in a meeting convened among park biologists, scientists, resource managers and administrators. We were joined by administrative staff from higher in the park service bureaucracy who flew in from Atlanta. I was asked: "Jack, what should we do about this *Schinus* problem?" I briefly related how our recent soil studies had revealed high concentrations of residual phosphorus (presumably from fertilizer) and described graduate student Chip Meador's findings on the positive mycorrhizal status of all those weeds, including *Schinus*, in what had been essentially a non-mycorrhizal ecosystem prior to rock plowing. Tongue-in-cheek, I made the remark that "The only way to restore the native wet prairies would be to come in here with bulldozers and cart that anthrosol out of the Hole-in-the-Donut." I then turned back to business and went on at length to summarize what we had learned about the ecology and life history of *Schinus* that made it so well suited to these former farmlands. Recognizing the futility of past blunt-force efforts (Fig. 2.2), I described what I thought at the time might be a promising approach to convert *Schinus* forests to native-species dominance. The recommended tactic consisted of killing all the females of this dioecious tree species and leaving the males in place to act as a nurse crop for native species, which we had observed reproducing in the understory. (Our t-shirts were to have said "Kill the Mothers!") With time, presumably the *Schinus* would die out – the males of old age and the females from triclopyr toxicity – and native species would take over.

Slogging around in a mosquito-filled *Schinus* tangle with a backpack sprayer and trying to get a ring of herbicide around each stem of a ten-trunked tree is slow-going work, even if you can find someone willing to do it. It is to the park's credit that they tried single-tree herbicide treatments, and it is not surprising that it was a flop. In subsequent years a number of approaches to restoration were undertaken, but only one of them gave promise of success at large scale. In 1997, 17 years after that meeting in the Research Center, word reached me that the park was undertaking Hole-in-the-Donut restoration by removing the anthrosol. I was incredulous.

That dramatic action reflected the thinking of the time: invasive exotics were to be controlled at all costs. In the Hole-in-the-Donut, this continues to be the story today. Heavy machinery is used to scrape up the rock-plowed soil, which is loaded onto big dump trucks and stockpiled in low mounds in the Hole-in-the-Donut (Fig. 2.3). The operation is clearly visible on Google Earth (longitude 80° 40′ 30″ W; latitude 25° 22′ 40″ N) and work has been completed on more than 1700 hectares (about two-thirds of the land authorized for treatment). More than $3 \times 10^6 m^3$ of soil have been moved; if piled on an American football field, the resulting mound would be a rectangular column reaching 628 m (about six times taller than the highest hill in the state). Native plants are again reclaiming the Hole-in-the-Donut, and the prairie viewscape is being restored (Fig. 2.4). The new substrate is not a twin of the original; it is relatively smooth and solid whereas the original limestone was rugged and pitted, containing pockets of marl and organic matter.

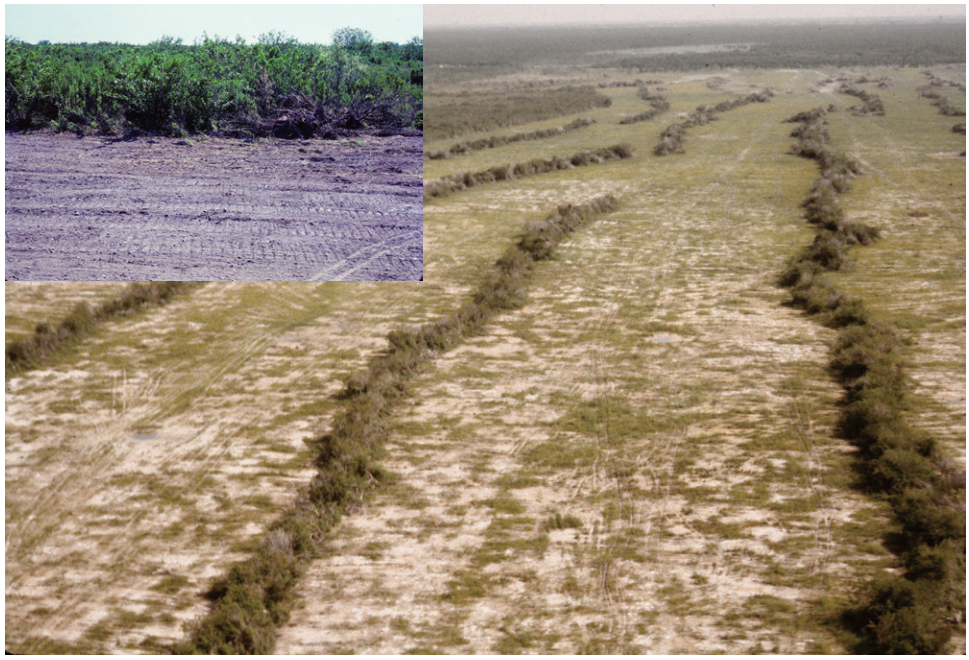

Figure 2.2 In the mid-1970s some of the *Schinus*-dominated vegetation was bulldozed into windrows, but this did not affect restoration on most sites. The novel ecosystem rebounded quickly, as the anthrosol remained even though the plants were piled and burned.

Figure 2.3 In the mid-1990s the decision was made to remove the anthrosol. The process, still underway, consists of: (a) cutting the vegetation; (b) loading the debris and soil; (c) hauling the material to local repositories within the Hole-in-the-Donut; and finally (d) scraping the remaining soil off the underlying limestone base rock. Photographs courtesy of Everglades National Park.

Figure 2.4 Vegetation that develops after soil removal resembles that of the original wetland and is maintained by prescribed fire. Photograph by Todd Osborne, courtesy of Everglades National Park and the photographer.

And what of the elusive panther? It would be a tragedy indeed if I reported that the last of Florida's panthers was scared out of the Hole-in-the-Donut by earth movers, to die of starvation, mosquito bites and collisions with automobiles. Happily, that is not the case. After much study, consultation and public debate, authorities made the decision in the mid-1990s to give the handful of remaining panthers a genetic boost by introducing eight Texan females. The genotype was sacrificed for the phenotype, but there are now more than 120 panthers in Florida. Our State Mammal is a novel hybrid.

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