Tropical Seagrass Restoration

Restorationists are venturing out into the nearshore sea to restore underwater meadows ruined by dredging, filling, and pollution.

As my host, Robin Lewis, and I got out of the water and removed our snorkeling gear at Lake Surprise in the Florida Keys, the sky grew even darker, the rain began in earnest, and I became lunch for a group of bloodthirsty mosquitoes. At least thunderstorms and mosquitoes were familiar to me from my work on prairie and oak savanna restoration in the upper Midwest. But as the cars sped by us on U.S. Route 1, I couldn't think of much else that reminded me of home and prairie, with its beautiful forbs and grasses waving in the wind, the colors bright in the Midwestern summer sun. As the thunderstorm and my itching continued, it seemed to me that my editor could have picked a better restored community for me to visit on my way home from Costa Rica. These seagrasses didn't have much to offer compared to prairies (or Costa Rican beaches, for that matter)—no beautiful colors, only one or two species of slime-covered grasslike plants, and to look at this green shag carpeting you had to go underwater and risk who knows what. That was my introduction to seagrass restoration, and this is a Midwesterner's view of a million-dollar business in Florida. I had a lot to learn.

To start with, what are seagrasses anyway? It turns out that they are true, monocotyledonous angiosperms, but with an important difference: they have returned to the sea and complete their entire life cycle submerged in sea water. There are about 50 species of seagrasses in the world in twelve genera distributed between two families, the Potamogetonaceae and the Hydrocharitaceae. They grow at almost every latitude except the very northern Arctic and the Antarctic, but only in shallow water, typically one to 15 m and rarely more than 45 m deep—the zone referred to as the "nearshore sea." This means that as people extend their influence away from land and into the sea, the first plants they encounter and affect are likely to be seagrasses.

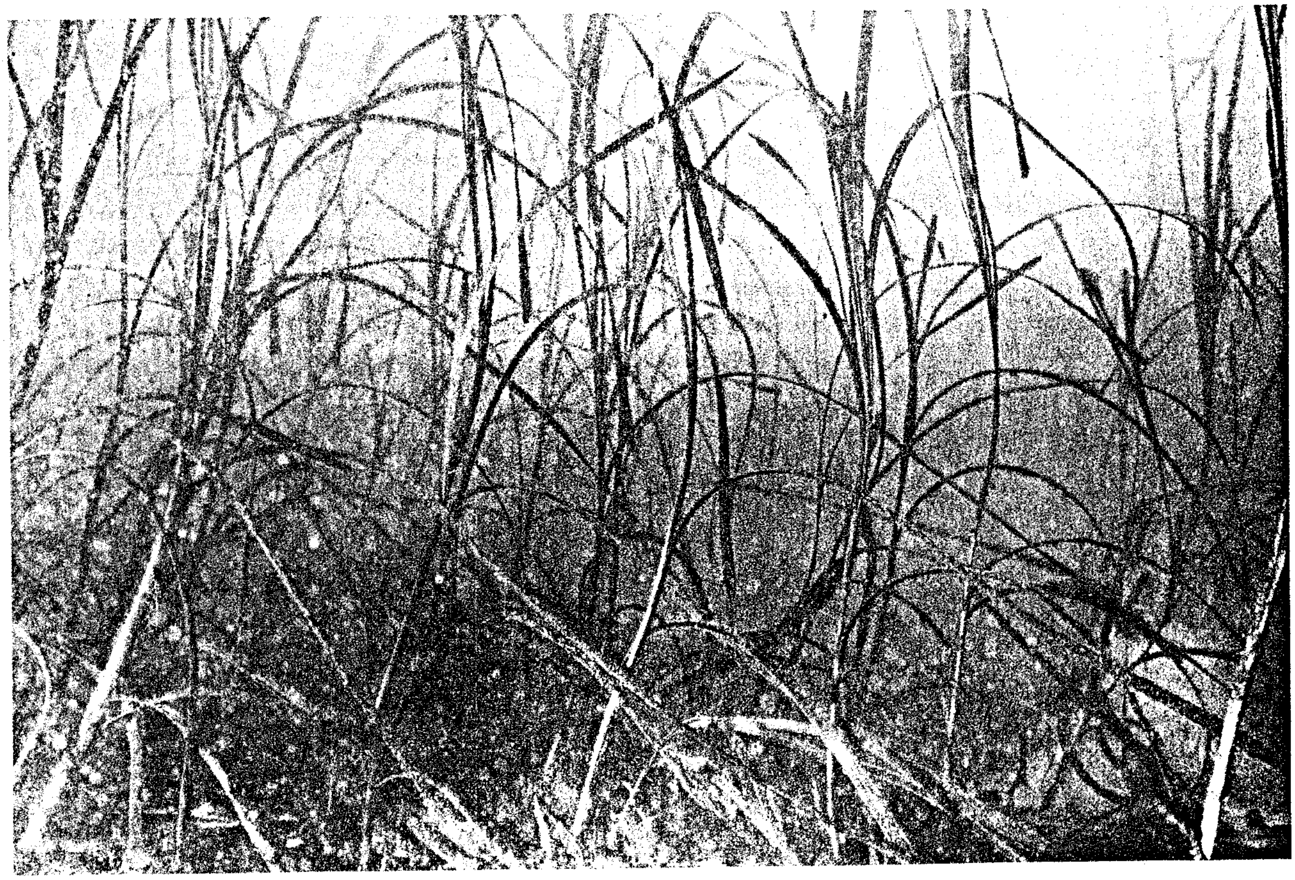
In sharp contrast to prairies, which have many species of grasses and forbs, seagrass communities in general are monotypic meadows, sometimes extending for miles. In southern Florida, for example, there are just six species of seagrasses, three of which are most commonly used in restorations: turtle grass, *Thalassia testudinum*, manatee grass, *Syringodium filiforme*, and shoal grass, *Halodule wrightii*. Turtle grass, the largest of these three and named for the great sea turtles that feed on it, usually forms monospecific meadows but sometimes mixes with manatee grass. Shoal grass, an early colonizer, grows in disturbed areas where other seagrasses cannot get started—in very deep or very shallow water, in areas with little sedimentation, or in water that varies in temperature or salinity. Manatee grass can associate with both of the other two but rarely occurs in extensive monotypic beds.

The prairies have provided some of the most productive soils in the world, like the rich, black soils of the Plains and the Midwest. But these extensive monocultures of seagrasses—what could they possibly produce? That was a question I had asked Ronald Phillips of Seattle Pacific University, referred to as Mr. Seagrass by a colleague. He had told me over the phone, "They're the basis of the entire nearshore marine chain." And further inquiry has reinforced that statement.

The seagrass systems, especially tropical seagrass beds, are among the most highly productive on Earth, producing as much as 500 to 1000 (some say 2000) grams of carbon per square meter per year, a figure that is comparable to that for tropical agricultural systems, but which seagrasses achieve without fertilizers or pesticides. The really interesting thing about all of this productivity is that most of what is produced is *not* eaten directly. The best estimates indicate that only about 5 percent is consumed by herbivores such as geese, ducks, and swans in accessible boreal and cool temperate beds, and sea turtles, parrotfish, sea urchins, and manatees in tropical beds. Some of the rest is exported from the system, while possibly as much as 70 percent enters the nearshore food chains as detritus. Even in this form, though, seagrasses may not be consumed directly. Typical detritus consumers such as invertebrates may actually be consuming the bacteria that use the detritus.

Even though most of the incredibly large seagrass "crop" is not consumed directly, seagrasses serve other functions in the nearshore marine ecosystem. For instance, seagrass beds provide shelter and feeding grounds for many creatures. In general, these animals are small but certainly not insignificant. All sorts of epiphytic organisms live on seagrass leaves, sometimes with a biomass that equals that of the leaves themselves, and these are consumed by other marine animals such as oysters in temperate areas and sea urchins, queen conchs, and starfish in the tropics. The sediment associated with the seagrass bed is home for other bacteria and algae. Some fish spend their entire lives in seagrass beds, but most of the commercially valuable fish are temporary residents, visiting the beds either diurnally, seasonally, or while young. Many human food favorites such as scallops, shrimp, lobsters, and groupers, to name just a few, spend part or all of their life in seagrass beds and depend on them directly for shelter and indirectly for food. Seagrass meadows also concentrate food sources for birds such as herons, egrets, spoonbills, cormorants, and pelicans.

Two other important functions of the beds are related to each other. Seagrass leaves, acting as baffles, slow down the current and reduce turbulence, allowing sediment to drop and accumulate. Seagrass roots and rhizomes then bind the sediments and thus reduce bottom erosion.



Bed of Zostera marina.

So, what looked to me like underwater monotony turns out to be an especially productive and diverse ecosystem: my initial estimation was the underwater counterpart of not seeing the forest for the trees—or the prairie for the grasses. In contrast to prairies, though, where the disappearance of one species may alter the species composition and relative species abundances within the community, the elimination of the seagrasses from a nearshore ecosystem means the elimination of the entire system. This was all too well shown by the virtual elimination of eelgrass (*Zostera marina*) along the Atlantic coasts of both Europe and North America following an epidemic known as the wasting disease (at first thought to be caused by fungi but more recently thought to be related to long-term change in the water temperature) during the 1930s, and along with it the almost complete destruction of the associated fauna.

It was this problem, faced by scientists a half-century ago, that led to some of the first seagrass restoration efforts, work that Ron Phillips told me ended in about 1935. During the 1940s there was also some monitoring of seagrasses, and some restoration was reported by C.E. Addy in Massachusetts, but Phillips told me that when he came to Florida as an algologist for the former State Board of Conservation in 1957, no one was doing any restoration at all. So, how did an algologist schooled at the University of Michigan get involved with seagrasses? "I was told that if I wanted to keep my job as an algologist, I would have to work on seagrasses, and I needed the job," Phillips told me. So he got working on seagrasses and became "the first one doing this new line of work."

At first, using an approach similar to that used by early restorers of terrestrial prairies, he tried laying sods of turtle grass and shoal grass in Tampa Bay to restore areas damaged by dredging. By 1964, though, Phillips had begun using seagrass restoration as a means for doing basic research. Using the standard garden or reciprocal transplanting technique, Phillips and others transplanted species of seagrasses from a variety of latitudes and from different habitats within the same latitude into a common garden where local species, serving as controls, were also transplanted. In this way Phillips answered a number of important ecological questions. He was able to determine the adaptive tolerances of different species of seagrasses, the amount of intraspecific variation, and which species are best able to grow under stress. In Puget Sound, for example, Phillips found five ecotypes of eelgrass, all adapted to specific environments. This was

Photo courtesy of Mangrove Systems, Inc.

Rare—and even more rarely photographed—flower of turtlegrass.

basic information of obvious value for restorationists, and of course in carrying out this basic genetic and ecological research, Phillips was also testing various transplanting techniques and was identifying species and ecotypes that could be used in restoration work under various conditions.

In the meantime, other researchers were becoming more interested in seagrasses—it was a "worldwide phenomenon," Phillips recalled. In 1973 Peter McRoy of the University of Alaska organized the International Seagrass Workshop in Leiden, The Netherlands, which brought together 37 scientists from eleven countries. The meeting embodied this renewed interest in seagrasses in general and in their restoration in particular, and marked the beginning of a new era in seagrass science.

Phillips, now professor of biology at Seattle Pacific University, continues the seagrass research work he started in Florida, but he now has plenty of company, since others have taken up seagrass restoration for both scientific and business purposes.

One of the most well-known is Anitra Thorhaug, one of the first women to receive a Ph.D. in marine biology from the University of Miami. A competitive person with a flair for the dramatic (she served as consultant to Christo during the design of his 1983 art work, "Surrounded Islands," in which he encircled eleven spoil islands off the coast of Florida with pink fabric), she operates out of her Key Biscayne business office, Applied Marine Ecological Services, Inc. She also maintains her position as research professor at Florida International University. Her work has taken her all over the world—to Israel, China, Jamaica, New Guinea, and, most recently, the Philippines—and she has compiled an impressive list of activities including work for the United Nations Fisheries and Agriculture Organization and the Greater Caribbean Energy and Environment Foundation.

Thorhaug was in the Philippines during my visit to Florida in October, but I caught up with her by phone at her Key Biscayne office in December. Her first work with seagrass restoration, which she called "an infant in respect to all other restoration," began in the early 1970s with a successful restoration at Turkey Point on Biscayne Bay, where an approximately 9-ha bed of turtle grass had been destroyed by hot water discharge from a power plant. Speaking of everyone's early efforts, Thorhaug told me, "There were lots of failures, especially at the beginning." This work was "restoration under the most difficult circumstances." "Marsh people really admire us because it's a very different medium in which to restore. There were times when I never saw what I planted; we planted by braille."

As with prairie restoration, there are several forms of plant material that can be used, including plugs, which are entire plants with the sediment attached; turions, which are rhizomes and shoots with no sediment; shoots; seeds; and of course Phillips's sod method. Obviously some of these planting methods require anchoring the propagules in some way in order to keep them from floating or being washed away.

Working in tropical waters with the sun beating down on your back and Key Lime pie waiting at the end of the day sounds like heaven to a pale midwestern restorationist used to facing short days and −60°F wind-chill factors for three months of the year (and sometimes more), but the reality of planting seagrasses, whether as plugs, sods, shoots, or turions, is back-breaking work—digging holes, anchoring turions, placing sods. In deeper water, of course, scuba divers or snorkelers, feeling somewhat weightless, may do less bending, but, as Thorhaug said, these are actually the most difficult circumstances, especially if the water is polluted or turbulent. And don't think that this is the underwater version of Mr. Rogers' Neighborhood. At the very least there are little stinging jellyfish (to which I can attest), and sharks forced one seagrass restorationist to pull his divers out of the water and to finish planting the project by throwing plugs over the side of the boat.

All of these methods were tried during the 1960s and 1970s—with varying results. Although Thorhaug reported success using seeds, other restorationists had no luck with them, and by the early 1980s it appeared that the use of plugs or sods was the only method that worked consistently for a variety of seagrass species.

Another person who has become involved in seagrass restoration is Roy R. (Robin) Lewis III, the president of Mangrove Systems, Inc. of Tampa, who introduced me to the world of seagrasses during my visit to Florida. A more recent entrant (competitive entrepreneur, as Thorhaug referred to him) into the restoration business, Lewis taught biology at Hillsborough Community College in Tampa before becoming an environmental consultant. (See accompanying story.) His first large-scale seagrass work, a project sponsored by the Florida Department of Transportation, was carried out with Ron Phillips at Craig Key in 1979. It was designed to analyze various transplantation methods in order to advise the DOT, which was involved in mitigation work to replace seagrass beds destroyed when the 37 bridges linking the

Florida Keys were replaced. As we surveyed this project, squinting in the bright sunlight, Lewis explained the results: "Craig Key was a learning process. Some of the plantings didn't work, but it wasn't a sediment problem. I think it may be related to the fact that Craig Key sat there for 30 years and the invertebrates colonized it first, so then the seagrasses couldn't get a foothold. Plugs worked; turions didn't. It's a learning process."

Moreover, the use of plugs and sods had serious drawbacks, both economically and ecologically. Cost estimates for the plug technique in the Craig Key project were between $27,000 and $86,500/ha. Using laboratory-cultivated seedlings in this same project raised the figure to $182,900/ha. Thorhaug's first project at Turkey Point cost somewhere in the vicinity of $41,000/ha. More recently she has estimated costs to run between $9,400 and $20,000/ha.

The ecological costs were high, too. Consider the source of sods, plugs, and turions in most cases: existing, healthy seagrass beds. Although shoal grass and manatee grass beds did not seem to suffer permanent damage from collecting, there was evidence that turtle grass donor meadows were slow to recover from this disturbance, an observation that led some restorationists to make a special effort to use beds scheduled for destruction as sources of transplants.

In addition to these costs, the success of seagrass restoration has not been without question. J.C. Zieman, a professor of environmental sciences at the University of Virginia who has been studying seagrasses for more than 15 years, told me over the phone that seagrass restoration is "still a dicey business; it's far more art than science." Zieman also stresses the importance of basic research for the development of restoration techniques. Too many agencies, he says, want a quick fix, but are not willing to pay for the research needed to determine why some projects work and some don't.

Michael Nagy, environmental supervisor of the dredge and fill permitting section of the Florida Department of Environmental Regulation, agreed with Zieman's assessment. "Seagrass restoration results have been mixed," he said. "Some projects have worked; some haven't. But it's hard to talk about it without talking about where it was done—the site. It's also hard to tell why [a project has not worked] because no one's done a qualitative analysis of site quality." He told me that because of the unreliability of the technique, few permits for mitigation of seagrass beds are issued by the Department. Only public works projects such as the Port of Miami or the DOT's bridge replacements, where there are no alternatives, receive permits. "There are not a lot [of permits issued] because basically it's not looked upon favorably to impact seagrass beds because they are so fragile, so productive, and so important," Nagy explained. "To sum it up, seagrass restoration is an unproven technology at this point; it's highly experimental."

Others would agree with that, especially the Port of Miami. It hired Thorhaug to restore 100 ha in Biscayne Bay—a mitigation project required in exchange for port

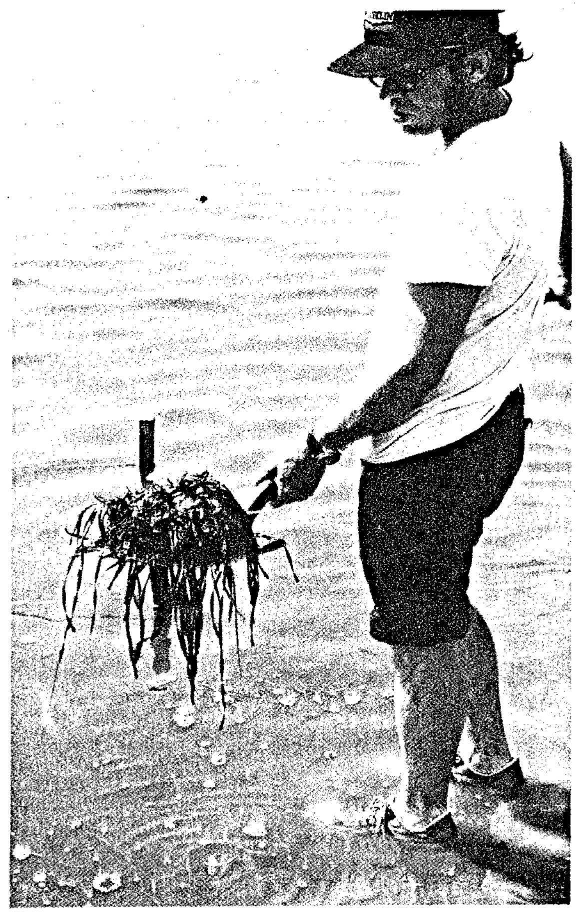


Photo courtesy of Ron Phillips

Worker hefts forkful of Thalassia *on site near Port Aransas, Texas.*

development. In 1982 she planted 15 ha; 2.5 were successful. And the price tag for this was $781,245. This situation led to quite a controversy, one that continues today.

These high costs of acquiring or producing, transporting, and planting large numbers of plants, together with the ecological costs of gathering plants from donor beds have led both Thorhaug and Lewis to investigate more seriously the use of seeds, which are difficult to locate and to grow. The major problem is that seed production by seagrasses is fairly unreliable. In fact, flowers and seeds of some species have never been found or are so rarely found that leaf morphology and other vegetative characters have traditionally been used to distinguish species. During the 1970s, however, Thorhaug found a turtle grass bed in the Caribbean that fruited reliably and used it as a source of seeds for some of her large-scale restorations, keeping its location a trade secret. These seeds were shipped back to Florida in special tanks and used in two ways: some were direct-seeded, and others were grown for transplanting using a laboratory method she developed—another trade secret, since most researchers and restorationists have had problems with indoor cultivation.

"Seeds are not an unviable technique; it's very dependent on the species of seagrass," Thorhaug told me. Despite evidence from Phillips's studies for the existence of numerous ecotypes of seagrass species, Thorhaug is not troubled by the use of seed collected far from the restoration site. Her own tests of seeds from all parts of the Caribbean during the 1960s and 1970s, to determine the sensitivity of seagrasses to pollution, indicated that they were physiologically similar. Moreover, Thorhaug pointed out that "because the current transports seeds, especially in the Caribbean, this argues for the same gene pool within the Caribbean, rather than a localized gene pool."

In the meantime Lewis and Philips, while doing their Craig Key experimental work in 1979, happened across huge numbers of turtle grass seeds and seedlings, washed ashore along a beach. In one half-kilometer stretch they gathered 37,000 seeds and seedlings, which they immediately recognized as a salvageable "unused resource." They published their discovery, and since then Lewis, Thorhaug, and others have collected seed for restoration projects there and at other southern Florida beaches. Thorhaug now resorts to her Bahamian seed only when she runs out of Florida seed.

During my October visit with Lewis we spent two days touring some of his restoration sites along the Florida Keys. The first one we toured via snorkeling was the mosquito-blessed Lake Surprise—so named, the story goes, because the surveyors were surprised to find it there. Here Lewis was hired to restore a 2-ha seagrass bed that had been destroyed by the laying of an aquaduct built to transport fresh water to the Keys. This mitigation project was done by the construction company under the supervision of the Florida Department of Environmental Regulation.

As we approached Lake Surprise, Lewis talked about mangrove restoration, the first community he restored, and we stopped along the highway so I could see for myself the different species of mangroves along U.S. 1. He applied his philosophy that restoration should mimic natural succession—"compressed succession" as he calls it—to his work with mangroves and to the seagrass restoration at Lake Surprise. As the rain spattered the car windows, he explained his seagrass restoration methods there: "We first put in *Halodule,* which produces long aerial runners—a nondestructive source of plant material—anchored with steel staples. Then we broadcast *Thalassia* seedlings. There was no wave energy to wash these out. It worked like a charm."

As we snorkeled through the project, I was impressed with the lush growth of seagrasses along the lake bottom. To me this restored area looked just like the undisturbed adjacent turtle grass bed. Lewis also pointed out areas where seagrasses from the undisturbed beds of shoal grass and turtle grass had naturally invaded the restoration site.

We swam back to the shore and piled our gear, sea water and all, into the trunk of the car. As we continued southwest along U.S. 1 towards Marathon, I asked what I thought was an obvious question: If seagrasses from adjacent beds can invade disturbed areas naturally, wouldn't Lake Surprise have restored itself eventually? And if so, why plant at all? Lewis's answer: "Politics and cosmetics as opposed to reality. . . . If (that area) had not been restored, it probably would have come back. But we don't know how much we speeded up the process."

Politics and cosmetics. Is that why seagrass restoration is being done? Most of the projects I saw were required under federal or state mitigation laws. Lewis sees mitigation as the impetus behind the development of seagrass restoration techniques and points out that this technology was "not paid for by government research funds, but by phosphate companies and developers, for instance," at least in Florida. But Lewis sees a problem with mitigation in that this "tradeoff has the potential for being abused." In other words, developers, industry, and government agencies may see no problem with the destruction of native ecological communities if it is taken for granted that they can easily be restored.

Thorhaug agrees that federal, and sometimes state coastal zone laws requiring mitigation have allowed for the testing of seagrass restoration technology. But she argues that seagrass restoration is cost effective, not only for industries such as fisheries that are dependent on seagrass beds, but for other businesses as well. Consider, for example, the building of a sewage pipeline. The shortest route would be the cheapest, but if that route were through a seagrass bed, and if techniques were not available to restore it, a longer, more expensive route would be required. Hence, seagrass restoration may pay, even if it is costly. Referring especially to her work in Jamaica and the Philippines, Thorhaug told me, "Once you teach people who care that you can restore, there's no economic conflict about restoring seagrasses."

Phillips thinks that Lewis's insight about speeding up the recovery process through restoration is the most important reason for restoration. Shortening the time that these areas are bare and open to erosion of bottom sediments is vitally important. So, although mitigation may require restoration, and the public may clamor for revegetation of an eyesore caused by construction, Phillips maintains that there is more to seagrass restoration. "It's not just a political mechanism, and not just for cosmetics," he told me. "The reason behind restoration is to restore the functions—sediment stabilization, generation of nearshore food chains."

Just how long natural recovery would take varies with the type of damage and the species, but it seems to be a slow process. Power boat propeller cuts, the smallest disturbances noted by researchers, take from two to five years to recolonize. Recovery from other, more extensive disturbances can take decades. The Craig Key project took place in an area that was still 25 percent barren after 30 years. Thorhaug has worked on sites still devoid of

Task of pinning together bits of seagrass for planting in Biscayne Bay exemplifies the meticulous, labor-intensive nature of seagrass restoration work. Mixed results in the early phase of this project, carried out as part of an environmental mitigation effort following disturbance of 100 ha of bay bottom, led to considerable controversy, but restorationists continue to exercise ingenuity to refine techniques.

seagrass invasion after 50 years. And the natural recovery of the temperate seagrass, eelgrass, following the wasting disease epidemic of the 1930s required 30 to 40 years in some areas.

Whether or not mitigation regulations compel restoration or private industry decides that it is cost-effective, there is still plenty of restoration work to be done, considering the vast losses of seagrass beds that took place during the years before regulations and permitting requirements took effect. One researcher estimates that 33 percent of seagrass acreage that existed in Florida before World War II has been destroyed. Lewis calculates that 81 percent of Tampa Bay's presettlement seagrasses are gone; another researcher found a 66 percent reduction in Christiansted Harbor, St. Croix, Virgin Islands; Thorhaug told me that there are no seagrasses at all now in Manila Bay. These losses are all in developed areas—implying human-caused destruction.

Probably the most important documented cause is dredging and filling—for port development and expansion; for residential and industrial development; for airport construction, and so on. Seagrass sites in addition to the ones directly affected by dredging and filling may be disturbed by secondary effects such as sediment loss, increased water turbidity, or increased wave energy. Human pollution in the form of sewage and industrial wastes also directly affects seagrasses. Thorhaug's first large restoration project at Turkey Point was an attempt to replace beds destroyed by hot water discharged from a power plant. Anchor and propeller damage are other destructive elements, and oil spills, although not deadly to seagrasses, destroy much of the fauna associated with them.

When I asked both Lewis and Thorhaug what the state of the art is, their answers supported Nagy's estimation that success relates directly to the site. Thorhaug told me, "The species and methods depend on the site. If it's a high energy site, it's important to use plugs or heavy anchors. If it's very shallow, for instance, use *Halodule.* Any of the three [turtle grass, shoal grass, and manatee grass] can colonize mud and muddy sand but *Thalassia* seems better on sand. If it's coarse sand, use plugs or heavy anchors. On some sites, you can use any method." And Lewis told me that for the ideal situation—characterized by good sediments and little or no wave energy—it is satisfactory to plant shoal grass as plugs right after the disturbance, and then seed with turtle or manatee grass.

What are these restorationists doing about cutting costs to make seagrass restoration a more realistic option for industry? "The real incentive [for customers] comes from having the plants there . . . the units available," Lewis said as we watched the ocean sparkle in the October sunshine near Craig Key. "For a big project one needs a nursery, but most of us operate on a shoestring." With this in mind, Lewis has just received a patent for a floating collar device that turns a group of standard horticultural trays holding pots of seagrasses into a flotilla of propagating beds. Except for Thorhaug's set-up, the early techniques for culturing seagrasses were prohibitively expensive since they required artificial light and an aquarium. With his outdoor nursery floating in salt water, however, Lewis can grow transplants more quickly and cheaply. He's doing this now in Tampa but hopes to move this operation to the Keys where, with warmer temperatures, he can grow them to marketable size in 30 days. Lewis thinks he might be able to use old borrow pits—quarry-like ponds from which material has been taken for construction projects—as nursery sites because they're protected from high energy currents or waves and because they contain salt water. If this arrangement succeeds, he can move on to the next step in the restoration business—building a market.

Thorhaug, on the other hand, has just finished planting a project using plugs mechanically cut by a sea witch, which is a dredging boat equipped with a scooping bucket that has a cutting edge. These plugs are cut into smaller pieces, bagged, and transported by boat to the restoration site where they are hand planted. Although the final figures are not in, Thorhaug estimates that this mechanization will reduce the cost to $2000 to $2500 per hectare. She also has two projects going outside the U.S., one in Jamaica and another in the Philippines.

As for the future of restoration science in general, Lewis thinks that the next big area for research is habitat measurement and monitoring. Restoration, he told me, is "no longer a question of technical know-how. It's the question: Is what you create a functional substitute for what you lost? It's not just the plants; it's much bigger than plants. I'm paid to plant seagrasses and I'm paid to monitor, but I'm not paid to measure animals. Most regulatory agencies are just happy to see vegetation there, but I think that will change. It's only a matter of time."

Signe Holtz

Ms. Holtz recently received a Master of Science degree in restoration and management of native plant communities from the University of Wisconsin–Madison and has served as notes editor for *Restoration & Management Notes*.

Restorationist Robin Lewis made two discoveries that guided him into the restoration business. As a graduate student at the University of South Florida in the late 1960s he discovered that a certain species of fish contained the pigment called pterin, a surprising finding to most scientists, who thought at the time that fish contained only carotenoid and melanin pigments. About the same time Lewis made the other discovery, one that would affect his future. At a conference where he was presenting a paper about his research, he walked into a room containing all the people in the world who knew what he was talking about. Three people sat there—four, of course, counting Lewis. It was then that he decided that an academic research career was not for him.

However, he did teach general biology, oceanography, and marine biology at Hillsborough Community College in Tampa. While there he joined Save Our Bay, a citizen's environmental action group, and in 1971 was assigned to watchdog the Tampa Bay Port Authority. For six years he attended its open meetings and, to some of the Authority's members, was SOB's acronym personified. An imposing figure at over six feet tall, with a clear, persuasive voice and logical manner, he gained some influence. At first he listened; then he listened and argued; then he began to present his own ideas; and finally he convinced the Authority to incorporate some of them into its projects.

His first work was aimed at doing something about the dredge spoil islands in Tampa Bay, which are subject to severe shifting and erosion. He planted mangroves with, as he says, advanced technological methods—he stuck the seed pods in the ground. But this did not solve the instability problem.

It was at this time that he met his mentor, Ed Garbisch, at an Estuarine Research Federation meeting. (An account of Garbisch's work appears in **R&MN** 1:4.) Impressed with Garbisch's use of cordgrass (*Spartina alterniflora*) as a stabilizer in the initial stages of restoration projects, Lewis thought he might be able to apply this technique to the spoil islands. He hesitated to use cordgrass, though, since it was not thought to be native to Florida and, as far as he knew, had not invaded either. But later, on a tour of the spoil islands with Garbisch, Lewis found it growing naturally. With his misgivings allayed and more money from the Authority, he tried *Spartina* as a stabilizer cover crop. This initial effort in 1974–1975 was such a success that now this technique is considered routine.

When Hillsborough would not allow Lewis to trade some of his salary for time, he traded his whole salary for freelancing. And the more restoration projects he did, the more excited he got.

Robin Lewis III

"The concept of restoration is catching on," Lewis maintains, although he encounters the constant problem that plagues other entrepreneurs: getting money. In fact, Lewis thinks that there are great restoration projects out there and that the technology to do them is available, but the money isn't. What's needed, he thinks, is a reliable source of money, possibly from a licensing fee. Since restoration is "not something that anyone budgets for," he sees the next step in the restoration business as convincing the public that it's a necessary process.

His business has grown over the past few years. Only about 10 percent of it is seagrass restoration. Another 30 percent is mangrove and marsh restoration, and the rest is work for public agencies or private developers—designing mitigation plans, doing environmental impact statements, and obtaining permits. His firm employed 15 persons in 1985 and had a gross income of more than $500,000 in 1984.

Lewis is guided by his philosophy that "To be successful at restoration, you have to understand the *natural history* of what you're trying to restore. This includes not only plant species but also the successional processes and the interactions with various animals in the community, how they affect and control it—the ecology of it."