In 1963 the Florida Geological Survey issued a pamphlet in which it confidently concluded that the state’s water resources were sufficient to meet all expected growth. Annual average rainfall was 53 inches, or 148 billion gallons a day. Under the hot Florida sun some 108 billion gallons a day evaporated or were utilized by vegetation, but this left 40 billion gallons a day to replenish rivers, lakes, and aquifers and this was eight times the amount currently being used. The pamphlet boasted of Florida’s many lakes, both natural and artificial. Four major dams on the Apalachicola, Ochlocknee, Withlacoochee, and Oklawaha rivers backed up a total of 187 billion gallons of water. There were 182 large springs, more than in any other state. Silver Springs alone discharged 500 million gallons a day, “enough to satisfy Florida’s municipal and rural and domestic needs, if it could be distributed to the place of need.” Underlying most of the state was the remarkable Floridan Aquifer, estimated to contain between 800 and 1,000 cubic miles of water—one hundred times the amount impounded in Lake Mead behind Hoover Dam.¹

In other words, why worry? Yet nine years later the legislature was enacting a series of laws providing for conservation and management of the state’s water resources to ensure an adequate supply for the future. Why this striking change of mood? The 1963 document was a typical example of Florida boosterism, extolling the state’s resources and inviting more industry, more farming, more tourists, and more residents. The 1972 legislation reflected the rise of environmentalism with its insistence that not all growth was good. Growth was bad when it resulted in polluted lakes, rivers, and bayfronts; growth was bad when it led to breakdowns in the water supply and salt intrusion into the wellfields; growth was bad when it destroyed the mangrove swamps and drained vital marshlands. By 1972 it had become obvious that the state had water problems. For one thing, the most
abundant supply was not always close to where water was most needed. Many of the biggest rivers, lakes, and springs were located in the Panhandle and northern Florida, several hundred miles from central and southern Florida where the larger cities were located and where farming and mining made heavy water demands. Moreover, average rainfall was a somewhat misleading concept in a state where 70 percent of the rain usually fell between May and October and only 30 percent the other six months of the year. There were wet years when hurricanes, tropical storms, and heavy rains flooded farms and homes and dry years when municipal supplies ran dry, irrigation water had to be rationed, and uncontrolled fires raged through the Everglades. Public concern about water rose and fell in a counter movement to the water level. During six of the seven years preceding the complacent 1963 pamphlet, Florida had received more than average rainfall; during five of the seven years preceding the 1972 legislation it had received less than the average.

The Water Resources Act of 1972 required the Department of Natural Resources, in cooperation with the Department of Administration, Bureau of Planning, to formulate "an integrated, coordinated plan for the use and development of the waters of the state." This water use plan, together with the water quality standards and classifications of the Department of Pollution Control, was to constitute the Florida water plan. The governing boards of the new water management districts were directed to gather data and advise in drafting those portions of the state plan that would apply to their region. The law obviously intended a vast coordinated planning effort to measure the water resources of the state, to estimate future water needs, and to determine how these needs might be met. At first the planning process proceeded rather slowly. Not until 1976 did the legislature finally draw the boundaries and the voters approve the taxing powers so that the water management districts could go into operation on 1 January 1977. At the state level responsibility was still divided until the Environmental Reorganization Act of 1975 charged the new Department of Environmental Regulation with responsibility for safeguarding both quantity and quality of water. The DER was to assume the duty of formulating both the water use plan and the quality standards for the final water plan.

Even before the formal planning process began, a number of agencies had been gathering important information about the Florida water situation. In 1975 a U.S. Geological Survey estimated that about 18.420 billion gallons a day were being withdrawn for all purposes. About 11.502 billion gallons of this was saltwater with-
drawn from bays or estuaries, mostly for electric power plants. About 6.918 billion gallons of fresh water were withdrawn in nearly equal quantities from surface water sources and from wells. Popular assumptions to the contrary, the heaviest water users were not the city dwellers. Only 1.146 billion gallons a day were withdrawn for public supplies. The heaviest water users were farmers and ranchers, who withdrew 2.868 billion gallons a day to irrigate their fields and pastures. Second to them were industrialists, who withdrew 2.638 billion gallons a day for various purposes.³

In the politics of water, farmers, ranchers, manufacturers, miners, real estate developers, homeowners, sportsmen, and nature lovers all had vital interests at stake. Historically, the strongest of these groups had always been the farmers. Although less than 1.5 million acres, or about 4.3 percent of Florida land, were under cultivation in 1976,⁴ three crops were highly important to the economy. Florida grew more citrus than any other state; in 1976 the orange crop was

Water management districts. On 1 January 1977, five districts charged with developing and administering water policy for the entire state went into operation. State of Florida, Bureau of Natural Resources. Map Collection, Strozier Library.
valued at $538 million. Vegetables brought in another $409 million, with Florida producing more tomatoes than any other state except California. The third major crop was sugar, worth $192 million in 1976. Florida was now growing more sugarcane than either Hawaii or Louisiana. Also important to the state were the cattle ranches, dairies, and poultry farms, with an aggregate income of $693 million in 1976. With 1.4 million head of beef cattle Florida ranked ninth among the states. The typical Florida farmer or rancher was not the sturdy individualist of American tradition. In 1971 the Florida Chamber of Commerce reported that one-third of the agricultural land was owned by corporations, a larger proportion than in any other state in the continental United States.

Because of Florida’s dry winters and springs, all of the major crops required extensive irrigation. In 1975 the state had 564,829 acres of irrigated citrus groves. Almost half of this acreage was in four counties of central and eastern Florida: Polk, 91,650 acres; St. Lucie, 73,000; Lake, 52,000; and Indian River, 50,000. Although the groves required large quantities of water, their demands were mitigated by several factors. During the summer and fall this region had abundant rainfall. Many of the groves were in the central highlands where the rolling country constituted a splendid recharge area for the Floridan Aquifer. Even when the growers had to irrigate with water drawn from nearby streams, canals, lakes, and rivers, the demands were moderate, and much of the water seeped back into the aquifer. Indeed an Orange County farm agent traveled through the region displaying an empty rain barrel to dramatize the warning that urban development in the region north of Disney World was reducing the acreage in orange groves, thereby endangering the aquifer.

The state had 317,716 acres of irrigated vegetable farms. Palm Beach County had 119,000 of these acres, more than 37 percent of the total, and other counties south of Lake Okeechobee—Dade, Collier, Hendry, Lee, and Broward accounted for almost 80,000 acres more. In all, this usually frost-free region of South Florida, ideal for growing winter vegetables, had more than 62 percent of the total irrigated truck farming acreage of the state. The other 38 percent was widely scattered, with 19,910 acres in St. Johns County on the northeast coast and 12,500 acres in Jackson County in the northern Panhandle. Although the vegetable growers of South Florida were heavy water users, they agitated for extensive drainage and a low water table. Only in this way could they farm low-lying acreage, especially that located near the coast in southern Dade County. The low water table was a threat, particularly in drought years, to the
urban wellfields on which the Gold Coast cities depended. In other ways, too, the location of the southern vegetable farms created problems. As the metropolitan areas expanded, developers bought up more and more of the agricultural land. The farmers, therefore, had to open up new acreage to the west and south. But whenever they did so, they alarmed the environmentalists, fearful that wetlands important to the flow of water into Everglades National Park would be invaded. In 1976 two large companies announced plans to grow vegetables on tracts close to the eastern entrance to the park. Nature lovers protested that this would diminish the flow and pollute the water of Taylor Slough, which was vital to the Anhinga Trail, the most popular nature walk in the park. They pressed the Dade County planning agencies to save the wetlands from further encroachment. At stake were not only the beauties of nature but the recharge of the Biscayne Aquifer and the preservation of marine life in the southern estuaries.\(^a\)

Sugar growers were very heavy irrigators. In 1975 Florida had 289,000 acres of irrigated sugar fields. Of this, 245,000 acres, or 85 percent, were located in Palm Beach County, and the rest was in three other counties bordering Lake Okeechobee—Hendry, Glades, and Martin.\(^b\) Sugar growers argued that their heavy use of irrigation water was offset by the runoff that was pumped back into Lake Okeechobee. But the water thus returned was so loaded with oxidized muck, fertilizers, and pesticides that it contributed seriously to the eutrophication problem.

Environmentalists criticized the sugar growers on other grounds as well. To protect the Everglades Agricultural Area from flooding, the Army Corps of Engineers had built levees, canals, and pumping stations, mostly at federal taxpayers’ expense. Thousands of acres of land had been drained before it was needed, interrupting the flow of water into the conservation areas and the aquifers as well as into Everglades National Park. All the drained lands, whether cultivated or uncultivated, were being rapidly depleted because this type of soil, unless it remained moist, oxidized and disappeared. Soil subsidence had, in fact, been a problem ever since drainage began in the region. Experts calculated the average rate of subsidence at one inch of muck soil per year. Unless the process could be halted or retarded, the famous muck soil—one advertised as richer than the soil of the Nile Valley—would become too shallow for cultivation before the year 2000. This was the reason why environmental scientists urged the state to sell no more Everglades land to the farmers and instead to allow as much as possible to revert to wetlands. They also urged
experiments with rice and other wetland crops that would be less destructive of the soil.\textsuperscript{12}

Sugar growers had always been heavily involved in national politics. Domestic producers, both of cane and beet sugar, had been adept in obtaining tariff protection and subsidies. At the beginning of 1979 warehouses in Belle Glade and other parts of South Florida were bulging with U.S.—owned sugar acquired during the Carter administration in the latest of these federal aid programs, a system of price supports based on government loans to sugar planters. At every level of government—federal, state, and regional—there were important decisions to be made for the future. Should tariffs, quotas, drainage policies, irrigation policies, and labor policies continue to foster the domestic cultivation of sugar? Environmentalists opposed these special privileges to an enterprise that was polluting the water and consuming the soil. Nutritionists joined in attacking a product whose overuse was injuring the health of millions of American children and adults. But the great sugar corporations continued to exert strong political power in defending their interests. They argued that domestic sugar production provided employment and retarded the outward flow of American dollars.

But sugar was not the only crop that created problems. In 1975 Florida had 537,600 acres of irrigated pasture land, more irrigated acres than for vegetables or sugar and second only to citrus. Over half of this acreage was in four counties bordering on Lake Okeechobee—Highlands with 100,000 acres, Hendry with 88,000, Palm Beach with 60,000, and Okeechobee with 40,000.\textsuperscript{13} This region of large cattle ranches and dairies had been transformed by the flood control works. Even before these were built, there had been an extensive livestock industry, but the cattle had usually grazed on natural range. The animals had adapted themselves to the climate and the terrain, feeding on the higher ground during the wet season and venturing down into the marshlands during the dry season. But the digging of canals and drainage ditches had brought drastic changes. Not only were thousands of acres reclaimed for ranching but heavy investments were made in artificial grasses to provide better forage. In the Kissimmee Basin alone improved pasture increased 370 percent between 1958 and 1972—from 122,000 acres to 576,000 acres.\textsuperscript{14}

This expansion of improved pasture had serious implications for water resources. To thrive, the artificial grasses had to have plenty of moisture, yet the drainage program had resulted in a rapid runoff of rainwater and a lower water table—hence the need for more and more irrigation. Even more serious were the pollution problems
from cattle wastes draining off into the streams and lakes. Environmental scientists argued that the number of cattle needed to be reduced, that better management should be required to prevent the discharge of wastes, and that more water should be retained in the uplands. Since the maintenance of improved pasture required heavy expenditures for ditching, fertilizing, and pumping water, the environmentalists argued that the ranchers would make more money by returning to a greater use of natural pasture, limiting the percentage of improved pasture to an average of 25 percent.\textsuperscript{15}

Much of the water withdrawn for irrigation soaked into the soil or ran off into neighboring streams and canals. Only the portion utilized by the vegetation or evaporated was actually consumed. Experts estimated that for the state as a whole, irrigation consumed 1.331 billion gallons a day, about 46 percent of the 2.867 billion gallons withdrawn. In the hot southern counties the consumption rate was higher, about 65 percent in Palm Beach County and about 58 percent in Hendry.\textsuperscript{16}

Throughout the state urban development was eating away at agriculture. The Institute of Food and Agricultural Sciences at the University of Florida estimated the annual reduction of farmland at 57,000 acres. Because of freezes and urban expansion there were 100,000 fewer acres in orange groves in 1975 than in 1969. Yet through better management the growers were actually growing more oranges. Agricultural experts hoped that more intensive methods and greater diversification would permit a continued growth of Florida agriculture. But heavier irrigation and greater use of fertilizers and pesticides meant more potential water problems.\textsuperscript{17}

During 1975 Florida industry withdrew about 2.738 billion gallons of fresh water a day. The heaviest use was for generating electricity. Steam and nuclear power plants used 13.137 billion gallons a day, mostly for their cooling processes. Of this, 11.439 billion gallons were saline water and 1.698 billion gallons fresh. Although electric power generation was increasing rapidly, growing by 42 percent between 1970 and 1975, the industry's water use increased by only 18 percent during the same period. Much of the fresh water was now recycled through cooling ponds and cooling towers. Because most of the water was returned to streams and lakes, the actual consumption was small, estimated at about 36 million gallons a day or 2 percent of the total withdrawals, in contrast with other industrial uses, estimated to consume about 28 percent of the water withdrawn.\textsuperscript{18}

The second heaviest industrial use of water was in phosphate mining. In 1976 Florida mines extracted more than 395 million tons
Phosphate mining on the Peace River. Producing a major share of the world's supply, the phosphate industry was so powerful in Florida politics that it long escaped effective regulation despite its damage to the environment. Environmental Information Center.
of phosphate—not only more than that of any other state but more than that of any other country. The few companies dominating the field exerted such power in Florida politics that the legislature did not even impose a severance tax until 1971. Environmentalists disliked phosphate mining because of its heavy water demands, its polluting discharges, and the ugly pit holes and waste piles that followed its operations.

In 1975 the Florida phosphate industry withdrew about 270 million gallons of water a day. Almost 90 percent of this was used in Polk County. Combined with the heavy demands of electric power plants and citrus groves, these withdrawals made Polk County the heaviest water user in the state, 713 million gallons a day. (Palm Beach County, with almost twice the population of Polk, withdrew 660 million gallons a day). Long careless in its disposal of wastes, the phosphate industry had four times since 1960 caused major fish kills in the Peace River. Responding to public criticism and pressure from the new environmental agencies, the mining companies were making a strong effort to clean up their act. They took measures to conserve and reuse as much water as possible and planted timber on their reserve lands and spoil piles to reduce erosion.

There were also phosphate mines in Hamilton County in the upper Suwannee River basin. In 1967 when Congress was considering protection of the Suwannee as one of the nation’s “wild and scenic rivers,” Senator Holland succeeded in having the proposal deferred for further study. But even this prospect disturbed the chemical companies. A Monsanto executive warned Holland that his company might have to reconsider its plans to expand operations, and a spokesman for the Occidental Agricultural Chemical Company urged that the proposed study be limited to the lower part of the river where there were no mines. Governor Kirk, the Florida cabinet, and the Florida legislature all went on record as opposed to any inclusion of the Suwannee. As finally passed, the bill limited the study to the lower reaches of the river.

In 1973 Occidental asked state permission to expand its operations along a thirty-mile stretch of the Suwannee. Environmentalists charged that this would mar the natural beauty of the area, pollute streams used by sportsmen, and impair the purity of springs and sinkholes that were connected with the aquifer. But the Bureau of Land Planning recommended against declaring the upper Suwannee an area of critical state concern. Instead it praised the phosphate company’s plan to refrain from mining along a 1,000-foot buffer zone on either side of the river and in other sensitive areas. “Occidental,”
the report said, “has shown a relatively high degree of environmental awareness in their existing Hamilton County operation. In their general willingness to cooperate with environmental agencies and their initiative in experimenting with techniques in reclamation and pollution control, the firm provides a fine example to the extractive industry.”

Three other industries resembled phosphate mining in that they were both heavy water users and heavy dischargers of polluting wastes. The pulp-and-paper mills of northern Florida withdrew more than 225 million gallons a day; the chemical industry located mostly in the Panhandle withdrew about 100 million gallons a day; and citrus processing in central Florida withdrew 70 million gallons a day.

Limerock mining, which used 88 million gallons a day, was another industry that created water problems. Limerock was the principal ingredient in the cement that Florida contractors used for almost everything they built—office buildings, condominiums, houses, highways, and airport runways. In 1968, the Coastal Petroleum Company, partly owned by Sen. James Buckley of New York and William Buckley, the columnist, sought permission to dig for limerock under the surface of Lake Okeechobee. The company claimed a legal right under an earlier lease from the state permitting it to drill for oil. The Flood Control District strongly objected to mining operations that would not only pollute the lake but might even knock a hole through the rock barrier separating the lake from the saltwater aquifer beneath it. Governor Kirk also strongly opposed the request. In the end, the Army Corps of Engineers denied permission to dredge, and a federal judge upheld the state and the corps. But elsewhere, especially in Hernando County north of Tampa, limerock mining boomed. Gouging out huge pits, sometimes fifty feet deep, the mines marred the landscape and created ponds lacking the pure water needed for healthy plant growth and fish and wildlife.

Although city dwellers required less water than farmers, ranchers, and industrialists, their needs increased rapidly with the burgeoning population. Between 1950 and 1970 Florida’s population grew by 145 percent, a faster rate than that of any other state expect Nevada. In 1950 the population had been 2.8 million; in 1970 it was 6.8 million. And the growth continued: in 1978 the population was 8.9 million, and the state’s rate of growth was almost four times that of the United States as a whole. Providing these millions of new residents with places to live brought big returns to landowners,
Melaleuca trees. Among the exotic species introduced by Florida foresters and nurserymen was the Melaleuca from Australia. With their dense, white, paperlike bark, these hardy trees spread rapidly, displacing native species, especially in overdrammed areas of South Florida. Environmental Information Center.

promoters, contractors, and construction workers. It also provided rich opportunities for lending institutions—banks, insurance companies, and pension funds. Continued growth was therefore of vital interest to many powerful groups.

Strong though this alliance was, the environmentalists were able to convince key public officials that not all construction was good. Experts could now present scientific data to expose the hidden costs involved in unplanned growth. In Dade County there was rising opposition to building projects that would add to the pollution of Biscayne Bay, drain too many of the western wetlands, or create water supply and sewage problems. All of the other urban areas—Tampa, St. Petersburg, Jacksonville, Orlando, West Palm Beach, Fort Lauderdale—were going through parallel experiences. Because of the high price of building lots and the popularity of suburban living, developers preferred to leapfrog over the nearby districts to open up more distant tracts where they could buy cheap swampland or moderately priced farms. By draining lands that might have remained
wet, the promoters seriously disrupted the ecology of whole regions. They destroyed the habitats of fish and wildlife; they polluted streams; they converted land better suited for pasturage or wetland crops into home lots. Draining these lowlands reduced aquifer levels, not only endangering water supplies but parching out healthy vegetation and promoting the growth of Melaleuca trees and other undesirable plants.

Many purchasers in these new developments assumed that the drainage ditches and flood control works gave them good protection. But experts predicted that any hurricane like those of 1926, 1928, 1947, or 1948 would inundate thousands of acres of low-lying land. According to Nat Reed, now a member of the South Florida WMD governing board, “tens of thousands” of owners would have their homes flooded for forty to sixty days. “The pain and suffering which our citizens will face is beyond comprehension,” Reed said. “They will be the lucky ones for thousands of mobile home owners will have lost their lives and all their personal property.”

Who was responsible for this dangerous situation? Reed blamed city and county governments, which had “abdicated their legal responsibilities to the ever present land developers who overbuilt on marginal and submarginal land throughout coastal Florida.” From the land planning viewpoint, Reed said, it was a tragedy that the state had not had a major wet hurricane in the last eighteen years of uncontrolled growth. He predicted that when more normal weather conditions again bring hurricanes every three to five years, the elected officials who have been so lax in administering the zoning laws will have passed from the scene, and the water management districts will reap the bitter crop of public wrath. And then what? If history repeats itself, Florida officials will besiege Congress with appeals for expensive new flood control projects. But Reed warned that Washington politicians, fearing taxpayer resentment, will be much less ready to come to the state’s rescue. It would be much wiser, Reed said, for the state to learn the lesson that “marginal lands cannot be heavily developed.”

Waterfront property commanded such a high price that developers hacked down mangrove swamps near the ocean and the intracoastal canals and dug finger canals. In interior Florida they used similar means to develop the lake fronts—cutting down the bordering cypress, dredging out the lake bottoms, and digging finger canals. Belated state efforts to halt this damage ran into a legal stonewall because the courts ruled that most Florida lakes were private property. The only publicly owned lakes were those that had
been "meandered" as navigable waters by federal surveyors during the nineteenth century. The passion for lakefront even extended to the excavation of artificial lakes despite the fact that cutting into the limestone might damage the aquifer and that these man-made lakes were difficult to keep clean of weeds and refuse.

The promoters who most damaged the environment were those who drained and cleared the land before it was needed. Attempting to add plausibility to their sales campaigns, they built roads and canals that completely disrupted the natural flow of the water and thereby disrupted the ecology. Golden Gate Estates in Collier County was the most notorious example of this, but there were many others. Under the pressure of the environmental movement, developers proceeded somewhat more cautiously during the 1970s, choosing their sites more carefully, preserving natural features, and making better provision for water supply and sewage disposal.

But the conscience of the developers was not so highly sensitized that it obviated the need for public regulation, and government at all levels played an increasingly active role. The Army Corps of Engineers gave more serious study to the environmental impact of its projects and blocked the digging of certain private canals. The Environmental Protection Agency took steps to protect the purity of drinking water and prevent pollution. The state legislature passed laws dealing with land and water use and gave important powers to the Department of Environmental Regulation. Municipal officers, county commissions, and regional agencies prepared land use plans to guide them in issuing building permits and authorizing water and sewer hookups.

Developers and their allies continued to fight against what they regarded as interference with the rights of private property. The struggle was particularly bitter in Dade County, where a master plan had carefully mapped areas where development would be permitted, areas that would be reserved for farming, and areas that would be preserved in their natural state. At a hearing of the Metro Planning Advisory Board in 1977, developers blamed the rigidity of the plan for the soaring costs of land and homes and for unemployment in the construction industry. A real estate sales executive said that he was "sick and tired" of this "no growth" policy. Another businessman said: "You and your plan are not the sole contributing cause to Dade County's demise—but you and your plan are one of the causes." To ask a Florida politician to vote against growth was almost like asking him to vote against God and motherhood. How then were the environmentalists able to stiffen so many backbones? One reason was
their broadening base. No longer could they be dismissed as birdwatching eccentrics; their ranks now contained thousands of staid newcomers from the North, convinced that helter-skelter development might ruin the state they now called home.

A state water plan was important to both the development lobby and the environmentalists. If growth was to continue at the same pace, it was necessary to make provision for future water needs; if growth was to be restrained or guided, it was vital to identify the regions that could and could not tolerate development. Because of earlier work by the Central and Southern Florida Flood Control District and the Army Corps of Engineers, the South Florida Water Management District had gone farther toward developing its water use plan than any other district. As we have seen, however, the early drafts encountered strong criticism because of their emphasis on technological answers to projected water needs. To meet objections voiced in public hearings and by state agencies, the district began to modify its plans to place more stress on storage and conservation.

Meanwhile, the Southwest Florida Water Management District had also been drafting its plans. Several warning signals had been observed during the 1960s and 1970s. Rainfall in the region had been less than normal during eleven of the thirteen years from 1961 through 1974. In southwestern Polk County and eastern Hillsborough County the groundwater level had dropped sometimes as much as 60 feet. Municipal wells in St. Petersburg were suffering from saltwater intrusion. The level of the Hillsborough River, from which Tampa drew its water supply, was dropping.

Garald Parker, chief hydrologist for the district, made some gloomy predictions. In 1970 the district was withdrawing 467 billion gallons of water a year, about 70 percent of the normal recharge. By 1984 the annual withdrawals would equal the recharge. It was necessary to utilize all the available water crop, but this was difficult to do because residents in the interior were unwilling to allow their water to be moved to the coastal cities where it was needed. Moreover, it was not easy to locate new sources of supply. The Tampa Bay cities could not look south because water was already scarce in Sarasota and Charlotte counties; they could not look east to the Green Swamp because of rapid urbanization along the cross-state highway leading to Disney World and Orlando. The most promising areas to develop were located to the north, in Pasco, Hernando, Citrus, and Levy counties. In the more distant future, Parker said, it might be possible to go out of the district completely and bring in water by aqueduct from the Suwannee and Apalachicola rivers, but there
would be strong political opposition to this. "It can only be achieved," said Parker, "when a regional water supply system is established which is incorporated into a workable and acceptable State Water Plan that will guarantee to supply and protect the water resources of this entire rapidly growing region."

In the 1977 draft of the district plan, there was a somewhat more optimistic view. It was estimated that the population of the district would more than double, rising from 2.2 million in 1976 to 4.9 million in 2020. If present consumption patterns continued, demand for water would almost double in the same period, rising from 1.2 billion gallons a day to 2.118 billion. Supplying these needs from sources within the district would require careful management, but it could be done. The Tampa Bay cities would have to develop new wellfields in a region to the north in Pasco and Hernando counties; the "Sun Belt" around Lakeland and Winter Haven would develop sources in the Green Swamp; Sarasota and the other Gulf cities south of Tampa would have to supplement local wellfields with desalination; the interior counties would need to use the Peace River. The future would be more secure, however, if rigorous conservation measures could be taken. The planners particularly recommended experiments in the reuse of wastewater. Industries could either recycle
their own or municipal wastewater; farmers could reuse industrial or municipal wastewater for irrigation in addition to cutting down their water needs in other ways; municipalities could reuse wastewater for sprinkling parks, road medians, and lawns, perhaps developing a dual system of mains for drinking water and water for other purposes. By combining such conservation measures, the planners believed that total water use for the year 2020 could be cut from 2.118 billion gallons to 1.494 billion—almost 30 percent. Environmentalists preferred the Southwest Florida WMD approach with its strong emphasis on conservation to that of the South Florida WMD with its continued reliance on more engineering works requiring the use of fossil fuels.

The three new water management districts were not as far advanced in their planning. Northwest and Suwannee were regions of abundant rainfall and brimming lakes, rivers, and springs. A few Panhandle cities like Panama City, Fort Walton Beach, and Quincy were troubled either by saltwater intrusion or dropping water tables, but the more serious problems involved industrial pollution. Chemical plants near Pensacola discharged wastes into Escambia Bay; pulp-and-paper mills in the eastern Panhandle and northern Gulf coast region injured several rivers; phosphate mining in the upper Suwannee Basin was a threat to a beautiful and historic stream.

In contrast to Northwest and Suwannee, the St. Johns Water Management District was in a region of rapidly growing cities—Jacksonville, St. Augustine, Daytona Beach, Titusville, Melbourne, and northern Orlando. The population of the district was expected to more than double in a 45-year period, from 2 million in 1975 to 4.3 million in 2020. In 1975 the district was withdrawing 1.655 billions gallons of fresh water a day. In 2020, according to an estimate made by the Department of Natural Resources in 1970, it would require over 2.6 billion gallons a day. The total available supply in the St. Johns River Basin had been estimated at 4.5 billion gallons a day, about 2.5 billion in groundwater and 2 billion in surface water. This might seem to assure a safe margin, but the situation was complicated by many factors. Not all water was available for all purposes. Many lakes and rivers were magnificent for boating and fishing but too polluted for drinking. Drainage from pastures and croplands conveyed animal wastes, fertilizers, and pesticides into the surface water and threatened to seep into the aquifers. There were serious saltwater intrusion problems in Jacksonville and other coastal cities. In the interior, excessive drainage, poorly planned
highways, overdevelopment, and huge parking lots interfered with the recharge of the aquifers and reduced local supplies. Even the much praised Floridan Aquifer did not always provide high quality water. In Indian River County and other eastern regions, the Floridan Aquifer water was too highly mineralized for municipal use although usually good enough for irrigation.

In 1970 DNR experts had recommended careful management to protect the water resources. They advised Jacksonville and Cocoa Beach to develop wellfields farther to the west in areas where the recharge of the aquifers was adequate. These recharge areas should be protected from development. Pumping from the wells should not be permitted to exceed the recharge of the aquifers. To prevent overpumping and saltwater intrusion, standby wells should be provided. The downpour from storms should not be allowed to flow into the ocean but should be impounded for future use. Provision should be made for transferring water from areas of surplus supply to areas of shortage. Minimum levels should be established for the lakes. Control structures should be built on the drainage canals to reduce the need for irrigation.  

Further planning for the region was the responsibility of the new water management district. In a draft released in 1977 the district engineers explained their basic problem in a simplified water budget. Out of an average annual rainfall of 53 inches, roughly 73 percent or 39 inches was lost through evapotranspiration. The remaining 14 inches ran out to the ocean through either surface or underground flow. The only water resources available for use came from capturing this 14 inches of runoff or withdrawing water stored in the aquifers. Even these sources had to be carefully used. If the discharge of the rivers into the estuaries was reduced too much, marine life would suffer. If too much groundwater was withdrawn, saltwater would intrude into the wellfields, and changes of vegetation would occur in the overdrained areas.

The 1977 draft plan emphasized environmentalism and conservation of fuels. In a list of management policies, the district committed itself to utilizing water near points of need before seeking more distant sources; considering aspects of quality as well as quantity; giving significant consideration to environmental impact; favoring nonstructural water management that utilized functional aspects of natural systems over structural alternatives; and considering economic impacts and regional and state implications of proposed projects.

While the new water management district was demonstrating
sensitivity to the new environmentalism, the International Telephone and Telegraph Company was providing a case study in the old boosterism in its plans for a huge development in Flagler County, midway between St. Augustine and Daytona Beach. The company announced that this new resort city, called Palm Coast, would have a population of 750,000 by the year 2010 and would need 50 million gallons of water a day. (Actually, a place that large would probably require twice that amount, judging from the experience of other Florida cities.) “You can’t remove that amount of water from that area,” warned Brice Auth, executive director of the St. Johns WMD. A more immediate threat was the honeycomb of canals—28 miles of them—that ITT had dug to provide waterfront lots, some of them priced at $20,000 apiece. Environmentalists warned that these canals with their poor water quality would be plagued with algae blooms and would in turn contaminate the Atlantic Intracoastal Waterway. The Army Corps of Engineers granted permission to connect only 13 miles of the new canals with the waterway. In drawing its grandiose plans, ITT had relied on earlier, more lenient, government policies; now it would have to reshape its project to conform with the more stringent requirements of the new environmental agencies.

While the five water management districts were gradually working out their water use plans, other building blocks in the state water plan were also being prepared. The Division of State Planning had provided one such block in the water section of the State Comprehensive Plan, and the Department of Environmental Regulation was putting together another in the water quality plan that would include state standards and the procedures for enforcing them.

To provide for Florida’s future needs, the improvement of water quality was all-important. From all parts of the state came news of rivers and lakes no longer safe for either drinking or swimming. Poisonous discharges from paper mills and cellulose factories had ruined the Amelia River north of Jacksonville and the Fenholloway on the northern Gulf coast; overenrichment from agricultural wastes and sewage had devastated Lake Apopka, once famous for its good fishing; suburban development was threatening Lake Jackson near Tallahassee; pasture runoff was polluting the Kissimmee River and Taylor Creek; discharges from these sources and from the sugar fields were injuring Lake Okeechobee.

If the natural streams and lakes were in poor condition, the artificial ones were in much worse condition. Weeds and trash choked the canals and drainage ditches; oil spillage and sewage fouled the in-
tracoastal waterways. The more heavily populated the areas through which the canals ran, the more they were polluted. According to state standards, water safe for recreational purposes should contain no more than 1,000 coliform bacteria per 100 milliliters. Yet the Miami Canal had a coliform count of 15,000 and ten other Gold Coast canals had 2,000 or more. An environmentalist commented bitterly: “Perhaps if people knew something about the water quality of our canals, they would hesitate before buying a waterfront home. A child can pick up less bacteria playing in a toilet bowl than in many canals.”

Miami, fill for Bayfront Park, ca. 1925. Construction of high-rise buildings completed the rapid transformation of the coastal area.

But bacteria were not the only hidden enemies in the waterways. In 1975 inspectors discovered the highest concentration of PCB chemicals ever recorded—1.3 million parts per billion—in Broward County’s South New River Canal and lesser concentrations in several other canals. Since PCBs were highly toxic industrial chemicals similar to DDT, they constituted a threat to wildlife in the Everglades, to fish and marine life along the shore, and to the local population. They were suspected, among other things, of causing cancer. But how did the PCBs get into the water? They were used in the manufacture of inks, plastics, paints, lubricants, and electrical equipment, but there was very little of this kind of industry in South
Florida. Puzzled authorities asked a marina to install a screen to help prevent particles of paint and fiber glass from being washed into the New River Canal. 42

In a state relying so heavily on well-water drawn from relatively shallow aquifers, the proper disposal of sewage was particularly important. Yet Florida cities seemed never to catch up with their needs. New tracts would be opened before there were sewers available. Each household would make do with a cesspool or septic tank. Overflow from these threatened to pollute first the individual’s well and then those of his neighbors. In 1948 there were so few sewers in Fort Lauderdale that the county health director said the city was “floating on top of a vast cesspool.” 43 In this and other cities sewer systems were gradually extended, but the individual septic tanks were never completely replaced. The systems, moreover, were no better than the treatment provided for the effluents, and these arrangements were rarely thorough and efficient. In the Miami region there were a large number of small, cheaply built systems. Raw or inadequately treated sewage frequently discharged into the ocean or the canals. In 1953 Helen Muir wrote: “Out of sight, out of mind would be Miami’s treatment of sewage through the years until the day would come when she had fouled up her clear, sweet river and her blue shining bay to such an extent that it was no longer out of sight and fish would die and sea gardens would disappear and the beautiful Biscayne Bay would lie, a pollution between man and God.” 44

During the 1960s and 1970s belated efforts were made to stop the pollution of the Miami River and Biscayne Bay. The establishment of a metropolitan government was followed by the organization of a Miami-Dade Water and Sewer Authority intended to consolidate the local units. But getting an effective handle on the problem was a slow and expensive process. From time to time an epidemic would remind the community of the continuing danger from the careless disposal of human wastes. In 1971 there was a rise in viral hepatitis both in Dade County and in other parts of Florida; and in 1973 there was an epidemic of typhoid fever among the migrant workers. 45

Florida public health officials tested the drinking water regularly, and the local authorities chlorinated and otherwise treated the water to maintain it at a safe standard. Episodes of turbidity and high bacteria count nevertheless led to occasional scares and orders to boil water. It was difficult to safeguard the water quality because in many cities the supply was decentralized, with many local water districts and small private water companies in operation. In testing the water
of 79 cities throughout the nation, the Environmental Protection Agency found that of Miami to contain the most chloroform—311 parts per billion. Two other chemicals, vinyl chloride and carbon tetrachloride, were also discovered in the Miami water. All three chemicals were suspected of causing cancer. The presence of vinyl chloride and carbon tetrachloride was not easily explained, but the heavy concentration of chloroform was believed to result from the water treatment itself. Because rainwater soaking through the Everglades muck into the aquifer took on an unsightly, though harmless, brown color, the Miami plant had been bleaching it with unusually high doses of chlorine, more than would be necessary to kill the bacteria. Further tests found chloroform and other suspect chemicals in other Dade County waters. EPA officials suggested that carbon filters might be necessary to remove these substances, but local authorities feared that this expensive process would increase water rates by 50 percent. They took no action, awaiting additional evidence on the dangers involved and further mandates from the EPA and other agencies.46

As early as 1913 the state legislature had directed the state board of health to prosecute anyone discharging harmful materials into the public waters. But for many decades Florida papermills, chemical factories, phosphate mines, and citrus processors continued to dump disagreeable wastes into the rivers and streams without serious challenge. Indeed, during the 1940s the legislature granted specific exemptions for the benefit of the paper and cellulose manufacturers of Nassau and Taylor counties. It was not until 1969 that a new Pollution Control Board under the leadership of Nat Reed began a more energetic program to protect water quality through a system of requiring waste discharge permits and enforcing compliance with state standards.47 Subsequent legislation and reorganizations finally deposited these functions in the Department of Environmental Regulation. In addition to safeguarding the quantity and quality of water, the DER was to maintain air quality, control noise, supervise solid waste disposal, protect coastal zones, and approve the location of new power plants.

Over the next few years the DER, headed by Jay Landers, set up a far-reaching program for establishing state standards for water quality, issuing permits, and forcing compliance. In an effort to decentralize these functions, field offices were established for regions roughly paralleling the water management districts. In fixing standards the DER sought to bring the state regulations into harmony with those established by its federal counterpart, the Environmental
Protection Agency. Indeed, one of the DER’s most important functions was to help local governments qualify for federal dollars in planning and building sewage treatment plants and other projects for restoring water quality.48

The DER established a system under which waters of the state were placed in seven classifications ranging from Class I-A “Potable Water Supplies: Surface Waters” to Class V-B “Freshwater Storage: Utility and Industrial Use: Saline Ground Waters.” Cutting across all the classifications was a special designation “Outstanding Florida Waters” (OFWs), which were to receive the highest protection. The OFWs included waters in the national and state parks, the scenic and wild rivers, the wilderness areas, the Big Cypress National Freshwater Preserve, and state-owned environmentally endangered lands.49

So far as other waters were concerned, the DER undertook to bring the state into compliance with a federal law specifying that by 1983 all public waters should be pure enough to support aquatic plant and fish life and to permit swimming (Class III, according to Florida standards). By 1977 some 90 percent of industrial and municipal wastewater treatment plants were in compliance with DER regulations or had projects underway to bring them into compliance. A few notorious streams—the Miami River, the Fen holloway on the Gulf coast, Rice Creek near Palatka, and Eleven Mile Creek near
Pensacola—were expected to be still below Class III standards in 1983, but even on these the offending industries, mostly pulp-and-paper or cellulose mills, had installed better facilities for treating their wastewaters.\textsuperscript{50} Difficult though it was to curb the discharge of industries and sewage treatment plants, the DER faced a still more challenging problem for the future in dealing with so-called non-point sources, such as agricultural wastes and forestry, mining, and stormwater runoff.

In 1977 the legislature extended the powers of the DER. By the Florida Safe Drinking Water Act the agency was directed to adopt and enforce drinking water standards no less stringent than those specified by the federal government. By the Water Resources Restoration and Preservation Act the DER was authorized to take measures to rehabilitate the state’s ailing lakes.\textsuperscript{34} Funded half by the federal government and half by the state, the agency concentrated its early efforts on eliminating the sources of pollution that had ruined Lake Apopka and damaged Lake Jackson.\textsuperscript{32}

In these efforts to restore the clarity of Florida’s lakes and rivers and the purity of her drinking water, we may detect an unconscious yearning to reverse history and return to those Edenic conditions that had existed when Americans first visited the territory. Naturalists like William Bartram and soldiers like George McCall had exulted in the clear blue skies, the balmy weather, and the lush vegetation. They had marveled particularly at the extraordinary transparency of the water—lakes and rivers alive with darting fish, and springs in which one could watch a tiny button sink slowly to the bottom. Even the rainwater seemed to taste better in Florida. In 1853 an early booster urged California-bound ships to fill their casks at Key West: “There is no sweeter water carried to sea than that afforded by our large cisterns. Rainwater never becomes sour, nor does it acquire an unpleasant bilgy taste, but it improves with age and remains pure for years.” Another resident boasted that South Florida rainwater was “the healthiest and sweetest water in the world.”\textsuperscript{33}

Nature had bestowed lavish gifts on Florida, but the early settlers were not happy with all of nature’s arrangements. The peninsula had a very long coastline, made doubly dangerous by reefs and by the region’s violent storms. Within a few years of American settlement, inhabitants began to agitate for a cross-Florida canal and other waterways that would prevent shipwrecks. The call for these improvements persisted for 150 years, long after the age of sailing vessels when the need had seemed acute.
Nature's second alleged mistake in Florida was to dump too much rain on a flat terrain with inadequate runoff. To repair that defect early dreamers concocted schemes for draining the Everglades and other wetlands. To aid in reclamation a generous federal government turned over to the state some 22 million acres of loosely defined swampland. Much of this endowment was diverted to aid the construction of railroads; other large portions fell into the hands of
timber lords and land speculators. Not until 1881 when the state made its contract with Hamilton Disston was any large amount of swampland used to promote reclamation. Disston’s drainage program had only minimal success, but the state itself went into the reclamation business under Governor Broward and his successors. This effort broke down completely during the Great Depression, but terrible floods brought assistance from the federal government. First around Lake Okeechobee, next in a wide area of South Florida, and finally in the Tampa Bay region, the Army Corps of Engineers carried on a massive campaign to bring errant nature under control. Their works provided flood protection to millions of residents, opened up thousands of acres to crop production and ranching, and stored water for various uses. But in calculating costs and benefits, there was never any adequate accounting for environmental damages—for vegetation destroyed, wildlife disrupted, rivers polluted, lakes killed, and marshes dried up.

The water shortages of the 1960s and 1970s provided a dramatic warning that man’s interference with nature had gone too far. For most of its history Florida’s problem had been too much water; now residents worried that there would not be enough water of adequate purity to meet future needs. How could a dependable supply be assured? Occasionally someone would suggest a giant aqueduct to transport water from the rivers and springs of northwestern Florida to the heavily populated cities of the central and southern sections. But most planners dismissed such dreams as too expensive and too controversial to win support in Florida’s regionally jealous legislature. Rejecting grandiose California-type solutions, the planners sought to have each city and district continue to provide its own supply from nearby wellfields, rivers, and lakes. Instead of radical new departures, they relied for the most part on traditional Florida sources. The only really new element was the strong recognition that water was a treasure to be guarded, not something to be squandered or taken for granted. Instead of treating the rainwater that poured down during summer afternoons as a nuisance to be gotten rid of as speedily as possible, it was to be cherished as a blessing. Open lots where the rainwater might stand for hours should serve to recharge the aquifers; crowded buildings, paved roads, and parking lots would impede such recharge. Good urban planning, therefore, required provision for more open space, better designed highways, and parking lots so constructed that the rainwater would run off onto open land. Individual homeowners could help by installing water-
saving faucets, shower heads, and toilet bowls and by landscaping with Bermuda grass and native vegetation rather than varieties that required heavy sprinkling. Farmers and industrialists could save large quantities of water by recycling it for further use. Engineers could devise better means of storing storm water, treating and reusing sewage water, and desalinating saltwater from the ocean and the deep aquifers.

It all added up to a renewed cooperation between man and nature. Nature did its part by dropping more annual rainfall on Florida than on any other state and by providing extraordinary underground reservoirs. Nature’s arrangements, however, did not always suit man’s convenience; some years nature flooded the state with more water than people could handle; other years it dispensed rain so grudgingly that wells ran dry, crops were parched, and animals died of thirst. Promethean man could sometimes improve on nature, but painful experience was teaching him humility. He was learning to study more carefully the ecological consequences of his levees and drainage ditches, to understand the importance of preserving swamplands and mangroves, and to restrain the excesses of his developers and land speculators. In a word, man was learning to treat water with due reverence.
T

e city of Miami Beach floods on such a predictable basis that if, out of curiosity or sheer perversity, a person wants to she can plan a visit to coincide with an inundation. Knowing the tides would be high around the time of the “super blood moon,” in late September, I arranged to meet up with Hal Wanless, the chairman of the University of Miami’s geological-sciences department. Wanless, who is seventy-three, has spent nearly half a century studying how South Florida came into being. From this, he’s concluded that much of the region may have less than half a century more to go.

We had breakfast at a greasy spoon not far from Wanless’s office, then set off across the MacArthur Causeway. (Out-of-towners often assume that Miami Beach is part of Miami, but it’s situated on a separate island, a few miles off the coast.) It was a hot, breathless day, with a brilliant blue sky. Wanless
turned onto a side street, and soon we were confronting a pond-sized puddle. Water gushed down the road and into an underground garage. We stopped in front of a four-story apartment building, which was surrounded by a groomed lawn. Water seemed to be bubbling out of the turf. Wanless took off his shoes and socks and pulled on a pair of polypropylene booties. As he stepped out of the car, a woman rushed over. She asked if he worked for the city. He said he did not, an answer that seemed to disappoint but not deter her. She gestured at a palm tree that was sticking out of the drowned grass.

"Look at our yard, at the landscaping," she said. "That palm tree was super-expensive." She went on, "It's crazy—this is saltwater."

"Welcome to rising sea levels," Wanless told her.

According to the Intergovernmental Panel on Climate Change, sea levels could rise by more than three feet by the end of this century. The United States Army Corps of Engineers projects that they could rise by as much as five feet; the National Oceanic and Atmospheric Administration predicts up to six and a half feet. According to Wanless, all these projections are probably low. In his office, Wanless keeps a jar of meltwater he collected from the Greenland ice sheet. He likes to point out that there is plenty more where that came from.

"Many geologists, we're looking at the possibility of a ten-to-thirty-foot range by the end of the century," he told me.

We got back into the car. Driving with one hand, Wanless shot pictures out the window with the other. "Look at that," he said. "Oh, my gosh!" We'd come to a neighborhood of multimillion-dollar homes
where the water was creeping under the security gates and up the driveways. Porsches and Mercedeses sat flooded up to their chassis.

“This is today, you know,” Wanless said. “This isn’t with two feet of sea-level rise.” He wanted to get better photos, and pulled over onto another side street. He handed me the camera so that I could take a picture of him standing in the middle of the submerged road. Wanless stretched out his arms, like a magician who’d just conjured a rabbit. Some workmen came bouncing along in the back of a pickup. Every few feet, they stuck a depth gauge into the water. A truck from the Miami Beach Public Works Department pulled up. The driver asked if we had called City Hall. Apparently, one of the residents of the street had mistaken the high tide for a water-main break. As we were chatting with him, an elderly woman leaning on a walker rounded the corner. She looked at the lake the street had become and wailed, “What am I supposed to do?” The men in the pickup truck agreed to take her home. They folded up her walker and hoisted her into the cab.

To cope with its recurrent flooding, Miami Beach has already spent something like a hundred million dollars. It is planning on spending several hundred million more. Such efforts are, in Wanless’s view, so much money down the drain. Sooner or later—and probably sooner—the city will have too much water to deal with. Even before that happens, Wanless believes, insurers will stop selling policies on the luxury condos that line Biscayne Bay. Banks will stop writing mortgages.

“If we don’t plan for this,” he told me, once we were in the car again, driving toward the Fontainebleau hotel, “these are the new Okies.” I tried to imagine Ma and Pa Joad heading north, their golf bags and espresso machine strapped to the Range Rover.
The amount of water on the planet is fixed (and has been for billions of years). Its distribution, however, is subject to all sorts of rearrangements. In the coldest part of the last ice age, about twenty thousand years ago, so much water was tied up in ice sheets that sea levels were almost four hundred feet lower than they are today. At that point, Miami Beach, instead of being an island, was fifteen miles from the Atlantic Coast. Sarasota was a hundred miles inland from the Gulf of Mexico, and the outline of the Sunshine State looked less like a skinny finger than like a plump heel.

As the ice age ended and the planet warmed, the world’s coastlines assumed their present configuration. There’s a good deal of evidence—much of it now submerged—that this process did not take place slowly and steadily but, rather, in fits and starts. Beginning around 12,500 B.C., during an event known as meltwater pulse 1A, sea levels rose by roughly fifty feet in three or four centuries, a rate of more than a foot per decade. Meltwater pulse 1A, along with pulses 1B, 1C, and 1D, was, most probably, the result of ice-sheet collapse. One after another, the enormous glaciers disintegrated and dumped their contents into the oceans. It’s been speculated—though the evidence is sketchy—that a sudden flooding of the Black Sea toward the end of meltwater pulse 1C, around seventy-five hundred years ago, inspired the deluge story in Genesis.

As temperatures climb again, so, too, will sea levels. One reason for this is that water, as it heats up, expands. The process of thermal expansion follows well-known physical laws, and its impact is relatively easy to calculate. It is more difficult to predict how the earth’s remaining ice sheets will behave, and this difficulty accounts for the wide range in projections.

Low-end forecasts, like the I.P.C.C.’s, assume that the contribution from the ice sheets will remain relatively stable through the end of the century. High-end projections, like NOAA’s, assume that ice-melt will accelerate as the earth warms (as, under any remotely plausible scenario, the planet will continue to
do at least through the end of this century, and probably beyond). Recent observations, meanwhile, tend to support the most worrisome scenarios.

The latest data from the Arctic, gathered by a pair of exquisitely sensitive satellites, show that in the past decade Greenland has been losing more ice each year. In August, NASA announced that, to supplement the satellites, it was launching a new monitoring program called—provocatively—Oceans Melting Greenland, or O.M.G. In November, researchers reported that, owing to the loss of an ice shelf off northeastern Greenland, a new “floodgate” on the ice sheet had opened. All told, Greenland’s ice holds enough water to raise global sea levels by twenty feet.

At the opposite end of the earth, two groups of researchers—one from NASA’s Jet Propulsion Lab and the other from the University of Washington—concluded last year that a segment of the West Antarctic ice sheet has gone into “irreversible decline.” The segment, known as the Amundsen Sea sector, contains enough water to raise global sea levels by four feet, and its melting could destabilize other parts of the ice sheet, which hold enough ice to add ten more feet. While the “decline” could take centuries, it’s also possible that it could be accomplished a lot sooner. NASA is already planning for the day when parts of the Kennedy Space Center, on Florida’s Cape Canaveral, will be underwater.

"Cherish this moment, because clearly our parents are getting a divorce." The day I toured Miami Beach with Hal Wanless, I also attended a panel discussion at the city’s Convention Center titled “Eyes on the Rise.” The discussion was hosted by the French government, as part of the lead-up to the climate convention in Paris, at that point two months away. Among the members of the panel was a French scientist named Eric Rignot, a professor at the University of California, Irvine. Rignot is one of the researchers on O.M.G., and in a conference call
with reporters during the summer he said he was “in awe” of how fast the Greenland ice sheet was changing. I ran into him just as he was about to go onstage.

“I’m going to scare people out of this room,” he told me. His fellow-panelists were a French geophysicist, a climate scientist from the University of Miami, and Miami Beach’s mayor, Philip Levine. Levine was elected in 2013, after airing a commercial that tapped into voters’ frustration with the continual flooding. It showed him preparing to paddle home from work in a kayak.

“Some people get swept into office,” Levine joked when it was his turn at the mike. “I always say I got floated in.” He described the steps his administration was taking to combat the effects of rising seas. These include installing enormous underground pumps that will suck water off the streets and dump it into Biscayne Bay. Six pumps have been completed, and fifty-four more are planned. “We had to raise people’s storm-water fees to be able to pay for the first hundred-million-dollar tranche,” Levine said. “So picture this: you get elected to office and the first thing you tell people is ‘By the way, I’m going to raise your rates.’”

He went on, “When you are doing this, there’s no textbooks, there’s no ‘How to Protect Your City from Sea Level Rise,’ go to Chapter 4.” So the city would have to write its own. “We have a team that’s going to get it done, that’s going to protect this city,” the Mayor said. “We can’t let investor confidence, resident confidence, confidence in our economy start to fall away.”

John Morales, the chief meteorologist at NBC’s South Florida affiliate, was moderating the discussion. He challenged the Mayor, offering a version of the argument I’d heard from Wanless—that today’s pumps will be submerged by the seas of tomorrow.
“Down the road, this is just a Band-Aid,” Morales said.

“I believe in human innovation,” Levine responded. “If, thirty or forty years ago, I’d told you that you were going to be able to communicate with your friends around the world by looking at your watch or with an iPad or an iPhone, you would think I was out of my mind.” Thirty or forty years from now, he said, “We’re going to have innovative solutions to fight back against sea-level rise that we cannot even imagine today.”

Many of the world’s largest cities sit along a coast, and all of them are, to one degree or another, threatened by rising seas. Entire countries are endangered—the Maldives, for instance, and the Marshall Islands. Globally, it’s estimated that a hundred million people live within three feet of mean high tide and another hundred million or so live within six feet of it. Hundreds of millions more live in areas likely to be affected by increasingly destructive storm surges.

Against this backdrop, South Florida still stands out. The region has been called “ground zero when it comes to sea-level rise.” It has also been described as “the poster child for the impacts of climate change,” the “epicenter for studying the effects of sea-level rise,” a “disaster scenario,” and “the New Atlantis.” Of all the world’s cities, Miami ranks second in terms of assets vulnerable to rising seas—No. 1 is Guangzhou—and in terms of population it ranks fourth, after Guangzhou, Mumbai, and Shanghai. A recent report on storm surges in the United States listed four Florida cities among the eight most at risk: (On that list, Tampa came in at No. 1.) For the past several years, the daily high-water mark in the Miami area has been racing up at the rate of almost an inch a year, nearly ten times the rate of average global sea-level rise. It’s unclear exactly why this is happening, but it’s been speculated that it has to do with changes in ocean currents which are causing water to pile up along the coast. Talking about climate
change in the Everglades this past Earth Day, President Obama said, "Nowhere is it going to have a bigger impact than here in South Florida."

The region's troubles start with its topography. Driving across South Florida is like driving across central Kansas, except that South Florida is greener and a whole lot lower. In Miami-Dade County, the average elevation is just six feet above sea level. The county's highest point, aside from man-made structures, is only about twenty-five feet, and no one seems entirely sure where it is. (The humorist Dave Barry once set out to climb Miami-Dade's tallest mountain, and ended up atop a local garbage dump nicknamed Mt. Trashmore.) Broward County, which includes Fort Lauderdale, is equally flat and low, and Monroe County, which includes the Florida Keys, is even more so.

But South Florida's problems also run deeper. The whole region—indeed, most of the state—consists of limestone that was laid down over the millions of years Florida sat at the bottom of a shallow sea. The limestone is filled with holes, and the holes are, for the most part, filled with water. (Near the surface, this is generally freshwater, which has a lower density than saltwater.)

Until the eighteen-eighties, when the first channels were cut through the region by steam-powered dredges, South Florida was one continuous wetland—the Everglades. Early efforts to drain the area were only half successful; Northerners lured by turn-of-the-century real-estate scams found the supposedly rich farmland they'd purchased was more suitable for swimming.

"I have bought land by the acre, and I have bought land by the foot; but, by God, I have never before bought land by the gallon," one arrival from Iowa complained.
Even today, with the Everglades reduced to half its former size, water in the region is constantly being shunted around. The South Florida Water Management District, a state agency, claims that it operates the “world’s largest water control system,” which includes twenty-three hundred miles of canals, sixty-one pump stations, and more than two thousand “water control structures.” Floridians south of Orlando depend on this system to prevent their lawns from drowning and their front steps from becoming docks. (Basement flooding isn’t an issue in South Florida, because no one has a basement—the water table is too high.)

When the system was designed—redesigned, really—in the nineteen-fifties, the water level in the canals could be maintained at least a foot and a half higher than the level of high tide. Thanks to this difference in elevation, water flowed off the land toward the sea. At the same time, there was enough freshwater pushing out to prevent saltwater from pressing in. Owing in part to sea-level rise, the gap has since been cut by about eight inches, and the region faces the discomfiting prospect that, during storms, it will be inundated not just along the coasts but also inland, by rainwater that has nowhere to go. Researchers at Florida Atlantic University have found that with just six more inches of sea-level rise the district will lose almost half its flood-control capacity. Meanwhile, what’s known as the saltwater front is advancing. One city—Hallandale Beach, just north of Miami—has already had to close most of its drinking wells, because the water is too salty. Many other cities are worried that they will have to do the same.

Jayantha Obeysekera is the Water Management District’s chief modeller, which means it’s his job to foresee South Florida’s future. One morning, I caught up with him at a flood-control structure known as S13, which sits on a canal known as C11, west of Fort Lauderdale.

“We have a triple whammy,” he said. “One whammy is sea-level rise. Another whammy is the water table comes up higher, too. And in this area the higher the water table, the less space you have to absorb storm
water. The third whammy is if the rainfall extremes change, and become more extreme. There are other whammies probably that I haven’t mentioned. Someone said the other day, “The water comes from six sides in Florida.”

A month after the super blood moon, South Florida experienced another series of very high tides—“king tides,” as Miamians call them. This time, I went out to see the effects with Nicole Hernandez Hammer, an environmental-studies researcher who works for the Union of Concerned Scientists. Hammer had looked over elevation maps and decided that Shorecrest, about five miles north of downtown Miami, was a neighborhood where we were likely to find flooding. It was another hot, blue morning, and as we drove along, in Hammer’s Honda, at first it seemed that she’d miscalculated. Then, all of a sudden, we arrived at a major intersection that was submerged. We parked and made our way onto a side street, also submerged. We were standing in front of a low-slung apartment building, debating what to do next, when one of the residents came by.

“Every day I live in fear that our jobs will be replaced by pillows.”

“I’ve been trying to figure out: Where is the water coming from?” he said. “It’ll be drying up and then it’ll be just like this again.” He had complained to the building’s superintendent. “I told him, ‘Something needs to be done about this water, man.’ He says he’ll try to do something.” A cable-repair truck trailing a large wake rolled by and then stalled out.

The water on the street was so deep that it was, indeed, hard to tell where it was coming from. Hammer explained that it was emerging from the storm drains. Instead of funneling rainwater into the bay, as they were designed to do, the drains were directing water from the bay onto the streets. “The infrastructure we have is built for a world that doesn’t exist anymore,” she said.
Neither of us was wearing boots, a fact that, as we picked our way along, we agreed we regretted. I couldn’t help recalling stories I’d heard about Miami’s antiquated sewer system, which leaks so much raw waste that it’s the subject of frequent lawsuits. (To settle a suit brought by the federal government, the county recently agreed to spend $1.6 billion to upgrade the system, though many question whether the planned repairs adequately account for sea-level rise.) Across the soaked intersection, in front of a single-family home, a middle-aged man was unloading groceries from his car. He, too, told us he didn’t know where the water was coming from.

“I heard on the news it’s because the moon turned red,” he said. “I don’t have that much detail about it.” During the past month, he added, “it’s happened very often.” (In an ominous development, Miami this past fall experienced several very high tides at times of the month when, astronomically speaking, it shouldn’t have.)

“Honestly, sometimes, when I’m talking to people, I think, Oh, I wish I had taken more psychology courses,” Hammer told me. A lot of her job involves visiting low-lying neighborhoods like Shorecrest, helping people understand what they’re seeing. She shows them elevation maps and climate-change projections, and explains that the situation is only going to get worse. Often, Hammer said, she feels like a doctor: “You hear that they’re trying to teach these skills in medical schools, to encourage them to have a better bedside manner. I think I might try to get that kind of training, because it’s really hard to break bad news.”

It was garbage-collection day, and in front of one house county-issued trash bins bobbed in a stretch of water streaked with oil. Two young women were surveying the scene from the driveway, as if from a pier.
“It’s horrible,” one of them said to us. “Sometimes the water actually smells.” They were sisters, originally from Colombia. They wanted to sell the house, but, as the other sister observed, “No one’s going to want to buy it like this.”

“I have called the city of Miami,” the first sister said. “And they said it’s just the moon. But I don’t think it’s the moon anymore.”

After a couple of minutes, their mother came out. Hammer, who was born in Guatemala, began chatting with her in Spanish. “Oh,” I heard the mother exclaim. “Dios mío! El cambio climático!”

Marco Rubio, Florida’s junior senator, who has been running third in Republican primary polls, grew up not far from Shorecrest, in West Miami, which sounds like it’s a neighborhood but is actually its own city. For several years, he served in Florida’s House of Representatives, and his district included Miami’s flood-vulnerable airport. Appearing this past spring on “Face the Nation,” Rubio was asked to explain a statement he had made about climate change. He offered the following: “What I said is, humans are not responsible for climate change in the way some of these people out there are trying to make us believe, for the following reason: I believe that climate is changing because there’s never been a moment where the climate is not changing.”

Around the same time, it was revealed that aides to Florida’s governor, Rick Scott, also a Republican, had instructed state workers not to discuss climate change, or even to use the term. The Scott administration, according to the Florida Center for Investigative Reporting, also tried to ban talk of sea-level rise; state employees were supposed to speak, instead, of “nuisance flooding.” Scott denied having imposed any such Orwellian restrictions, but I met several people who told me they’d bumped up against them. One was Hammer, who, a few years ago, worked on a report to the state about threats to Florida’s
transportation system. She said that she was instructed to remove all climate-change references from it. "In some places, it was impossible," she recalled. "Like when we talked about the Intergovernmental Panel on Climate Change, which has 'climate change' in the title."

Scientists who study climate change (and the reporters who cover them) often speculate about when the partisan debate on the issue will end. If Florida is a guide, the answer seems to be never. During September's series of king tides, former Vice-President Al Gore spent a morning sloshing through the flooded streets of Miami Beach with Mayor Levine, a Democrat. I met up with Gore the following day, and he told me that the boots he'd worn had turned out to be too low; the water had poured in over the top.

"When the governor of the state is a full-out climate denier, the irony is just excruciatingly painful," Gore observed. He said that he thought Florida ought to "join with the Maldives and some of the small island states that are urging the world to adopt stronger restrictions on global-warming pollution."

Instead, the state is doing the opposite. In October, Florida filed suit against the Environmental Protection Agency, seeking to block new rules aimed at limiting warming by reducing power-plant emissions. (Two dozen states are participating in the lawsuit.)

"The level of disconnect from reality is pretty profound," Jeff Goodell, a journalist who's working on a book on the impacts of sea-level rise, told me. "We're sort of used to that in the climate world. But in Florida there are real consequences. The water is rising right now."

Meanwhile, people continue to flock to South Florida. Miami's metropolitan area, which includes Fort Lauderdale, has been one of the fastest growing in the country; from 2013 to 2014, in absolute terms it
added more residents than San Francisco and, proportionally speaking, it outdid Los Angeles and New York. Currently, in downtown Miami there are more than twenty-five thousand new condominium units either proposed or under construction. Much of the boom is being financed by “flight capital” from countries like Argentina and Venezuela; something like half of recent home sales in Miami were paid for in cash.

And just about everyone who can afford to buys near the water. Not long ago, Kenneth Griffin, a hedge-fund billionaire, bought a penthouse in Miami Beach for sixty million dollars, the highest amount ever paid for a single-family residence in Miami-Dade County (and ten million dollars more than the original asking price). The penthouse, in a new building called Faena House, offers eight bedrooms and a seventy-foot rooftop pool. When I read about the sale, I plugged the building’s address into a handy program called the Sea Level Rise Toolbox, created by students and professors at Florida International University. According to the program, with a little more than one foot of rise the roads around the building will frequently flood. With two feet, most of the streets will be underwater, and with three it seems that, if Faena House is still habitable, it will be accessible only by boat.

I asked everyone I met in South Florida who seemed at all concerned about sea-level rise the same question: What could be done? More than a quarter of the Netherlands is below sea level and those areas are home to millions of people, so low-elevation living is certainly possible. But the geology of South Florida is peculiarly intractable. Building a dike on porous limestone is like putting a fence on top of a tunnel: it alters the route of travel, but not necessarily the amount.

“You can't build levees on the coast and stop the water” is the way Jayantha Obeysekera put it. “The water would just come underground.”
Some people told me that they thought the only realistic response for South Florida was retreat.

"I live opposite a park," Philip Stoddard, the mayor of South Miami—also a city in its own right—told me. "And there's a low area in it that fills up when it rains. I was out there this morning walking my dog, and I saw fish in it. Where the heck did the fish come from? They came from underground. We have fish that travel underground!"

"What that means is, there's no keeping the water out," he went on. "So ultimately this area has to depopulate. What I want to work toward is a slow and graceful depopulation, rather than a sudden and catastrophic one."

"You the guy who donated his body to science?"

More often, I heard echoes of Mayor Levine's Apple Watch line. Who knows what amazing breakthroughs the future will bring?

"I think people are underestimating the incredible innovative imagination in the world of adaptive design," Harvey Ruvin, the Clerk of the Courts of Miami-Dade County and the chairman of the county's Sea Level Rise Task Force, said when I went to visit him in his office. A quote from Buckminster Fuller hung on the wall: "We are all passengers on Spaceship Earth." Ruvin became friendly with Fuller in the nineteen-sixties, after reading about a plan Fuller had drawn up for a floating city in Tokyo Bay.

"I would agree that things can't continue exactly the way they are today," Ruvin told me. "But what we will evolve to may be better."

http://www.newyorker.com/magazine/2015/12/21/the-siege-of-miami
“I keep telling people, ‘This is my patient,’” Bruce Mowry, Miami Beach’s city engineer, was saying. “I can’t lose my patient. If I don’t do anything, Miami Beach may not be here.” It was yet another day of bright-blue skies and “nuisance flooding,” and I was walking with Mowry through one of Miami Beach’s lowest neighborhoods, Sunset Harbour.

If Miami Beach is on a gurney, then Mowry might be said to be thumping its chest. It’s his job to keep the city viable, and since no one has yet come up with a smart-watch-like breakthrough, he’s been forced to rely on more primitive means, like pumps and asphalt. We rounded a corner and came to a set of stairs, which led down to some restaurants and shops. Until recently, Mowry explained, the shops and the street had been at the same level. But the street had recently been raised. It was now almost a yard higher than the sidewalk.

“I call this my five-step program,” he said. “What are the five steps?” He counted off the stairs as we descended: “One, two, three, four, five.” Some restaurants had set up tables at the bottom, next to what used to be a curb but now, with the elevation of the road, is a three-foot wall. Cars whizzed by at the diners’ eye level. I found the arrangement disconcerting, as if I’d suddenly shrunk. Mowry told me that some of the business owners, who had been unhappy when the street flooded, now were unhappy because they had no direct access to the road: “It’s, like, can you win?”

Several nearby streets had also been raised, by about a foot. The elevated roadbeds were higher than the driveways, which now all sloped down. The parking lot of a car-rental agency sat in a kind of hollow.

I asked about the limestone problem. “That is the one that scares us more than anything,” Mowry said. “New Orleans, the Netherlands—everybody understands putting in barriers, perimeter levees, pumps. Very few people understand: What do you do when the water’s coming up through the ground?
“What I’d really like to do is pick the whole city up, spray on a membrane, and drop it back down,” he went on. I thought of Calvino’s “Invisible Cities,” where such fantastical engineering schemes are the norm.

Mowry said he was intrigued by the possibility of finding some kind of resin that could be injected into the limestone. The resin would fill the holes, then set to form a seal. Or, he suggested, perhaps one day the city would require that builders, before constructing a house, lay a waterproof shield underneath it, the way a camper spreads a tarp under a tent. Or maybe some sort of clay could be pumped into the ground that would ooze out and fill the interstices.

“Will it hold?” Mowry said of the clay. “I doubt it. But these are things we’re exploring.” It was hard to tell how seriously he took any of these ideas; even if one of them turned out to be workable, the effort required to, in effect, caulk the entire island seemed staggering. At one point, Mowry declared, “If we can put a man on the moon, then we can figure out a way to keep Miami Beach dry.” At another, he mused about the city’s reverting to “what it came from,” which was largely mangrove swamp: “I’m sure if we had poets, they’d be writing about the swallowing of Miami Beach by the sea.”

We headed back toward Mowry’s office around the time of maximum high tide. The elevated streets were still dry, but on the way to City Hall we came to an unreconstructed stretch of road that was flooding. Evidently, this situation had been anticipated, because two mobile pumps, the size and shape of ice-cream trucks, were parked near the quickly expanding pool. Neither was operating. After making a couple of phone calls, Mowry decided that he would try to switch them on himself. As he fiddled with the controls, I realized that we were standing not far from the drowned palm tree I’d seen on my first day in Miami Beach, and that it was once again underwater.
About a dozen miles due west of Miami, the land gives out, and what's left of the Everglades begins. The best way to get around in this part of Florida is by airboat, and on a gray morning I set out in one with a hydrologist named Christopher McVoy. We rented the boat from a concession run by members of the Miccosukee tribe, which, before the Europeans arrived, occupied large swaths of Georgia and Tennessee. The colonists hounded the Miccosukee ever farther south, until, eventually, they ended up with a few hundred mostly flooded square miles between Miami and Naples. On a fence in front of the dock, a sign read, "Beware: Wild alligators are dangerous. Do not feed or tease." Our guide, Betty Osceola, handed out headsets to block the noise of the rotors, and we zipped off.

The Everglades is often referred to as a "river of grass," but it might just as accurately be described as a prairie of water. Where the airboats had made a track, the water was open, but mostly it was patchy—interrupted by clumps of sawgrass and an occasional tree island. We hadn't been out very long when it started to pour. As the boat sped into the rain, it felt as if we were driving through a sandstorm.

The same features that now make South Florida so vulnerable—its flatness, its high water table, its heavy rains—are the features that brought the Everglades into being. Before the drainage canals were dug, water flowed from Lake Okeechobee, about seventy miles north of Miami, to Florida Bay, about forty miles to the south of the city, in one wide, slow-moving sheet. Now much of the water is diverted, and the water that does make it to the wetlands gets impounded, so the once continuous "sheet flow" is no more. There's a comprehensive Everglades restoration plan, which goes by the acronym CERP, but this has got hung up on one political snag after another, and climate change adds yet one more obstacle. The Everglades is a freshwater ecosystem; already, at the southern margin of Everglades National Park, the water is becoming salty. The sawgrass is in retreat, and mangroves are moving in. In coming decades, there's likely to be more and more demand for the freshwater that remains. As McVoy put it, "You've got a big chunk of agriculture, a big chunk of people, and a big chunk of nature reserve all competing for the same resources."
The best that can be hoped for with the restoration project is that it will prolong the life of the wetland and, with that, of Miami’s drinking-water system. But you can’t get around geophysics. Send the ice sheets into “irreversible decline,” as it seems increasingly likely we have done, and there’s no going back. Eventually, the Everglades, along with Shorecrest and Miami Beach and much of the rest of South Florida, will be inundated. And, if Hal Wanless is right, eventually isn’t very far off.

To me, the gunmetal expanse of water and grass appeared utterly without markers, but Osceola, who could read the subtlest of ridges, knew exactly where we were at every moment. We stopped to have sandwiches on an island with enough dry land for a tiny farm, and stopped again at a research site that McVoy had set up in the muck. There was a box of electrical equipment on stilts, and a solar panel to provide power. McVoy dropped out of the boat to collect some samples in empty water-cooler bottles. The rain let up, and then started again. ♦

Elizabeth Kolbert has been a staff writer at The New Yorker since 1999. She won the 2015 Pulitzer Prize for general nonfiction for “The Sixth Extinction: An Unnatural History.”
That sea levels are rising is hardly new news—they have been doing so since the end of the last major glaciation some 18,000 years ago. The current rate of rise, a little more than a tenth of an inch per year, is also not that unusual—6000-8000 years ago the seas were often rising ten times faster. What is different today and the reason for concern is that back then in response to rapidly rising waters, coastal dwelling Floridians just picked up and moved uphill, leaving their villages, burrows, nests, and rooted parents behind. Today it is not so easy to move uphill, for humans nor the rest of the biota, but move we must.

Francis E. “Jack” Putz
The effects of sea level rise are often difficult to differentiate from the myriad of other drivers of coastal change, but the expanses of dead trees looming over Gulf Coast marshes is compelling evidence. The story unfolds very clearly in Yankeetown’s Withlacoochee Gulf Preserve (www.withlacoocheegulfpreserve.com) where saltwater intrusion due to over-pumping from the aquifer is not the confounding factor that it is near large cities. The comparatively small tidal fluxes in the Gulf also help in differentiation of the signal of sea level rise from the noise of tides. Another advantage of the Yankeetown marshes and coastal forests is that they are perched atop a stable limestone platform and not on subsiding mucks like in the Mississippi Delta. Finally, as a study site or the destination for an outing, Withlacoochee Gulf Preserve is startlingly beautiful.

What you first see when you approach the coast near Yankeetown are breathtaking expanses of saltmarsh dotted with forested islands of mostly cedars and palms. After gazing at these splendid vistas for a while, an over-abundance of dead trees may become evident. Those adventurous souls that venture out into the marsh might be surprised to stumble over tree stumps in dense swards of black needle-rush or in the more sparse patches of glassworts and saltworts. Closer inspection of a forested island in the sea of saltmarsh will reveal many more dead trees, especially in low-lying areas. The really astute observer will notice that while the canopy on the healthier-looking islands might still be dominated by cabbage palms and red cedars, with perhaps even a few scraggly slash pines and live oaks, the understory is choked with marsh elder, lycium, and other saltmarsh shrubs, not tree seedlings and saplings.

Faculty and students from the University of Florida have been investigating coastal forest decline and replacement by saltmarsh in the Yankeetown area since the mid-1990s (Williams et al. 1999, Castaneda and Putz 2007, DeSantis et al. 2007). These studies revealed that the die-off described above is mostly a consequence of chronic stresses of sea level rise coupled with the punctuated disturbances of storms and droughts. Data from regularly monitored permanent sample plots on forested islands supported by field and greenhouse experiments reveal that salt is the principal culprit; the abundance of cabbage palms and red cedars is a consequence of
their relatively high tolerance of salinity. That increased flooding is not the main driver of forest replacement by saltmarsh is made obvious by a drive west out State Road 40 towards the Yankeetown Boat Ramp.

South of State Road 40, the fresh waters of the Withlacoochee River wash away the salt, while areas to the north of the road are completely exposed to the effects of sea level rise. The health and diversity of the river side forests is testimony to this occasional cleansing by fresh water. At the same elevation, the northern forests are species-poor and obviously in declining health while those to the south are lush with live oaks, red maples, green ashes, slash pines, hop trees, slippery elms, and occasional cabbage palms and red cedars.

Greenhouse experiments involving potted plants grown in salt solutions in colorful plastic swimming pools confirmed the ranking of tree species’ salt tolerance observed in the field. Cabbage palms and red cedar were tolerant of up to 8 parts per thousand salt, about quarter the strength of open ocean water. Other tree species were not nearly as tolerant, dying when exposed to concentrations as low as 2 parts per thousand. For salt-sensitive species, even the occasional sea surge, especially if followed by dry conditions, can be fatal. As sea levels rise, so do the impacts of surges along with soil salinities to the point that, one after another, these salt-sensitive species first fail to reproduce and then die out entirely, leaving the palms and cedar to flourish for a few decades before they too succumb.

To gauge how salt exposure affects trees in the field, we have been monitoring tree mortality, recruitment, and growth in permanent sample plots since 1994. Measuring the growth rates of most trees simply involves stretching a tape around their circumference every few years, but for palms the method is more exciting. Because palm stems do not grow in diameter once they emerge from their below-ground establishment phase, changes in their above-ground stem diameter is not useful as an index of vigor. Fortunately, each palm leaf leaves a scar at its node when it falls; monitoring palm growth rates and estimating tree ages involves monitoring leaf production rates and measuring internode lengths. To keep track of which leaves were new, we dabbed paint on the youngest...
leaf present at the time of each census; for short palms this operation involved the use of a pole with a paint brush attached to the end, but tall ones needed be ascended with our handy tree bicycle.

On the forested islands in the saltmarsh, as salinity increased, growth and survival rates declined in all species, including palms and cedars. We also noticed that in response to high but still tolerable salinities, the leaves that cabbage palms slowly produced were small, and the few fruits and seeds they managed to produce were also small.

Based on the absence of seedlings and saplings of tree species still present in the canopies of forested islands, we concluded that salt tolerance increases with tree size. For cabbage palms, we used the growth rate and internode count data to estimate how many years had elapsed since the last successful reproduction. In forests below about 25 cm elevation that are tidally flooded at least 50 times per year, the overstory palms are truly the living dead—their leaves are about half normal size, they grow at a small fraction of the rate of trees away from sea water, and they last produced seedlings way back in the 1940s (Williams et al. 1998).

While the death of huge swaths of forests along our coasts may seem like a bleak image and a harbinger of a dismal future, it is important to remember that the forests are being replaced by saltmarshes, which have their own virtues. Simultaneously, saltmarshes must in turn be replaced by mud flats, oyster bars, and sea grass beds, but those transitions have been less well studied. In any event, sea levels have risen and fallen repeatedly over the past few million years, inundating villages, forests and saltmarshes. Although we need to do all we can to reduce the accumulation of carbon dioxide and other heat-trapping gases in the atmosphere, we also need to adapt to the unavoidable impacts of global climate change including sea level rise.

Even if we stopped emitting greenhouse gases tomorrow, sea levels would continue to rise for at least the next century and coastal ecosystems would continue to need to adapt to these rapidly changing conditions. Given that emissions are increasing, not decreasing, and the rate of sea level rise is accelerating, not decelerating, the need for adaptation grows daily (Geselbracht et al. 2011). For now the best we can do for the species in our coastal ecosystems is to provide them unimpeded opportunities to move uphill. We also need to determine which species will require our assistance in their migration, but providing pathways for upslope migration should be the priority.

REFERENCES CITED AND FURTHER READING


About the Author

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What Does Shell Mound Archaeological Site Have to Do with Water and Climate Change?

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It goes without saying that life of the coast is life on the water. But did you know that the potential for human settlement on the coast is greatly enhanced by water that comes from elsewhere? Where rivers that drain the interior of Florida empty into the ocean, freshwater mixes with saltwater to create estuaries. As transitional zones between land and water, estuaries are some of the most diverse and productive marine habitats in the world. Numerous species of fish, shellfish, and other sources of food thrive in healthy estuaries.

Shell Mound is an archaeological site on an estuary of the northern Gulf Coast of Florida (Figure 1). It was occupied by ancestral Native Americans from A.D. 200–700, over 1300 years ago. This is too long ago to connect its residents directly to more recent or existing native people, but Shell Mound is nonetheless part of a long history of coastal dwelling going back at least 4,500 years, when the Suwannee estuary reached its more-or-less present form. Archaeological work at Shell Mound and vicinity shows that culture change over the ensuing centuries came in fits and starts, some tied to rapid changes in sea level, which impacted estuaries.

Climatic conditions in the interior of Florida—particularly rainfall, which feeds rivers—factor into this history too. We know from modern conditions that diminished freshwater flow into the Gulf can negatively impact the health of estuaries. With less freshwater input, estuaries become more salty, more saline. That’s good for some species, but negative impacts on keystone species like oyster can ripple throughout the ecosystem. An especially bad consequence is the collapse of oyster reefs that trap the freshwater and sediment necessary for estuarine health. Groundwater extraction in the interior of Florida has been cited as the leading cause for oyster reef collapse in the Lower Suwannee over the past several decades (Seavey et al. 2011). Ancient droughts may have had similar consequences on reefs.

Shell Mound Lives

Shell Mound is an archaeological archive of changing estuarine ecology and human dwelling over many centuries. It is one of many sites in the area, but it was a particularly important site. Shell Mound was one of the civic-ceremonial centers of the northern Gulf Coast that arose during an era of heightened ritual, much of it involving ancestors. Just west of Shell Mound, across a straight of tidal water, is Palmetto Mound (Figure 2), a cemetery that contained hundreds of people and over 1,000 pottery vessels that were left as offerings. Palmetto Mound housed the ancestors of people who occupied Shell Mound. These were people who lived

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1 A keystone species is a species that has a disproportionately large effect on its environment relative to its abundance. Although they can be abundant, oysters are a keystone species due to their critical roles in maintaining water quality and biodiversity, and cycling water and nutrients throughout the ecosystem.
Figure 1. Locator map (left) of the study area of the Lower Suwannee Archaeological Survey, University of Florida, and an inset map (right) of the Shell Mound Tract, with locations of sites mentioned in text. Note that the Suwannee Reef is the main impoundment of water and sediment of the Suwannee estuary; the recent collapse of this reef has had cascading effects on estuarine health. It came into existence about 4,500 years ago.

through a great deal of climate change, the ups and downs of estuary living. They were also part of something much bigger, a regional network of like-minded people, those who shared basic principles about life, the afterlife, and more. They gathered at Shell Mound by the hundreds at times, to commemorate the dead, to renew the world, and to sustain their way of life through a variety of collective practices. Among these practices were (1) terraforming; (2) intensification; and (3) networking. Let’s take a brief look at each of these practices through the lens of archaeology.

_Terraforming_

The most obvious thing you will notice about Shell Mound is that it is a large pile of oyster shell. It is indeed. We have estimated that upwards of 1.2 billion oysters were deposited at Shell
Figure 2. LiDAR-generated topographic map of Shell Mound and Palmetto Mound. Separated by intertidal water, these two mounds are oriented on an east-west axis. Separation of the dead from the living by water is not uncommon among nonwestern people worldwide, and through time, as is the direction of west for death, the direction of the setting sun.

Mound over a period of about 200 years, from A.D. 450 to 650. To put that into perspective, 100 people would each have to eat 165 oysters a day, every day, for two centuries to account for Shell Mound. Put another way, it would take 1,370 people eating one dozen oysters every day for two centuries. Never mind that oysters were not the only the food on the menu; Shell Mound residents ate lots of fish, turtles, birds, deer, hickory nuts, tubers, and a variety of other plants and animals. But no matter how you count them, oysters were collected and piled up in large numbers to form the U-shaped ridge that is Shell Mound (Figure 3).

Now, archaeologists of yesteryear simply assumed that shells at Shell Mound were the inedible remains of everyday meals. They did not know how long the site was occupied. If they assumed that it was occupied over a period of, say, 1,000 years, then the rate of oyster harvesting would not be all that dramatic. In fact, this would take it down to less than three dozen oysters a day for the entire group, no matter what size.

They also assumed that the shape of Shell Mound was merely a consequence of the way people organized themselves on the landscape. That is, if people lived in houses arranged in a circle or semi-circle and threw their refuse behind them, the result would be a ring or arc of shell.
Modern perspectives on Shell Mound—informied by recent archaeological work (Sassaman et al. 2016)—are much different. We now know that shell accumulated over a relatively short period of time (~200 years) and that much of it was emplaced quickly to create the U-shaped form we see today (Figure 4). In fact, the very last layers of shell, which were emplaced at about A.D. 650, include some that were dug up from earlier deposits (A.D. 450–550) and moved to locations to complete the form (Figure 5). We refer to this activity as *terraforming*, meaning that it was an intentional act of landscape engineering.

Figure 3. LiDAR-generated topographic map of Shell Mound (8LV42), showing locations (in red) of all the test units (TU) excavated by staff of the Lower Suwannee Archaeological Survey, University of Florida. The goal of testing Shell Mound has been to sample widely so as to reveal a full range of the variation in subsurface deposits, both in form and in age. Test units range from 1 x 1 m to 2 x 2 m in plan and go as deep as they need to reach “sterile” substrate (i.e., below the depth of human impact).
Figure 4. Evolution of Shell Mound as locus of small-scale settlement (ca. A.D. 200), to relocation to relict dune arm (ca. A.D. 400), where pit digging ensued, to terraforming the south ridge with oyster shell (ca. A.D. 600). Red areas in each of these panels signify the intensity of human activity, both pit digging and shell deposition.

Figure 5. Three examples of reverse stratigraphy, where older deposits are emplaced over younger deposits. This is good evidence for terraforming, essentially the engineering of earth, in this case a U-shaped shell ridge.

Terraforming at civic-ceremonial centers in the region was actually quite common. In additional to ridges like Shell Mound, construction projects involved burial mounds like Palmetto, flat-topped platform mounds for public feasting and other events, and even the infrastructure of food getting, such as fish traps and oyster farms.
Terraforming at Shell Mound and other civic-ceremonial centers in the region may have had a practical purpose for people facing rapid climate change. Geologists tell us that at about A.D. 100 a climate event occurred that led to a 2–3 km transgression of the sea. The shoreline was flooded and the estuary was impacted as the balance between saltwater, freshwater, and sediment was thrown out of whack. The estuary would recover soon enough. Coastal dwellers, in the meantime, relocated their settlements either back from the coast or on higher ground, such as the sand dune on which Shell Mound lies. All this took place during the period of climate known as the Roman Warm Period (ca. 400 B.C. – A.D. 450), when sea levels were generally on the rise and the estuary subject to higher salinity.

Relocating to higher ground solved the immediate concerns of rising sea, but there was far more to it than that. The earlier civic-ceremonial centers, and eventually Shell Mound, were constructed according to plans that were consistent with peoples’ belief in the forces of nature and the power of their ancestors. We do not know much about the particulars of their beliefs, but we can infer that they involved solar alignments, notably the positions of the rising and setting sun during the summer and winter solstices, when the sun reaches its maximum north and south positions in the sky. Shell Mound is open to the rising winter solstice sun and closed to the setting summer solstice sun. Ritual gatherings at Shell Mound were likely timed to the solstices, and the terraformed landscape people created was an earthly expression of these cosmic alignments. It was in this sense that the economy of Shell Mound people was intensified by the demands of ritual.

**Intensification**

The residences of Shell Mound, like their predecessors, were able to make a living through the daily collection of shellfish, small fish, turtles, local plants, and the occasional deer. They of course had canoes and could move about their estuary to find whatever they needed to get by. Disruptions to estuary ecology may not have been all that impactful for small communities that were able to relocate at will.

But when the time came for large gatherings of people, the daily economy of Shell Mound was not likely enough and the venue itself was not portable; it was, after all, the resting place of centuries of ancestors. On top of that, ritual protocols likely involved the collection and consumption of special foods: big fish, waterbirds of symbolic import, sea turtles, and the best oysters. The remains of these sorts of foods show up in Shell Mound in special contexts, and in association with pottery and other items that signal large-scale, special events.

Events of large-scale gathering put demands on the ritual economy of Shell Mound and its people responded by intensifying production. Intensification means to produce more, in this case to feed more people, but intensification often comes with higher per-unit costs and thus may not be as efficient as the daily or domestic economy. Until now, archaeologists have not given much thought about the impact of a ritual economy on sustainable coastal living, perhaps because it was thought to be incidental to everyday practice. In its scale of terraforming, oyster harvesting, and deep ancestral history, Shell Mound’s ritual economy was hardly incidental.
Recent archaeological research has revealed several measures of the scale and organization of the ritual economy at Shell Mound. Foremost is the assemblage of massive pits that were used to process lots of food (Figure 6). These pits were dug into the dune sands underlying Shell Mound and were backfilled, after used for steaming oysters, with the bones of large fish, waterbirds, sea turtles, and deer. In addition, pits were filled with objects from far away, such as quartz crystal and mica, as well as nonlocal pottery. Locally made pottery is found in pits too, but in extra-large sizes, well beyond that needed to cook food for normal-sized families.

Second, the oyster shells that accumulated during the period of terraforming include a high proportion of individuals that show evidence of *mariculture*. This is the work of UF graduate student Jessica Jenkins (2016), whose data suggest that Shell Mound residents cultivated oysters much in the way modern people do: that is, they separated oyster clusters to enable individuals to reach maximum growth, and they placed some shell back into the water to encourage the growth of spat, which are the embryos of future oyster generations.

Third, some locations in the intertidal zone near Shell Mound were possibly modified or terraformed to enable fish like mullet to be harvested in large numbers. One such location is about two kilometers south of Shell Mound, at Richards Island (Figure 7). A wall of oyster shell on the Gulf side of this island encloses a series of tidal pools that trap fish at low tide. People using nets could harvest hundreds of fish from these pools. Whether the seawall of shell and the pools are “natural” or human-made—or, most likely, natural features that were enhanced and
maintained though human effort—the scale of fish harvest could be intensified for large gatherings of people. We certainly find the evidence for such activities in the pits at Shell Mound: large quantities of bone from mullet and other schooling fish.

Many of the activities that we attribute to the ritual economy could well have been effective at mitigating the impact of climate change on estuarine health. Terraforming and large gatherings at Shell Mound appear to have started when climate was still warming and water levels rising. However, by about A.D. 500, climate change had reversed as the region entered a cooler and wetter period known as the Vandal Minimum (ca. A.D. 500–800). Sea levels may not have dropped all that much but freshwater entered the estuary at accelerated volume and rate. Mariculture may thus have been in response to such change as much as it was to the demands of a ritual economy. Either way, the commitment people made to build such a large, permanent facility locked them in to this particular place, the place of their ancestors. They would eventually give up on living at Shell Mound, as climate once again warmed and water rose after A.D. 800, the onset of the Medieval Warm Period. The social networks that brought so many people to Shell Mound for feasts and other rituals provided options for relocating to the interior and away from the climate impacts of coastal dwelling.
Networking

The connections people had throughout this entire history stretched from northern Gulf coastal Florida to the panhandle, southern Georgia, northeast Florida, and the lakes regions near Orlando. We know this because of the provenance (location of origin) of so much of the material culture that was deposited at Palmetto Mound. Networks of affiliation were indeed vast and large: they account for the large number of people who converged occasionally at Shell Mound and other civic-ceremonial centers in the region. When coastal centers were abandoned during the eight century A.D., many people moved to the interior of Florida, to places in Alachua County, for instance. Notably, descendants of some of these displaced people continued to return to the coast for centuries to come, interring their dead and grave offerings in Palmetto Mound through A.D. 1300. Although it had become perhaps too difficult to maintain permanent settlement on the coast—at least at such large scale and with intensified demands on its resources—ancestors continued to beckon people to return, perhaps reminding them with each visit of the limits to growth in a place that was subject to so much environmental change.

Lessons Learned

The archaeological record of Gulf-coastal living for the thousands of years before Europeans arrived offers several lessons for our own futures with climate change and its effects on water availability and quality.

First, so long as people were able to relocate at will, and not lock into particular places and practices, they were able to adjust to changes in estuarine ecology. This is not so much the story of Shell Mound as it is the preceding 3,000 years, when people did not establish large, permanent settlements. Oh sure, they had their cemeteries too, but as cemeteries were flooded with rising water, they disinterred their ancestors and relocated them landward. Palmetto Mound was simply the last of a series of such relocation projects, and this time for good.

Second, people did not simply live by fate alone but took their future into their own hands. The terraforming of Shell Mound is a good example, as is the practice mariculture and infrastructure for fishing. The practical aspects of building settlements back from the coast or on top of dunes should be obvious, but less obvious is the effort to align mounds and ridges to the solstices. This signals a sense of cosmology and religion in which the forces of the universe are respected and perhaps manipulated to maintain balance and thus sustainability. The downside is that much of the infrastructure of this belief system was built to last, and given the practices of large-scale gathering that occurred at places intended to be permanent, ecological limits were likely encountered and eventually too much to overcome.

And that leads to the third major lesson. Social networks that account for the large-scale of coastal settlement and ritual gatherings had their costs, but they also provided options for relocating in times of need. It must have been a good insurance plan for people confronting climate change. The coast would never stop being important to descendants of those who left, and their continued pilgrimages were no doubt important reminders to the limits of growth.

2 The main costs were those of provisioning large feasts, but additional costs may have been realized in the production and distribution of ritual objects, such as the pottery interred in Palmetto Mound.
Having lived through similar change in more ancient times, the ancestors must have known when to stop and rethink their futures. We face the same challenge today: will we consult the ancient past, the ancestors, for possible solutions to climate change, or will we go blithely into the future as if it never happened before?

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A big tamarisk can suck 73,000 gallons of river water a year. For $2.88 a day, plus water bounty, Lolo rips tamarisk all winter long.

Ten years ago, it was a good living. Back then, tamarisk shouldered up against every riverbank in the Colorado River Basin, along with cottonwoods, Russian olives, and elms. Ten years ago, towns like Grand Junction and Moab thought they could still squeeze life from a river.

Lolo stands on the edge of a canyon, Maggie the camel his only companion. He stares down into the deeps. It's an hour's scramble to the bottom. He ties Maggie to a juniper and starts down, boot-skiing a gully. A few blades of green grass sprout neon around him, piercing juniper-tagged snow clods. In the late winter, there is just a beginning surge of water down in the deeps; the ice is off the river edges. Up high, the mountains still wear their ragged snow mantles. Lolo smears through mud and hits a channel of scree, sliding and scattering rocks. His jugs of tamarisk poison gurgle and slosh on his back. His shovel and rockbar snag on occasional junipers as he skids by. It will be a long hike out. But then, that's what makes this patch so perfect. It's a long way down, and the riverbanks are largely hidden.

It's a living; where other people have dried out and blown away, he has remained: a tamarisk hunter, a water tick, a stubborn bit of weed.
Everyone else has been blown off the land as surely as dandelion seeds, set free to fly south or east or, most of all, north where watersheds sometimes still run deep and where even if there are no more lush ferns or deep cold fish runs, at least there is still water for people.

Eventually, Lolo reaches the canyon bottom. Down in the cold shadows, his breath steams.

He pulls out a digital camera and starts shooting his proof. The Bureau of Reclamation has gotten uptight about proof. They want different angles on the offending tamarisk, they want each one photographed before and after, the whole process documented, GPSd, and uploaded directly by the camera. They want it done on site. And then they still sometimes come out to spot-check before they calibrate his headgate for water bounty.

But all their due diligence can't protect them from the likes of Lolo. Lolo has found the secret to eternal life as a tamarisk hunter. Unknown to the Interior Department and its BuRec subsidiary, he has been seeding new patches of tamarisk, encouraging vigorous brushy groves in previously cleared areas. He has hauled and planted healthy root balls up and down the river system in strategically hidden and inaccessible corridors, all in a bid for security against the swarms of other tamarisk hunters that scour these same tributaries. Lolo is catty. Stands like this one, a quarter mile long and thick with salt-laden tamarisk, are his insurance policy.

Documentation finished, he unstraps a folding saw along with his rockbar and shovel, and sets his poison jugs on the dead salt bank. He starts cutting, slicing into the roots of the tamarisk, pausing every thirty seconds to spread Garlon 4 on the cuts, poisoning the tamarisk wounds faster than they can heal. But some of the best tamarisk, the most vigorous, he uproots and sets aside for later use.

$2.88 a day, plus water bounty.

It takes Maggie's rolling, bleating camel stride a week to make it back to Lolo's homestead. They follow the river, occasionally climbing above it onto cold mesas or wandering off into the open desert in a bid to avoid the skeleton sprawl of emptied towns. Guardie choppers buzz up and down the river like swarms of angry yellow jackets, hunting for portumpers and wildcat diversions. They rush overhead in a wash of beaten air and gleaming National Guard logos. Lolo remembers a time when the guardies traded potshots with people down on the riverbanks, tracer-fire and machine-gun chatter echoing in the canyons. He remembers the glorious hiss and arc of a Stinger missile as it flashed across red rock desert and blue sky and burned a chopper where it hovered.

But that's long in the past. Now, guardie patrols skim up the river unmolested.

Lolo tops another mesa and stares down at the familiar landscape of an eviscerated town, its curving streets and subdivision cul-de-sacs all sitting silent in the sun. At the very edge of the empty town, one-acre ranchettes and snazzy five-thousand-square-foot houses with dead-stick trees and dust-hill landscaping fringe a brown-tumbleweed golf course. The sand traps don't even show anymore.

When California put its first calls on the river, no one really worried. A couple towns went begging for water. Some idiot newcomers with bad water rights stopped grazing their horses, and that was it. A few years later, people started showering real fast. And a few after that, they showered once a week. And then people started using the buckets. By then, everyone had stopped joking about how "hot" it was. It didn't really matter how "hot" it was. The problem wasn't lack of water or an excess of heat, not really. The problem was that 4.4 million acre-feet of water were supposed to go down the river to California. There was water; they just couldn't touch it.

They were supposed to stand there like dumb monkeys and watch it flow on by.

"Lolo?"

The voice catches him by surprise. Maggie startles and groans and lunes for the mesa edge before Lolo can rein her around. The camel's great
padded feet scuffle dust, and Lolo flails for his shotgun where it nestles in a scabbard at the camel’s side. He forces Maggie to turn, shotgun half drawn, holding barely to his seat and swearing.

A familiar face, tucked amongst juniper tangle.

“Goddamnit!” Lolo lets the shotgun drop back into its scabbard. “Jesus Christ, Travis. You scared the hell out of me.”

Travis grins. He emerges from amongst the junipers’ silver bark rags, one hand on his gray fedora, the other on the reins as he guides his mule out of the trees. “Surprised?”

“I could’ve shot you!”

“Don’t be so jittery. There’s no one out here ‘cept us water ticks.”

“That’s what I thought the last time I went shopping down there. I had a whole set of new dishes for Annie and I broke them all when I ran into an ultralight parked right in the middle of the main drag.”

“Meth flyers?”

“Beats the hell out of me. I didn’t stick around to ask.”

“Shit. I’ll bet they were as surprised as you were.”

“They almost killed me.”

“I guess they didn’t.”

Lolo shakes his head and swears again, this time without anger. Despite the ambush, he’s happy to run into Travis. It’s lonely country, and Lolo’s been out long enough to notice the silence of talking to Maggie. They trade ritual sips of water from their canteens and make camp together. They swap stories about BuRec and avoid discussing where they’ve been ripping tamarisk and enjoy the view of the empty town far below, with its serpentine streets and quiet houses and shining, untouched river.

It isn’t until the sun is setting and they’ve finished roasting a magpie that Lolo finally asks the question that’s been on his mind ever since Travis’s sun-baked face came out of the tangle. It goes against etiquette, but he can’t help himself. He picks magpie out of his teeth and says, “I thought you were working downriver.”

Travis glances sidelong at Lolo, and in that one suspicious, uncertain look, Lolo sees that Travis has hit a lean patch. He’s not smart like Lolo. He hasn’t been reseeding. He’s got no insurance. He hasn’t been thinking ahead about all the competition and what the tamarisk endgame looks like, and now he’s feeling the pinch. Lolo feels a twinge of pity. He likes Travis. A part of him wants to tell Travis the secret, but he stifles the urge. The stakes are too high. Water crimes are serious now, so serious Lolo hasn’t even told his wife, Annie, for fear of what she’ll say. Like all of the most shameful crimes, water theft is a private business, and at the scale Lolo works, forced labor on the Straw is the best punishment he can hope for.

Travis gets his hackles down over Lolo’s invasion of his privacy and says, “I had a couple cows I was running up here, but I lost ’em. I think something got ’em.”

“Long way to graze cows.”

“Yeah, well, down my way, even the sagebrush is dead. Big Daddy Drought’s doing a real number on my patch.” He pinches his lip, thoughtful. “Wish I could find those cows.”

“They probably went down to the river.”

Travis sighs. “Then the guardies probably got ’em.”

“Probably shot ’em from a chopper and roasted ’em.”

“Californians.”

They both spit at the word. The sun continues to sink. Shadows fall across the town’s silent structures. The rooftops gleam red, a ruby cluster decorating the blue river necklace.

“You think there’s any stands worth pulling down there?” Travis asks.

“You can go down and look. But I think I got it all last year. And someone had already been through before me, so I doubt much is coming up.”

“Shit. Well, maybe I’ll go shopping. Might as well get something out of this trip.”

“There sure isn’t anyone to stop you.”

As if to emphasize the fact, the thud-thwap of a guardie chopper breaks the evening silence. The black-fly dot of its movement barely shows
against the darkening sky. Soon, it’s out of sight and cricket chirps swallow the last evidence of its passing.

Travis laughs. “Remember when the guardies said they’d keep out looters? I saw them on TV with all their choppers and Humvees and them all saying they were going to protect everything until the situation improved.” He laughs again. “You remember that? All of them driving up and down the streets?”

“I remember.”

“Sometimes, I wonder if we shouldn’t have fought them more.”

“Annie was in Lake Havasu City when they fought there. You saw what happened.” Lolo shivers. “Anyway, there’s not much to fight for once they blow up your water treatment plant. If nothing’s coming out of your faucet, you might as well move on.”

“Yeah, well, sometimes I think you still got to fight. Even if it’s just for pride.” Travis gestures at the town below, a shadow movement. “I remember when all that land down there was selling like hotcakes and they were building shit as fast as they could ship in the lumber. Shopping malls and parking lots and subdivisions, anywhere they could scrape a flat spot.”

“We weren’t calling it Big Daddy Drought back then.”

“Forty-five thousand people. And none of us had a clue. And I was a real estate agent.” Travis laughs, a self-mocking sound that ends quickly. It sounds too much like self-pity for Lolo’s taste. They’re quiet again, looking down at the town wreckage.

“I think I might be heading north,” Travis says finally.

Lolo glances over, surprised. Again, he has the urge to let Travis in on his secret, but he stifles it. “And do what?”

“Pick fruit, maybe. Maybe something else. Anyway, there’s water up there.”

Lolo points down at the river. “There’s water.”

“Not for us.” Travis pauses. “I got to level with you, Lolo. I went down to the Straw.”

For a second, Lolo is confused by the non sequitur. The statement is too outrageous. And yet Travis’s face is serious. “The Straw? No kidding? All the way there?”

“All the way there.” He shrugs defensively. “I wasn’t finding any tamarisk, anyway. And it didn’t actually take that long. It’s a lot closer than it used to be. A week out to the train tracks, and then I hopped a coal train and rode it right to the interstate, and then I hitched.”

“What’s it like out there?”

“Empty. A trucker told me that California and the Interior Department drew up all these plans to decide which cities they’d turn off when.” He looks at Lolo significantly. “That was after Lake Havasu. They figured they had to do it slow. They worked out some kind of formula: how many cities, how many people they could deplete at a time without making too much unrest. Got advice from the Chinese, from when they were shutting down their old communist industries. Anyway, it looks like they’re pretty much done with it. There’s nothing moving out there except highway trucks and coal trains and a couple truck stops.”

“And you saw the Straw?”

“Oh, sure, I saw it. Out toward the border. Big old mother. So big you couldn’t climb on top of it, flopped out on the desert like a damn silver snake. All the way to California.” He spits reflexively. “They’re spraying with concrete to keep water from seeping into the ground and they’ve got some kind of carbon-fiber stuff over the top to stop the evaporation. And the river just disappears inside. Nothing but an empty canyon below it. Bone dry. And choppers and Humvees everywhere, like a damn hornets’ nest. They wouldn’t let me get any closer than a half mile on account of the eco-crazies trying to blow it up. They weren’t nice about it, either.”

“What did you expect?”

“I dunno. It sure depressed me, though. They work us out here and toss us a little water bounty, and then all that water next year goes right down into that big old pipe. Some Californian’s probably filling his swimming pool with last year’s water bounty right now.”

Cricket song pulses in the darkness. Off in the distance, a pack of
coyotes starts yipping. The two of them are quiet for a while. Finally, Lolo chucks his friend on the shoulder. "Hell, Travis, it's probably for the best. A desert's a stupid place to put a river, anyway."

Lolo’s homestead runs across a couple acres of semi-alkaline soil, conveniently close to the river’s edge. Annie is out in the field when he crests the low hills that overlook his patch. She waves but keeps digging, planting for whatever water he can collect in bounty.

Lolo pauses, watching Annie work. Hot wind kicks up, carrying with it the scents of sage and clay. A dust devil swirls around Annie, whipping her bandana off her head. Lolo smiles as she snags it; she sees him still watching her and waves at him to quit loafing.

He grins to himself and starts Maggie down the hill, but he doesn’t stop watching Annie work. He’s grateful for her. Grateful that every time he comes back from tamarisk hunting, she is still here. She’s steady. Steadier than the people like Travis who give up when times get dry. Steadier than anyone Lolo knows, really. And if she has nightmares sometimes, and can’t stand being in towns or crowds, and wakes up in the middle of the night calling out for family she’ll never see again, well, then it’s all the more reason to seed more tamarisk and make sure they never get pushed off their patch like she was pushed.

Lolo gets Maggie to kneel down so he can dismount, then leads her over to a water trough, half full of slime and water skippers. He gets a bucket and heads for the river while Maggie groans and complains behind him. The patch used to have a well and running water, but like everyone else, they lost their pumping rights and BuRec stuffed the well with Quikrete when the water table dropped below the Minimum Allowable Reserve. Now he and Annie steal buckets from the river, or, when the Interior Department isn’t watching, they jump up and down on a foot pump and dump water into a hidden underground cistern he built when the Resource Conservation and Allowable Use Guidelines went into effect.

Annie calls the guidelines “ReCAUG” and it sounds like she’s hawking spit when she says it, but even with their filled-in well, they’re lucky. They aren’t like Spanish Oaks or Antelope Valley or River Reaches: expensive places that had rotten water rights and turned to dust, money or no, when Vegas and LA put in their calls. And they didn’t have to bail out of Phoenix Metro when the Central Arizona Project got turned off and then had its aqueducts blown to smithereens when Arizona wouldn’t stop pumping out of Lake Havasu.

Pouring water into Maggie’s water trough, and looking around at his dusty patch with Annie out in the fields, Lolo reminds himself how lucky he is. He hasn’t blown away. He and Annie are dug in. Calies may call them water ticks, but fuck them. If it weren’t for people like him and Annie, they’d dry up and blow away the same as everyone else. And if Lolo moves a little bit of tamarisk around, well, the Calies deserve it, considering what they’ve done to everyone else.

Finished with Maggie, Lolo goes into the house and gets a drink of his own out of the filter urn. The water is cool in the shadows of the adobe house. Juniper beams hang low overhead. He sits down and connects his BuRec camera to the solar panel they’ve got scabbed onto the roof. Its charge light blinks amber. Lolo goes and gets some more water. He’s used to being thirsty, but for some reason, he can’t get enough today. Big Daddy Drought’s got his hands around Lolo’s neck today.

Annie comes in, wiping her forehead with a tanned arm. “Don’t drink too much water,” she says. “I haven’t been able to pump. Bunch of guardies around.”

“What the hell are they doing around? We haven’t even opened our headgates yet.”

“They said they were looking for you.”

Lolo almost drops his cup.

They know.

They know about his tamarisk reseeding. They know he’s been splitting and planting root clusters. That he’s been dragging big, healthy chunks of
tamarisk up and down the river. A week ago, he uploaded his claim on 
the canyon tamarisk—his biggest stand yet—almost worth an acre-foot 
in itself in water bounty. And now the guardies are knocking on his door. 

Lolo forces his hand not to shake as he puts his cup down. "They say 
what they want?" He's surprised his voice doesn't crack. 

"Just that they wanted to talk to you." She pauses. "They had one of 
those Humvees. With the guns."

Lolo closes his eyes. Forces himself to take a deep breath. "They've 
always got guns. It's probably nothing."

"It reminded me of Lake Havasu. When they cleared us out. When 
they shut down the water treatment plant and everyone tried to burn 
down the BLM office."

"It's probably nothing." Suddenly, he's glad he never told her about his 
tamarisk hijinks. They can't punish her the same. How many acre-feet is 
he liable for? It must be hundreds. They'll want him, all right. Put him 
on a Straw work crew and make him work for life, repay his water debt 
forever. He's replanted hundreds, maybe thousands of tamarisk, shuffling 
them around like a cardsharp on a poker table, moving them from one 
bank to another, killing them again and again and again, and always 
happily sending in his "evidence."

"It's probably nothing," he says again.

"That's what people said in Havasu."

Lolo waves out at their newly tilled patch. The sun shines down hot 
and hard on the small plot. "We're not worth that kind of effort." He forces 
a grin. "It probably has to do with those enviro crazies who tried to blow 
up the Straw. Some of them supposedly ran this way. It's probably that."

Annie shakes her head, unconvinced. "I don't know. They could have 
asked me the same as you."

"Yeah, but I cover a lot of ground. See a lot of things. I'll bet that's why 
they want to talk to me. They're just looking for eco-freaks."

"Yeah, maybe you're right. It's probably that." She nods slowly, trying 
to make herself believe. "Those enviros, they don't make any sense at all.

Not enough water for people, and they want to give the river to a bunch 
of fish and birds."

Lolo nods emphatically and grins wider. "Yeah. Stupid." But suddenly, 
he views the eco-crazies with something approaching brotherly affection. 
The Californians are after him, too.

Lolo doesn't sleep all night. His instincts tell him to run, but he doesn't 
have the heart to tell Annie or to leave her. He goes out in the morning 
hunting tamarisk and fails at that as well. He doesn't cut a single stand 
all day. He considers shooting himself with his shotgun but chickens out 
when he gets the barrels in his mouth. Better alive and on the run than 
death. Finally, as he stares into the twin barrels, he knows that he has to 
tell Annie, tell her he's been a water thief for years and that he's got to 
rush north. Maybe she'll come with him. Maybe she'll see reason. They'll 
run together. At least they have that. For sure, he's not going to let those 
bastards take him off to a labor camp for the rest of his life.

But the guardies are already waiting when Lolo gets back. They're 
squatting in the shade of their Humvee, talking. When Lolo comes over 
the crest of the hill, one of them taps the other and points. They both 
stand. Annie is out in the field again, turning over dirt, unaware of what's 
about to happen. Lolo reins in and studies the guardies. They lean against 
their Humvee and watch him back.

Suddenly, Lolo sees his future. It plays out in his mind the way it does 
in a movie, as clear as the blue sky above. He puts his hand on his shot-
gun. Where it sits on Maggie's far side, the guardies can't see it. He keeps 
Maggie angled away from them and lets the camel start down the hill.

The guardies saunter toward him. They've got their Humvee with a .50 
caliber on the back, and they've both got M-16s slung over their shoulder. 
They're in full bulletproof gear and they look flushed and hot. Lolo 
rides down slowly. He'll have to hit them both in the face. Sweat trickles 
between his shoulder blades. His hand is slick on the shotgun's stock.
The guardies are playing it cool. They've still got their rifles slung, and they let Lolo keep approaching. One of them has a wide smile. He's maybe forty years old and tanned. He's been out for a while, picking up a tan like that. The other raises a hand and says, “Hey there, Lolo.”

Lolo's so surprised he takes his hand off his shotgun. “Hale?” He recognizes the guardie. He grew up with him. They played football together a million years ago, when football fields still had green grass and sprinklers sprayed their water straight into the air. Hale. Hale Perkins. Lolo scowls. He can't shoot Hale.

Hale says, “You're still out here, huh?”

“What the hell are you doing in that uniform? You with the Calies now?”

Hale grimaces and points to his uniform patches: Utah National Guard.

Lolo scowls. Utah National Guard. Colorado National Guard. Arizona National Guard. They're all the same. There's hardly a single member of the “National Guard” that isn't an out-of-state mercenary. Most of the local guardies quit a long time ago, sick to death of goose-stepping family and friends off their properties and sick to death of trading potshots with people who just wanted to stay in their homes. So, even if there's still a Colorado National Guard, or an Arizona or a Utah, inside those uniforms with all their expensive night-sight gear and their brand-new choppers flying the river bends, it's pure California.

And then there are a few like Hale.

Lolo remembers Hale as being an okay guy. Remembers stealing a keg of beer from behind the Elks Club one night with him. Lolo eyes him. “How you liking that Supplementary Assistance Program?” He glances at the other guardie. “That working real well for you? The Calies a big help?”

Hale's eyes plead for understanding. “Come on, Lolo. I'm not like you. I got a family to look after. If I do another year of duty, they let Shannon and the kids base out of California.”

“They give you a swimming pool in your back yard, too?”

“You know it's not like that. Water's scarce there, too.”

Lolo wants to taunt him, but his heart isn't in it. A part of him wonders if Hale is just smart. At first, when California started winning its water lawsuits and shutting off cities, the displaced people just followed the water—right to California. It took a little while before the bureaucrats realized what was going on, but finally someone with a sharp pencil did the math and realized that taking in people along with their water didn't solve a water shortage. So, the immigration fences went up.

But people like Hale can still get in.

“So, what do you two want?” Inside, Lolo's wondering why they haven't already pulled him off Maggie and hauled him away, but he's willing to play this out.

The other guardie grins. “Maybe we're just out here seeing how the water ticks live.”

Lolo eyes him. This one, he could shoot. He lets his hand fall to his shotgun again. “BuRec sets my headgate. No reason for you to be out here.”

The Calie says, “There were some marks on it. Big ones.”

Lolo smiles tightly. He knows which marks the Calie is talking about. He made them with five different wrenches when he tried to dismember the entire headgate apparatus in a fit of obsession. Finally, he gave up trying to open the bolts and just beat on the thing, banging the steel of the gate, smashing it at, while on the other side he had plants withering. After that, he gave up and just carried buckets of water to his plants and left it at that. But the dents and nicks are still there, reminding him of a period of madness. “It still works, don't it?”

Hale holds up a hand to his partner, quieting him. “Yeah, it still works. That's not why we're here.”

“So, what do you two want? You didn't drive all the way out here with your machine gun just to talk about dents in my headgate.”

Hale sighs, put-upon, trying to be reasonable. “You mind getting down off that damn camel so we can talk?”
Lolo studies the two guardies, figuring his chances on the ground. "Shit." He spits. "Yeah, Okay. You got me." He urges Maggie to kneel and climbs off her hump. "Annie didn't know anything about this. Don't get her involved. It was all me."

Hale's brow wrinkles, puzzled. "What are you talking about?"

"You're not arresting me?"

The Calie with Hale laughs. "Why? Cause you take a couple buckets of water from the river? Cause you probably got an illegal cistern around here somewhere?" He laughs again. "You ticks are all the same. You think we don't know about all that crap?"

Hale scowls at the Calie, then turns back to Lolo. "No, we're not here to arrest you. You know about the Straw?"

"Yeah." Lolo says it slowly, but inside, he's grinning. A great weight is suddenly off him. They don't know. They don't know shit. It was a good plan when he started it, and it's a good plan still. Lolo schools his face to keep the glee off and tries to listen to what Hale's saying, but he can't; he's jumping up and down and gibbering like a monkey. They don't know—

"Wait." Lolo holds up his hand. "What did you just say?"

Hale repeats himself. "California's ending the water bounty. They've got enough Straw sections built up now that they don't need the program. They've got half the river enclosed. They got an agreement from the Department of the Interior to focus their budget on seep and evaporation control. That's where all the big benefits are. They're shutting down the water bounty payout program." He pauses. "I'm sorry, Lolo."

Lolo frowns. "But a tamarisk is still a tamarisk. Why should one of those damn plants get the water? If I knock out a tamarisk, even if Cali doesn't want the water, I could still take it. Lots of people could use the water."

Hale looks pityingly at Lolo. "We don't make the regulations; we just enforce them. I'm supposed to tell you that your headgate won't get opened next year. If you keep hunting tamarisk, it won't do any good." He looks around the patch, then shrugs. "Anyway, in another couple years, they were going to pipe this whole stretch. There won't be any tamarisk at all after that."

"What am I supposed to do, then?"

"California and BuRec is offering early buyout money." Hale pulls a booklet out of his bulletproof vest and flips it open. "Sort of to soften the blow. The pages of the booklet flap in the hot breeze. Hale pins the pages with a thumb and pulls a pen out of another vest pocket. He marks something on the booklet, then tears off a perforated check. "It's not a bad deal."

Lolo takes the check. Stares at it. "Five hundred dollars?"

Hale shrugs sadly. "It's what they're offering. That's just the paper codes. You confirm it online. Use your BuRec camera phone, and they'll deposit it in whatever bank you want. Or they can hold it in trust until you get into a town and want to withdraw it. Any place with a BLM office, you can do that. But you need to confirm before April 15. Then BuRec will send out a guy to shut down your headgate before this season gets going."

"Five hundred dollars?"

"It's enough to get you north. That's more than they're offering next year."

"But this is my patch."

"Not as long as we've got Big Daddy Drought. I'm sorry, Lolo."

"The drought could break any time. Why can't they give us a couple more years? It could break any time." But even as he says it, Lolo doesn't believe. Ten years ago, he might have. But not now. Big Daddy Drought's here to stay. He clutches the check and its key codes to his chest.

A hundred yards away, the river flows on to California.
ABOUT THE AUTHOR

The Wicked Ditch Will Never Die: The On-Going Controversy over Rodman Reservoir

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On January 22, 1991, Governor Lawton Chiles and the Florida Cabinet signed a deauthorization bill that finally ended the Cross Florida Barge Canal, the Army Corps of Engineers project designed to cut a 107 mile swash across the Florida peninsula. Started in 1964 and stopped in 1971 by both presidential edict and judicial decree, the canal lay dormant for twenty more years, with not enough political support to either re-start the project or officially stop it. Much of the credit for halting the canal went to Marjorie Harris Carr, the feisty Micanopy scientist and housewife who made it her life’s work to fight against the canal and its destruction of her beloved Ocklawaha River. Though Carr and the Florida Defenders of the Environment (FDE), the organization she helped to found in 1969 to galvanize both public opinion and the scientific community, felt justifiably proud of their efforts, they also understood that their fight was far from over. Profound questions remained over the shape of the 77,000 acre linear park that was to take the place of the canal. The rancorous debate over the fate of the Ocklawaha River loomed largest of all. The Rodman Dam and its attendant Rodman Reservoir, built as part of the canal’s infrastructure in the late 1960s, still remained intact and prevented the Ocklawaha from flowing freely. If the issue of the dam was not solved to the satisfaction of Marjorie Carr, if it still blocked the river, would her years of hard work be all in vain? After all, her efforts to prevent the canal from being built had started as a campaign to save the river itself.

The Rodman controversy provided the last, longest, and still on-going chapter in a story that began with European encounters in Florida as early as the 16th century. Though Spanish explorers searched for a water passage across the peninsula, it was not until Florida became an American territory in 1821 that the push for the development of a cross-peninsular canal
took shape. Throughout the 19th and into the early 20th centuries (during both territorial and statehood phases), Army Corps of Engineers personnel repeatedly surveyed Florida, looking for the optimal route for a canal. While the engineers determined a cross-peninsular transit was feasible, they simultaneously concluded that building it would be difficult, expensive, and probably not worth the effort. Supporters of a waterway, anxious to develop Florida as a center of trade and commerce, latched onto the possibility of building a canal and assiduously lobbied Congress for funding and support. However, it was not until September 1935, with a need for jobs in the wake of the Great Depression, that President Franklin Roosevelt allocated $5 million for the construction of a ship canal across Florida from Jacksonville on the Atlantic coast to Yankeetown on the Gulf of Mexico. This 107 mile long, 30 foot deep gash would utilize the paths of the existing St. Johns, Ocklawaha, and Withlacoochee Rivers to cross the state. Within a year, however, construction was halted due to significant opposition from Florida agricultural interests concerned about the canal’s potential for destroying the state’s fresh water supply. Refusing to concede their dreams of economic growth had failed, canal boosters re-designed the waterway as a shallower barge canal which would not harm Florida’s fragile aquifer. Tying the necessity of the canal to national defense issues in a time of war, supporters from Ocala and Jacksonville pushed Congress to approve construction of the newly-designed barge canal along the same route as the defunct ship canal. In July of 1942, Congress authorized the building of the Cross Florida Barge Canal, but did not allocate any funds for that project. It would take twenty-two years for the federal government to finally provide funding for the canal- and in February 1964, President Lyndon Johnson came to Palatka and oversaw the long-awaited ground breaking for the project. Floridians remained profoundly divided about the necessity of the canal, and by the late 1960s public opinion shifted towards ending construction. Marjorie Carr of Gainesville and her environmental organization, Florida Defenders of the Environment (FDE), proved crucial in that change. In 1969, FDE sued the Corps of Engineers to stop
construction, and in January 1971, both the courts and President Richard Nixon ordered work halted on environmental grounds: that continued canal construction would endanger the beautiful, subtropical Ocklawaha River. Carr and her allies had won a significant victory by halting canal construction, but it took twenty more agonizing years to turn canal lands into a state park. Even with that accomplishment, however, Rodman Dam still blocked the flow of the Ocklawaha, making Carr’s success incomplete.¹

The on-going controversy over the fate of Rodman reservoir reflects broader issues surrounding both the political and environmental history of modern Florida. FDE’s success in stopping barge canal construction represented a watershed moment in the state, as citizen activists showed their ability to shape public policy. It seemed to portend a prospect where concern for Florida’s fragile ecology would become a paramount issue in determining the state’s political future. But the continuing Rodman deadlock indicated another path, one directed by conservative politicians more concerned about development than the environment. The impasse over the ultimate disposition of the dam and reservoir, and the fate of the Ocklawaha River itself, reveals much about the nature of the political culture in the Sunshine State in the late 20th and early 21st centuries. With the tide seemingly irrevocably turning away from environmental issues and concerns, activists cling tenuously to the memories of their hard-won political victories (like stopping the Cross Florida Barge Canal) and hope they can re-energize.²

In the summer of 1991, the Florida legislature began the process of preparing to decide how to best utilize the land once designated for the Cross Florida Barge Canal but now cumbersomely labeled the Cross Florida Greenbelt State Recreation and Conservation Area. When the federal government turned the canal property back to the state of Florida in 1990, it mandated that it be turned into a park for the benefit of state citizens. As the initial part of that process, the state legislature established the Canal Lands Advisory Committee (CLAC), an advisory board composed of politicians and interested citizens, whose input would
help shape the future status of the canal lands. In recognition of her importance to the issues surrounding the disposition of the property, the legislature appointed Carr to serve on the committee, representing “the public at large.” CLAC’s primary responsibility lay in creating a master plan for the best use of the land. That meant balancing a variety of competing interests, articulated during more than a year of local public meetings. For Carr and many in FDE there was not much to debate. They felt such passive recreational pursuits as hiking and canoeing should stand alone at the center of the greenway experience. On the east side of the canal cut, however, many of Putnam County’s residents remained steadfast in their demand for the retention of Rodman Reservoir as a bass fishing paradise. Spending the weekend trolling on a motorized bass boat, they saw “something magic about the shout of the adult female when she realizes she has caught her first fish. Take them to Rodman reservoir and enjoy life.” All of this was rather alien to Carr and her allies. For them, fishing was something better experienced on the free-flowing, densely canopied Ocklawaha with a “canoe or johnboat, . . .not a noisy two-cycle smoke-belching gasoline guzzling outboard engine” on what they saw as the flat and unappealing waters of the stagnant Rodman reservoir.

On September 17, 1992, CLAC met in Ocala to issue its final report on the future of the Greenbelt, now called the Cross Florida Greenway. As an advisory board, its recommendations held considerable weight but the ultimate fate of the land rested in the hands of state officials. In many respects, CLAC validated much of Carr’s environmental vision. Yet, it abdicated its most important responsibility by refusing to address the contentious issue concerning the ultimate disposition of Rodman Dam and the Ocklawaha River. Instead, it voted for yet another study on what to do with the dam, this time proposing a three year review under the auspices of the St. Johns River Water Management District. This new review would once again examine the usual technical, environmental, and economic cost-benefits of the reservoir. The proposal left many members of FDE howling in protest at what they saw as just another round of delays. With Marjorie Carr now
weak with emphysema at the age of seventy-seven, FDE officials plaintively conceded their leader would not live to see her dream fulfilled. After the meeting, David Godfrey, FDE’s Ocklawaha Restoration Project Director plaintively announced that “the river will not be restored in her lifetime. This decision today means that action may not even begin in her lifetime” (Panel: Study Rodman September 18, 1982).

The September committee meeting represented an important transitional moment. Besides wrestling with the issues associated with the deauthorization of the canal itself, it also introduced state senator George Kirkpatrick of Gainesville to the debate. A member of the state legislature since 1980, the fifty-three year old Democrat quickly became the face of the movement to retain Rodman Reservoir. Contentious and prickly, he reveled in his well-earned reputation as a political street fighter. “I’m someone who comes on the scene asking the questions that these frustrated rednecks have always wanted to ask,” he remarked in a 1995 interview. “I keep refusing to take no for an answer. I’m perceived as arrogant. But if someone manages to turn me on their side . . . then they’ve got their own personal Rottweiler.” With the influence of senatorial seniority, he became the chairman of the powerful Senate Rules Committee in 1993 and remained a bitter adversary of Marjorie Carr and other environmentalists who wanted to see the Ocklawaha flowing freely (Dunkelberger February 6, 2003; Swirko February 6, 2003). Even before the final CLAC meeting, Kirkpatrick organized a coalition of interests bent on preserving Rodman Reservoir, which had become a haven for recreational and sports fishing, even considered by some as one of the best bass lakes in America. In July, the Senator encouraged Dan Canfield, a professor at the University of Florida’s Department of Fisheries and Aquatic Sciences, to conduct yet another study–this time specifically designed to refute FDE’s claim that the reservoir was nothing more than a weed-congested ecological disaster. Funded in part by the Putnam County Chamber of Commerce, Canfield’s forty-six page report added to the furor over the disposition of Rodman. Kirkpatrick and pro-Rodman supporters used Canfield’s research to
buttress their position to protect the lake. Canfield concluded that his study was designed “to determine if a case could be made for Rodman Reservoir.” Asserting that the reservoir was “not a ‘dying’ water body that is destined for ‘biological senility’ in our lifetime,” he added it “would continue to serve as a refuge for not only fish and wildlife, but also anglers.” With consideration of the reservoir’s economic benefits for the local Putnam County economy, Canfield reached a simple conclusion: “we recommend that Rodman Reservoir be retained for now. . . . There is no compelling biological/ecological reason to rush restoration at this time.” The scientific rationale behind the Canfield report soon became the basis of support for keeping the reservoir intact (Canfield February 1993).

Canfield delivered his report to CLAC’s September meeting. Kirkpatrick praised the study as a significant improvement over previous studies done at the behest of FDE, which he claimed had “numbers . . . quoted from a study done in 1988 whose numbers were collected from a report done in 1978 which had been taken straight from biased studies done . . . in the early 1970s.” Not surprisingly, FDE dismissed Canfield’s conclusions as “garbage” and accused him of being, in their biting words, a “biostitute” in the pay of pro-Rodman advocates. CLAC did not take FDE’s assertions at face value; instead, the committee played it safe and concluded that Canfield’s study necessitated even further scientific investigation. This further round of delays led many FDE members to see a more sinister reason for the decision in the very person of Senator Kirkpatrick himself. Marjorie Carr blasted him for his strong-arm bullying tactics. “Senator Kirkpatrick has clobbered them [CLAC members],” she fumed. “He has carried out the most intensive campaign of intimidation that I have ever seen.” FDE, recognizing Kirkpatrick’s power as the incoming chairman of both the Rules Committee and next session’s Appropriations Committee, accused the Senator of threatening various state agencies with budget cuts if they blocked any effort to study the lake and dam once again. Kirkpatrick downplayed his influence. “My effort,” he averred, “has been to make sure that the recommendation
is based on accurate information.” When asked about his alleged threats, Kirkpatrick played coy. “I didn’t do any of that,” he said. “I talked to DNR [Department of Natural Resources] and asked how we could come up with a compromise. There’s been no threats by me.” With the cockiness that became part of his persona, he loudly proclaimed FDE’s complaints were “just sour grapes” (Kirkpatrick n.d. 3; Rodman Decision Relayed September 18, 1992; Hamaker September 18, 1992; Panel: Study Rodman 3 Years September 18, 1982).

In December 1992, the Governor and Cabinet met in Tallahassee to review CLAC’s recommendations on turning the former canal into a linear park. Though the public meeting dealt with many of the broader concerns related to the transitional process, contentious debate centered squarely on the fate of Rodman Reservoir. Once again, adversaries descended on the capital and staked out their positions to hopefully sway government officials their way. This time, however, Marjorie Carr’s illness made her too weak to appear in person. Instead, her supporters brought along an emotional videotaped appeal from their leader. In it, Carr called the Ocklawaha “a natural work of art” and asked the Cabinet to “restore it and care for it as if it was a Pieta by Michelangelo.” She summarily dismissed the economic and recreational concerns of those who pleaded for retaining Rodman Reservoir. “I realize bass fisherman will be inconvenienced,” she said. “I trust they will find good fishing in nearby lakes.” Heeding Carr’s words, Commissioner of Education (and Cabinet member) Betty Castor offered an amendment to the CLAC proposals that overrode their call for another study of the Rodman area. Directing the Department of Natural Resources to “immediately take steps” to “complete the restoration of the free flowing Ocklawaha River,” she called for the drawdown of Rodman Reservoir. Backed by Governor Lawton Chiles, who expressed frustration with the glacial pace of resolving the controversy, the amendment passed unanimously. This policy statement placed the executive branch and its agencies firmly on the side of Marjorie Carr and river restoration. FDE and fellow environmentalists were elated. Calling the amendment a “wise decision,” Timothy
Keyser of the Florida Wildlife Federation agreed that “restoration of the wildlife habitat is more important than maintaining a degrading [sic] system.” From Gainesville, Carr concurred, “It is a giant step forward for Floridians” (Cabinet: Pull Rodman Plug December 16, 1992; Cabinet Urges End to Dam December 16, 1992; Castor December 15, 1992).

Not all Floridians were as sanguine as Carr. In Putnam County, local fishermen expressed disbelief as the Cabinet appeared to pull the plug on Lake Ocklawaha. “I can’t imagine how anybody can go to Rodman,” announced fishing guide Billy Peoples, “and see what’s there and make that kind of decision.” Wes Larson of the Putnam County Chamber of Commerce bemoaned the estimated loss of 110 jobs and $7.2 million in annual fishing revenue if the dam was removed. Putnam County Administrator Gary Adams concluded, “I think it is a terrible economic blow to Putnam County.” In Gainesville, George Kirkpatrick seconded Adams’ assessment. Embittered with the Cabinet meeting’s result, he claimed its vote was “based on strong emotions that had very little relationships to the facts,” and concluded that the Cabinet “bypass[ed] an appointed task force and completely rejected all their recommendations” (Fishermen Worried About Another One Getting Away December 16, 1992; Cabinet: Pull Rodman Plug December 16, 1992; Beebe December 16, 1992; Cabinet Urges End to Dam December 16, 1992).

At first glance the Cabinet decision seemed to finally resolve the issue in FDE’s favor. However, buried in the language of Castor’s amendment was the phrase, “upon favorable legislative action,” which took the controversy out of the governor’s hands and placed it firmly in the hands of the state house. Even FDE recognized the tentative nature of their victory. We are “fully aware that only half the task is done,” David Godfrey admitted. “The unanimous vote gives us momentum going to the legislature, and that’s a whole other ball game. But it sends a strong message.” That message would be countered by George Kirkpatrick, who warned “the Cabinet decision Tuesday is far from the final say on the future of the Rodman Dam and the lower Ocklawaha River.” On the other side of the Capitol,
Ocala Representative George Albright concurred: “By no means is this cast in stone.” For the next few months, Kirkpatrick and his allies prepared for battle over the fate of Rodman (Cabinet Urges End to Dam December 16, 1992; Beebe December 16, 1992).

By the next legislative session, George Kirkpatrick dominated the debate surrounding Rodman Dam. Beating back numerous efforts to comply with the Cabinet’s decision, Kirkpatrick instead offered a plan to fulfill CLAC’s demand for further study. By the summer of 1993, the legislature passed a measure allocating $900,000 for an eighteen month examination of Rodman Reservoir. In many respects, that study—managed by the newly established Department of Environmental Protection (DEP), which then subcontracted most of the research to the St. Johns River Water Management District—was the summation of a generation of scientific research. And given the contentious nature of much of that work, the resulting twenty volume report, submitted in January 1995, offered no final resolution of the issue. Though it concluded that “no further studies are necessary to answer the question” concerning Rodman, the report was often so ambiguous and technically arcane that both sides saw it as confirming their position. George Kirkpatrick most certainly thought so. After combing the report for any evidence that would favor his cause, he announced he was “elated by the findings included in the DEP report,” which “gave us even greater evidence of the positive environmental impact of the [Rodman] ecosystem.” Though small parts of the study may have supported his position, the thrust of the report clearly warmed Marjorie Carr’s heart. Hidden in the volumes of dense prose was the simple statement—“efforts should be directed instead at restoration of the Ocklawaha River” (Galantowicz 1994; George Kirkpatrick n.d.).

Following the report’s recommendation, Governor Chiles ordered the Department of Environmental Protection to begin an immediate drawdown of the reservoir in anticipation of restoration. Kirkpatrick lashed back, informing DEP Secretary Virginia Wetherell that he, representing the legislature, and not the
governor, was in charge. “Any movement towards restoration would presume . . . the legislature will eventually decide against keeping the structure [Rodman Dam].” He added presciently, “This would be highly premature.” Thus began what became an annual ritual of Florida politics. With the emergence of spring, the Governor and executive agencies, in addition to a majority of the state legislature, would call for the removal of Rodman Dam. And George Kirkpatrick, much like his Congressional predecessors who had blocked deauthorization, stood in the way (Kirkpatrick April 4, 1995).

When first examined, George Kirkpatrick’s commitment to Rodman Dam appeared rather unusual. Representing a university town that stood at the center of the movement to restore the Ocklawaha River, he seemed out of sync with much of his environmentally conscious constituency. However, his district stretched far beyond the city limits and embraced rural areas of north central Florida, particularly Putnam County. An avid angler, Kirkpatrick had an affinity for the lake created by the dam and the “good ole boys” who fished in it. As he once noted, I “represent the interests of the folks who love, use and depend on the Reservoir for their livelihood.” He had to, for he recognized more than anyone that his political fate rested in their hands.

Kirkpatrick’s support came from those rural residents who saw him as a defender of their way of life. And with the Governor and Cabinet consistently calling for restoration, both he and the people of Putnam County joined forces to fight against what they considered an elitist alliance between government bureaucrats and scientific experts, who either at best ignored them or at worst dismissed them as ignorant rednecks (Kirkpatrick April 4, 1995).

Things were ironically coming full circle. In the summer of 1995, a group of Putnam County residents and recreational fishermen organized a group called Save Rodman Reservoir, Inc. to “fight off the wishes of ‘those who know better.’” Working within the neo-populist legacy of Ronald Reagan and the conservative revolution of the 1980s, they were determined to protect “their” lake from outsiders, those they considered “paid ‘enviro-wonks’ [who] pontificated at public
hearings about the evil that is Rodman.”
Relying on strategies strangely similar to the nascent anti-canal movement thirty years earlier, they sought the preservation of Lake Ocklawaha and its new “ecosystem with abundant flora and fauna.” “Our band of ragtag supporters had grown into a throng,” Kirkpatrick reminisced, “with folks calling and writing from every place imaginable. Weary travelers made the trip to Tallahassee for committee meetings on a weekly basis just to make their presence felt. . . . Like a modern day barn raising, they rallied the troops with newsletters, phone calls and faxes. . . . Meanwhile paid consultants and strangers to Rodman pushed the anti-retention agenda.” Those very same words could well have described Marjorie Carr’s earlier efforts against the Canal Authority and the Army Corps of Engineers.
Kirkpatrick’s chief legislative aide, Mike Murtha, certainly thought so. “They [FDE] had something they loved back in the Sixties and some bastards came and took it away from them,” he exclaimed. “Well, now we have something that we love and some bastards are trying to take it away from us” (Kirkpatrick April 4, 1995; Patrick November 1998).

Over the next three legislative sessions, Kirkpatrick and his allies did their job well, as they blocked any effort toward restoration by Governor Chiles and the Department of Environmental Protection. For Marjorie Carr, eighty-two years old and now terminally ill, these setbacks must have seemed like all her work was for nought. Rodman Dam—“that obscenity, that ridiculous mistake, that hideous monstrosity”—remained. By the summer of 1997, “feeling lousy,” tethered to an oxygen bottle, and forced to move from her cherished Micanopy homestead to a patio home in the middle of Gainesville, Carr plaintively asked “will I live to see it [the Ocklawaha] run free or not? I don’t know.” What she did know was that George Kirkpatrick was now the source of all her frustration. Characterizing his defense of Rodman as “an obsession,” she added that the Senator’s success stemmed from the fact that “he is feared and I don’t think he cares.” Though no longer able to lead the battle for restoration, she still showed signs of her legendary feistiness. She railed against
those who failed to see the wisdom of Rodman’s removal. She complained that bass fishermen “ought to be ashamed of themselves” for their unyielding support for the reservoir. At the same time, Carr reaffirmed her sentimental attachment to the river, sounding more like Sidney Lanier than a research scientist with a stubborn commitment to the facts. “Once the dam is gone,” she reflected, “the manatees will be able to come up there during the winter. What a sight that will be” (Dewar February 4, 1990; Ritchie June 13, 1997).

On October 10, 1997, Marjorie Carr finally succumbed to her illness. Accolades immediately began pouring in for the woman now beatified as “Our Lady of the Rivers.” Governor Lawton Chiles commended her as “a true giant in the environmental community.” Senator Bob Graham, who had met with Carr only weeks before her death, said her “name will always be synonymous with conservation.” She “served as the environmental conscience for Florida’s leaders.” Closer to home, her friends and allies within FDE sorrowfully lamented their loss. Her longtime colleague David Anthony reflected on her commitment to the river. Considering she had dedicated nearly forty years of her life to the struggle, he lamented, “it’s sad to realize that Marjorie has died without the Ocklawaha running free. It was our dream to have a celebration on its banks.” Alyson Flourney, current member of FDE’s Board of Trustees, took Carr’s death as a call to action. “Just as she was an inspiration in life . . . [in death] she can only inspire us to continue to work to see that restoration happens. It’s the best tribute we can pay to her” (Martin October 11, 1997; Arndorfer October 17, 1997).

Six days later, almost three hundred people paid their respects to Marjorie Carr at Gainesville’s First Presbyterian Church. The service featured eulogies from, among others, Lieutenant Governor Buddy MacKay. Reflecting on Carr’s years of activism, MacKay commended her for establishing “the prototype of modern citizen advocacy groups in America.” She “redefined our relationship to the environment,” he continued, “causing movement from development based on the cash register to an ethic of sustainability.” FDE’s David Godfrey reinforced the bond
between Marjorie Carr and the Ocklawaha with a reading of Sidney Lanier’s prosaic ode which had so inspired her to action. Pastor Robert Battles poignantly ended the service by reminding mourners that “Marjorie responded with passionate devotion to the common good. . . . From her, I caught a glimpse of what it means to be a steward of the garden of God.” As pallbearers placed the casket in a hearse bound for Carr’s final resting place in Gainesville’s Evergreen Cemetery, a green and white bumper sticker mysteriously appeared on the back window of the big black Cadillac. It read, “Free the Ocklawaha River,” a fitting legacy for Marjorie Carr’s remarkable life. Her daughter Mimi, who had cared for her in those last difficult years, could only smile as she said, “maybe mother put it there.” An editor from the Gainesville Sun went a step further. “In death,” a headline announced, “she still had last word” (Arndorfer October 17, 1997).

FDE members hoped Carr’s demise would signal a change of heart in Tallahassee. Their expectations were buoyed in late May of 1998, when the legislature commemorated Carr by naming the Cross Florida Greenway after her. In many respects it marked the crowning achievement for a woman who had dedicated her life to environmental protection.

However, if FDE’s membership thought this could provide the political momentum to finally restore the Ocklawaha, they were sadly mistaken. Indeed, the day after the legislature honored Carr with the name change, it also saw fit to memorialize her leading adversary by renaming Rodman Dam after Senator George Kirkpatrick. Calling the Senator “an avid bass fisherman, naturalist, and outdoorsman” with a “keen interest in the final disposition of Rodman Dam,” the legislature complimented him for leading “the opposition to the removal of the dam throughout his Senate career.” It was the worst form of tit-for-tat in an already rancorous debate (http://election.dos.state.fl.us/laws/98laws/ch_98-398.pdf).

With the turn of a new century, the future of the Ocklawaha still remained unresolved. Even with such federal agencies as the U.S. Forest Service pushing
for Rodman’s removal, nothing changed. Even with Jeb Bush, the popular new Republican Governor, publicly committed to restoring the river, nothing changed. Even with Kirkpatrick’s forced retirement in 2000 due to term limits, nothing changed. With their nemesis now removed by state-mandated term limits, FDE mistakenly thought they had a chance for success. “Especially with George Kirkpatrick gone,” one member asked, “who else is going to be there to champion the dam?” The answer was a bi-partisan coalition of north Florida politicians led by Republicans Jim Pickens of Palatka and Jim King of Jacksonville, and Democrat Rod Smith of Gainesville. Smith had not only taken Kirkpatrick’s seat, but his passion for the reservoir. Not only would he block restoration efforts, he would even introduce legislation protecting the reservoir as the George Kirkpatrick State Reserve. If such a measure became law, it would make it nearly impossible to remove the dam. Though the legislation was vetoed by Governor Bush in 2003, it remained a legislative perennial, introduced session after session, which demanded FDE’s constant vigilance. Even seemingly insignificant issues placed environmental activists on the defensive. Every tax dollar spent on the reservoir’s recreational facilities reinforced Rodman’s permanence. Reservoir supporters argued that after nearly forty years of existence, the artificial lake had become part of the natural environment itself. As one explained, “it’s got its own ecology. It’s got its own value.” Newspaper headlines as late as the spring of 2010 observed with a hint of frustration that “Year after Year, it’s the Same Dam Debate,” and that the “Ocklawaha Restoration Remains in Limbo;” the reservoir remained alive (Pfankuch March 13, 2000; Dunkelberger April 26, 2007; Dunkelberger April 26, 2007).

The dam, now renamed after its staunchest defender, may have endured, but its namesake, former Senator George Kirkpatrick, died suddenly on February 5, 2003 at the age of 64. His love of fishing, of course, closely identified him with the longstanding struggle to keep the reservoir intact. Ordinary citizens and politicians alike took a moment at his passing to express just what Kirkpatrick meant to their cause. Ed Taylor, a Palatka resident and
President of Save Rodman Reservoir, called the Senator “the greatest warrior for the survival of Rodman Reservoir I have ever known.” It was a fitting tribute for such a combative man. Representative Joe Pickens recognized both the importance of Kirkpatrick’s legislative chicanery and the necessity to continue that struggle. “We all know,” he said, “that I would have no Rodman to protect, no torch to carry, if it were not for Senator Kirkpatrick’s lifelong commitment to its preservation” (Kirkpatrick Hailed for Work on Putnam’s Behalf February 7, 2003).

George Kirkpatrick was no doubt a larger than life figure; much like his long time adversary Marjorie Carr. Considering how much they were singularly associated with the struggle over the river and the reservoir, they were equally associated with each other. Both were doggedly determined and willing to do whatever necessary to advance their cause. Thus it was only fitting that Kirkpatrick’s funeral eerily paralleled Carr’s. His service was not only held in the same downtown Gainesville church, but officiated by the very same pastor. What must Reverend Robert Battles have thought knowing he had performed the same ceremony for Marjorie Carr just five years earlier? What did the mourners think when they caught a glimpse of another bumper sticker—this time a blue and white “Save Rodman Reservoir” one—attached to the Senator’s casket? The similarities continued even after the service was completed. Upon leaving the church, Kirkpatrick’s funeral procession ended its journey in Gainesville’s Evergreen Cemetery, where the Senator was laid to rest only yards from the grave of Marjorie Carr.

In the years since the death of both Carr & Kirkpatrick, little has changed. The dam and reservoir still remain and the Florida legislature still annually debates whether they should be removed. In 2003 both houses of the Florida legislature passed a bill creating the George Kirkpatrick State Reserve around the reservoir, virtually assuring the dam would remain. A veto by Governor Jeb Bush defeated the measure, insuring the controversy would continue. Similar bills were filed for the next four legislative sessions with no success for the supporters of the reserve idea. That did not mean, however, that pro-restoration forces
were any more successful in removing the dam. The latest iteration of the on-going battle occurred in 2009 when developers proposed building a $2 million 400 slip marina on the reservoir, which would have essentially preserved the reservoir for the foreseeable future. Though supported by those in favor of keeping the dam intact, a coalition of government agencies and pro-restoration forces managed to defeat the measure in the Florida legislature. In spite of the continuous (and so far successful) efforts to retain Kirkpatrick Dam, Marjorie Carr’s vision of a free-flowing Ocklawaha remains as a viable alternative. In 1996, a year before her death, she wrote that the effort to save the Ocklawaha “is not a north central Florida local issue. The Ocklawaha River is a glorious part of Florida’s natural heritage. Floridians should be aware that if they can’t save the Ocklawaha they have little chance of saving any of the remaining lovely wild places in Florida. The twenty-five year delay in the restoration of the Ocklawaha River is indeed a major scandal. The Ocklawaha must now run free.”
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The Historical Roots of Our Ecologic Crisis

Lynn White, Jr.

A conversation with Aldous Huxley not infrequently put one at the receiving end of an unforgettable monologue. About a year before his lamented death he was discoursing on a favorite topic: Man's unnatural treatment of nature and its sad results. To illustrate his point he told how, during the previous summer, he had returned to a little valley in England where he had spent many happy months as a child. Once it had been composed of delightful grassy glades; now it was becoming overgrown with unsightly brush because the rabbits that formerly kept such growth under control had largely succumbed to a disease, myxomatosis, that was deliberately introduced by the local farmers to reduce the rabbits' destruction of crops. Being something of a Philistine, I could be silent no longer, even in the interests of great rhetoric. I interrupted to point out that the rabbit itself had been brought as a domestic animal to England in 1176, presumably to improve the protein diet of the peasantry.

All forms of life modify their contexts. The most spectacular and benign instance is doubtless the coral polyp. By serving its own ends, it has created a vast undersea world favorable to thousands of other kinds of animals and plants. Ever since man became a numerous species he has affected his environment notably. The hypothesis that his fire-drive method of hunting created the world's great grasslands and helped to exterminate the monster mammals of the Pleistocene from much of the globe is plausible, if not proved. For 6 millennia at least, the banks of the lower Nile have been a human artifact rather than the swampy African jungle which nature, apart from man, would have made it. The Aswan Dam, flooding 5000 square miles, is only the latest stage in a long process. In many regions terracing or irrigation, overgrazing, the cutting of forests by Romans to build ships to fight Carthaginians or by Crusaders to solve the logistics problems of their expeditions, have profoundly changed some ecologies. Observers that the French landscape falls into two basic types, the open fields of the north and the bocage of the south and west, inspired Marc Bloch to undertake his classic study of medieval agricultural methods. Quite unintentionally, changes in human ways often affect nonhuman nature. It has been noted, for example, that the advent of the automobile eliminated huge flocks of sparrows that once fed on the horse manure littering every street.

The history of ecologic change is still so rudimentary that we know little about what really happened, or what the results were. The extinction of the European aurochs as late as 1627 would seem to have been a simple case of overenthusiastic hunting. On more intricate matters it often is impossible to find solid information. For a thousand years or more the Frisians and Hollanders have been pushing back the North Sea, and the process is culminating in our own time in the reclamation of the Zuidersche. What, if any, species of animals, birds, fish, shore life, or plants have died out in the process? In their epic conflict with Neptune have the Netherlands overlooked ecological values in such a way that the quality of human life in the Netherlands has suffered? I cannot discover that the questions have ever been asked, much less answered.

People, then, have often been a dynamic element in their own environment, but in the present state of historical scholarship we usually do not know exactly when, where, or with what effects man-induced changes came. As we enter the last third of the 20th century, however, concern for the problem of ecologic backlash is mounting feverishly. Natural science, conceived as the effort to understand the nature of things, had flourished in several eras and among several peoples. Similarly there had been an age-old accumulation of technological skills, sometimes growing rapidly, sometimes slowly. But it was not until about four generations ago that Western Europe and North America arranged a marriage between science and technology, a union of the theoretical and the empirical approaches to our natural environment. The emergence in widespread practice of the Baconian credo that scientific knowledge means technological power over nature can scarcely be dated before about 1850, save in the chemical industries, where it is anticipated in the 19th century. Its acceptance as a normal pattern of action may mark the greatest event in human history since the invention of agriculture, and perhaps in nonhuman terrestrial history as well.

Almost at once the new situation forced the crystallization of the novel concept of ecology; indeed, the word ecology first appeared in the English language in 1873. Today, less than a century later, the impact of our race upon the environment has so increased in force that it has changed in essence. When the first cannons were fired, in the early 14th century, they affected ecology by sending workers scrambling to the forests and moun-
tains for more potash, sulfur, iron ore, and charcoal, with some resulting erosion and deforestation. Hydrogen bombs are of a different order: a war fought with them might alter the genetics of all life on this planet. By 1285 London had a smog problem arising from the burning of soft coal, but our present combustion of fossil fuels threatens to change the chemistry of the globe's atmosphere as a whole, with consequences which we are only beginning to guess. With the population explosion, the carcinoma of planless urbanism, the new geological deposits of sewage and garbage, surely no creature other than man has ever managed to foul its nest in such short order.

There are many calls to action, but specific proposals, however worthy as individual items, seem too partial, palliative, negative: ban the bomb, tear down the billboards, give the Hindus contraceptives and tell them to eat their sacred cows. The simplest solution to any suspect change is, of course, to stop it, or, better yet, to revert to a romanticized past: make those ugly gasoline stations look like Anne Hathaway's cottage or (in the Far West) like ghost-town saloons. The "wilderness area" mentality invariably advocates deep-freezing an ecology, whether San Gimignano or the High Sierra, as it was before the first Kleenex was dropped. But neither atavism nor prettification will cope with the ecologic crisis of our time.

What shall we do? No one yet knows. Unless we think about fundamentals, our specific measures may produce new backlashes more serious than those they are designed to remedy.

As a beginning we should try to clarify our thinking by looking, in some historical depth, at the presuppositions that underlie modern technology and science. Science was traditionally aristocratic, speculative, intellectual in intent; technology was lowerclass, empirical, action-oriented. The quite sudden fusion of these two, towards the middle of the 19th century, is surely related to the slightly prior and contemporary democratic revolutions which, by reducing social barriers, tended to assert a functional unity of brain and hand. Our ecologic crisis is the product of an emerging, entirely novel, democratic culture. The issue is whether a democratized world can survive its own implications. Presumably we cannot unless we rethink our axioms.

The Western Traditions of Technology and Science

One thing is so certain that it seems stupid to verbalize it: both modern technology and modern science are distinctly Occidental. Our technology has absorbed elements from all over the world, notably from China; yet everywhere today, whether in Japan or in Nigeria, successful technology is Western. Our science is the heir to all the sciences of the past, especially perhaps to the work of the great Islamic scientists of the Middle Ages, who so often outdid the ancient Greeks in skill and perspicacity: al-Razi in medicine, for example, or ibn-al-Haytham in optics, or Omar Khayyam in mathematics. Indeed, not a few works of such geniuses seem to have vanished in the original Arabic and to survive only in medieval Latin translations that helped to lay the foundations for later Western developments.

Today, around the globe, all significant science is Western in style and method, whatever the pigmentation or language of the scientists.

A second pair of facts is less well recognized because they result from quite recent historical scholarship. The leadership of the West, both in technology and in science, is far older than the so-called Scientific Revolution of the 17th century or the so-called Industrial Revolution of the 18th century. These terms are in fact outmoded and obscure the true nature of what they try to describe—significant stages in two long and separate developments. By A.D. 1000 at the latest—and perhaps, feebly, as much as 200 years earlier—the West began to apply water power to industrial processes other than milling grain. This was followed in the late 12th century by the harnassing of wind power. From simple beginnings, but with remarkable consistency of style, the West rapidly expanded its skills in the development of power machinery, labor-saving devices, and automation. Those who doubt should contemplate that most monumental achievement in the history of automation: the weight-driven mechanical clock, which appeared in two forms in the early 14th century. Not in craftsmanship but in basic logical capacity, the Latin West of the later Middle Ages far outstripped its elaborate, sophisticated, and esthetically magnificent sister cultures, Byzantium and Islam. In 1444 a great Greek ecclesiastic, Bessarion, who had gone to Italy, wrote a letter to a prince in Greece. He is amazed by the superiority of Western ships, arms, textiles, glass. But above all he is astonished by the spectacle of waterwheels sawing timbers and pumping the bellows of blast furnaces. Clearly, he had seen nothing of the sort in the Near East.

By the end of the 15th century the technological superiority of Europe was such that its small, mutually hostile nations could spill out over all the rest of the world, conquering, looting, and colonizing. The symbol of this technological superiority is the fact that Portugal, one of the weakest states of the Occident, was able to become, and to remain for a century, mistress of the East Indies. And we must remember that the technology of Vasco da Gama and Albuquerque was built by pure empiricism, drawing remarkably little support or inspiration from science.

In the present-day vernacular understanding, modern science is supposed to have begun in 1543, when both Copernicus and Vesalius published their great works. It is no derogation of their accomplishments, however, to point out that such structures as the Fabrica and the De revolutionibus do not appear overnight. The distinctive Western tradition of science, in fact, began in the late 11th century with a massive movement of translation of Arab and Greek scientific works into Latin. A few notable books—Theophrastus, for example—escaped the West's avid new appetite for science, but within less than 200 years effectively the entire corpus of Greek and Muslim science was available in Latin, and was being eagerly read and criticized in the new European universities. Out of criticism arose new observation, speculation, and increasing distrust of ancient authorities. By the late 13th century Europe had seized global scientific leadership from the faltering hands of Islam. It would be as absurd to deny the profound originality of Newton, Galileo, or Copernicus as to deny that of the 14th century scholasticists like Buridan or Oresme on whose work they built. Before the 11th century, science scarcely existed in the Latin West, even in Roman times. From the 11th century onward, the scientific sector of Occidental culture has increased in a steady crescendo.

Since both our technological and our scientific movements got their start, acquired their character, and achieved...
world dominance in the Middle Ages, it would seem that we cannot understand their nature or their present impact upon ecology without examining fundamental medieval assumptions and developments.

**Medieval View of Man and Nature**

Until recently, agriculture has been the chief occupation even in "advanced" societies; hence, any change in methods of tillage has much importance. Early plows, drawn by two oxen, did not normally turn the sod but merely scratched it. Thus, cross-plowing was needed and fields tended to be square. In the fairly light soils and semiarid climates of the Near East and Mediterranean, this worked well. But such a plow was inappropriate to the wet clime and often sticky soils of northern Europe. By the latter part of the 7th century after Christ, however, following obscure beginnings, certain northern peasants were using an entirely new kind of plow, equipped with a vertical knife to cut the line of the furrow, a horizontal share to slice under the sod, and a moldboard to turn it over. The friction of this plow with the soil was so great that it normally required not two but eight oxen. It attacked the land with such violence that cross-plowing was not needed, and fields tended to be shaped in long strips.

In the days of the scratch-plow, fields were distributed generally in units capable of supporting a single family. Subsistence farming was the presupposition. But no peasant owned eight oxen: to use the new and more efficient plow, peasants pooled their oxen to form large plow-teams, originally receiving (it would appear) plowed strips in proportion to their contribution. Thus, distribution of land was based no longer on the needs of a family but, rather, on the capacity of a power machine to till the earth. Man's relation to the soil was profoundly changed. Formerly man had been part of nature; now he was the exploiter of nature. Nowhere else in the world did farmers develop any analogous agricultural implement. Is it coincidence that modern technology, with its ruthlessness toward nature, has so largely been produced by descendants of these peasants of northern Europe?

This same exploitive attitude appears slightly before A.D. 830 in Western illustrated calendars. In older calendars the months were shown as passive personifications. The new Frankish calendars, which set the style for the Middle Ages, are very different; they show men coercing the world around them—plowing, harvesting, chopping trees, butchering pigs. Man and nature are two things, and man is master.

These novelties seem to be in harmony with larger intellectual patterns. What people do about their ecology depends on what they think about themselves in relation to things around them. Human ecology is deeply conditioned by beliefs about our nature and destiny—that is, by religion. To Westerners this is very evident in, say, India or Ceylon. It is equally true of ourselves and of our medieval ancestors.

The victory of Christianity over paganism was the greatest psychic revolution in the history of our culture. It has become fashionable today to say that, for better or worse, we live in "the post-Christian age." Certainly the forms of our thinking and language have largely ceased to be Christian, but to my eye the substance often remains amazingly akin to that of the past. Our daily habits of action, for example, are dominated by an implicit faith in perpetual progress which was unknown either to Greco-Roman antiquity or to the Orient. It is rooted in, and indefensible apart from, Judeo-Christian teleology. The fact that Communists share it merely helps to show what can be demonstrated on many other grounds: that Marxism, like Islam, is a Judeo-Christian heresy. We continue today to live, as we have lived for about 1700 years, very largely in a context of Christian axioms.

What did Christianity tell people about their relations with the environment?

While many of the world's mythologies provide stories of creation, Greco-Roman mythology was singularly incoherent in this respect. Like Aristotle, the intellectuals of the ancient West denied that the visible world had had a beginning. Indeed, the idea of a beginning was impossible in the framework of their cyclical notion of time. In sharp contrast, Christianity inherited from Judaism not only a concept of time as nonrepetitive and linear but also a striking story of creation. By gradual stages a loving and all-powerful God had created light and darkness, the heavenly bodies, the earth and all its plants, animals, birds, and fishes. Finally, God had created Adam and, as an afterthought, Eve to keep man from being lonely. Man named all the animals, thus establishing his dominance over them. God planned all of this explicitly for man's benefit and rule: no item in the physical creation had any purpose save to serve man's purposes. And, although man's body is made of clay, he is not simply part of nature; he is made in God's image.

Especially in its Western form, Christianity is the most anthropocentric religion the world has seen. As early as the 2nd century both Tertullian and Saint Irenaeus of Lyons were insisting that when God shaped Adam he was foreshadowing the image of the incarnate Christ, the Second Adam. Man shares, in great measure, God's transcendence of nature. Christianity, in absolute contrast to ancient paganism and Asia's religions (except, perhaps, Zoroastrianism), not only established a dualism of man and nature but also insisted that it is God's will that man exploit nature for his proper ends.

At the level of the common people this worked out in an interesting way. In Antiquity every tree, every spring, every stream, every hill had its own genius loci, its guardian spirit. These spirits were accessible to men, but were very unlike men; centaurs, fauns, and mermaids show their ambivalence. Before one cut a tree, mined a mountain, or dammed a brook, it was important to placate the spirit in charge of that particular situation, and to keep it placated. By destroying pagan animism, Christianity made it possible to exploit nature in a mood of indifference to the feelings of natural objects.

It is often said that for animism the Church substituted the cult of saints. True; but the cult of saints is functionally quite different from animism. The saint is not in natural objects; he may have special shrines, but his citizenship is in heaven. Moreover, a saint is entirely a man; he can be approached in human terms. In addition to saints, Christianity of course also had angels and demons inherited from Judaism and perhaps, at one remove, from Zoroastrianism. But these were all as mobile as the saints themselves. The spirits in natural objects, which formerly had protected nature from man, evaporated. Man's effective monopoly on spirit in this world was confirmed, and the old inhibitions to the exploitation of nature crumbled.

When one speaks in such sweeping terms, a note of caution is in order,
Christianity is a complex faith, and its consequences differ in differing contexts. What I have said may well apply to the medieval West, where in fact technology made spectacular advances. But the Greek East, a highly civilized realm of equal Christian devotion, seems to have produced no marked technological innovation after the late 7th century, when Greek fire was invented. The key to the contrast may perhaps be found in a difference in the tonality of piety and thought which students of comparative theology find between the Greek and the Latin Churches. The Greeks believed that sin was intellectual blindness, and that salvation was found in illumination, orthodoxy—that is, clear thinking. The Latins, on the other hand, felt that sin was moral evil, and that salvation was to be found in right conduct. Eastern theology has been intellectualist. Western theology has been voluntarist. The Greek saint contemplates; the Western saint acts. The implications of Christianity for the conquest of nature would emerge more easily in the Western atmosphere.

The Christian dogma of creation, which is found in the first clause of all the Creeds, has another meaning for our comprehension of today's ecologic crisis. By revelation, God had given man the Bible, the Book of Scripture. But since God had made nature, nature also must reveal the divine mentality. The religious study of nature for the better understanding of God was known as natural theology. In the early Church, and always in the Greek East, nature was conceived primarily as a symbolic system through which God speaks to men: the ant is a sermon to sluggards; rising flames are the symbol of the soul's aspiration. This view of nature was essentially artistic rather than scientific. While Byzantium preserved and copied great numbers of ancient Greek scientific texts, science as we conceive it could scarcely flourish in such an ambiance.

However, in the Latin West by the early 13th century natural theology was following a very different bent. It was ceasing to be the decoding of the physical symbols of God's communication with man and was becoming the effort to understand God's mind by discovering how his creation operates. The rainbow was no longer simply a symbol of hope first sent to Noah after the Deluge: Robert Grosseteste, Friar Roger Bacon, and Theodoric of Freiberg produced startlingly sophisticated work on the optics of the rainbow, but they did it as a venture in religious understanding. From the 13th century onward, up to and including Leibnitz and Newton, every major scientist, in effect, explained his motivations in religious terms. Indeed, if Galileo had not been so expert an amateur theologian he would have got into far less trouble; the professionals resented his intrusion. And Newton seems to have regarded himself more as a theologian than as a scientist. It was not until the late 18th century that the hypothesis of God became unnecessary to many scientists.

It is often hard for the historian to judge, when men explain why they are doing what they want to do, whether they are offering real reasons or merely culturally acceptable reasons. The consistency with which scientists during the long formative centuries of Western science said that the task and the reward of the scientist was "to think God's thoughts after him" leads one to believe that this was their real motivation. If so, then modern Western science was cast in a matrix of Christian theology. The dynamism of religious devotion, shaped by the Judeo-Christian dogma of creation, gave it impetus.

An Alternative Christian View

We would seem to be headed toward conclusions unpalatable to many Christians. Since both science and technology are blessed words in our contemporary vocabulary, some may be happy at the notions, first, that, viewed historically, modern science is an extrapolation of natural theology and, second, that modern technology is at least partly to be explained as an Occidental, voluntarist realization of the Christian dogma of man's transcendence of and rightful mastery over nature. But, as we now recognize, somewhat over a century ago science and technology—hitherto quite separate activities—joined to give mankind power which, to judge by many of the ecologic effects, are out of control. If so, Christianity bears a huge burden of guilt.

I personally doubt that disastrous ecologic backlash can be avoided simply by applying to our problems more science and more technology. Our science and technology have grown out of Christian attitudes toward man's relation to nature which are almost universally held not only by Christians and neo-Christians but also by those who fondly regard themselves as post-Christians. Despite Copernicus, all the cosmos rotates around our little globe. Despite Darwin, we are not, in our hearts, part of the natural process. We are superior to nature, contemptuous of it, willing to use it for our slightest whim. The newly elected Governor of California, like myself a churchman but less troubled than I, spoke for the Christian tradition when he said (as is alleged), "when you've seen one redwood tree, you've seen them all." To a Christian a tree can be no more than a physical fact. The whole concept of the sacred grove is alien to Christianity and to the ethos of the West. For nearly 2 millennia Christian missionaries have been chopping down sacred groves, which are idolatrous because they assume spirit in nature.

What we do about ecology depends on our ideas of the man-nature relationship. More science and more technology are not going to get us out of the present ecologic crisis until we find a new religion, or rethink our old one. The beatniks, who are the basic revolutionaries of our time, show a sound instinct in their affinity for Zen Buddhism, which conceives of the man-nature relationship as very nearly the mirror image of the Christian view. Zen, however, is as deeply conditioned by Asian history as Christianity is by the experience of the West, and I am dubious of its viability among us.

Possibly we should ponder the greatest radical in Christian history since Christ: Saint Francis of Assisi. The prime miracle of Saint Francis is the fact that he did not end at the stake, as many of his left-wing followers did. He was so clearly heretical that a General of the Franciscan Order, Saint Bonaventura, a great and perceptive Christian, tried to suppress the early accounts of Franciscanism. The key to an understanding of Francis is his belief in the virtue of humility—not merely for the individual but for man as a species. Francis tried to depose man from his monarchy over creation and set up a democracy of all God's creatures. With him the ant is no longer simply a homily for the lazy, flames a sign of the thrust of the soul toward union with God; now they are Brother Ant and Sister Fire, praising the Creator in their own ways as Brother Man does in his.
Later commentators have said that Francis preached to the birds as a rebuke to men who would not listen. The records do not read so: he urged the little birds to praise God, and in spiritual ecstasy they flapped their wings and chirped rejoicing. Legends of saints, especially the Irish saints, had long told of their dealings with animals but always, I believe, to show their human dominance over creatures. With Francis it is different. The land around Gubbio in the Apennines was being ravaged by a fierce wolf. Saint Francis, says the legend, talked to the wolf and persuaded him of the error of his ways. The wolf repented, died in the odor of sanctity, and was buried in consecrated ground.

What Sir Steven Runciman calls "the Franciscan doctrine of the animal soul" was quickly stamped out. Quite possibly it was in part inspired, consciously or unconsciously, by the belief in reincarnation held by the Cathar heretics who at that time teemed in Italy and southern France, and who presumably had got it originally from India. It is significant that at just the same moment, about 1200, traces of metempsychosis are found also in western Judaism, in the Provençal Cabala. But Francis held neither to transmigration of souls nor to pantheism. His view of nature and of man rested on a unique sort of pan-psychism of all things animate and inanimate, designed for the glorification of their transcendent Creator, who, in the ultimate gesture of cosmic humility, assumed flesh, lay helpless in a manger, and hung dying on a scaffold.

I am not suggesting that many contemporary Americans who are concerned about our ecologic crisis will be either able or willing to counsel with wolves or exhort birds. However, the present increasing disruption of the global environment is the product of a dynamic technology and science which were originating in the Western medieval world against which Saint Francis was rebelling in so original a way. Their growth cannot be understood historically apart from distinctive attitudes toward nature which are deeply grounded in Christian dogma. The fact that most people do not think of these attitudes as Christian is irrelevant. No new set of basic values has been accepted in our society to displace those of Christianity. Hence we shall continue to have a worsening ecologic crisis until we reject the Christian axiom that nature has no reason for existence save to serve man.

The greatest spiritual revolutionary in Western history, Saint Francis, proposed what he thought was an alternative Christian view of nature and man's relation to it: he tried to substitute the idea of the equality of all creatures, including man, for the idea of man's limitless rule of creation. He failed. Both our present science and our present technology are so tinctured with orthodox Christian arrogance toward nature that no solution for our ecologic crisis can be expected from them alone. Since the roots of our trouble are so largely religious, the remedy must also be essentially religious, whether we call it that or not. We must rethink and refelt our nature and destiny. The profoundly religious, but heretical, sense of the primitive Franciscans for the spiritual autonomy of all parts of nature may point a direction. I propose Francis as a patron saint for ecologists.

One Hundred Periodic Comets

Modern techniques of observation and computation are enabling us to clarify our ideas about these bodies.

Brian G. Marsden

Although Seneca remarked almost 2000 years ago that comets were celestial bodies that might reappear periodically, ideas on the subject were dominated until the 16th century by the pronouncements of Aristotle and Ptolemy that comets were meteorological phenomena to be regarded as the fore-runners of disaster.

The turning point came when Tycho Brahe showed the comet of 1577 to be more distant than Moon, Tycho supposed it to travel about Sun in a circular orbit somewhat larger than that of Venus. Curiously enough, Kepler never applied his laws of planetary motion to comets and believed them to move through the solar system in straight lines. Some of Kepler's contemporaries, however, such as Horatio Grassi and William Lübner, held that cometary orbits were indeed ellipses.

It was of course Newton who settled the question by demonstrating that the comet of 1680 moved, in accordance with the law of gravitation, in an orbit that was an ellipse of such great eccentricity that it could be approximated by a parabola. Shortly afterwards, in the course of his celebrated calculations on the orbits of the planets, Newton was able to deduce the orbit of the comet in 1682, and he showed that another comet whose parabolic orbit was observed in 1683 could be considered as a member of the same family. The comet of 1680 was observed again in 1682 and later, and the comet of 1683 in 1684 and 1686, and it was found that the comets of 1531, 1577, 1607, 1682, and 1686 were members of the same family.

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