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The Invisible and Indeterminable Valueof Ecology: From Malaria Control toEcological Research in the AmericanSouth

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Abstract: This essay tells the story of the Emory University Field Station, a malaria research station in southwest Georgia that operated from 1939 to 1958. Using the tools of environmental history and the history of science, it examines the station's founding, its fieldwork, and its place within the broader history of malaria control, eradication, and research. A joint effort of Emory University, the U.S. Public Health Service, and the Communicable Disease Center (CDC), this station was closely aligned with a broader movement of ideas about tropical diseases across the globe, but it also offers a case study of how science in the field can veer from mainstream thinking and official policy. As the CDC and other disease-fighting organizations were moving toward a global strategy of malaria eradication through the use of DDT, the Emory Field Station developed a postsanitarian approach to malaria. Drawing on resistance among American conservationists to environmental transformation in the name of malaria control, the station's staff embraced the science and worldview of ecology in an effort to lighten public health's hand on the land and to link human health to the environment in innovative, if sometimes opaque, ways. This essay, then, argues that the Emory Field Station represents an early confluence of ecology with the biomedical sciences, something very similar to what is now the important discipline of disease ecology.

Melvin Goodwin had several problems on his hands in the fall of 1953. He was busy keeping afloat the Emory University Field Station, a fifteen-year-old research station in rural southwest Georgia devoted to the study of malaria prevention and mosquito ecology. The station was a joint venture of Emory and the U.S. Public Health Service's Communicable Disease Center (CDC), but in reality only one opinion of its operations mattered. Robert Woodruff, chairman of the Coca Cola Company, funded much of its activity and

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owned the station's land base in Baker County, known as Ichauway Plantation. If Woodruff was not happy, the station would dissolve. Woodruff asked Clarence Walker, an administrator at Emory, to investigate the station's doings in 1953; after a survey of the ongoing research and a tour of the grounds, Walker concluded "that research purposes and results are a far cry from the original purpose—malaria control. Now, a major part of the operation carried on by Emory with Mr. Woodruff's contributions is Biology Research." The "invisible and indeterminable value" of the data generated by such research, it seemed to Walker, offered little benefit to Ichauway, its residents, or Woodruff's philanthropic goals. It was time, he argued, to shutter the station.[1]

Goodwin's other major problem was actually a cause for celebration. Malaria had disappeared from the American South. Rates of infection had been on a steady decline since the mid 1930s, and Goodwin had not found the malaria parasite in Ichauway's residents since 1944. A variety of factors contributed to the decline, including prophylactics, environmental control, and, perhaps most important, the dismantling of the sharecropper and tenant system of agriculture throughout the region. Without a critical mass of the hosts—tenants and sharecroppers—living in, and perhaps creating, places where malaria-carrying mosquitoes thrived, the disease could not survive.[2]

The decline of malaria, however, did not bode well for what had become a highly productive center for scientific research. Goodwin and his staff found themselves wondering how to justify their work after their original object of study was no longer a problem. The official explanation for the continuing work at the Emory Field Station and others like it was to "detect as far in advance as possible any indication of an increase or recurrence of malaria," as well as to explain its decline.[3] But as the malaria threat subsided and the scientific infrastructure remained, the field station's staff expanded their research program to embrace an ecological approach to mosquito biology, linking human health to the environment in innovative, if sometimes opaque, ways. Using the lowly mosquito as their centerpiece, they constructed a highly technical research framework that included the fields of geology, hydrology, botany, zoology, entomology, and epidemiology.

This essay tells the story of the Emory University Field Station, with attention to its founding, its fieldwork, and its place within the broader history of malaria control, eradication, and research. Small though it was, the Emory Field Station was closely aligned with a broader movement of ideas about tropical diseases throughout the globe. From their colonial experiences in Panama, Cuba, the Philippines, and, indeed, the U.S. South, specialists had come by the 1920s and 1930s to see vector diseases such as malaria as diseases of place. Despite the late nineteenth-century revelation of the germ theory and its tracing of disease to the human body rather than the surrounding environment, malaria represented an anomaly.[4] The

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[1] Clarence Walker to Joseph Jones, 17 Nov. 1953, Robert Winship Woodruff Papers (hereafter **Woodruff Papers**), Box 85, Folder: Emory University, Emory University Field Station (hereafter **EUFS**), 1948–1955, Manuscripts, Archives, and Rare Books Library, Emory University, Atlanta, Georgia.

[2] On the decline of malaria in the South see Margaret Humphreys, *Malaria: Poverty, Race, and Public Health in the United States* (Baltimore: Johns Hopkins Univ. Press, 2001); on the decline of malaria at Ichauway see "Report of Activities for Period September 1, 1945–August 31, 1946," Woodruff Papers, Box 84, Folder: EUFS, 1941–1947.

[3] George H. Bradley and Melvin H. Goodwin, Jr., "Malaria Observation Stations of the Public Health Service," *Journal of the National Malaria Society*, 1949, 8:181–191, on p. 181.

[4] On the connections between health, disease, and the environment see Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: Univ. California Press, 2006); Conevery Bolton Valencius, *The Health of the Country: How American Settlers Understood Themselves and Their Land* (New York: Basic, 2002); Gregg Mitman, *Breathing Space: How Allergies Shape Our Lives and Landscapes* (New Haven, Conn.: Yale Univ. Press, 2007); Mitman, "In Search of

turn-of-the-century discovery that mosquitoes transmitted the disease confirmed an environmentalist approach to malaria and made its management the domain of scientists in the field— usually entomologists and sanitary engineers. These experts attacked the problem in the landscape rather than in the human body: they drained wetlands, redirected waterways, and made landscaping recommendations; they sprayed oils and arsenics on mosquito breeding grounds; and in the postwar era they embraced the use of DDT and other chlorinated hydrocarbons to kill adult mosquitoes and their larvae. The work of these entomologists and sanitarians, and to a lesser extent physicians, has dominated much of the recent historical discussion about malaria in the United States.[5] But a closer look at malaria research in the interwar and postwar years reveals another influence altogether: that of field biologists who approached the problem from the perspective of ecology, an approach that developed in direct opposition to contemporary efforts at environmental manipulation. This approach to malaria research also offers an early glimpse at the type of thinking that would eventually coalesce around the field of disease ecology.

Disease ecology is a relatively new interdisciplinary field within the disciplines of ecology and the biomedical sciences. Its origins are usually dated to the 1980s, when a series of emerging diseases vexed researchers and new strains of other diseases shook our confidence in the power of antibiotics. Such developments brought evolutionary questions of competition and the interrelations of organisms to the forefront of thought on disease, with proponents of an ecological approach arguing that global environmental change was facilitating an onslaught of new and more destructive diseases.[6] This approach seemed novel, but several scholars have recently found much deeper seams of ecological thought within the biomedical sciences. J. Andrew Mendelsohn has found ecological thinking about infectious diseases among practitioners in the early twentieth century. He argues that such thinking developed across many disciplines, including from within the ranks of "medical men" who faced a puzzling set of emerging diseases during and after World War I, not unlike disease ecologists later in the century. Helen Tilley has located the roots of disease ecology in the processes of imperialism, especially in the work of turn-of-the-century British scientists studying tsetse flies and trypanosomiasis in Africa. An increasing awareness of the complexity of vector-borne diseases, Tilley argues, led researchers to develop cross-disciplinary networks in an effort to construct a full understanding of the ecology of disease. Paul Sutter has also examined tropical medicine for ecological strains of thought and found them in the efforts of the United States

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Health: Landscape and Disease in American Environmental History," *Environmental History*, 2005, *10*:184–210; and Paul S. Sutter, "Nature's Agents or Agents of Empire: Entomological Workers and Environmental Change During the Construction of the Panama Canal," *Isis*, 2007, 98:724–754. On the declension narrative of body–environmental relations see Charles E. Rosenberg, "Pathologies of Progress: The Idea of Civilization as Risk," *Bulletin of the History of Medicine*, 1998, 72:714–730.

[5] Humphreys, *Malaria* (cit. n. 2); Gordon Patterson, *The Mosquito Crusades: A History of the American Anti-Mosquito Movement from the Reed Commission to the First Earth Day* (New Brunswick, N.J.: Rutgers Univ. Press, 2009); and Patterson, *The Mosquito Wars: A History of Mosquito Control in Florida* (Gainesville: Univ. Press Florida, 2004).

[6] On the origins of contemporary disease ecology see Nicholas B. King, "The Scale Politics of Emerging Diseases," in *Landscapes of Exposure: Knowledge and Illness in Modern Environments*, *Osiris*, 2004, N.S., *19*:62–76. King and others point to the work of the virologist Stephen S. Morse as a touchstone for the emerging diseases concept. See Stephen S. Morse, ed., *Emerging Viruses* (New York: Oxford Univ. Press, 1993). For examples of continuing work to merge ecology with the biomedical sciences see Tony McMichael, *Human Frontiers, Environments, and Disease: Past Patterns, Uncertain Futures* (Cambridge: Cambridge Univ. Press, 2001); Margot W. Parkes *et al.*, "All Hands on Deck: Transdisciplinary Approaches to Emerging Infectious Disease," *EcoHealth*, 2005, 2:258–272; and Richard S. Ostfeld, Felicia Keesing, and Valerie T. Eviner, *Infectious Disease Ecology: Effects of Ecosystems on Disease and of Disease on Ecosystems* (Princeton, N.J.: Princeton Univ. Press, 2008).

to build the Panama Canal. Fieldworkers there came to understand that large mosquito populations were as much the result of disturbed environments as they were elements of tropical nature, leading them to look for ecological fixes to medical problems. In addition, Warwick Anderson has followed the work of the infectious disease researchers Theobald Smith, F. Macfarland Burnet, René Dubos, and Frank Fenner, all of whom began to use an ecological lens on infectious disease research long before disease ecology developed into a field of its own.[7] Collectively, these scholars demonstrate that the germ theory of disease never held the dominance we once thought; it was overlooked, ignored, or chipped away by field scientists in infectious disease research and related disciplines even as it was beginning to gain a stronghold among medical professionals. More crucially, they also show how innovative research programs move in fits and starts and are rooted in particular social and historical moments that often dictate their dissemination or demise.

This essay adds to this growing body of work, but it does so from the regional perspective of the southeastern United States. The South was a critical hub in the transnational distribution of expertise in what became known as "tropical" diseases. Organizations like the U.S. Public Health Service (PHS) and the Rockefeller Foundation, in conjunction with state health departments, set up a sprawling public health infrastructure in the early twentieth century to curtail a number of diseases that persisted in the colonial-like setting of the region. Entomologists, sanitary engineers, and physicians imported the environmental control techniques they had developed in the tropics and honed them in the more familiar milieu of the South; they then, in turn, exported them anew across the globe. While it is appealing to follow such a unilateral movement of knowledge and experience, Warwick Anderson and Steven Palmer have recently complicated our understanding of early U.S. disease control efforts. In constructing their genealogies of global public health workers, they demonstrate that knowledge and personnel came from a variety places at a variety of times and did not simply move in a straight line from one place to another.[8] In his work on the Philippines, Anderson has shown that U.S. colonial health workers at the turn of the century were closely connected to each other and that the knowledge they carried was closely tied to specific tropical places. And Palmer complicates things even further by charting the diverse organizational origins of workers in the Rockefeller Foundation International Health Division and the significant influence of local actors on the execution of its hookworm projects in the Caribbean. Their genealogies reveal a shift among American specialists from a racialized view of tropical diseases that depended on the colonial military tactics of control and domination to a more technical, scientific, even ecological, approach that largely bypassed sufferers altogether. And as practitioners became more confident in their technical abilities, the general aim of disease work moved from control to eradication through environmental manipulation.

The Emory Field Station was very much a part of this larger biomedical genealogy, but a

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[7] J. Andrew Mendelsohn, "From Eradication to Equilibrium: How Epidemics Became Complex after World War I," in *Greater Than the Parts: Holism in Biomedicine, 1920–1950*, ed. Christopher Lawrence and George Weisz (New York: Oxford Univ. Press, 1998), pp. 303–331; Helen Tilley, "Ecologies of Complexity: Tropical Environments, African Trypanosomiasis, and the Science of Disease Control in British Colonial Africa, 1900–1940," *Osiris*, 2004, N.S., *19*:21–38; Tilley, *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870–1950* (Chicago: Univ. Chicago Press, 2011); Sutter, "Nature's Agents or Agents of Empire" (cit. n. 4); and Warwick Anderson, "Natural Histories of Infectious Disease: Ecological Vision in Twentieth-Century Biomedical Science," *Osiris*, 2004, *19*:39–61.

[8] Warwick Anderson, *Colonial Pathologies: American Tropical Medicine, Race, and Hygiene in the Philippines* (Durham, N.C.: Duke Univ. Press, 2006); and Steven Palmer, *Launching Global Health: The Caribbean Odyssey of the Rockefeller Foundation* (Ann Arbor: Univ. Michigan Press, 2010).

close examination of its field practice reveals another line of influence that shifted some focus away from disease eradication to a postsanitarian model of disease research. By the time of the station's founding in 1938, the family of disease researchers was expanding to include a number of fieldworkers steeped not only in the science of ecology but also in its worldview. As suggested above, an ecological view of disease was nothing new, but an embrace of its worldview was. Specifically, the ecological turn at the Emory Field Station grew from its close ties to an American conservation movement that increased in importance before and after World War II.[9] As an advocate in that movement, the station's director, Melvin Goodwin, embarked on an attempt to curtail the environmentally destructive methods of control that had long been embraced by sanitarians. These methods—moving land and water and spraying poisons on both—caused a great deal of concern among many American biologists, and the direct influence of wildlife biologists such as William Vogt, Herbert Stoddard, and Eugene Odum led Goodwin and his staff to ask questions about mosquito and malaria habitat instead of turning immediately to the standard of eradication.[10] Even while other PHS research sites embraced the widespread use of DDT after World War II, the Emory station used it only sparingly, in home spraying programs but not in the field; instead, they invested more time and effort in fieldwork such as water flow studies, vertebrate and invertebrate life history studies, botanical surveys, and a host of studies on mosquitoes themselves.[11] By shifting to a postsanitarian model of malaria control, the Emory Field Station went against the grain of eradication just as the miracle of DDT made it seem most attainable. Well before Rachel Carson's *Silent Spring* questioned the wisdom of eradication through chemicals, then, advocates in an earlier American conservation movement had already questioned the methods and assumptions of the disease control establishment.

The practical dimensions of this effort, however, were eventually undone by the disappearance of malaria in the United States. Regarding these practical dimensions, this essay draws on an active and growing literature on the history of field science. Historians of science in the field examine the constellation of social and environmental factors that come to bear

[9] On American conservation in the interwar years see Thomas Dunlap, *Saving America's Wildlife: Ecology and the American Mind, 1850–1990* (Princeton, N.J.: Princeton Univ. Press, 1991); Curt Meine, *Aldo Leopold: His Life and Work* (Madison: Univ. Wisconsin Press, 1988); Neil M. Maher, *Nature's New Deal: The Civilian Conservation Corps and the Roots of the American Conservation Movement* (Oxford: Oxford Univ. Press, 2008); Sarah T. Phillips, *This Land, This Nation: Conservation, Rural America, and the New Deal* (Oxford: Oxford Univ. Press, 2007); and Paul S. Sutter, *Driven Wild: How the Fight against the Automobile Launched the Modern Wilderness Movement* (Seattle: Univ. Washington Press, 2002). On the postwar era see Samuel P. Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955–1985* (Cambridge: Cambridge Univ. Press, 1989); and Adam Rome, *Bulldozer in the Countryside: Suburban Sprawl and the Rise of American Environmentalism* (Cambridge: Cambridge Univ. Press, 2001). On the history of ecology see Donald Worster, *Nature's Economy: A History of Ecological Ideas*, 2nd ed. (Cambridge: Cambridge Univ. Press, 1994); Sharon E. Kingsland, *The Evolution of American Ecology, 1890–2000* (Baltimore: Johns Hopkins Univ. Press, 2005); Gregg Mitman, *The State of Nature: Ecology, Community, and American Social Thought, 1900–1950* (Chicago: Univ. Chicago Press, 1992); Frank Benjamin Golley, *A History of the Ecosystem Concept in Ecology: More Than the Sum of Its Parts* (New Haven, Conn.: Yale Univ. Press, 1996); and Joel B. Hagen, *An Entangled Bank: The Origins of Ecosystems Ecology* (New Brunswick, N.J.: Rutgers Univ. Press, 1992).

[10] Helen Tilley also recognizes the important influence of animal ecologists on disease research in British Colonial Africa. See Tilley, "Ecologies of Complexity" (cit. n. 7), p. 32.

[11] On the use of DDT at other PHS sites see Leo Slater and Margaret Humphreys, "Parasites and Progress: Ethical Decision-Making and the Santee-Cooper Malaria Study, 1944–1949," *Perspectives in Biology and Medicine*, 2008, *51*:103–120; Humphreys, "Kicking a Dying Dog: DDT and the Demise of Malaria in the American South, 1942–1950," *Isis*, 1996, 87:1–17; and Humphreys, *Malaria* (cit. n. 2). On the centrality of DDT in postwar health campaigns see David Kinkela, *DDT and the American Century: Global Health, Environmental Politics, and the Pesticide That Changed the World* (Chapel Hill: Univ. North Carolina Press, 2011).

on the making of field science; that is, they "put science in its place," to quote the geographer David Livingstone.[12] Whereas Warwick Anderson has referred to turn-of-the-twentieth-century U.S. medical workers as "itinerants" who were passing through, carrying and building on their knowledge as they traveled from outpost to outpost in the course of building an American empire, the history of field science offers another way of seeing disease scientists. Robert Kohler's concept of "residential" science is an especially apt descriptor of the Emory Field Station staff.[13] Like Anderson's colonial workers, they possessed a cosmopolitan view of the world and they moved around a lot; but they also took up residence in a way that influenced their science. The Emory Field Station was embedded within the complex social and environmental landscape of the rural American South, which blended racial subjugation, paternalism, and environmental manipulation in ways that directly affected the ability of Goodwin and his staff to do science in the field. The staff dealt with the complexities of the field on a daily basis: they made astute staffing decisions to "make nice" with the local community; they learned to navigate a countryside of unmarked roads and nebulous swampy terrain; and they left their own mark on a rural landscape dominated by the activities of row-crop agriculture and recreational hunting. Science, in other words, became another product of the region's environment; and as the social, political, economic, and environmental context shifted, so, too, did scientific production.

MALARIA CONTROL'S PAST

Robert Woodruff was never wild about inviting a team of researchers to descend on his property. He pieced Ichauway together in the late 1920s and early 1930s—about 30,000 acres in all—as a retreat, a place to escape the demanding life of modern business. It was also a haven where he could make business deals under the relaxed circumstances of exclusive field sport, perhaps during the mid-morning lull of a quail hunt or at the card table afterward. Indeed, the idea for the field station came from such conversations. Woodruff and other southern leaders had long been concerned about the toll of malaria on the rural labor force of the South. He began to think seriously about the problem of malaria during a stay at Ichauway in the fall of 1937, when he had a long discussion with his farm superintendent, Roy Rogers, about some possible remedies for the region's health problems. Rogers knew of a small organization in Thomas County, the Malaria Research Foundation, that had been administering a new synthetic substitute for quinine called Atabrine. He soon contacted the men in charge of that effort—the physician Roy Hill and his able assistant Melvin Goodwin—about the possibility of bringing doses of Atabrine to Baker County. They did, and soon after learning of the local goodwill engendered by those visits, Woodruff began talking to his contacts at Emory University, as well his friends in the Atlanta business community and the

[12] David N. Livingstone, *Putting Science in Its Place: Geographies of Scientific Knowledge* (Chicago: Univ. Chicago Press, 2003). On the history of the field sciences see the essays in Henrika Kuklick and Robert E. Kohler, eds., *Science in the Field*, *Osiris*, 1996, N.S., *11*; Kohler, *Landscapes and Labscapes: Exploring the Lab–Field Border in Biology* (Chicago: Univ. Chicago Press, 2002); Kohler, *All Creatures: Naturalists, Collectors, and Biodiversity* (Princeton, N.J.: Princeton Univ. Press, 2006); Jeremy Vetter, ed., *Knowing Global Environments: New Historical Perspectives on the Field Sciences* (New Brunswick, N.J.: Rutgers Univ. Press, 2010); and Albert G. Way, *Conserving Southern Longleaf: Herbert Stoddard and the Rise of Ecological Land Management* (Athens: Univ. Georgia Press, 2011).

[13] Anderson, *Colonial Pathologies* (cit. n. 8), p. 7; and Robert E. Kohler, "Paul Errington, Aldo Leopold, and Wildlife Ecology: Residential Science," *Historical Studies in the Natural Sciences*, 2011, *41*:216–254.

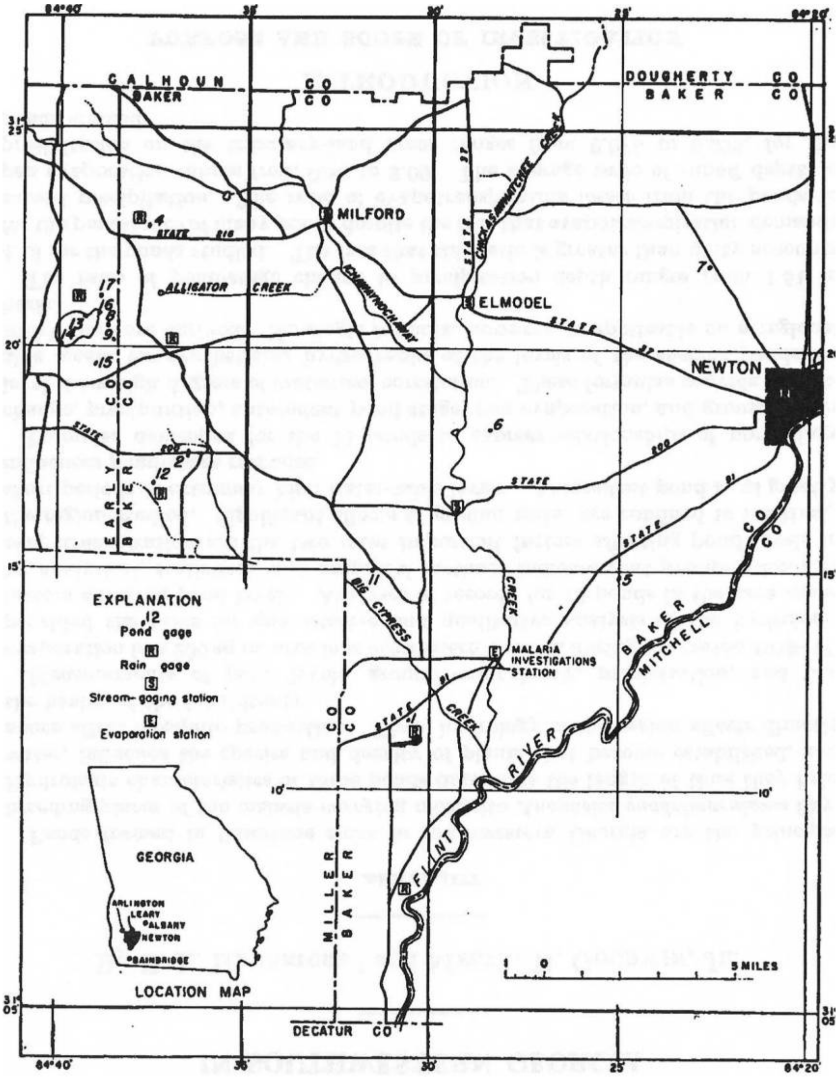

Figure 1. Area map of Emory University Field Station land base in southwest Georgia. From E. L. Hendricks and Melvin H. Goodwin, Jr., *Water-Level Fluctuations in Limestone Sinks in Southwestern Georgia* (Geological Survey Water-Supply Paper 1110-E) (Washington, D.C.: U.S. Government Printing Office, 1952).

Georgia Department of Public Health (GDPH), about organizing a temporary effort at malaria control using Ichauway as its land base.[14] (See Figure 1.)

[14] See correspondence and clippings in Woodruff Papers, Box 145, Folder: Ichauway Plantations, Inc., Malaria Research, 1937–1945. For background on Ichauway see Charles Elliot, *Ichauway Plantation* (Baker County, Ga.: Robert Woodruff, 1974); and Lindsay R. Boring, "The Joseph W. Jones Ecological Research Center: Co-Directed Applied and Basic Research in the Private Sector," in *Holistic Science: The Evolutions of the Georgia Institute of Ecology*, ed. G. W. Bartlett and T. L. Barrett (New York: Taylor & Francis, 2000), pp. 233–258.

Woodruff approached the project with caution. As he told the Atlanta lawyer Robert Troutman, "I'm not 'rearing' to do this particular thing, but if it is the opinion of the authorities that it will be very constructive and beneficial . . . I might be inclined to really make the effort." He was interested in any "constructive thing that would improve the health conditions in [Baker] county, but would want to be sure that . . . there would be no obligation of any kind to carry it on beyond the prescribed period" of two years. For Woodruff and his collaborators, the idea was to determine malaria's extent in the area, knock it out with the medicine, and then let the field scientists be on their way. Thinking back years later, he was frank about his motivations for the project: "I wasn't thinking of it as a humane program, because it was an economic situation, too. A man that is ill can't work. He's no good."[15] He had little interest in supporting research on the mechanics of mosquito and malaria ecology. The field scientists themselves, however, would eventually have something else in mind.

The early years of the Emory Field Station proceeded along the path of most antimalaria projects in the South, a path established decades earlier with the discovery that mosquitoes spread the disease. The real cause of malaria is not the mosquito itself, but a protozoan of the genus *Plasmodium*, a parasite that passes from host to host only via female *Anopheles* mosquitoes. Five malaria plasmodia infect humans, but only *P. vivax* and the more lethal *P. falciparum* were ever a concern in the Americas.[16] Worldwide, dozens of anopheline mosquitoes are capable of transmitting the plasmodium, but A. *quadrimaculatus* was the malaria vector of note in the American South. The quad, as it came to be known, is a native of North America and was a ready recipient of vivax and falciparum malaria when early European settlers and African slaves brought the parasites with them in their bloodstreams.[17] Eighteenth- and nineteenth-century Americans knew malaria as the fever, ague, or chills and considered it a result of bad air, the legendary miasmas that infected low-lying areas such as swamps and coastal marshes. Such areas abounded in the South, and the ecological transformation of the region for agricultural production helped to make it even more productive of malaria. The kind of watery environments that tend to follow the land-moving activities of plantation agriculture—stillwater pools and back-forty swamps—made perfect breeding grounds for the quad. The agroecologies of coastal rice production were famously malarious, as were those of upland cotton, especially in areas of karst geology where natural features such as "limesinks" predominated. These bodies of water would dry up intermittently and thus did not harbor many fish—a primary predator of mosquito larvae—making them even more prone to large breeding populations of mosquitoes. As large-scale cotton agriculture advanced across the South in the nineteenth century, malaria became endemic in much of the region.[18]

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[15] Robert Woodruff to Robert B. Troutman, 22 Feb. 1938, Woodruff Papers, Box 84, Folder: EUFS, 1938–1940; and *Atlanta Journal and Constitution Magazine*, 9 May 1976, p. 15. Whether the motivations for malaria control and other public health reforms in the South were philanthropic or economic has long been a subject of historical debate. For a review of the contours of that debate see William Link, "Privies, Progressivism, and Public Schools: Health Reform and Education in the Rural South, 1909–1920," *Journal of Southern History*, 1988, 54:623–642.

[16] Only four malaria plasmodia infected humans historically, but a fifth, *P. knowlesi*, has recently been found to spread from primates to humans in Southeast Asia. See Loretta A. Cormier, *The Ten-Thousand Year Fever: Rethinking Human and Wild-Primate Malarias* (Walnut Creek, Calif.: Left Coast, 2011).

[17] J. R. McNeill, *Mosquito Empires: Ecology and War in the Greater Caribbean, 1620–1914* (Cambridge: Cambridge Univ. Press, 2010); and Randall M. Packard, *The Making of a Tropical Disease: A Short History of Malaria* (Baltimore: Johns Hopkins Univ. Press, 2007).

[18] On early American understandings of malaria, especially in the South, see Darrett Rutman and Anita Rutman, "Of Agues and Fevers: Malaria in the Early Chesapeake," *William and Mary Quarterly*, 1976, 33:31–60; H. Roy Meterns and George D. Terry, "Dying in Paradise: Malaria, Mortality, and the Perceptual Environment in Colonial South Carolina," *J. South. Hist.*, 1984, 50:533–550; John Duffy, "The Impact of Malaria on the South," in *Disease and Distinctiveness in the American South*,

Even after the role of mosquitoes became clear, physicians and laypersons held on to many ideas about miasmas for years to come. The discovery of the mosquito vector actually confirmed the dangers of swampy environments for many, but it also presented new alternatives for fighting malaria. Although the human body remained a site of the disease, and physicians continued to search for effective prophylactics, the mosquito vector became the focus of most control efforts; thus the responsibility for malaria control shifted gradually from physicians to entomologists and sanitary engineers. The imperial efforts of the United States to control and "sanitize" tropical places made quick studies of these experts, and their successes with yellow fever in Cuba and malaria in the Panama Canal Zone established their supremacy in dealing with vector-borne disease. Pioneers such as William Gorgas, L. O. Howard, and Joseph LePrince studied the behavior and preferred habitats of *Anopheles* and *Aedes* (the yellow fever vector) mosquitoes and developed detailed protocols for killing them, diminishing their habitat, and segregating them from humans. Scientists in the tropics also came to recognize human-caused environmental change—such as the massive land-moving project in Panama—as an aid to malaria's spread. The stillwater pools and stagnant drainage ditches that proliferated in the Canal Zone, for instance, provided ideal breeding grounds for *Anopheles* mosquitoes.[19]

The turn-of-the-century campaigns in Cuba and Panama informed every project that followed in the United States and abroad. Indeed, colonial public health officers left Panama as heroes and descended on places such as the U.S. South, Puerto Rico, and the Philippines to replicate their successes. Joseph LePrince, for instance, became one of the most sought-after malaria technicians in the South after he completed his work in Panama in 1914. As the director of the malaria control section of the U.S. Public Health Service, he trained others in the techniques he had developed in the tropics and led the effort to control malaria at southern military installations during World War I. Along with Thomas Griffitts of the PHS, LePrince identified *A. quadrimaculatus* as the primary vector of human malaria in North America and also determined the quad's one-mile flight range, a critical step toward identifying vulnerable human populations.[20]

Veterans of the U.S. colonial enterprise also infiltrated the Rockefeller Foundation's ambitious public health programs. Its Sanitary Commission for the Eradication of Hookworm worked throughout the South from 1909 to 1914, a project that would provide critical experience for the foundation's International Health Division in other parts of the world. The International Health Division took aim at a number of tropical diseases, beginning in 1913 with hookworm in the Caribbean and then malaria, yellow fever, and influenza in places as far-flung as Italy, the Philippines, India, Mexico, and Colombia. The U.S. South remained a core location of Rockefeller activity after the hookworm program, and the organization sent scores of health workers to train in the region before heading abroad.[21] Like the efforts in

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ed. Todd L. Savitt and James Harvey Young (Knoxville: Univ. Tennessee Press, 1988), pp. 29–54; and Mart A. Stewart, "*What Nature Suffers to Groe*": *Life and Labor on the Georgia Coast* (Athens: Univ. Georgia Press, 1996). On the link between agriculture and malaria see Humphreys, *Malaria* (cit. n. 2), p. 52; and Packard, *Making of a Tropical Disease*, pp. 68–78.

[19] Sutter, "Nature's Agents or Agents of Empire" (cit. n. 4).

[20] J. A. LePrince and Thomas H. D. Griffitts, "Flight of Mosquitoes," *Public Health Reports*, Jan.–June 1917, 32(1):656–659. On LePrince see Patricia M. LaPointe, "Joseph Augustine LePrince: His Battle against Mosquitoes and Malaria," *West Tennessee Historical Society Papers*, 1987, *41*:48–61.

[21] Palmer, *Launching Global Health* (cit. n. 8). See also John Ettling, *The Germ of Laziness: Rockefeller Philanthropy and Public Health in the New South* (Cambridge, Mass.: Harvard Univ. Press, 1981); Link, "Privies, Progressivism, and Public Schools" (cit. n. 15); and John Farley, *To Cast Out Disease: A History of the International Health Division of the Rockefeller Foundation, 1913–1951* (Oxford: Oxford Univ. Press, 2004).

Panama, the malaria projects of the International Health Division focused on attacking the mosquito vector by ditching, draining, and oiling watery areas. By the early 1920s, they turned to spraying Paris green, an arsenic-based compound long used in agriculture and silviculture that had recently proved effective in killing *Anopheles* larvae. Indeed, before the development of DDT, Paris green was by far the most common insecticide used in malaria control projects during the interwar years.[22]

The Emory Field Station had several direct connections with the Rockefeller programs. The foundation had maintained a malaria program in the neighboring town of Leesburg, Georgia, in the 1920s, and the Rockefeller malariologist Mark Boyd carried out important work just down the road in Tallahassee, Florida, throughout the lifespan of the Emory Field Station. Though much of Boyd's work was medical in nature and loosely related to that of the field station, he visited often and would provide suggestive evidence connecting areas of karst geology with high malaria rates, a link that would form one of the research bases for the field station's turn to ecology.[23]

The South, then, became a critical space for designing public health programs and training workers in the methods of disease surveillance and sanitary engineering. Through their efforts both in the South and abroad, workers in the PHS, the Rockefeller Foundation, and state health departments implemented what became standard protocols for mapping and eradicating disease by the interwar years. The Emory Field Station was among the second-generation progeny of these efforts, and there was little initial indication that it would amount to much more than a routine post in the South's public health structure. But the loose structure of the field station mimicked the overall structure of global public health, with multiple sources of authority and influence that ultimately allowed a great deal of autonomy for the project.[24] No fewer than five organizational entities—Woodruff, Emory, the Georgia Department of Public Health, the PHS, and the CDC— had an interest in the station at one time or another, and none could claim complete control over its research agenda. The result was the eventual consignment of control to Goodwin, who had latitude to pursue a broad range of research interests and to call on a number of field scientists not usually involved in infectious disease research.

ICHAUWAY ENTERS THE FRAY

The field station officially began operation in April 1939 as a partnership between Emory and the Georgia Department of Public Health, to be funded with a $15,000 yearly budget provided by Woodruff. Physicians Roy Kracke and Elizabeth Gambrell organized the medical work from the Department of Pathology in Emory's School of Medicine, and by 1940 Justin Andrews, then head of the Malaria and Hookworm Division of the GDPH, became the station's director of research. Before moving to Georgia in 1938, Andrews taught in the Johns Hopkins School of Hygiene and Public Health and had spent two years teaching parasitology

[22] Darwin H. Stapleton, "Historical Perspectives on Malaria: The Rockefeller Antimalaria Strategy in the Twentieth Century," *Mount Sinai Journal of Medicine*, 2009, 76:468–473.

[23] Mark F. Boyd and Gerald Ponton, "The Recent Distribution of Malaria in the Southeastern United States," *American Journal of Tropical Medicine*, 1933, *13*:143–166. On the work of Mark Boyd see Margaret Humphreys, "Whose Body? Which Disease? Studying Malaria While Treating Neurosyphilis," in *Useful Bodies: Humans in the Service of Medical Science in the Twentieth Century*, ed. Jordan Goodman, Anthony McElligott, and Laura Marks (Baltimore: Johns Hopkins Univ. Press, 2003), pp. 53–77.

[24] Steven Palmer details a global health structure in which the "serial replication of rational health-processing methods and techniques was offset by a willingness to give the individual U.S. supervisors wide leeway in developing strategies to fulfill broadly defined mission objectives." See Palmer, *Launching Global Health* (cit. n. 8), p. 11.

at the University of the Philippines in Manila, both leading institutions of public health education. Andrews developed a two-pronged research program that mirrored many of the previous efforts in the tropics and the South. He sought to determine the relationship between groundwater fluctuations, mosquito density, and malaria and to study what he called the "time-honored problem of environmental factors which condition the production of *Anopheles quadrimaculatus*."[25] Melvin Goodwin, still enrolled as an undergraduate at the University of Georgia at the time, became responsible for directing this research on the ground as the station's appointed field biologist. Luther R. Mills, on loan from the U.S. Geological Survey, began mapping the area and devising a plan to survey its hydrological and geological characteristics; and two nurses from Albany, an African-American woman named Victoria Thompson and a white woman named Holliday, came on board to organize home visits in the community.

The first task for all involved was to learn something of the area's social, geographic, and environmental dynamics. Baker County sits in the middle of a physiographical area known as the Dougherty Plain, a relatively flat expanse of karst topography in southwest Georgia. When the Emory Field Station began operation in 1939, Baker County's social and economic milieu was dominated by the legacies of slavery. In the 1850s, it had become part of one of the largest inland plantation districts of the South, attracting migrant planters who brought their slaves with them from piedmont sections of Georgia and South Carolina. Little changed after emancipation, as the sharecropper and tenant system took hold. Rural segregation kept educational opportunities at a minimum for African Americans, and the crop-lien system kept them in perpetual debt. The 1920s and 1930s saw the arrival of a handful of hunting preserves in this agricultural landscape, a phenomenon that brought wealthy businessmen from the North and parts of the South in search of outdoor recreation. Plenty of land was available for such endeavors in the Depression-era market, and the agricultural system of tenantry produced desirable habitat for a number of game animals—especially bobwhite quail. Tenants, then, remained on most of these new preserves and largely continued to farm under arrangements much like those that had gone before.[26]

The countryside was sparsely populated throughout the first half of the twentieth century (there are even fewer residents today). In 1930, a total of 7,818 people lived within Baker County's 228,480 acres. Of those, 4,794 were black—not quite as disproportional as some plantation districts, but still a clear majority. Of the 108,866 acres in farms in 1930, 99,056 of them continued to be farmed by tenants or sharecroppers. There were 1,190 black and 700 white heads of household operating farms of all types in Baker County in 1930, while only 45 African Americans and 128 whites owned their own farms.[27]

On Ichauway, tenants received more supervision than those farming elsewhere. According to the posted rules of the "farm program" in 1939, "Tenants will be shown what and where to plant and must not break any land until the Superintendent shows them where to plow." All crops, "other than vegetables and meat raised for home consumption," were farmed on halves—a system whereby the sharecropper and the landowner split the harvest fifty-fifty. All tenants furnished their own stock, implements, and seed (or Ichauway would finance them if

[25] "Progress Report on Malaria, Emory University Project for Malaria and Hookworm Investigation, April 1, 1939–October 1, 1939"; and Justin Andrews, Memorandum to Woodruff Malaria Fund Committee, 19 June 1940: Woodruff Papers, Box 84, Folder: EUFS, 1938–1940.

[26] Susan Eva O'Donovan, *Becoming Free in the Cotton South* (Cambridge, Mass.: Harvard Univ. Press, 2007) (conditions after emancipation); and Way, *Conserving Southern Longleaf* (cit. n. 12) (hunting preserves).

[27] Historical Census Browser, http://fisher.lib.virginia.edu.collections/stats/histcensus/php.county.php (accessed 2 June 2010).

necessary), and Ichauway supplied fertilizer. In addition, Ichauway required tenants to plant 38 acres to the plow, with 8 acres in cotton, 10 acres in peanuts, and 20 acres in corn intermixed with velvet beans and cowpeas.[28] Woodruff and Rogers aimed to create "a model farming operation," and when combined with the home garden required of every tenant their plan represented a fairly diverse model in an otherwise cotton-reliant region.[29]

Woodruff's efforts to make Ichauway a progressive rural enclave reflected a genuine concern for human well-being and economic progress. But the image of Ichauway he chose to present to visitors mirrored many of the still-popular conceits of a mythical Old South. As one self-published booklet from 1931 explained, one might find a "touch of the Old South" in this isolated pocket of southwest Georgia. Picture books about the place featured images of contented black tenant farmers and domestic help eager to serve, coupled with depictions of whites spending the day afield with gun on horseback or relaxing on a lakeshore with a picnic lunch. It was important to Woodruff that Ichauway remained both a working plantation and a place of respite. The 1931 booklet concluded, "Many white and negro families carry on the agricultural activities of Ichauway, living in standardized white tenant cottages located at convenient points over the plantation. . . . Thus, the visitor to Ichauway sees a daily blending of agricultural life with the sports of field and stream." The idea of providing medical care for residents fit perfectly with Woodruff's ideas of benevolent paternalism, and the early efforts of Goodwin and his staff were an extension of this mission to improve local living conditions, maintain a healthy workforce, and contribute to an image of Ichauway as a reservation for a mythical southern past.[30]

Tenants and their families experienced this place intimately, as they did its diseases. A combination of factors—the living conditions of tenantry, meager medical care, and the region's watery geography—made Baker County ripe for a number of diseases, including malaria. In supporting the field station, Woodruff hoped to alleviate, if not fix, some of the region's health problems, and he stipulated that basic medical care would be a part of the research program. This made for a busy start to the station's life. Nurses Thompson and Holliday, often accompanied by Goodwin, made a total of 9,025 home visits between April and December 1939 and, in an attempt to "secure the confidence and cooperation of the residents of Baker County," performed an array of services that went far beyond malaria screening.[31] The staff conducted general health clinics, midwife classes, school dental surveys, and first aid training; they treated or diagnosed a host of diseases, including anemia, scarlet fever, tuberculosis, and appendicitis; and they constructed sanitary privies to combat hookworm. Malaria, though, was their primary target. In those first nine months, nurses administered Atabrine treatments to 1,204 people and took 6,219 blood smears for malaria detection.

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[28] "Farm Program, September 1939," Woodruff Papers, Box 134, Folder: Ichauway Plantations, Inc., 1929–1939; and "Rules and Regulations, December 7, 1934," Woodruff Papers, Box 153, Folder: [Ichauway Plantations, Inc.] Tenant Contracts, 1934–1935.

[29] J. T. Curtis to Roy Rogers, 7 Jan. 1935, Woodruff Papers, Box 153, Folder: [Ichauway Plantations, Inc.] Tenant Contracts, 1934–1935. On Depression-era agriculture in the South see Pete Daniel, *Breaking the Land: The Transformation of Cotton, Tobacco, and Rice Cultures since 1880* (Urbana: Univ. Illinois Press, 1986); and Jack Temple Kirby, *Rural Worlds Lost: The American South, 1920–1960* (Baton Rouge: Louisiana State Univ. Press, 1986).

[30] "Ichauway," Dec. 1931, Archives of Joseph W. Jones Ecological Research Center at Ichauway, Newton, Georgia. In some ways, Woodruff's effort to blend agricultural reform with increased access to health care mirrored the large-scale efforts of some federal agencies during the New Deal, especially those of the Farm Security Administration. See Michael R. Grey, *New Deal Medicine: The Rural Health Programs of the Farm Security Administration* (Baltimore: Johns Hopkins Univ. Press, 1999).

[31] "Emory University Field Station Annual Report, April 1, 1939–March 31, 1940," p. 31, Woodruff Papers, Box 84, Folder: EUFS, 1938–1940.

These showed that 64 African Americans and 24 whites carried the malaria plasmodium, and no deaths were attributable to malaria.[32] Malaria rates in the South had been on a steady decline for several years, and they would continue to dwindle from this point.

While the staff accomplished a great deal in these first few years before World War II, they also encountered several hurdles typical to such a young effort. Goodwin, for example, expressed frustration in the first progress report that the staff was not able properly to scout the location and develop adequate maps of the area before diving into their work. "The usual procedure," he wrote, "is to send the engineer in the field a year before other activities . . . [to create] an accurate map showing the locations of all houses, roads, and aquatic situations. . . . This was not possible since all activities had to be started at the same time." Baker County's population was widely dispersed, and the rural landscape, with its unmarked roads and meandering creeks and swamps, was difficult for outsiders to navigate. Such a quick start made the knowledge of locals all the more important to the task. Goodwin hired Robert Lofton, "a local 'handy man' [who] proved to be an indispensable assistant to the engineer in orientation of roads, and directions to various recognized land marks." In addition to Lofton, Thompson and Holliday were also familiar with the area. Nurse Thompson was particularly vital because her presence allayed any skepticism among the African-American population. Not surprisingly, her initial salary was lower than Holliday's, but Glenville Giddings, one of Woodruff's medical advisors on the project, thought "it would be well to pay Nurse Thompson the same amount; . . . with the Negroes, she is probably more valuable" than Nurse Holliday.[33] Indeed, Holliday would not return to the station after World War II.

Though the field station borrowed from existing strategies of malaria detection, Melvin Goodwin was beginning to see their mission as novel. As he wrote in the first annual report, "There have been few efforts to execute [malaria] research programs in the field independent of [malaria] control activities. . . . In the execution of field work we have tried to outline a program which would be of interest and value to agencies interested in research work other than that pertaining to malaria and hookworm."[34] Goodwin argued that the three traditional approaches to malaria control—attack the parasites in humans, attack the mosquitoes in their habitat, and separate humans from mosquitoes— contributed little to a general knowledge of malaria ecology or to an understanding of the specific habitats essential to A. *quadrimaculatus*. Indeed, beyond the mandated Atabrine treatments, traditional malaria control played a very small part in the station's research. "None of these [control approaches] is completely satisfactory," wrote Goodwin, and the "time-honored" method of draining mosquito-breeding habitat was particularly troubling; it had "been done promiscuously without evaluating its effect on water resources and conservation."[35] (See Figure 2.)

Goodwin's impulse to find alternatives to draining, or anything else perceived to have harsh environmental side effects, had been brewing since his time in Thomas County with the

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[32] *Ibid.*, pp. 17–25 (totals added from monthly charts). They did not distinguish between falciparum and vivax malaria in the annual report.

[33] "Progress Report on Malaria, Emory University Project for Malaria and Hookworm Investigation, April 1, 1939–October 1, 1939" (cit. n. 25); M. H. Goodwin, "Malaria Research at the Emory University Field Station, Briefing Memorandum Submitted to Field Station Committee, March, 1941," p. 13, Emory University Field Station Papers, Archives of Joseph W. Jones Ecological Research Center at Ichauway; and Glenville Giddings to Woodruff, 28 Feb. 1940, Woodruff Papers, Box 106, Folder: Glenville Giddings, 1934–1944.

[34] "Emory University Field Station Annual Report, April 1, 1939–March 31, 1940" (cit. n. 31), p. 1. Treatment of hookworm was a small part of the station's early mission, but they dropped it after World War II.

[35] Goodwin, "Malaria Research at the Emory University Field Station, Briefing Memorandum Submitted to Field Station Committee, March, 1941" (cit. n. 33), pp. 3–4.

Figure 2. This image showing Melvin Goodwin collecting plant material in a limesink is from the Emory Field Station Annual Report, 1946–1947. The caption reads, "In the mosquito habitat, plants are studied to learn their relation to mosquito breeding." Courtesy of the Joseph W. Jones Ecological Research Center at Ichauway.

Malaria Research Foundation. One of the trustees of that project, Herbert Stoddard, proved to be an important influence on Goodwin. Stoddard was a wildlife biologist and land manager best known for his work on bobwhite quail while employed by the U.S. Bureau of the Biological Survey; he was also a leader in an interwar conservation movement that was changing the ways Americans understood and interacted with the environment. Stemming from earlier Progressive Era concerns about dwindling natural resources and a faith in scientific expertise to provide a fix, the interwar movement also promoted basic science for its utility in mediating human–environmental relations. But it worked on an ethical level as well, which was best represented by the work of Stoddard's close friend Aldo Leopold. Drawing on his understanding of ecology as a science premised on interconnection, and human ethics as a set of moral principles premised on community, Leopold argued in one of his most celebrated essays for what he called a "land ethic," an idea that "simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land."[36] With such an inclusive ethical view, Leopold went on to charge humans with the moral obligation to

[36] Way, *Conserving Southern Longleaf* (cit. n. 12); and Aldo Leopold, *A Sand County Almanac, and Sketches Here and There* (1949; Oxford: Oxford Univ. Press, 1989), p. 204. On Leopold's influence see Meine, *Aldo Leopold* (cit. n. 9).

care for environmental health, which is difficult to achieve without knowing something of what makes the environment tick. Such moral nuance animated the scientific work of a growing number of biologists in the interwar years. Herbert Stoddard was among them, and, as a trusted advisor, he encouraged Goodwin to find alternatives to the land-moving and drainage projects of the Works Progress Administration (WPA) and the PHS.

Stoddard was particularly impressed with the antidrainage campaigns of William Vogt, a leading ornithologist who would soon become a major figure in American conservation circles. In the meantime, Vogt was a serious thorn in the side of the nation's malaria control structure. His 1937 booklet *Thirst on the Land* was making the rounds within the nation's wildlife community just as Goodwin was beginning to develop the station's research agenda and was inspiring a growing resistance to many accepted methods of malaria control. Published by the National Association of Audubon Societies and produced in conjunction with Jay "Ding" Darling, a cartoonist and former director of the Biological Survey, the booklet was a fierce polemic that exposed the environmental damage caused by government drainage projects. In it, Vogt described the various physical characteristics of fresh- and saltwater wetlands, detailed their importance to human welfare and animal life, and articulated an argument for American wetlands as "a source of national wealth of the first magnitude." Drainage projects of many different types threatened that source, but Vogt reserved special contempt for "the malaria racket," his label for the drainage projects of the PHS. "Under the guise of 'education,'" he wrote, "officials concerned with mosquito control work have made sweeping claims without producing scientific proof" that drainage would actually lower malaria rates. "Many of their assertions, which are nothing more nor less than sales talks to support and swell the supplies of money they wish to spend, will not stand the test of logic."[37] The presumed purpose of drainage was to reduce populations of *A. quadrimaculatus*, the only southern mosquito that mattered in the control of human malaria, and Vogt wanted at least to see evidence that the projects did what they were supposed to do.

Others were offering similar critiques of the PHS drainage projects. The Biological Survey voiced considerable opposition once the Works Progress Administration provided enough labor and funds to carry out drainage on a large scale. By the late 1930s, the Biological Survey ordered agents in the field to survey WPA operations in the southeastern states and to report on any projects they considered "unjustified drainage." They found many. Not only was "drainage for the control of malaria . . . done by the most destructive methods available"; it was usually unnecessary, according to one agent: "Many watered areas need not be drained, since the only mosquitos breeding are of species not a menace to public health." One of the most damning indictments of the drainage efforts came via Melvin Goodwin himself, who told an agent that he often dipped the larvae of *A. quadrimaculatus* out of malaria control ditches and "that they were more abundant in these ditches than in any natural watered

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[37] William Vogt, *Thirst on the Land: A Plea for Water Conservation for the Benefit of Man and Wild Life* (Circular 32) (New York: National Association of Audubon Societies, 1937), pp. 3, 20, 19. Vogt's best-known work of conservation writing appeared eleven years later; see Vogt, *Road to Survival* (New York: Sloane, 1948). On Vogt's background and influence see Thomas Robertson, "Total War and the Total Environment: Fairfield Osborn, William Vogt, and the Birth of Global Ecology," *Environ. Hist.*, 2012, *17*:336–364; Gregory T. Cushman, "'The Most Valuable Birds in the World': International Conservation Science and the Revival of Peru's Guano Industry, 1909–1965," *ibid.*, 2005, *10*:477–509; Ann Vileisis, *Discovering the Unknown Landscape: A History of America's Wetlands* (Washington, D.C.: Island, 1999), p. 185; Patterson, *Mosquito Crusades* (cit. n. 5), pp. 136–142; and David Cameron Duffy, "William Vogt: A Pilgrim on the Road to Survival," *American Birds*, 1989, 43:1256–1257. On drainage more generally see Jeffrey K. Stine, *America's Forested Wetlands: From Wasteland to Valued Resource* (Durham, N.C.: Forest History Society, 2008).

areas."[38] Drainage, in other words, had the potential to make the problem even worse. Indeed, as one PHS scientist later recalled, "no precise method was used to determine the malaria hazard" ahead of WPA drainage, "nor was there a regular entomological or epidemiological service for evaluating the effectiveness of the work."[39] Between Vogt's polemic and the Biological Survey's persuasion, the PHS felt the heat from the nation's wildlife community and soon became more circumspect about its drainage activities.

After reading *Thirst on the Land*, Goodwin became an enthusiastic partisan for research over control. As he recalled sometime after the station closed, "At that time wildlife interests and conservationists were concerned about the extensive destruction of aquatic habitats to eliminate breeding of malaria-carrying mosquitos. For these and many other reasons, a thorough assessment of the ecology of malaria was needed." Toward that end, Goodwin eagerly sought Vogt's counsel. Stoddard acted as intermediary at first, telling Vogt of what he hoped would be a new approach to malaria work, something that would "furnish a club for the fight on general drainage of wildlife habitat." Vogt, though "skittish about some of these malaria control people," was encouraged to find in Goodwin a "malariologist saying exactly the same thing about the futility of malaria control by drainage that wild life people have been saying."[40] Vogt could offer little more than his stamp of approval on the project, but that was enough for Goodwin.

As he eased into a leadership role at the Emory Field Station, Goodwin looked for alternatives to drainage, oiling, and spraying by taking the biological research more seriously. Indeed, much like wildlife biologists who had come to see predator eradication as counterproductive earlier in the decade, Goodwin thought killing all the mosquitoes and wiping out their habitat had prevented scientists from learning something about them and their surroundings. Of *A. quadrimaculatus*, Goodwin wrote, "We know, for example, that there are certain watered areas in which these insects do not breed but we do not know why these places are unfavorable." Learning what natural factors attracted quads to some habitats and repelled them from others, Goodwin hoped, might lead to "a type of natural or biological control of malaria high in efficiency, presumably harmless to other wild life."[41] In some ways, this biological approach echoed earlier malariologists who looked into the surrounding environment for medical solutions; but, critically, the Emory Field Station came into being during a burgeoning age of ecology, when one of the most compelling views of the life sciences emphasized the interconnecting parts of nature and our ethical responsibility to protect its health as well as our own. Wildlife biologists such as Stoddard, Vogt, Leopold, and many others were already investigating the complexities of animal population dynamics and the consequences of altering habitats or eradicating species; it made sense for Goodwin to study disease vectors in a similar way. As malaria itself disappeared and the station's medical work began to seem superfluous to its mission, this ecological view eventually captured the station's research agenda.

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[38] Robert C. McClanahan, "Confidential Report on WPA Malaria Drainage Projects in Georgia," 25 May 1938, p. 12; and McClanahan, "Memorandum Re: Unjustified Drainage," 24 May 1939, pp. 2, 1: Box 12, Folder: Unjustified Drainage, Research Reports, 1912–1951, Records of the Bureau of the Biological Survey, Entry 177, Record Group 22, National Archives and Records Administration (hereafter **NARA**), College Park, Maryland.

[39] Robert Usinger, "Early History," Box 4, Folder: Origin and History, Files of the Office of the Director, Information Office, Records of the Centers for Disease Control and Prevention, Record Group 442, NARA, Southeast Region, Atlanta, Georgia.

[40] Melvin Goodwin, "Initial Work at the Emory University Field Station," n.d., Melvin Goodwin Papers, Unprocessed Collection, Box 1, Manuscripts, Archives, and Rare Books Library, Emory University; and Herbert L. Stoddard to William Vogt, 9 Apr. 1938, and Vogt to Stoddard, Goodwin Papers, Box 1, Folder: Malaria Research Foundation.

[41] Goodwin, "Malaria Research at the Emory University Field Station, Briefing Memorandum Submitted to Field Station Committee, March, 1941" (cit. n. 33), pp. 5–6. On debates over predator eradication see Dunlap, *Saving America's Wildlife* (cit. n. 9); and Way, *Conserving Southern Longleaf* (cit. n. 12), Ch. 4.

WORLD WAR II

World War II, however, delayed the field station's anticipated shift toward ecological research. The station shut down in 1942, and Goodwin joined the brigade of malaria control officers in the U.S. Public Health Service charged with protecting the fighting forces at the many military bases popping up around the South. Justin Andrews, too, joined the effort as an Army malariologist and was assigned to malaria control activities in North Africa and the Pacific theater. Any inclination toward basic field research went out the window during the war. The PHS, already organized on a military command structure, did not have time to dawdle over such questions. Nonetheless, the war resulted in a tremendous expansion of U.S. capacity for combating disease. The PHS developed the Malaria Control in War Areas (MCWA) program, which was based in Atlanta and became "the most gigantic mosquito-control campaign carried out in the history of the world," according to one army official. The MCWA's early activities followed the old patterns of attacking mosquito larvae by draining, oiling, and spraying watery areas with Paris green, but by war's end they had embraced the seeming miracle that was DDT, an insecticide that effectively killed mosquitoes in both their larval and adult stages.[42]

As the war came to a close and officials began to process the overwhelming successes and institutional momentum of the MCWA program, they hatched a plan to continue their work during peacetime. The PHS had already organized their "extended program," an offspring of the MCWA that sought to protect civilians from the threat of malaria traveling in the bodies of returning military personnel. Soon the upper-tier leadership of both programs, including Louis Williams, Joseph Mountin, and Justin Andrews, successfully petitioned Congress and the PHS to establish a permanent organization in Atlanta for the control of malaria and other communicable diseases. By July 1946, what had been the MCWA officially became the Communicable Disease Center—later to become the Centers for Disease Control.[43] If the South was already an important location for the development of knowledge about disease before the war, it would be even more so afterward.

In the meantime, Mel Goodwin had risen through the ranks of the PHS, and by war's end he was a lieutenant, soon to become a captain. Malaria was largely gone from the South by then, but most malariologists still thought the disease was cyclical, so the PHS set up monitoring stations throughout the South to wait for its expected return. The Emory Field Station became one of those stations, along with two other outposts in Manning, South Carolina, and Helena, Arkansas. In 1944 the PHS worked out a deal with Emory and Woodruff to bring personnel back to Ichauway for research and monitoring, and the new CDC took over in July 1946. For Emory's part, the biology department joined with the School of Medicine to take an integral role in the field research. As an Emory administrator, Robert Mizell, told Woodruff before the war, "From the beginning, this was a project which Emory Medical School was not in position to handle" because of the nonmedical fieldwork.[44] With

[42] Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to "Silent Spring"* (Cambridge: Cambridge Univ. Press, 2001), p. 112 (quoting army official). On the development of the Malaria Control in War Areas program see Elizabeth Etheridge, *Sentinel for Health: A History of the Centers for Disease Control* (Berkeley: Univ. California Press, 1992), pp. 3–17; and Humphreys, "Kicking a Dying Dog" (cit. n. 11). On the development of DDT see Kinkela, *DDT and the American Century* (cit. n. 11); and Thomas Dunlap, *DDT: Scientists, Citizens, and Public Policy* (Princeton, N.J.: Princeton Univ. Press, 1983).

[43] Etheridge, *Sentinel for Health*.

[44] Robert Mizell to Woodruff, 2 Sept. 1941, Woodruff Papers, Box 187, Folder: Robert C. Mizell, 1941. The station's initial postwar budget was $30,000. The PHS contributed 44 percent, Emory University 39 percent, the U.S. Geological Survey 12

Justin Andrews entrenched in a CDC leadership role in Atlanta, Goodwin, who had received his undergraduate degree in biology only in 1941, took over as the revamped station's on-site director because of his familiarity with the previous work, as well as with the countryside and its residents. By 1948 he was named head of the CDC's Malaria Investigations Section and had oversight of all three of the malaria field stations.

THE POSTWAR YEARS

With the war over, the station's staff set about fieldwork with renewed dedication. Returning members of the staff—Goodwin, Mills, Lofton, and Thompson—were joined by several scientists from the PHS and Emory within a couple of years. The station's organizational structure began to look like that of a modern laboratory, with lead scientists and technicians specializing in various fields. Lead scientists included the entomologists Gory Love and Samuel Breeland from the PHS, the biologist Robert Platt from Emory, and an additional hydrologist from the U.S. Geological Survey, E. L. Hendricks. Scores of technicians filtered through the station during the 1940s and 1950s, all at various stages in their careers either with the PHS or in academia. In addition, the station hosted a number of visiting scientists and graduate student fellows and served as a field training station for CDC staff from Atlanta. According to a 1947 note from Robert Mizell, "scientists in various parts of the country are beginning to take notice and to request the privilege of visiting the station for short term explorations of their own . . . and the Station has now reached the point where it can be used in the technician training programs of both Emory and the Communicable Disease Center."[45] The station became a hub of activity and ideas, with personnel from a wide variety of disciplines.

Melvin Goodwin organized the staff's work along three primary lines of inquiry: epidemiological, hydrological, and biological. The epidemiological work continued the residential visits and blood work that played such a central role at the station before the war, but that effort diminished in importance as it became clear that malaria would likely not return. Goodwin curtailed the routine residential visits after the war because of negligible malaria rates, but Thompson continued to make periodic blood parasite surveys in selected residential areas and at local schools. They also cooperated with the state health department to run a public health clinic in Newton and conducted many immunization clinics at Ichauway throughout the life span of the station.[46]

The hydrological and biological lines of inquiry became central to the station's work, which made it an outlier among postwar CDC malaria projects. In 1947, the "extended program" became the "malaria eradication program" (1947–1952), which, as its name suggests, set out to rid North America of malaria through an abundant use of DDT. The promise of DDT gave a new urgency to the long-brewing idea of malaria eradication, and it also simplified the task. The CDC largely abandoned earlier methods of environmental manipulation in favor of scheduled DDT applications in homes in targeted areas. Margaret Humphreys has argued persuasively that this eradication campaign was as much an exercise in "kicking a dying dog," as well as institution building, as anything else. Certainly, the CDC leadership used malaria eradication to justify their funding and build their brand, and the

percent, and the Georgia Department of Public Health 5 percent. Emory's portion was covered by a grant from Woodruff. See "Budget Report, July 2, 1945," Woodruff Papers, Box 84, Folder: EUFS, 1941–1947.

[45] Mizell to Trawick Stubbs, 31 Jan. 1947, Woodruff Papers, Box 84, Folder: EUFS, 1941–1947.

[46] "Report on Activities for Period September 1, 1945–August 31, 1946," Woodruff Papers, Box 84, Folder: EUFS, 1941–1947.

methodology and technology of DDT application became a centerpiece of the CDC's mission during these years, as it did for most malaria projects around the world.[47]

But this focus on DDT and eradication tends to obscure much of the scientific work that continued in the field. While the Emory Field Station was part of the structure of eradication, its stated research focus in the immediate postwar years was mosquito and malaria "bionomics," a term that referred to the study of organisms within their natural environment.[48] Bionomics studies were well established by this point, especially in entomology. Past studies, however, had sought to replicate an organism's environmental surroundings in a laboratory setting in an effort to establish experimental controls. The staff at Ichauway did this in their lab, but they also borrowed from ecological concepts to take bionomics a couple of steps further. They not only studied "all aspects of malaria under natural conditions" in the field, according to one PHS report, but also studied the environment itself, especially how changing environmental conditions affected the disease and its vectors. "Much of the work," the report continued, "pertains to fundamental biological problems, since all investigations in field biology are inter-related in some way."[49] To answer one of their central research questions—What caused high populations of *Anopheles* mosquitoes?—they cast a wide net in the field, collecting basic data on weather, hydrological fluctuations, plant and animal life, and mosquito densities and composition. And then they looked for connections, both between their data and between scientific fields of study.

One of the primary research goals was to learn how the area's changing hydrology and geology affected mosquito habitat and, thus, mosquito populations. The mechanics of karst topography, in particular, helped to explain how the Dougherty Plain had become known for malaria in the previous decades. The defining characteristic of karst topography, wherever it may be, is that the cumulative effects of weathering dissolve the bedrock layer beneath the land surface. Streams, creeks, and rivers do the work of erosion as well, but the steady drainage of rainwater through the ground creates a landscape pockmarked by sinkholes above ground and caves below. Limestone is the most common bedrock material in karst regions, and a curious chemical process aids in its dissolution. Pure water would hardly affect limestone, but the addition of carbon dioxide creates carbonic acid, a substance that makes limestone soluble. Decaying plant material emits considerable carbon dioxide, so when ordinary rainwater passes through the soil it soaks up the carbon dioxide as it drains through the cracks, fissures, and pores in the limestone. While karst areas occur throughout the world, the limestone of southwest Georgia is younger and more porous than most. In time, it easily gives way, creating "limesinks" on the surface. These limesinks are shallow depressions that hold water intermittently throughout the year, and they constitute one of the dominant, and dynamic, ecological features of the Dougherty Plain.[50] (See Figure 3.)

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[47] Humphreys, "Kicking a Dying Dog" (cit. n. 11). On the centrality of the technological aspects of DDT in the Rockefeller Foundation malaria programs see Darwin H. Stapleton, "Technology and Malaria Control, 1930–1960: The Career of Rockefeller Foundation Engineer Frederick W. Knipe," *Parassitologia*, 2000, *42*:59–68.

[48] "*Anopheles* Bionomics Studies, Newton, Georgia," Box 2, Folder: Georgia 1 of 2, Files of the Office of the Director, Information Office, Records of the Centers for Disease Control and Prevention, Record Group 442, NARA, Southeast Region. Brief reports on the studies at the Emory Field Station appear as well in CDC Activity Reports, 1946–1954, also found in the Files of the Office of the Director.

[49] Mark A. Largent, "Bionomics: Vernon Lyman Kellogg and the Defense of Darwinism," *Journal of the History of Biology*, 1999, 32:465–488; and "*Anopheles* Bionomics Studies, Newton, Georgia," p. 1.

[50] L. Katherine Kirkman, Lora L. Smith, and Stephen W. Golladay, "Southeastern Depressional Wetlands," in *Wetland Habitats of North America: Ecology and Conservation Concerns*, ed. Darold P. Batzer and Andrew H. Baldwin (Berkeley: Univ. California Press, 2012), pp. 203–215; and Barry F. Beck and Daniel D. Arden, *Karst Hydrogeology and Geomorphology of the*

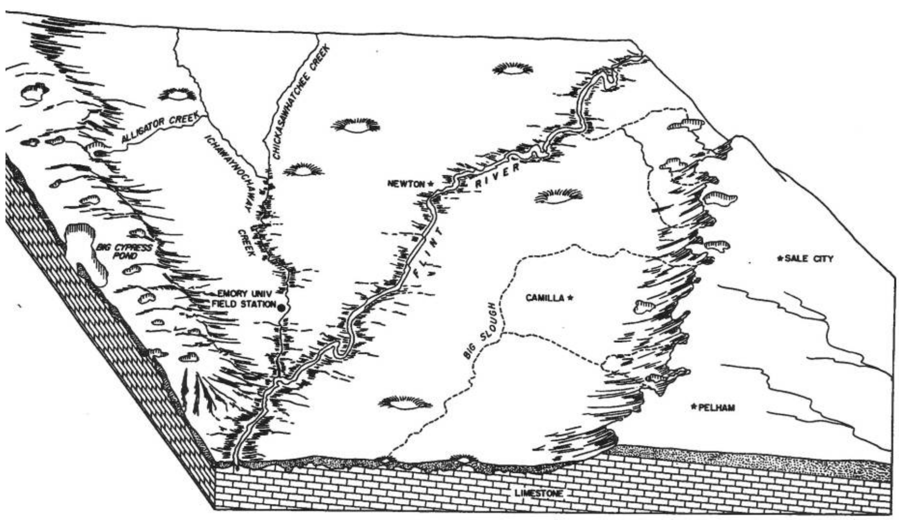

Figure 3. Topographical relief map of the Dougherty Plain. The largest limesinks are visible, and the area contains hundreds of smaller sinks as well. From E. L. Hendricks and Melvin H. Goodwin, Jr., *Water-Level Fluctuations in Limestone Sinks in Southwestern Georgia* (Geological Survey Water-Supply Paper 1110-E) (Washington, D.C.: U.S. Government Printing Office, 1952).

Goodwin and his collaborators knew that the limesinks would be central to their field research. The earlier work of the Rockefeller malariologist Mark Boyd supplied strong circumstantial evidence on the link between karst topography and the distribution of malaria in the Southeast. Along with Gerald Ponton of Florida's State Geological Survey, Boyd used overlapping maps to illustrate how areas with high malaria rates in the 1920s almost invariably correlated with areas underlain with soluble limestone. *A. quadrimaculatus* preferred the still, clean, alkaline water held by limesinks in these areas, and Boyd's work marked a significant revelation about the environmental particularities of malaria in the South. Despite the disease's yearly fluctuations in severity, Boyd and Ponton recognized that "few of the communicable diseases are as peculiarly diseases of place as is malaria," and the limesink region turned out to be one of the disease's preferred places.[51] Boyd did not, however, have the capacity or the inclination to conduct sustained fieldwork in these places. The hydrological and biological particulars of these watery habitats remained unexamined until the place-based research of the Emory Field Station.

Goodwin and his staff tackled limesink ecology in several stages. First, they conducted extensive hydrological fieldwork to determine what controlled water levels and how water-level fluctuations influenced the composition of limesink plant communities. With Mills and Hendricks, Goodwin installed a series of wells and instrument stations in and around thirteen limesinks that measured the daily groundwater and pond-level fluctuations and the amounts

Dougherty Plain, Southwest Georgia (Tallahassee, Fla.: Southeastern Geological Society, 1984), pp. 1–7. For early descriptions of Georgia's limesink region see Otto Veatch and Lloyd William Stephenson, *Preliminary Report on the Geology of the Coastal Plain of Georgia* (Bulletin 26) (Atlanta: Geological Survey of Georgia, 1911), pp. 30–31, 41–43; and M. Earl Carr, H. Jennings, Thomas D. Rice, and David D. Long, *Soil Survey of Dougherty County, Georgia* (Washington, D.C.: U.S. Government Printing Office, 1913).

[51] Boyd and Ponton, "Recent Distribution of Malaria in the Southeastern United States" (cit. n. 23), p. 143.

of daily precipitation and evaporation; they also monitored the region's streams for changes in depth and current strength. In essence, they sought to explain what happened to precipitation: How did runoff affect pond stages? How much rain remained locked above ground in limesink ponds? How much seeped into the water table? How much drained into established waterways? How much evaporated? How long did all of this take? The ultimate goal was to learn how to predict limesink water levels and the types of watery habitats certain weather conditions might create, thus developing a predictive model for forecasting mosquito densities. The "hydrologic characteristics of these ponds," they concluded, "influence[d] the species and density of plants that become established, and hence affect mosquito production. Thus, hydrology of the region affects directly the health of the inhabitants."[52] (See Figure 4.)

The study of limesinks and their connection to the region's hydrology, then, was an attempt to link human health to environmental change in predictable ways, which really formed the core of the field station's work. As it became clearer that malaria might not return to the South, Goodwin and his staff continued to stress this link as a reason to make the station a center for a broader scientific effort. The hydrological work, for instance, came to represent what might be possible for other lines of inquiry related to mosquitoes and malaria: "it appeared that possible benefit to the field of hydrology, aside from its immediate application to the malaria research program, warranted development of a program designed to study somewhat independently the hydrologic characteristics of limestone-sink terrane." This was one of many times when Goodwin would argue that the station's work had advanced beyond the practical aspects of malaria control. His researchers were asking questions of basic science and looking for results that would speak to a much broader audience. And, indeed, the station's research broadened considerably in its postwar years. With the hydrological characteristics of the region worked out and measurement activities ongoing, the biological work rose to a prominent place in the station's research agenda. The various habits and habitats of *Anopheles* mosquitoes, not just *A. quadrimaculatus*, became the primary research focus, which "served as a means of coordinating research and has prevented excursions too far afield," as Goodwin put it in a 1946 report. "But many observations," he continued, "are related to more comprehensive problems in human biology, and much of the work pertains to fundamental biology problems."[53]

To examine such problems properly, Goodwin and his staff solicited visiting scientists and graduate students to work on component parts of the region's ecology. They started a fellows program to fund graduate research and offered their equipment and land base to visiting scientists seeking a place for fieldwork. Among the early fellows was Robert Thorne, a graduate student in botany at Cornell, who began a botanical survey during the summers of 1946 and 1947 and returned to Ichauway several times over the life of the station to survey plant communities throughout southwest Georgia. Thorne's work was comprehensive. He produced the most complete plant survey of the region to date, created a herbarium for the

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[52] E. L. Hendricks and Melvin H. Goodwin, Jr., *Water-Level Fluctuations in Limestone Sinks in Southwestern Georgia* (Geological Survey Water-Supply Paper 1110-E) (Washington, D.C.: U.S. Government Printing Office, 1952), p. 157; see also Goodwin and Louva G. Lenert, "Methods Used for Investigating Certain Hydrologic Problems Related to Malaria," *J. Nat. Malaria Soc.*, 1943, 2:63–72. There is a deeper history of using seemingly self-contained communities such as ponds as a model of study in ecology. See Daniel W. Schneider, "Local Knowledge, Environmental Politics, and the Founding of Ecology in the United States: Stephen Forbes and 'The Lake as a Microcosm,'" *Isis*, 2000, 91:681–705; and Golley, *History of the Ecosystem Concept in Ecology* (cit. n. 9), pp. 36–37.

[53] Hendricks and Goodwin, *Water-Level Fluctuations in Limestone Sinks in Southwestern Georgia*, p. 158; and "Report on Activities for Period September 1, 1945–August 31, 1946" (cit. n. 46), p. 8.

Figure 4. This image of a woodland limesink showing typical mosquito habitat, with instrumentation set up in the water, is from the Emory Field Station Annual Report, 1946–1947. The caption reads, "Most of these investigations are concerned with studies of animal and plant life in ponds, and with factors responsible for formation and existence of ponds." Courtesy of the Joseph W. Jones Ecological Research Center at Ichauway.

station, and identified a number of species previously not known to exist in the state.[54] The plant communities in and around the limesinks were of special interest, because the still water encouraged a blanket growth of surface vegetation that was prime breeding ground for many different species of mosquitoes. Goodwin and company were learning a great deal about limesink hydrology; but they also wanted to find causative linkages between hydrological fluctuations and the watery botanical communities necessary for mosquito breeding. Knowing which limesink plant associations created suitable *Anopheles* habitat and how those associations responded to hydrological fluctuations became an important piece of the ecological puzzle. What they found—more rain = more habitat = more mosquitoes—was hardly earth-shattering news to anyone. But in the process of reaching that conclusion, they delin-

[54] Thorne completed his doctoral work at Cornell in 1949 and went on to become an important figure in systematic botany at the University of Iowa and then at the Rancho Santa Ana Botanical Garden in Claremont, California. His dissertation is Robert F. Thorne, "The Flora of Southwestern Georgia" (Ph.D. diss., Cornell Univ., 1949). His publications from the Ichauway fieldwork include Thorne, "Inland Plants on the Gulf Coastal Plain of Georgia," *Castanea*, 1949, *14*:88–97; Thorne, "Vascular Plants Previously Unreported from Georgia," *ibid.*, 1951, *16*:29–48; and Thorne, "The Vascular Plants of Southwestern Georgia," *American Midland Naturalist*, 1954, 2: 257–327.

eated the remarkable ecological complexities of the relationship between precipitation and mosquito populations in general and those of the limesink region in particular.[55]

As station personnel continued to broaden their approach to malaria ecology, they also became interested in forms of malaria that infected animals such as birds and lizards. The staff remained small and resources for such an endeavor were few, so in 1947 Goodwin reached out to Eugene Odum, a young zoologist at the University of Georgia, to begin wildlife studies at Ichauway. Odum had already used Ichauway's land base for small mammal and avian studies and was well familiar with the work of the field station. When he heard that the station would reopen during the war, Odum thought it perfectly positioned to become a pioneering field base for the interdisciplinary study of ecology. Writing to Herbert Stoddard in 1944, he noted that "the medical aspects of biology on the one hand and the practical agricultural and game management aspects [referring to Stoddard's work in the region] on the other hand are being well worked; in between there are unlimited vistas of 'pure science' research which ultimately may bring man and nature in better harmony." Odum's interest in harmony, or holism, in nature and society became well known a few years later with the publication of his groundbreaking textbook *Fundamentals of Ecology* (1953). In it, he first presented the influential model of ecosystems ecology, which argued that component parts of nature sought to reach "homeostasis," a state in which organisms functioned to stabilize whole systems. Humans were part of an ecosystem, according to Odum, but they also represented the primary threat to homeostasis and, thus, to their own health as well. Odum's ecosystem model was not yet fully formed when he joined the station, and he would continue to tweak it throughout his career. But the value of intact environments to human health was on his mind, and the opportunity to join a field station already working on ecological questions as they related to human well-being was surely a boon to his young career.[56]

Odum secured fellowships with the station for a succession of his graduate students. While primarily focused on wildlife ecology, these projects supplied critical information on the transmission of malaria parasites among animals. Avian malaria was of special interest. While humans cannot contract it, malaria in birds had a long history of aiding the study of human malaria. Earlier researchers—Ronald Ross, most famously—tracked bird malaria in the 1890s to reveal mosquitoes as the malaria vector, and birds continued to be valuable models for human malaria into the twentieth century.[57] Odum's first graduate student, Robert Norris, aided in this work with his field survey of summer-breeding birds on Ichauway. He introduced several common field methods of wildlife biology to the station, including nest monitoring, trapping, and banding, and also prepared a large collection of bird skins to aid in species identification. Lab technicians examined each collected bird—dead or alive—for blood parasites and extracted any plasmodia for parasitological study in the lab.[58]

[55] For the most complete iteration of this work see Hendricks and Goodwin, *Water-Level Fluctuations in Limestone Sinks in Southwestern Georgia* (cit. n. 52).

[56] Eugene Odum to Stoddard, 15 Sept. 1944, Box 51, Folder: Georgia Bird Checklist Correspondence, 1943–1945, Eugene Odum Papers, Hargrett Rare Book and Manuscript Library, University of Georgia Special Collections Libraries, Athens. On Odum's life and career see Betty Jean Craige, *Eugene Odum: Ecosystem Ecologist and Environmentalist* (Athens: Univ. Georgia Press, 2002); Golley, *History of the Ecosystem Concept of Ecology* (cit. n. 9); and Levi Van Sant, "Representing Nature, Reordering Society: Eugene Odum, Ecosystem Ecology, and Environmental Politics" (M.A. thesis, Univ. Georgia, 2009). On the scientific controversies surrounding ecosystem ecology see Hagen, *Entangled Bank* (cit. n. 9).

[57] See Leo B. Slater, *War and Disease: Biomedical Research on Malaria in the Twentieth Century* (New Brunswick, N.J.: Rutgers Univ. Press, 2009), esp. Ch. 2.

[58] Robert A. Norris, "Distribution and Populations of Summer Birds in Southwestern Georgia," *Georgia Ornithological Society Occasional Publications*, 1951, 3:1–67; and Gory J. Love, Sara Ann Wilkin, and Melvin H. Goodwin, "Incidence of Blood

Several additional studies of note came from Odum's connection to the station. Like Norris's study of summer-breeding birds, Milton Hopkins's life history study of mourning doves supplied blood specimens for the laboratory. It was also one of the first of its kind in the field, providing not only information on mourning dove ecology but also methods for surveying population numbers of this popular game bird for the Georgia Game and Fish Commission.[59] Goodwin embraced the station's role in such conservation work, at one point reporting that nesting conditions were "not conducive to the conservation of doves"— hardly the stuff of a typical malaria research station report. This was partly a nod to Robert Woodruff and his interest in game birds— dove hunts were among the more popular social activities at Ichauway during the fall of every year. But Goodwin's interest in such studies also stemmed from his general interest in conservation of all sorts, as well as his desire to see a broad range of research at the station. As he had reported a few years earlier, "The Field Station was established for the primary purpose of conducting observations on malaria under natural conditions," but "it is difficult to conceive of investigations in field biology not related in some way."[60]

In addition to avian malaria, Odum's students also studied other forms of malaria in wildlife. John Crenshaw, for instance, completed a life history of the southern fence lizard (*Sceloporus undulatus undulatus*) and in the process supplied specimens to Goodwin and developed the field methods for continued fieldwork on saurian malaria after he left. Crenshaw found that female southern fence lizards rarely ranged outside of a thirty-foot radius, so individuals were easily tagged and could be observed repeatedly. Goodwin seized on such access to identify cases of saurian malaria and follow the course of individual infections in the wild. He found a high prevalence of *P. floridense* in fence lizards—about 40 percent—with patent periods lasting anywhere from three to ten months.[61] As with the bird malarias, these results indicated that despite the disappearance of human malaria, various types of animal malarias persisted at endemic levels. There was no threat of saurian or avian malaria crossing over to humans, but given the ongoing interest in animals as a reservoir for human malaria and possibly responsible for its persistence in some regions today, the research at the field station represents an important marker for early scientific interest in the subject.[62] But more to the point here, this animal research was part of a broader effort at the station to understand the ecology of malaria, and that of the region, on a deeper level.

Given the disappearance of malaria, it comes as no surprise that the Emory Field Station shut down in 1958. But that outcome was never inevitable, and many at Emory and the CDC continued to argue for its relevance. The exact reasons for the shutdown, and who made the

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Parasites in Birds Collected in Southwestern Georgia," *Journal of Parasitology*, 1953, 39:52–57. Reports on the lab work on avian malaria can be found in the Quarterly Reports, Woodruff Papers, Box 85, Folder: EUFS, 1948–1955.

[59] Hopkins's research was funded by both the Emory Field Station and the Georgia Game and Fish Commission. See Milton N. Hopkins and Eugene P. Odum, "Some Aspects of the Population Ecology of Breeding Mourning Doves in Georgia," *Journal of Wildlife Management*, 1953, *17*:132–143; and Hopkins, "A Comparison of the Population Ecology of the Mourning Dove on the Coastal Plain and Piedmont of Georgia" (M.S. thesis, Univ. Georgia, 1951).

[60] "Emory University Field Station Quarterly Report—July, August, and September 1950," Woodruff Papers, Box 85, Folder: EUFS, 1948–1955; and "Report of Activities for Period September 1, 1945–August 31, 1946" (cit. n. 2), p. 8.

[61] John W. Crenshaw, "The Life History of the Southern Spiny Lizard, *Sceloporus undulatus undulatus* Latreille," *Amer. Midland Natur.*, 1955, *54*:257–298; and Melvin Goodwin, Jr., "Observations on the Natural Occurrence of *Plasmodium floridense*, Saurian Malaria Parasite, in *Sceloporus undulatus undulatus*," *J. Nat. Malaria Soc.*, 1951, *10*:57–67. Researchers are still unsure of saurian malaria vectors, though a species of the *Culex* mosquito is the most likely culprit for *P. floridense*. See Sam Roundtree Telford, Jr., *Hemoparasites of the Reptilia* (Boca Raton, Fla.: CRC, 2009), pp. 1–3.

[62] Cormier, *Ten-Thousand Year Fever* (cit. n. 16), pp. 7–20.

call, are still unclear. Besides Clarence Walker, several Woodruff advisors were bewildered by the seemingly esoteric studies carried out at Ichauway. Robert Mizell, for example, in answering a direct question from Woodruff—"Should the Research Program be Continued?"—could only respond, "The only answer I can give is that I don't know. I confess surprise that the work has stirred up so much interest and received so much commendation in USPH circles. I never could tell from my own observation whether anything worth-while was being done. I grant readily the value of the work done by the nurse, but the geologist, entomologist, and engineering angles kept me puzzled." Mizell also recognized his own limitations in judging the significance of the science, as did Woodruff. They both trusted what the experts had to say. In the same letter to Woodruff, Mizell concluded, "So far as I can get the evidence, however, something of value has been started. It seems clear that many scientists will come there if we get better facilities. If something of value has been done, the credit would seem to go to Goodwin." Three years later, Mizell continued to support the program, writing to Woodruff's associate, Joseph Jones, "My guess is that [the station] will continue to grow in usefulness, will attract more and more scientific attention, and will ultimately crystallize Mr. Woodruff's thinking about how Ichauway should be used when he is through with it. It will continue to be a problem to Mr. W[oodruff], to Dean Wood, to you, and me—but anything worth-while presses for attention and is a long problem."[63]

As it turned out, the station only pressed for attention for another ten years. It officially shut its doors in September 1958, though activity had begun to wind down a couple of years earlier. Woodruff began to cut his funding soon after Clarence Walker's appraisal in 1953, and the booming CDC had little interest in sustaining a program ostensibly devoted to an absent disease, no matter how impressive the science. In addition, Melvin Goodwin was always the station's strongest advocate, and after he finally received his Ph.D. in biology and parasitology from Emory in 1955 he became the chief of the CDC's Ecology Division, a wide-ranging position that added field stations in Taunton, Massachusetts, and San Juan, Puerto Rico, to his list of responsibilities. The Emory Field Station remained Goodwin's home base for two more years, but these additional duties often took him away and left him out of the loop on critical decisions. Once the CDC transferred Goodwin to lead their field station in Phoenix, Arizona, in October 1957, the end was near. What began with a great deal of fanfare in Baker County, then, ended with barely a mention.

CONCLUSION

The wholesale embrace of DDT in the decades after World War II prevented the field station's work from gaining wide attention in public health circles. Compared to the boldness of the malaria eradication program and the wonder of DDT, ecological research seemed to have an "invisible and indeterminable value" to many. Indeed, it was the CDC's narrow approach to eradication, not its broader field research, that caught on with other malaria-fighting organizations. The Rockefeller Foundation's International Health Division largely abandoned other control methods, as well as research, for the extensive use of DDT in its malaria programs after the war. And the World Health Organization (WHO) developed its Global Malaria Eradication Programme in 1955, an overly ambitious project that adopted the spraying of DDT as its only plan of attack—and this despite clear evidence that some

[63] Mizell to Woodruff, 8 Jan. 1945, Woodruff Papers, Box 187, Folder: Mizell, 1945–1946; and Mizell to Jones, 26 Oct. 1948, Woodruff Papers, Box 188, Folder: Mizell, 1948.

anopheline species had already developed resistance to DDT.[64] Eradication via DDT was the primary strategy for dealing with malaria for two decades after the war, until an international audience developed its own resistance to the chemical after Rachel Carson published *Silent Spring* in 1962. That landmark book was the culmination of growing concerns among scientists and laypersons about the harmful effects of chemicals on wildlife and the unknown consequences for humans. Carson's bestseller transformed public perception about DDT and other pesticides; what were once marvels of postwar science and technology were recognized by many as threats to human well-being. As a consequence, public health officials clashed with environmentalists and the use of DDT in public health campaigns gradually waned. The WHO eradication program ended in 1969—though more because of mosquito resistance and lack of funding and coordination than opposition to DDT—and the United States and most of Europe banned the use of DDT in 1972.[65]

The conflict that emerged between public health and environmentalism after *Silent Spring* had precedent in the interwar years. As I have shown, conservationists and wildlife biologists objected to the methods of sanitary engineers nearly as forcefully as a broader-based environmental movement would later object to chemicals; both objections drew on an ecological worldview that valued intact environments and worried about the consequences when humans interfered. As the work of the Emory Field Station demonstrates, these ecological ideas were not only in conflict with public health work; they also infiltrated it. The knowledge, methods, and ideas of biologists like William Vogt, Herbert Stoddard, Aldo Leopold, Eugene Odum, and others crossed with those of public health practitioners like Melvin Goodwin to form a hybrid science most accurately called disease ecology.

The point here is not to prioritize the ecological worldview that took hold at the Emory Field Station or to suggest that it was the only place where this type of work was happening. Instead, it is to use this case study to suggest ways that public health researchers resisted the course of global malaria policy in the twentieth century, from the prewar penchant for controlling land and water to the postwar preoccupation with spraying chemical insecticides. The experience at the Emory Field Station reveals that the course was never so clear. Diffuse influences, experiences, and places came to bear on disease scientists, leading them in unexpected directions. Even with the contemporary devotion to DDT and eradication, researchers at the Emory Field Station increasingly asked questions about the relationship of human health to environmental change. The CDC's eradication program was loosely organized, with plenty of leeway for agents like Melvin Goodwin to develop an alternative approach that was overshadowed by grander plans but never completely overlooked. In fact, a look at the CDC's field operations after the Emory Field Station's closure reveals a network of stations that retained a broad-based research model similar to that at Ichauway. Under Goodwin's leadership from Phoenix, the Ecology Division continued a multidisciplinary focus on the environmental aspects of disease in response to a number of outbreaks, including dysentery, hepatitis, encephalitis, and other diseases of environmental origin. Goodwin retired from the CDC in 1966 to become director of the Arizona Health Planning Authority, the

[64] Randall M. Packard, "'No Other Logical Choice': Global Malaria Eradication and the Politics of International Health in the Post-War Era," *Parassitologia*, 1998, *40*:217–229; Packard, *Making of a Tropical Disease* (cit. n. 17), Ch. 6; and Stapleton, "Technology and Malaria Control, 1930–1960" (cit. n. 47).

[65] On the global controversy over DDT after *Silent Spring* see Kinkela, *DDT and the American Century* (cit. n. 11). On the conflict between public health and environmentalists see also Mark Lytle, *The Gentle Subversive: Rachel Carson, "Silent Spring," and the Rise of the Environmental Movement* (Oxford: Oxford Univ. Press, 2007); and Malcolm Gladwell, "The Mosquito Killer," *New Yorker*, 2 July 2001.

same year the Ecology Division was folded into the Ecological Investigations Program. This much larger branch oversaw all of the CDC's field stations, and word from the top indicated that their work would explicitly study the relationship between human health and the environment. In a speech at the Fort Collins, Colorado, Field Station in 1967, CDC Chief David Sensor acknowledged the shortcomings of past policy and the promise of the Ecological Investigations Program when he said, "We are emerging from an era during which faith in 'magic drugs' and 'magic insecticides' blunted the critical senses of both scientists and laymen." The Fort Collins station was devoted to studying the ecology of encephalitis, another mosquito-borne disease that reached epidemic status several times in the mid-twentieth century. Despite Sensor's suggestion that global public health had been duped by a faith in silver bullets, he also recognized that a broader methodological framework existed within the CDC for studying and fighting environmentally based diseases.[66] Disease ecology, then, did not simply emerge fully formed in the late twentieth century in response to new diseases; it was part of a longer, if largely shrouded, legacy of ecological thinking among disease researchers. At the Emory Field Station, it surfaced as part of a resistance to environmental transformation in the name of malaria control and continued as an ancillary but insistent focus of disease researchers until changing global circumstances forced it back to the forefront.[67]

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[66] Sensor is quoted in Etheridge, *Sentinel for Health* (cit. n. 42), p. 156. On the reorganization and shift in research focus at the CDC see *ibid.*, pp. 128–129, 150–157.

[67] One of the interesting complements to this story is that after decades of relative dormancy as a space for scientific research, Ichauway became home in 1991 to the Joseph W. Jones Ecological Research Center, an independent station funded by the Robert W. Woodruff Foundation that has recently turned its attention to the sort of work Goodwin and company sought to do long ago. For background on the Jones Center see Boring, "Joseph W. Jones Ecological Research Center" (cit. n. 14). Some recent work by Jones Center scientists in disease ecology includes L. K. Kirkman, E. A. Whitehead, S. W. Golladay, L. L. Smith, and S. P. Opsahl, "A Research Framework for Identifying Potential Linkages between Isolated Wetlands and Disease Ecology," *Ecological Research*, 2011, 26:875–883; and Eva A. Buckner, Mark S. Blackmore, Golladay, and Alan P. Covich, "Weather and Landscape Factors Associated with Adult Mosquito Abundance in Southwestern Georgia, U.S.A." *Journal of Vector Ecology*, 2011, 36:269–278.