11
LABORATORIES AND FIELD EXPERIENCES

Michael J. Lannoo

The origins of field biology lie simply in observing nature in nature, an activity that historically encompassed everything from taking detailed notes on backyard song sparrows to the well-funded and meticulously organized nineteenth-century United States’ expeditions to survey railroad routes, national boundaries, and the sea.1 Over time, the tasks of field biologists have multiplied and the work increasingly applied as these scientists found themselves involved in more and more diverse and important activities, such as ecosystem management, creating wildlife corridors, radio-tracking the migrations of endangered species, and translocating large predators to reestablish ecosystem integrity. The knowledge accumulated by field biologists also underpinned America’s public lands initiatives (i.e., National Parks [what Wallace Stegner called “America’s best idea”2], National Forests and Grasslands, National Wildlife Refuges, and Wilderness Areas), as well as legislation designed to protect environmental integrity (including the Endangered Species Act and the Clean Air and Water Acts).3

Natural History

In North America, formalized field biology began with the pioneer natural historians of the nineteenth century, a period initiated by Lewis and Clark’s voyage of discovery.4 Natural historians were typically the first to discover and describe plant and animal species, or, in modern terminology, assess biodiversity. At that time, Alexander von Humboldt was the world’s most influential scientist.5 (His last book, *Cosmos,*6 may have been the inspiration for the name of the Washington, DC, scientists’ club founded by the explorer John Wesley Powell and his colleagues.)7 Alexander von Humboldt was a friend of Thomas Jefferson’s and visited him during the summer of 1804.8 Much of their correspondence dealt with the location of the then vague Spanish-American border,9 but both men were interested in natural history,10 and von Humboldt generously shared with Jefferson his data on barometric surveys of the Andes and the formal reports of his explorations.11

There was a political urgency to the first American explorations. By 1780, the explorer Peter Pond had pushed beyond the range of the existing fur trade around the Great Lakes Basin and into the Athabasca Basin of present-day Saskatchewan and Alberta “to explore a country hitherto unknown but from an Indian report.”12 Pond was confident that he had gotten near the Pacific Ocean, and in 1789, his colleague Alexander Mackenzie set out to prove it. On 3 June, Mackenzie left Lake Athabasca and, traveling down the river that now bears his name, arrived not at the Pacific but at the Arctic Ocean. Realizing his mistake, three years later Mackenzie corrected it, after he discovered a route to the Pacific Ocean through the Canadian Rockies and down the Frazier River. He
reached the Pacific on 17 July 1793, thus becoming the first European to cross the North American continent north of Mexico.

In 1801, Mackenzie published, and Jefferson read, the journals from his two expeditions. Shortly after, Jefferson purchased the vast Louisiana Territory from France. As Evans wrote, “The Louisiana Purchase . . . approximately doubled the size of the United States, adding 800,000 square miles of ignorance—land that had never been well explored or adequately mapped.”13 Fully understanding this, Jefferson gave the following instructions to Captains Meriwether Lewis and William Clark:

The object of your mission is to explore the Missouri river, & such principle stream of it, as, by its course & communication with the waters of the Pacific Ocean, may offer the most direct & practicable water communication across this continent, for the purposes of commerce.14

A year later, Lewis and Clark embarked from St. Louis on their voyage of discovery. Although Lewis and Clark’s biological specimens were never adequately studied,15 their tally of newly discovered species ran to 178 plants and 122 animals.16 Today, only one of their prepared animal specimens, a Lewis’s woodpecker (Melanerpes lewis), survives intact, at Harvard’s Museum of Comparative Zoology.17

The federal government sponsored other explorations concurrent with, but not as well-known as Lewis and Clark’s. In 1804, William Dunbar and his naturalist George Hunter traveled up the Ouachita River, a tributary of the lower Red River, at that time the legal boundary between American and Spanish lands. There, Dunbar and Hunter discovered the Hot Springs area of central Arkansas. In April 1806, Thomas Freeman and the naturalist Peter Custis conducted a second Red River expedition. They traveled upriver 615 miles before being forced by Indigenous tribes to turn back. These two Red River surveys were the first to deploy civilian scientists (Hunter and Custis). In addition, in 1806, governor of the Louisiana Territory, General James Wilkinson, ordered Zebulon Pike on a third survey of the Red River, this time to discover its source. By Pike’s own admission, he was untrained and lacked the “time and placity of mind” required to study the plants and animals he encountered. Pike’s report, published in 1810, was considered “poorly organized, unreliable . . . scientifically and geographically incorrect, and in many places dishonest.”18

A decade and a half after Lewis and Clark’s return, U.S. Army engineer Stephen H. Long led a government-sponsored expedition up the Missouri River, this time from St. Louis to the Platte River, then west to the Colorado Front Range.19 Long Expedition personnel included the botanist Edwin James and the zoologist Thomas Say and therefore was the first Western survey to include trained naturalists. James and Say became the first scientists to provide formal descriptions and Latinized names of the plants and animals of the American High Plains.20 The artists Titian Peale and Samuel Seymour were also on the survey and drew what they encountered.21

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<th>Table 11.1</th>
<th>Tasks of Field Biologists</th>
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<td>The tasks performed by American field biologists and their approximate dates of origin fall out as follows:</td>
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<td>What species are out there? (= Natural History [= Biodiversity]): 1803;</td>
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<td>How do species change over time? (= Evolutionary Biology): 1859;</td>
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<td>How do different species fit together to form relationships? (= Ecology/Animal Behavior [Ethology]): 1875/1935;</td>
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<td>How can we save the species we desire? (= Wildlife Biology): 1889;</td>
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<td>How can we save all species? (= Conservation Biology): 1900;</td>
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<tr>
<td>How can we bring back the species (or species functions) we could not originally save? (= Restoration Biology): 1935.</td>
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report, released in 1823, included illustrations by Peale and Seymour, which meant curious Easterners could see for the first time images of the Great Plains and the Rockies, along with renderings of native indigenous North Americans and depictions of their lifestyle.22

The federal government also sponsored a sea-based expedition. On 18 August 1838, the United States South Sea Exploring Expedition (U.S. Ex. Ex.) set sail under the command of Lieutenant Charles Wilkes. The expedition’s scientists, called “clam diggers” or “bug catchers” by Wilkes’ sailors, explored about 280 islands, mostly in the Pacific, and mapped 800 miles of the Pacific Northwest coast. They collected over 60,000 plant and bird specimens, which would form the foundation of the holdings of the Smithsonian Institution, established in 1846.23

A few years after the Wilkes Expedition returned, the federal government sponsored surveys of both the northern and southern national boundaries, as well as potential routes for transcontinental railroads. These surveys were thorough; teams included geologists, botanists, zoologists, and ethnographers. The Border Surveys resulted in fixing the United States’ northern boundary with Britain (in 1846) and the southern boundary with Spain (in 1848).24 The Pacific Railroad Surveys, conducted from 1853 to 1855, consisted of four east–west surveys: the Northern Pacific Survey along the 47th parallel from St. Paul to Puget Sound; the Central Pacific survey between the 37th and 39th parallel from St. Louis to San Francisco; and two Southern Pacific surveys, the Whipple Survey from Oklahoma to Los Angeles, and a more southern route from Texas to San Diego. A fifth survey ran north–south along the Pacific Coast from San Diego to Seattle. As with the Border Surveys, each team consisted of surveyors, scientists, and artists and resulted in an immense body of data covering at least 400,000 square miles (1,000,000 km²) of the United States west of the Mississippi River—essentially the Louisiana Purchase, the Spanish lands north of the Rio Grande, and the Pacific Coast. Findings were published between 1855 and 1860 in separate volumes, one per survey, by the United States War Department and contained extensive data on the natural history of the West as well as physical and cultural descriptions of the remaining Indigenous peoples. As with the Wilkes Expedition, animal specimens collected during these surveys were deposited in the Smithsonian Institution; many were described by the brilliant zoologist Spencer Fullerton Baird.25 Baird was a meticulous and exacting scientist, and these reports demonstrate his unprecedented understanding of the North American fauna.26

Many of the plants from these early surveys were sent to John Torrey, at what is now Columbia University, for formal description. Torrey received Evans’ plants collected on the 1819–1820 Long Expedition, as well as the plants from the 1820 Cass Expedition to the Upper Mississippi River basin. Torrey also received the plants from the U.S. Topographical Surveys, including the Border and Railroad Surveys mentioned previously. He was overwhelmed and enlisted Harvard’s Asa Gray to help him describe and classify this material.

Gray had been offered the first permanent paid professorship in the history of the University of Michigan, which also happened to be the first United States university position dedicated solely to botany. When the University of Michigan sent Gray to Europe, he saw it as an opportunity to visit the North American plant collections in England and on the continent. Strangely, upon Gray’s return to the United States in November 1839, his familiarity with the specimens housed in European herbaria made him the authority on the fauna of North America. In April 1840, the University of Michigan’s financial difficulties resulted in the suspension of Gray’s salary. Two years later, still unpaid, Gray resigned his Michigan appointment to accept Harvard’s Fisher Professorship of Natural History, where his duties were to oversee the botanical garden, curate the herbarium, and teach botany. Gray’s passion became building the Harvard Herbarium, which was established in 1842. After Torrey and Gray published their results, the regional flora of the West was considered generally known.27 Biogeography never much interested Torrey, so Gray became “the first botanist ever to gain a simultaneous and accurate knowledge of the general outlines of the vegetation of North America.”28
The Army Corps of Topographical Engineers, begun in 1838 and led by uncommonly competent fieldmen such as Stephen Long and Joseph Nicollet, had been disbanded as a unit during the Civil War and merged with the United States Army Corps of Engineers. Following the Civil War, the U.S. Army sponsored four more western surveys. Beginning in 1867, Ferdinand Hayden led the Rocky Mountain Survey, and Clarence King led the 40th Parallel Survey. Lieutenant George M. Wheeler, a former topographical engineer, led the survey west of the 100th meridian. Three years after King’s survey was completed in 1872, Major John Wesley Powell led the Second Division of the Rocky Mountain Survey to the Uinta Mountains. The specimens collected by these expeditions were also deposited in the Smithsonian. The Army’s role in Western exploration came to an end when the U.S. Geological Survey was formally established in 1878.29

In 1885, one of the members of Hayden’s 1872 expedition, C. Hart Merriam, became the director of the federal Division of Economic Ornithology, which would eventually become the Bureau of the Biological Survey. As a teenager, Hart Merriam impressed the Smithsonian’s Baird. Merriam had always shown a great interest in animals. Teenaged Merriam learned the basic tissue preservation skills of taxidermy and became proficient.30 Not long after, his father, a U.S. congressman, took him to DC to meet Baird. Baird was stunned; most of young Merriam’s specimens were professional grade.

The next spring, Baird invited Merriam, then only 16 years old, to accompany the Second Division of the Hayden Survey to Wyoming, Utah, Idaho, and Montana, with a primary focus on exploring the newly established Yellowstone National Park. Merriam’s Report on the Mammals and Birds of the Expedition listed 33 species of mammals, 313 birds, and 67 nests collected,31 and appeared in 1873 as part of Hayden’s Sixth Annual Report.32

At Baird’s invitation, Merriam spent the summer of 1875 as a seasonal employee of the U.S. Fish Commission at Woods Hole.33 Baird then secured Merriam a post as surgeon on the Proteus in order to collect seal specimens for the Smithsonian. Baird asked Merriam to sketch the animals in life, in order for the National Museum’s taxidermists, guided by William Temple Hornaday, to reproduce the seals’ postures and behaviors in realistic mounts.34

In early 1884, Merriam oversaw the first national bird count as the American Ornithologist’s Union’s chairman of the committee on migration.35 Merriam wrote to his cousin, New York senator Warner Miller, about receiving a federal appropriation for his committee’s work. In response, in January 1885, the House passed a bill to begin work on economic ornithology within the Bureau of Entomology, which was formed within the Department of Agriculture in response to an 1874 infestation of locusts.36 Also in 1885, Henry Wetherbee Henshaw nominated Merriam to be the head of the Division of Economic Ornithology within the Department of Agriculture. Baird seconded the motion, it was approved unanimously, and shortly after, Merriam terminated his profitable but increasingly part-time medical practice and entered government service.37

In 1886, Merriam’s political connections again served him well as Congress doubled his funding and expanded his responsibilities to include economic mammalogy, and with that, in spirit if not exactly in name, the Biological Survey was born (the Bureau of Biological Survey officially began on 3 March 1905, the day of Teddy Roosevelt’s inauguration38). Merriam used his position to assemble a team of rugged and talented naturalists who continued to survey the West. The legendary Merriam field method consisted of sending field parties out to collect mammals and other vertebrates in the region of interest. Skins and skulls were taken from mammals, birds were stuffed, and reptiles and amphibians were fixed and stored in alcohol. Representative plants were also collected, photographs of the habitats were taken, and a scientific report of the region was assembled. When survey staff members were unfamiliar with the organisms or a region, they consulted outside authorities. Most of the division’s fieldwork was accomplished by men working alone. In 1940, the Biological Survey was combined with the Bureau of Fisheries to form the U.S. Fish and Wildlife Service.
Evolutionary Biology

Field biologists who then studied this newly discovered biodiversity in order to understand the relationships among organisms became evolutionary biologists. Asa Gray was the first major American scientist to embrace evolution, while his larger-than-life Harvard colleague, Louis Agassiz, did not.\(^\text{39}\) The idea of evolution through natural selection was conceived independently by Charles Darwin and Alfred Russell Wallace during (in Wallace’s case) or after (in Darwin’s) extensive explorations in the New World, and there can be no doubt that evolutionary biology has its roots in field biology.\(^\text{40}\)

America’s first major contribution to Darwin and Wallace’s evolutionary theory came from Othniel Marsh, who, upon accepting his appointment at Yale, became the first professor of paleontology in the United States. Marsh’s impact on evolutionary theory came from his fossils of ancestral horses, excavated in the American West. The original sequence of species then thought to have evolved into the horse—from the ancient *Eohippus* to the modern *Equus*—was excavated and described by Marsh and subsequently popularized by “Darwin’s bulldog,” Thomas Henry Huxley. Even though equine evolution is now understood to be much more “bushy” than Marsh’s original fossil lineage suggested, Marsh’s fossils produced the best supportive physical evidence at the critical time when Darwin and Wallace’s theory was struggling to become established.

Ecology and Animal Behavior

Field biologists who work as ecologists and animal behavioralists (ethologists) ask questions about the relationships of species to each other and to their environment—how they interact. America’s first ecologist was the Illinoisan Stephen Forbes. With his bird and fish food habits studies and his crop pest work, Forbes, more than anyone else at the time, examined interactions among species while pursuing questions in both basic and applied science. In the wake of Forbes, “ecology became self-conscious,”\(^\text{41}\) and the four, great early ecological “schools” defined by Frank Egerton—the Nebraska school of plant ecology, the Chicago school of plant ecology, the Chicago school of animal ecology, and the Wisconsin school of limnology—were instituted and matured.\(^\text{42}\) It was no accident that they flourished in the Midwest. The science of ecology was developing just as land-grant universities were forming, and these new schools adopted this novel discipline. The University of Chicago also embraced ecology; the botanist John Coulter (who had been on the 1872 Hayden Expedition with Merriam) was determined to make this new science a featured component of the university’s East Coast–provoking curriculum.

At the University of Wisconsin, Edward Birge and Chauncey Juday developed their Limnological School in parallel with the terrestrial plant and animal ecological schools. Their science was all about data and interpretation; they set the bar and had no peers.

The relationships among the faculty across these schools were complicated. There was a certain amount of antagonism—Chicago’s plant ecologist Henry Cowles had no patience for Nebraska’s plant ecologist Frederic Clements’ hardline views of succession. But there was also a great deal of cooperation—the Chicago animal ecologist Victor Shelford collaborated with Clements to write the classic book *Bio-Ecology*, which contains a staggering number of ecological facts; read it and you will be stunned by what these early ecologists knew.

*Bio-Ecology*—the collaboration between Chicago’s Shelford and Nebraska’s Clements—signaled both the climax and the end of the run for these great ecological schools. While the early ecologists emphasized ecology as organisms having interactions, with the natural history emphasis on organisms, in his sharp criticism of *Bio-Ecology* in 1940,\(^\text{15}\) G. Evelyn Hutchinson defined ecology as interactions (such as energy flow and nutrient cycling) having organisms, with the heaviest emphasis on interactions (so-called “modern ecology”). Both sides, of course, are correct, but it would take the
environmental movement several decades later, with its focus on endangered and threatened species, to counter Hutchison’s perspective and bring respect back to field-based ecology.

The discipline of animal behavior, or ethology, was, like ecology, a European invention, developed by the Austrians Konrad Lorenz and Karl von Frisch and the Dutchman Niko Tinbergen. In North America, Margaret Morse Nice discovered territoriality in songbirds and became its first superstar. Her painstakingly patient and persistent studies of individually marked birds as they set about establishing and defending territories and tending to nests set the bar for the field.

Ecology and ethology, as they were practiced in the Midwest land-grants and at Cornell University (the only Ivy land-grant), had one great consequence and one great spin-off. The consequence was that ecology and animal behavior offered unprecedented opportunities for women to become scientists. In her review of women ecologists,44 Langenheim lists 11 women who received their degrees in ecology between 1902 and 1932; eight of them came from Midwestern universities—Chicago (3), U. Nebraska, U. Minnesota, U. Illinois (2), and U. Cincinnati; the only Ivy represented is Cornell. Harvard and Yale did not graduate a woman ecologist until the mid-1950s. Not only was there quantity, there was quality; no woman ecologist working on the East Coast or in Europe had the scientific chops of Lucy Braun, who received her PhD from the University of Cincinnati in 1914.

The spin-off from the development of ecology and animal behavior was the formation of field stations. Field stations originated because faculty realized they could not authentically teach the biology of sea life from a classroom, hundreds of miles from the ocean.45 Consequently, the first field stations were marine, situated on coasts. In the 1830s a handful of Swedish naturalists established an extemporized summer station. A decade later, Professor P.-J. Van Beneden founded what may have been the world’s first true biological station, in Ostend, Belgium, in 1843. In 1859, the College of France at Concarneau established the Laboratory of Marine Zoology and Physiology on the coast of Brittany. Fourteen years later, Harvard’s Louis Agassiz created the first field station in North America, the Anderson School of Natural History, on Penikese Island, off the coast of Massachusetts. At about the same time, Dr. Anton Dohrn founded the prestigious Zoological Station of Naples.

The biological station idea eventually expanded beyond coastal regions to embrace all habitats, particularly areas of floral or faunal specialization, or regions where biodiversity is high. By 1880, 16 biological stations had been established in Europe and the United States. By 1888, both the Marine Biological Laboratory at Woods Hole, Massachusetts, and the Laboratory of the Marine Biological Association at Plymouth, England, were in operation. Between 1920 and 1930 alone, 70 new field stations were established.

Initial enthusiasm aside, field stations often failed. Prior to the Second World War, roughly 90 stations, about one quarter of all existing stations, had closed. The most common causes were the death of its major proponent (e.g., Louis Agassiz’s death ended the Anderson School on Penikese Island), disasters (e.g., fire at the Cornell University Biological Station, the wreck of the French research vessel Pourquoi Pas? off the coast of Iceland), war (e.g., Royal Hungarian Marine Biological Station), budget cuts (e.g., the Biological Station of the United States Bureau of Fisheries at Woods Hole), and disagreements over control (e.g., Mountain Laboratory of the University of Utah). During the Second World War, field stations also struggled. Young men and women who would have otherwise populated courses and research positions were overseas or in factories, and wartime academic budgets were bare-bones.

Postwar participation in biological field stations ebbed and flowed. The surge in students supported by the G. I. Bill saw interest initially swell, then, in the mid-1950s, the first flush of enthusiasm for the new field of molecular biology drained interest in organismal biology, including field stations. A new enthusiasm emerged in 1962, following the publication of Rachel Carson’s Silent Spring and the birthing of the environmental movement. Field station enrollments again waned in the 1970s and have generally held steady ever since.
As is true in many social and cultural settings, once field biology was down, there was a tendency to pile on. In the early twentieth century, the nuclear physicist Ernest Rutherford purportedly said, “All science is either physics or stamp collecting.” Admittedly, one serious drawback to field biology as a science is its contingent nature. Robert Kohler notes that if you run a laboratory benchtop experiment anywhere in the world, as long as all the variables are controlled, the results obtained should be identical; therefore, laboratory benchtops become the place where ideas can be tested and retested and variables manipulated to determine effect. This is not true with field biology. Most natural historians conducting long-term research studies will tell you that no two years are identical—that some years remind them of others, but the fine details differ. Mark Twain is credited with saying, “History doesn’t repeat itself, but it does rhyme.”

While ecology developed and prospered in the Midwest and offered women unprecedented opportunities to become professional academics, it never really took the time to contemplate itself as a scientific discipline. Its early natural history phase was succinctly encapsulated in Clements and Shelford’s (1939) *Bio-Ecology*. But G. Evelyn Hutchinson’s criticism of *Bio-Ecology* produced a reorientation of ecology toward phenomena such as energy flow and nutrient cycling (so-called “modern ecology”). There were several unintended consequences to this shift away from studying organisms in their own right. Eric Engles notes that after adopting Hutchinson’s philosophy, ecology drifted toward specialization, abstraction, theoretical modeling, and reductionism, making it a subject impossible for the common man to understand (and easy to criticize). As a result, professional ecology became diminished in its ability to influence public policy and, therefore, society at large. Steven Herman has also criticized this situation, “I think the thing [Aldo Leopold] would most lament is the decline of the role of natural history.” And elaborates, “I find considerable evidence that [ecology] has broken partially free of its roots and is showing signs of malnourishment.” Among its problems include “addiction to technology [and a] lust for statistics.” Herman explains that ecology “started as applied natural history, and most of its star practitioners were broad-based naturalists, intimate with the landscapes and organisms in their charge. There are reasons to believe that [we] would do well to re-graft itself to those natural history roots.” My favorite one-liner on this subject comes not from science but literature. When asked why he had never accepted any of the cushy academic jobs he had been offered, the legendary writer Jim Harrison quipped, “Somebody’s got to stay outside.”

The root cause of the discrepancy between fieldwork and mathematical interpretations comes from how we currently reward science, where professional advance is more likely to derive from being indoors generating models rather than outdoors gathering facts. This, despite the clear distinction between the quality of the information being generated. While Richard Fortey emphasizes that “facts are truths that endure,” the modeler George Box unabashedly notes that “all models are lies; some of them are useful.” Accepting these two statements, we are forced to conclude modern science places more stock in the world of transient lies than in the world of enduring truths. Nevertheless, models are the way of the modern world, and if we want our models about the fate of biodiversity to be accurate, they must incorporate as much field data as possible. The only way to obtain these data is to go outside and collect them; until we do, our models will be something less than useful lies. It is curious that in all this, as Hutchinson’s review intimates, ecology as a discipline did not view itself, at least historically, as big enough to simultaneously accommodate both organismal (field based, bottom up, organisms having relationships) and theoretical (model based, top down, relationships having organisms) perspectives.

Biologists who became interested in ecology because they liked working outdoors with living organisms began populating disciplines such as wildlife biology, conservation biology, and restoration biology, where ecological techniques could be applied in the field. These biologists took to heart Paul Dayton’s comment:

“Natural history is the foundation of ecology and evolution science. There is no ecology, no understanding of the function of ecosystems and communities, no restoration, or
in fact, little useful environmental science without an understanding of the basic relationships between species and their environment, which is to be discovered in natural history.\textsuperscript{55}

There is a second, perhaps more basic, reason why field biologists choose fieldwork over model building and the professional rewards it offers—it’s more fun. E. O. Wilson observed that field biologists have a lot more “gee whiz” or “sense of wonder” than other kinds of scientists.\textsuperscript{56} Field biologists like to, in Edward Abbey’s (no date) words, “ramble out yonder and explore the forests, climb the mountains, bag the peaks, run the rivers, [and] breathe deep of that yet sweet and lucid air.”\textsuperscript{57} Clearly field biologists enjoy themselves; hang around them and listen to the ease and character of their laughter\textsuperscript{58}—the epitome of the notion that in wilderness lays human wellness. These are folks, as Abbey advocated, who have kept their brains in their heads and their heads firmly attached to their bodies, bodies obviously attuned and active. Joseph Campbell summed up this approach to life in a one-liner from his masterwork, \textit{The Power of Myth}: “What we’re all really seeking . . . is an experience where we can feel the rapture of being alive.”\textsuperscript{59}

Campbell’s West Coast friends Ed Ricketts and John Steinbeck were referring to this “aliveness” when they wrote in their collaboration, \textit{Sea of Cortez}:

\begin{quote}
We sat on a crate of oranges and thought what good men most biologists are, the tenors of the scientific world—temperamental, moody, lecherous, loud laughing, and healthy. . . . Your true biologist will sing you a song as loud and as off-key as will a blacksmith, for he knows that morals are too often diagnostic of prostatitis and stomach ulcers. Sometimes he may proliferate a little too much in all directions, but he is as easy to kill as any other organism, and meanwhile he is very good company, and at least he does not confuse a low hormone productivity with moral ethics.”\textsuperscript{60}
\end{quote}

There is power here, and a field biologist is the type of person many people want to be.

As disciplines, wildlife, conservation, and restoration biology share two distinctive features. First, they are hands-on—their goal is to produce tangible results measurable in the field; no one can do any actual conservation or restoration activity sitting at a desk. Second, each discipline contains subjective elements—features that are generally considered to be outside the domain of science. For example, wildlife biology began because biologists asked how they could save the parts of nature society found useful. Useful taxa included game species—birds, mammals, and fishes—as opposed to nongame backyard birds, field mice, and minnows. With this distinction, wildlife biologists made a subjective decision about which species were valuable and which were not, a classification of worth no pure scientist would attempt. Yet wildlife biology has thrived as a science and provided key scientific insights, especially in ecological areas such as population biology.

\textbf{Wildlife Biology}

The nineteenth century work of the Bronx Zoo’s William Temple Hornaday on bison conservation was at the forefront of early wildlife biology, although the University of Wisconsin’s Aldo Leopold can rightfully be said to have formalized the discipline with his 1933 book, \textit{Game Management}.\textsuperscript{61} Wildlife biology got its biggest boost from Jay Norwood (“Ding”) Darling, who is famous as the two-time Pulitzer Prize–winning cartoonist for the \textit{Des Moines Register}, but better known among field biologists as the Father of the Duck Stamp.

As a boy, Darling explored the Loess Hills region of Iowa and, across the Big Sioux River, the prairies and bottomlands of southeastern South Dakota. At first, he experienced clear streams filled
with fish, migratory waterfowl, and songbirds. Later, he noted the farm was dying; where there had once been deep topsoil that produced 60 bushels of wheat an acre, the soil was eroded and unproductive. “This was my first conscious realization of what could happen to land, what could happen to clear running streams, what could happen to bird life and human life when the common laws of Mother Nature were disregarded.” Darling was a “witness to waste,” and he carried the memories with him for the rest of his life.

As his biographer detailed,

Darling . . . turned his avocation as an outdoorsman to the serious business of conservation of precious natural resources. . . . [He had been] distressed at the interference of politics in the life-and-death business of conserving limited resources. Officials in charge of saving irreplaceable water, air, and land were hog-tied. Because of short-term political considerations, they could not institute what seemed to be only moderate and sensible programs for the long-term maintenance of America’s natural bounty. Darling’s love of nature and his distrust of politicians combined to create a fiery desire to see the politician’s hands removed from the natural resources cookie jar.

Darling realized that the roots of most wildlife issues could be found in society’s priorities and fought to realign them. In 1931, he convinced the Iowa General Assembly to establish a nonpolitical state Fish and Game Commission but soon realized the state did not have enough scientifically trained personnel to staff a Department of Natural Resources. Darling proposed that Iowa State College participate in a cooperative program to conduct research in conservation and train wildlife biologists. It was accepted, and Paul Errington, a disciple of Aldo Leopold, became the leader of the nation’s first Cooperative Wildlife Research Unit.

In 1934, Darling was appointed to the so-called Beck Committee “to devise a [national] wildlife program that would dovetail with [FDR’s] submarginal land elimination program.” The committee consisted of Darling, the chair; Thomas Beck, editor of Collier’s Magazine; and Aldo Leopold. As Darling would later describe,

Out of that committee came the first enunciation of the essential program of restoring ducks’ nesting grounds, it being recognized that the drainage program in the duck nesting areas had reduced the nesting areas to a very small percent of their former acreages. On the basis of that conclusion, we solicited advice from every state conservation officer or commission in the whole United States as to areas which might be subject to restoration, and laid out quite a program of possibilities. It was a hasty job and we knew at the time that much of the ground which we recommended for restoration was in agricultural production and probably too high priced for restoration to marshes and lakes.

The creation of a “Duck Stamp” became the solution to this funding problem, and Darling provided the artwork for the initial offering, issued for the 1934–1935 waterfowl season. At about the same time, Darling became the head of the federal Bureau of the Biological Survey, the agency Hart Merriam had founded. Darling quickly recognized the need for professionally trained field biologists nationwide and proposed creating wildlife units similar to the one he had created at Iowa State, at nine additional land-grant colleges. To fund the effort, he organized a national wildlife conference dinner and invited members of the sporting arms industry. Out of this meeting came several important initiatives, including the federal Cooperative Wildlife Research Unit Program, the National Wildlife Federation, the American Wildlife Institute, and the North American Wildlife Conference. It was, perhaps, the most productive three hours in the history of wildlife conservation.
Conservation Biology

Once the idea of preserving species arose, field biologists began asking how they could save all components of nature, not just the species or ecosystems useful to man. This idea spawned the field of conservation biology. As a formal discipline, conservation biology arose in fits and starts, then gained traction around 1900, when an influential portion of American society, represented best, although not exclusively, by Teddy Roosevelt’s Progressive Party, became disturbed by the expansive clear-cutting of the nation’s forests, the extinction of the impossibly abundant passenger pigeon, and the appalling slaughter of wading birds for the plume trade. As with its predecessor, wildlife biology, conservation biology has subjective components and contains elements of both preservation (as promoted by John Muir) and wise-use conservation (as promoted by Gifford Pinchot). Again, Aldo Leopold offered a fundamental contribution. With his land ethic—“A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.”—Leopold blended ecology (“integrity”), the growing science of conservation (“stability”), and the romanticism of American transcendentalists (“beauty”), to provide conservation biology’s philosophical underpinnings.

The scope of conservation biology’s concerns can be gleaned from subjects covered in its first textbook, now twice revised. These include biodiversity, latitudinal gradients in species richness, diversity over time, the effects of disturbance on species richness, and the value of species richness. This text also covers threats to biodiversity, which involve habitat loss, habitat fragmentation, and degeneration in overall quality; overexploitation of species and resources; invasive species impacts; climate change impacts; restricted gene pools from diminished population sizes; and genetic pollution from hybridization.

Restoration Biology

Lastly, field biologists in North America have been reconstituting important ecosystems. That is, when habitats could not be conserved, restoration biologists set out to bring them back. The origins of American restoration biology lay in the late nineteenth-century forestry practice of replanting trees in clear-cuts and include Hornaday’s efforts to captive-breed and release bison. But organized restoration biology formally began in the mid-1930s, again in the Midwest, when Norman Fassett constructed Curtis Prairie on the University of Wisconsin campus. From there, the idea of ecological restoration spread 50 or so miles north, to Aldo Leopold’s Shack near Baraboo, and from its Shack hub, the idea radiated globally.

In practice, the distinctions between these applied ecological disciplines are not as clean or clear-cut as I make them out to be. Across disciplines, wildlife biology texts include sections on conservation and restoration biology, conservation biology texts often include multiple chapters on restoration, and restoration biology texts lean heavily on techniques used in conservation biology. Within disciplines, each has its own existential issues similar to those experienced by ecology in the middle of the twentieth century. For example, wildlife biologists struggle with how to define wildlife and thus delimit their domain (while most wildlife biologists do not study frogs, aren’t frogs wildlife?). Conservation biology also struggles with the scope of its interests (should conservation biologists treat all species equally with the goal of keeping common species common, or emphasize only species that are threatened and endangered?). Restoration biology wrestles with whether or not to include industrial and forestry reclamations under the umbrella of its interests. Nevertheless, each of these applied disciplines is essential if we are to maintain the level of ecosystem integrity necessary to sustain a livable planet.
The tangible evidence of the work of American field biologists lies in the acquisition and management of land—including national parks, forests, and wildlife refuges, as well as wilderness areas (Figure 11.1)—and environmental legislation, including the Endangered Species Act and the Clean Air and Water Acts (Figure 11.2), that Wallace Stegner broadly called “America’s best idea[s].”71
Laboratories and Field Experiences

Conclusion

Aldo Leopold has famously said, “To keep every cog and wheel is the first precaution of intelligent tinkering.” But we are not just losing the cogs and wheels, we are losing the knowledge necessary to identify them and put them back together again. We risk becoming “all the King’s horses and all the King’s men” to a world of Humpy Dumptys. The larger purpose of field biology has always been to know and understand nature’s cogs and wheels.

Despite its reputation for being unreproducible, the work of field biologists has had a crucial place in American science. The scientific method, at least as it was taught to me in sixth grade, consists of observations, hypothesis formation, and hypothesis testing, which is accomplished by collecting more data (facts). Hypotheses can never be proven correct, but if their results hold after repeated attempts to refute, they become, if not established truths, then at least workable templates. The work of field biologists fits into the scientific method at its most basic level—creating observations—and as such, it is our sole source for obtaining facts, making it indispensable to every branch of science dedicated to the understanding and persistence of life on planet Earth.

Notes

1 Lannoo (2018).
3 The longer argument for many of the points I make here is presented in Lannoo (2018).
4 For an excellent description of the explorers and explorations prior to Lewis and Clark’s voyage of discovery, see Bakeless (1950); Savage (1979).
5 Egerton (2012).
6 von Humboldt (1858).
References


von Humboldt, A. 1858. *Cosmos: A Sketch or a Physical Description of the Universe*. The version I used was translated by E.C. Otte and is a facsimile copy purchased on Amazon.com, with no information about the publisher provided.