Part 5

Science at Engineer Cantonment

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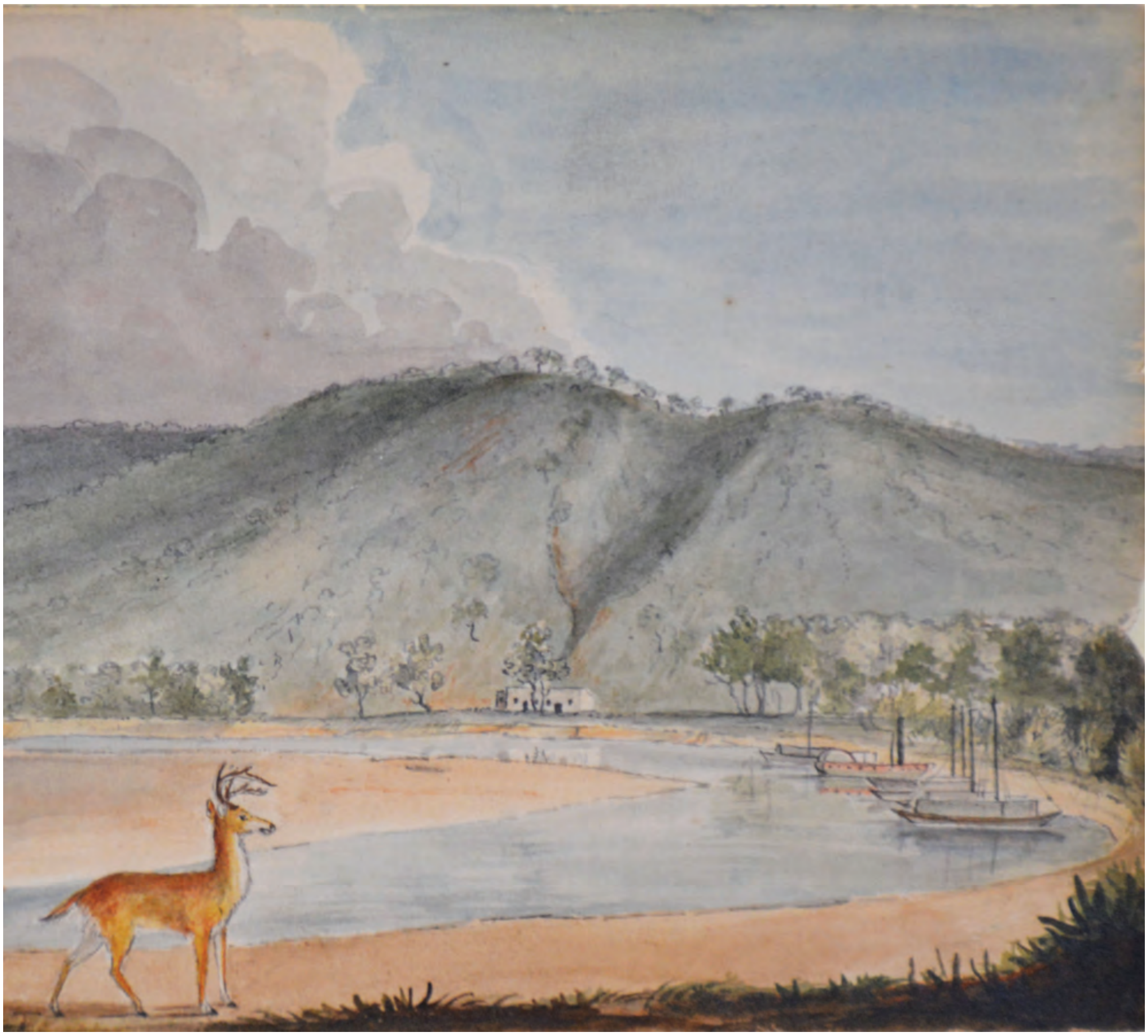
Introduction

Long's Expedition was the first party with trained scientists to explore the American West in the name of the United States government.[1] Historians have not been particularly kind to the expedition. William Goetzmann described the party as "A curious cavalcade of disgruntled career officers, eccentric scientists, and artist-playboys, . . ."[2] Hiram Chittenden believed that the expedition of 1819 had failed, and that "a small side show was organized for the season of 1820 in the form of an expedition to the Rocky Mountains."[3]

On the other hand, biologists have had a much more positive view of the expedition's results.[4] However, biologists have concentrated their interest, not surprisingly, on the summer expedition, because members of the party were the first to study and collect in the foothills of the Rocky Mountain Front. However, recent papers by Genoways and Ratcliffe, and others conclude that both biologists and historians have missed the most important scientific work of the Long Expedition, which was accomplished during the winter of 1819-1820 at Engineer Cantonment.[5] Here the scientific and ethnographic work was conducted over a nearly nine-month period. Nicholls and Halley made a similar observation, stating: "the rest of the explorers set to work gathering specimens, making sketches, interviewing Indians, and making notes. In fact, they probably gathered as much scientific data during the winter at Engineer Cantonment as they did on the rest of the expedition."[6]

Many new taxa of plants and animals were discovered in the vicinity of the cantonment. The specimens, drawings, and catalogs of the plants and animals prepared by the scientists are the most valuable result of the entire expedition. These materials serve as the vouchers and documentation for what would be called, in modern scientific terminology, a biodiversity inventory. This is the first place in America of which we are aware that a party of scientists attempted to produce a complete inventory of the mammals, birds, amphibians, reptiles, insects, snails, and plants occurring in a limited geographic area (our estimate is that most of these plants and animals were collected or observed within 20 mi, primarily to west and north).



Engineer Cantonment with Deer in Foreground, by Titian R. Peale. A buck white-tailed deer *(Odocoileus virginianus)* is in the foreground and the *Western Engineer* and keelboats are nearer to the cabins. White-tailed deer were abundant in the environs of Engineer Cantonment and venison was a major component of the diet of the military contingent and the scientific party. Image courtesy of State Historical Museum of Iowa, Des Moines

What is Biodiversity?

Biodiversity, or biological diversity, refers to all species of plants, animals, and microorganisms and the ecosystems and ecological processes of which they are parts.[7] Although humans have studied biological diversity since the time of Aristotle, it has only been after the late 1980s that the term has become commonplace, both in the biological sciences and with the public. The definition adopted by the United Nations Convention on Biological Diversity is “the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are a part.” In short, biodiversity is the sum total of life on Earth.

Biodiversity is important to humankind practically, aesthetically, and ethically, because our very existence depends on our direct use of, and care for, the plants, animals, and ecosystem functions that comprise biodiversity.[8] The presence of many different kinds of species is important because many species provide food, shelter, clothing, medicine, and enhanced spirituality to humans. Knowledge of biodiversity also serves society as an indicator of ecological change that could affect human welfare. Comparing baseline biodiversity information through time, such as that documented by the Long Expedition at Engineer Cantonment with what we see there today, illustrates changes in habitats and their inhabitants and how or why these changes may have occurred.

Shown larger than actual size, examples of lead shot and ball sizes ranging from about 0.08 to 0.7 inches in diameter. The very small examples are 'dust shot' used for killing small birds and mammals for scientific study. NSHS, State Archeology Office. Prepared by Kelli Bacon

Thus, comparisons with historical biodiversity inventories have predictive value by showing how changes in the composition of plants and animals occurring in an area can be extrapolated to other, modern events given a similar set of circumstances.

Losses in biodiversity may occur from human impacts on habitats (habitat destruction, degradation, fragmentation, restructuring) and on organisms (over-exploitation and introduction of invasive species, predators, and parasites).[9] This can clearly be seen at Engineer Cantonment where today's habitats consisting of urban areas and agriculture are vastly different from the broad floodplain of almost 200 years ago. Habitat fragmentation and destruction results in a net loss of biodiversity as plants and animals lose their homes and are extirpated, or when invasive species replace native species. We know that human population growth is causing the extinction of biodiversity, and that it is altering biosphere-level processes that we depend on for $3 to $33 trillion of environmental services annually.[10] This has broad implications for conservation and, ultimately, for human survival.

At a National Academy of Sciences colloquium, "The Future of Evolution," held in March 2000, panel discussants agreed that current extinction rates are 50 to 500 times background rates and are increasing, and that the consequences for the future evolution of life are serious. We are now living in what will eventually be recognized as a mass extinction event. If current area-species curve-based projections are correct, we could lose up to 50 percent of the planet's species in the next 1,000 years.[11]

> In response to the on-going rapid decline of biomes and homogenization of biotas, the panelists predicted changes in species geographic ranges, genetic risks of extinction, genetic assimilation, natural selection, mutation rates, the shortening of food chains, the increase in nutrient-enriched niches permitting the ascendancy of microbes, and the differential survival of ecological generalists. Action taken over the next few decades will determine how impoverished the biosphere will be in 1,000 years when many species will suffer reduced evolvability and require interventionist genetic and ecological management. Whether the biota will continue to provide the dependable ecological services humans take for granted is less clear. Our inability to make clearer predictions about the future of evolution has serious consequences for both biodiversity and humanity.[12]

McNeely et al. observed that biological diversity is an umbrella term covering the totality of species, genes, and ecosystems, but also that biological resources can actually be managed, consumed, replenished, and can be the subject of directed conservation action.[13] The efficient and rational use of natural resources depends on accurate ecological knowledge, but the major deterrent to ecological studies is the lack of biodiversity data that are fundamental for all subsequent studies. To arrive at a sound view of ecology, we must first identify and catalog the fauna and flora. Cataloging the fauna and flora was the prime directive for the scientific contingent of the Long Expedition.

Biodiversity inventories, in general, have specific goals of discovery and documentation and so are organized, systematic, and sustained.[14] Since the late 1700s, biotic surveys have generated vast scientific collections of specimens that were the foundation for many natural history museums and the descriptive science of taxonomy. In turn, taxonomy is the foundational discipline for all of the biological sciences, because it documents all of life on Earth and organizes this knowledge into a hierarchical system of data retrieval.

Kohler observed an important distinction between surveys and exploration.[15] Exploration usually consisted of journeys into the unknown for commercial, military, or political reasons. Occasionally, a biologist might accompany such an expedition, but they were incidental to the principal goals of the journey. By contrast, survey collecting expeditions were primarily scientific and their goal was to inventory the flora and fauna of a given area. The most notable example is Charles Darwin and the second voyage of *HMS Beagle* (1830s). The many biotic surveys both here and abroad sponsored by natural history museums, including the recently published *Flora of Nebraska*, surveys of the mammals of Nebraska, and scarabs of Nebraska, and the Long Expedition's intensive and sustained inventory activities at Engineer Cantonment from the fall of 1819 to the late spring of 1820.[16]

Landscape Changes

The expedition cabins at Engineer Cantonment were located at the eastern base of a steep ridge that is bisected by a ravine just south of the camp. This ridge and associated ridges and cliffs marked the western edge of the old Missouri River channel. The cabins were located only a few meters from the edge of the water, along what is believed to have been an oxbow off the main channel of the river.

Through word descriptions, sketches, and paintings, members of the expedition have left an excellent record of the general landscape in the vicinity of Engineer Cantonment. As the party rode along the eastern side of the Missouri River across from the modern city of Omaha, they approached the site of Engineer Cantonment from the south on September 16, 1819, and made the following initial observations of the river valley:

> Above the Platte, the scenery of the Missouri becomes much more interesting. The bluffs on each side are more elevated and abrupt, and being absolutely naked, rising into conic points, split by innumerable ravines, they have an imposing resemblance to groups of high granitic mountains, seen at a distance. The forests within the valley of the Missouri, are of small extent, interspersed with wide meadows covered in Carices and Cyperaceae (= sedges), . . . sometimes sinking into marshes occupied by Saggittarias (= arrowhead), Alismas (= water plantain), ...[17]

The dominant vegetative feature now in the valley is trees, and the only areas not covered by them are those under cultivation and urban development. The loess hills and cliffs bordering the valley are still present, but they are difficult to observe because they are covered in trees. The Missouri River has been channelized, being confined to a much narrower and deeper channel. The associated wetlands were drained and converted to rich farmland, so only a few of the restricted meadows and marshes described by James are present. Encroaching on the site from the south and west is the rapidly growing metropolitan area of Omaha, which stands at 42nd in population among American cities with just over 408,000 residents (2010 U.S. Census). In the area, on the east side of river from which James described the valley, is the city of Council Bluffs, Iowa, with 60,000 residents.[18]

Stephen Long carefully chose the site of Engineer Cantonment within about a mile of Manuel Lisa's trading post. He obviously selected the site with the eye of an experienced explorer to take advantage of all of the local resources:

> . . . a very narrow plain or beach, closely covered with trees, intervenes between the immediate bank of the river, and the bluffs, which rise near two hundred feet, but are so gradually sloped as to be ascended without great difficulty, and are also covered with trees. . . . Here were abundant supplies of wood and stone, immediately on the spot where we wished to erect our cabins, and the situation was sheltered by the high bluffs from

the northwest winds. The place was called Engineer Cantonment.[19]

Titian Peale left us an excellent watercolor of a view of Engineer Cantonment, which gives a visual record of the site (pp. 46-47). In the watercolor, we can see the cabins near the water's edge with a few surrounding trees. To the north (right) along the plain there appears to be a dense growth of trees. The ridge behind camp appears to have trees as well, but they do not appear to be as dense a growth as along the plain. In the foreground of the painting, the *Western Engineer* and four keelboats (based on number of masts) are anchored in an area believed to be an oxbow off the Missouri River.

After the military contingent of the expedition had arrived and settled at Camp Missouri, the scientists visited the site, which was established a few kilometers upstream along the main channel of the Missouri River. They made observations in the area of the Council Bluff of Lewis and Clark, which was on the bluff above Camp Missouri. These observations help give a fuller picture of the landscape along this segment of the Missouri River Valley:

The Council Bluff, so called by Lewis and Clark . . . is a remarkable bank, rising abruptly from the brink of the river, to an elevation of about one hundred and fifty feet. This is a most beautiful position . . . . Its defects are a want of wood within a convenient distance, there being little within a mile above, and much farther below, also a want of stone and of water, except that of the river. From the summits of the hills, about one mile in the rear of the Bluff, is presented the view of a most extensive and beautiful landscape. The bluffs on the east side of the river, exhibit a chain of peaks stretching as far as the eye can reach. The river is here and there seen meandering in serpentine folds, along its broad valley, chequered with woodlands and prairies, while at a nearer view you look down on an extensive plain interspersed with a few scattered copses or bushes, and terminated at a distance by the Council Bluff.[20]

This view from Cemetery Hill at the western edge of Fort Calhoun, Washington County, is unfortunately no longer available, because it is blocked by numerous trees on this hill, the prairie, the Council Bluff, and in many areas of the Missouri River Valley. The Missouri River no longer meanders through the valley, because it is confined to its considerably straightened, channelized course. The area of prairie at the base of the hill has been replaced by the town of Fort Calhoun with 1,000 residents and shady, tree-lined streets. Beyond the city to the east at the top of Council Bluff stands the restored Fort Atkinson. It also is nearly impossible to get a view of the valley from here because the entire slope of Council Bluff is heavily forested. The valley at this point is in agricultural use, and the river, currently located about 1.6 km to the east, is extensively lined by cottonwood trees.

Leaving Engineer Cantonment on June 6, 1820, and riding to the west, Captain Bell made the following observations:

After ascending the hill distant from the Missouri half a mile we enter the prairie which is undulating and entirely destitute of timber—from the hills of the prairie we had a beautiful view of Council Bluff and the country on the opposite side of the river—variegated with wood and meadow land.[21]

The previous fall, members of the Scientific Party had commented on the problems that they had encountered from the smoke of prairie fires burning in the area. These fires were stopped only with two days of rain and a shift in the wind direction. They made the following observations about the smoke:

From the 24th of October to the 10th of November, the atmosphere was generally filled with dense smoke like a fog or stratus, which proceeded from the conflagrated prairies. . . . On the morning of the 8th instant (= November 8) it occurred in greater quantity than at other time, when it was so extremely dense as to intercept a view of the opposite shore of the Missouri from Engineer Cantonment.[22]

Coyote. Thomas Say was the first scientist to describe and give a scientific name to the coyote *(Canis latrans)* based on specimens from the vicinity of Engineer Cantonment. In the expedition journal for January 6, 1820, it was noted: "We hear the barking of the prairie wolves every night about us; they venture close to our huts; last night they ran down and killed a doe, within a short distance of our huts." Courtesy of American Philosophical Society, Philadelphia (APSimg2051)

The area of prairie and the view to the east described by Bell was lost long ago, being replaced with an area of forest and residential development. Fires in this area and other areas of the Great Plains have been actively suppressed since the first settlements were established. Stambaugh et al. studied the fire history of trees at the extreme southern end of the loess hills that border the eastern floodplain of the Missouri River just south of the Iowa border in northwestern Missouri.[23] In this area, the minimum fire interval from 1672 to 1820 was 6.6 years and the rate of fire occurrence increased between 1821 and 1880 so that fires were occurring every 2.5 years. This increased rate was associated with the settlement period and probably represents fires set intentionally, as part of land clearing, and accidental fires, resulting from increased human activity. From 1881 to 1980, the rate dropped significantly again so that fires occurred only every 5.8 years. Stambaugh et al. also found that fires after 1900 were smaller and burned with less intensity and that only one fire had occurred in the area after the mid-1950s.[24]

In summary, comparing this area of the Missouri River in 1819-1820 to 2018 clearly shows that the landscape has been significantly altered, primarily by human activity. A broad valley with a meandering river prone to seasonal flooding, especially in the spring, and a mixture of forests, open wetlands and meadows has been transformed into a suburban area dominated by cottonwoods and non-native tree species, a narrow and nearly straight river, and agricultural fields. The river was altered by channelizing and the building of upstream dams in the 1940s by the Army Corp of Engineers to prevent flooding, allowing the permanent draining of wetlands for conversion to agricultural use and to maintain a constant river flow to allow barge traffic at least as far as Omaha. All of these actions have encouraged the growth of trees, especially cottonwoods, as has the suppression of fires that are necessary to maintain the prairies in these areas of the ecotone with

Two views of the eastern red bat *(Lasiurus borealis)*. At the top of the illustration is an eastern red bat "roosting" on a tree branch. This is an incorrect depiction and gives a good indication of the poor state of knowledge of bats and other mammals in 1820. Courtesy of American Philosophical Society, Philadelphia (APSimg5503)

eastern deciduous forests.[25] Knopf also attributed the development of forests along prairie rivers to the effects of subirrigation when water is diverted from the river for agricultural purposes and then slowly allowed to work its way underground back to the river.[26] As should be clear from this discussion, it is impossible today to get the same impressions of the landscape that greeted Long and his scientific party as they arrived at Engineer Cantonment.

New Plants and Animals

Certainly, one of the major contributions to science made by the Long Expedition lies in the number of new species of plants and animals described from the vicinity of Engineer Cantonment. Genoways et al. counted at least 56 new species—4 plants, 1 snail, 38 insects, 3 snakes, 4 birds, and 6 mammals—that can be confirmed as being described from this area and many others may have been as well, because in a number of instances the sources of the specimens later described by Thomas Say are not noted.[27] The formal method for making new plants and animals known to science involves a description of the new species, how it differs from related species, and the proposal of a scientific name for the new species. One individual specimen is usually designated to represent the species, and it is referred to as the "holotype." The geographic place where the holotype originated becomes known as the "type locality," and other specimens from this site become known as "topotypes." The type locality and topotypes become valuable in science, because it is the place where "typical" representatives of the species may be obtained in future studies. Topotypes are important for conveying variation in the new species beyond what can be learned from the single holotype.

There is no doubt that Engineer Cantonment is the most important type locality in the modern state of Nebraska, and we are comfortable with the claim that Engineer Cantonment is the most important type locality on the Great Plains. Clearly, more new plants and animals were described from this area than from any other visited by the Long Expedition. This should not be overly surprising given that the expedition spent no more than a few days at any other site from the time they left Engineer Cantonment in June 1820 until they arrived at Fort Smith in September.

Examining the list of new species allows several observations. The number of new plants is unusually low given the time at Engineer Cantonment.[28] However, it must be remembered that William Baldwin, the original botanist on the expedition, became ill and never reached Engineer Cantonment. Edwin James, Baldwin's replacement, only reached the site on May 27 and departed for the Rocky Mountains on June 6. Little time was available for botanizing, because time was devoted to preparations for the summer expedition. The four new plants from Engineer Cantonment were described by John Torrey, one of Edwin James' mentors and one of the founders of American botany. The fact that insects comprise the largest group of new species of animals described should not be surprising, because all of the new animal species were described by Thomas Say, whose specialty was insects, and he is considered by many to be the father of American entomology. Even though birds comprised the largest group of vertebrates present at Engineer Cantonment, the fact that only four species of new birds were described by Say should not be considered an unexpected result. Birds had been studied longer and in much more depth, and so fewer new species remained to be discovered. Say described only another eight species of birds from the remainder of the expedition even though much more new territory was surveyed.[29]

Mammals present an interesting counterpoint to birds, because they were poorly studied throughout North America in 1819-1820. Say described and named six new mammals of which four names are still in use for widespread species.[30] The coyote (*Canis latrans*), which ranges throughout the western two-thirds of North America and from Alaska to Costa Rica, was first made known to science from Engineer Cantonment, as was the prairie wolf (*Canis lupus nubilus*), which occurred throughout the Great Plains east of the Rocky Mountains from southern Canada to Oklahoma and as far east as Iowa and Missouri. Say also described two species of short-tailed shrews from Engineer Cantonment that are common inhabitants of the eastern United States. The techniques for catching small mammals, such as the northern short-tailed shrew (*Blarina brevicauda*) and the least shrew (*Cryptotis parva*), were not fully developed until the invention of the cyclone trap in the 1880s. These two shrews were actually captured in large pitfalls constructed in an attempt to catch specimens of the prairie wolf. Only in the last 30 years have mammalogists regularly used pitfall traps, albeit much smaller ones, as an effective method for capturing small mammals.

Banded killifish *(Fundulus diaphanous)*, recognized by the black vertical bars along its side. Noted on the drawing is "Eng Cant, Feb 1820," and noted in Expedition journal: "12th. (Feb) Messrs. Dougherty, Peale, and myself, with an assistant, encamped at a pond near the Boyer to obtain fish; we cut several holes in the ice of the pond, and obtained one Otter and a number of small fishes . . . ." Courtesy of American Philosophical Society, Philadelphia (APSimg5645).

The other two species of mammals described by Say were bats. Say described the big brown bat under the name *Vespertilio arquatus* and the hoary bat under the name *Vespertilio pruinosus*. However, both of these species had been described and named earlier by the French naturalist, Palisot de Beauvois, in a catalog of the collection of Charles Willson Peale's museum in Philadelphia.[31] Undoubtedly, these species, which are now known to have geographic ranges that cover most of North America, were described by Palisot de Beauvois based on specimens from the Philadelphia area, and Say did not make the connection to these specimens from half a continent away.

Species Richness and Engineer Cantonment

The most fundamental measure of biodiversity is expressed as species richness.[32] Various methods have been devised to estimate species richness, but our data set does not fulfill the assumptions of these statistical methods. However, as Peet stated "Direct species counts, while lacking theoretical elegance, provides one of the simplest, most practical, and most objective measures of species richness."[33] More recently Hellman and Fowler compared four measures of species richness and concluded: "The simple richness estimator was the most precise estimator in all studied communities, but it yielded the largest underestimate of species richness at all sample sizes."[34] The simple richness estimator used by Hellman and Fowler was "the sum total of species observed in a sample."[35] This is similar to alpha diversity, which is the number of species within a habitat, of other authors.[36] Genoways and Ratcliffe calculated the simple richness estimator, or alpha diversity, for the vicinity of Engineer Cantonment in 1819-1820.[37] Using data compiled in Appendices 1- 6 of Genoways and Ratcliffe, the following species counts are found for the surveyed groups: 51 plants in 34 families; 14 snails in 7 families; 46 insects in 30 families; 2 amphibians in 2 families; 14 reptiles in 6 families; 143 birds in 44 families; and 33 mammals in 20 families. This gives a species richness of 303 species.[38] We are not aware of another site in North America that was surveyed during the remainder of the nineteenth century with a species richness that even approached 303 species. Most areas during this time were surveyed for a few days and then the field parties moved along. Most were not interested in broad taxonomic representation in their surveys, but focused on plants and larger vertebrates.

Now after adding data from the phytoarcheological and zooarcheological surveys the species richness number increases by 6.5 percent. The 20 new species added by the archeological work include 6 plants, 4 mollusks, 5 fish, 2 amphibians, 1 bird, and 2 mammals. With these archeological additions and inclusion of the overlooked historical record of the killifish, the species richness number for Engineer Cantonment in 1819-1820 becomes 324.

Conclusions

It is our contention that Thomas Say, Titian Peale, Edwin James, and their colleagues of the Stephen Long Expedition of 1819-1820 were heavily engaged in scientific research, which took the form of the first biodiversity inventory undertaken in the United States. This accomplishment has been overlooked both by biologists and historians, but it should rank among the most significant accomplishments of the expedition. The results of this inventory continue to inform us today about environmental, faunal, and floral changes along the Missouri River in an area that is known to be an ecotone between the deciduous forests of the eastern United States and the prairies of the Great Plains. This inventory was completed at a time when the impact of Euroamericans was just beginning.

The written documents, collections, and drawings left to us, along with the archeological inventory, form an image of a dynamic riverine system with a highly meandering river having a wide valley filled with oxbows, palustrine wetlands, and scattered groves of trees. This has now been modified to an area that has a channelized river with the surrounding wetlands being drained and converted to agricultural and municipal purposes. Construction of upriver dams has controlled flooding, especially in the spring, so that the river valley is not renewed and changed. Irrigation of farmlands has promoted the growth of riparian forests composed primarily of cottonwood. Suppression of prairie fires, which were prevalent during the fall of 1819, also has promoted the growth of trees and other woody vegetation. The city of Omaha and its suburbs are expanding and encroaching on the site from the south and west, converting once open grasslands and scattered trees to housing tracts with well-manicured lawns and non-native Nebraska shade trees.

The impacts of these landscape and environmental changes are clearly reflected in the plants and animals of the area. Although the U. S. Fish and Wildlife Service has done some habitat restoration in the Boyer Chute National Wildlife Refuge and continues fish and wildlife habitat restoration in associated upland and wetland areas along the Missouri River, their efforts will never be totally successful, because many of the plants and animals no longer occur in the area. Among mammals, three of the top herbivores are gone as are four of the top carnivores. We would not be advocating reintroduction of bison or wolves, but without these species interacting with the plant and animal communities, no restoration will truly re-establish what once was. Secondary herbivores and carnivores have now filled these top niches and make a vastly different impact. The gray squirrel and eastern chipmunk appear to indicate that it is not just trees that make a forest, because the forest established along the Missouri River and its former floodplain is dominated by cottonwoods that do not provide the necessary habitat for these species.

We believe our examination of the Engineer Cantonment area in eastern Nebraska demonstrates the value of biodiversity inventories, both historical and modern. Although it is beyond our power to undertake historical inventories, we urge efforts be directed toward the reconstruction of other historical biodiversity inventories, including phytoarcheological and zooarcheological surveys. This may be feasible in areas such as historical forts, which were visited by traveling biologists on a recurring basis. The results of these explorations, especially when combining the work of a number of parties and scientists, may result in useful historical biodiversity inventories. Other places on the Great Plains where this may be possible would include Fort Union in North Dakota, Fort Sisseton in South Dakota, Fort Hays in Kansas, and Fort Sill in Oklahoma. Today's modern inventory is tomorrow's historical inventory, and so there is still an ongoing need for biodiversity inventories. They provide the baseline information for dynamic biological systems that will change over time and with environmental shifts.

NOTES

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[12] Woodruff, "Declines of Biomes and Biotas and the Future of Evolution."

[13] McNeely, Miller, Reid, Mittermeier, and Werner, *Conserving.*

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