PART ONE

Historical and Theoretical Underpinnings

CHAPTER ONE

DISCOVERING THE ROOTS OF ECOLOGY AND ECOLOGICAL RESTORATION IN THE MIDWEST

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Ecology is the field of science devoted to the study of the interrelationship of life and its biotic and abiotic environment. The field officially began in the United States with the organization of the Ecological Society of America in 1915 (Burgess 1976). However, individual scientists were conducting ecological studies decades earlier. Biologists, amateur naturalists, and explorers made observations on the occurrence and abundance of the flora and fauna in the 1800s (McIntosh 1986). Ecology originated in Europe, but its rise was rapid in the United States in the early 1900s, and American ecologists were soon recognized as leaders in this new subdiscipline of biology (McIntosh 1986). Since its inception, ecology has gone from mostly a descriptive natural history approach to the quantitative, hypothetical, deductive approach that dominates the field today (McIntosh 1986).

Ecological restoration is the science and practice devoted to assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER 2004). Similar to the field of ecology, a few individuals and organizations began practicing ecological restoration well before it formally organized as a professional discipline (Jordan and Lubick 2011). Although the practice garnered a lot of interest in the late 1800s and early 1900s, it went on hiatus for much of the mid–twentieth century before reemerging in the late 1900s (Jordan and Lubick 2011). The field of ecological restoration began to mature rapidly in the 1960s, which coincided with the rise of the

environmental movement and the maturation of the field of ecology. In 1988, it became a formal discipline with the establishment of the Society for Ecological Restoration (Jordan and Lubick 2011). In light of increasing concerns over habitat loss, climate change, and decreasing biodiversity, the interest in ecological restoration continues to rise and its application is currently a multi–million dollar industry (BenDor et al. 2015).

The definition of *restoration* has been debated hotly since the 1980s, and the Society for Ecological Restoration has altered how it is defined multiple times (Higgs 2003). Early definitions centered on a return to historical conditions, but the current definition focuses on the repair and recovery of degraded ecosystems with the recognition that while historical conditions can serve as a guide, the final outcome might be different physically and biologically from what existed previously. Additionally, ecological restoration in its strictest sense is an ecocentric approach having an intent to benefit the biota and the ecosystem being restored (Jordan and Lubick 2011). The ecocentric approach separates ecological restoration from other management types (i.e., forestry, wildlife/fisheries management, environmental management, landscape architecture) that are guided primarily by anthropogenic concerns and interests. The most current understanding of the history of ecological restoration (Jordan and Lubick 2011) is limited because it focuses only on the history of the field based on ecocentric restoration efforts. Historical restoration efforts and other types of management projects having anthropogenic objectives represent the precursor to ecological restoration and can result in what can be considered restoration. Thus our understanding of the historical trends in ecological restoration will be expanded by considering the role that these historical precursory restoration efforts played.

Similarities between ecology and ecological restoration are apparent, as they involve working with living organisms that are influenced simultaneously by multiple abiotic and biotic factors operating at a wide range of spatial and temporal scales. Both are interdisciplinary fields that use information from various physical and biological sciences to achieve their goals. Ecology is a scientific discipline that focuses on increasing our understanding of the world, while ecological restoration is the application of ecology to the repair of degraded ecosystems. Restoration ecology, which is the science of ecological restoration, focuses on the use of the scientific method and ecology to increase the effectiveness of the practice of ecological restoration.

Ecological restoration is more than just restoration ecology and the practice of restoration. It encompasses all ideas, concepts, and practices from the life and physical sciences, economic fields, social fields, political fields, and art that are relevant to ecosystem restoration (Higgs 2003). While ecological restoration is influenced by many disciplines, the link between ecology and ecological restoration is clear. Furthermore, many key historical events in these fields occurred in the Midwest, but their historical links have not been explored in detail. Our objective is to expand our understanding of the history of ecological restoration by synthesizing the contributions of historical precursory restoration efforts resulting from the common rise of ecology and ecological restoration in the Midwest. We focus on the interrelationships and accomplishments of four pioneers in ecology and landscape architecture from the late 1800s to the 1950s to illustrate their contributions to ecological restoration and the intermingled history of ecology and ecological restoration in the region. We further highlight the importance of historical precursory restoration efforts by detailing the history of a current restoration project that began as a designed landscape implemented by famed landscape architect and conservationist Jens Jensen.

CULTURAL VIEWS

We begin with an overview of the cultural perspective of midwesterners in the early 1800s. In this period, Americans were settling the Midwest. As new settlers explored and moved west, they encountered prairies, forests, lakes, and streams in relatively pristine conditions. The hunter-gatherer lifestyle of Native Americans had likely altered the habitat, but these changes were small in scale and less intense than the changes that occurred with agrarian settlers and the coming of the Industrial Revolution. The early settlers focused on obtaining the resources that they needed for survival and establishing their homesteads without concern for the impact of their activities on the environment. Technology improved as the region became more populated, which made travel and obtaining needed resources easier (Kline 2011). Agriculture became increasingly mechanized with increasing industrialization, resulting in increasing amounts of land being put into production (Kline 2011). The belief that nature existed to benefit humanity encouraged the exploitation of natural resources during this period (Kline

2011). Additionally, increasing population size and the closing of the western frontier led to increasing urbanization and, in combination with growing industrialization in Midwest cities, crowding, air and water pollution, and destruction of natural landscapes (Kline 2011). By the late 1800s individuals and groups were becoming concerned with the habitat destruction and degradation they were observing (Egan and Tishler 1999; Grese 2011). Many of these conservation-minded and progressive individuals felt nature could provide a respite for the ills of modern life (Jensen 1939; Engel 1983; Egan and Tishler 1999; Grese 2011). This feeling of ongoing social and environmental decline provided the initiative to beautify, preserve, and restore (Miller 1915). This impulse ultimately led to the rise of ecology and ecological restoration in the Midwest (Egan and Tishler 1999).

IN THE BEGINNING

In the late 1800s and early 1900s science and practice were not separated into the fields of biology and ecology as they currently are. The sciences generally were less specialized as many early naturalists, biologists, and ecologists worked with multiple taxonomic groups and different ecosystem types over their careers (Croker 1991, 2001). In contrast, today many scientists specialize in a single ecosystem and/or taxonomic type. As a result, the early ecological restoration attempts in the Midwest were undertaken by biologists, botanists, ecologists, and landscape architects with broad interests and experiences (Jordan and Lubick 2011). For example, mammalogist Benjamin Patterson Bole Jr. and ecologist Arthur B. Williams conceived and carried out the restoration project at Holden Arboretum in Ohio in 1930 (Jordan and Lubick 2011). Biology professor Harvey Stork and grounds superintendent D. Blake Stewart planted native trees and shrubs on the grounds of the Carleton College Arboretum in Minnesota beginning in 1926 (Jordan and Lubick 2011). Wildlife ecologist Aldo Leopold, horticulturalist and landscape architect G. William Longenecker, and botanist Norman Fassett supervised the initial restoration projects at the University of Wisconsin–Madison Arboretum in the 1930s (Sachse 1974). Foresters, wildlife managers, and fisheries managers working for state and federal agencies carried out other early precursory restoration efforts. Early landscape architects were particularly influential through their on-

the-ground activities and writings. Landscape architects associated with the prairie style of landscape design promoted the use of a naturalistic style of landscaping reflective of midwestern and regional plant species and materials. Many of these individuals learned to identify native plants and understood their natural history in order to use them in their landscape designs (Grese 2011). Likely the common link among the individuals who contributed to the rise of ecology and ecological restoration in these early days was a shared love of the flora, fauna, and the landscape of the Midwest.

RELATIONSHIPS BETWEEN PIONEERS IN LANDSCAPE ARCHITECTURE AND ECOLOGY

Ecological restoration is the application of ecology and as such must go beyond the science and encompass individuals with expertise in terrestrial and aquatic ecology as well as in the design and implementation of landscape alteration projects. Jens Jensen (1860–1951), Henry Chandler Cowles (1869–1939), Stephen Forbes (1844–1930), and Victor Shelford (1877–1968) were all pioneers in ecology, ecological restoration, and conservation. Jensen was by profession a landscape architect, and Cowles, Forbes, and Shelford were ecologists. The relationships between these four individuals during their careers highlight the contributions of precursory restoration efforts and the rise of ecology and ecological restoration within the Midwest. The following synthesis draws on Croker (1991), Grese (1995), Engel (1983), Croker (2001), Cassidy (2007), and Grese (2011).

Cowles was a faculty member at the University of Chicago in the early 1900s. Cowles conducted his dissertation on the successional dynamics of the vegetation at the Indiana Dunes. This work was widely considered a significant contribution to ecology through its contribution to the theory of succession, and it was considered instrumental in establishing ecology within the United States. Following the completion of his PhD, Cowles was hired as a laboratory assistant to develop the ecology curriculum at the University of Chicago and he worked his way up to the rank of full professor. Cowles was a gifted and dedicated teacher who donated his time generously to a number of conservation-oriented organizations. It was through his volunteer activities with the Geographic Society of Chicago that he met Jensen in 1901.

Cowles and Jensen became friends and took trips into the Indiana Dunes and other natural areas for the collection and identification of plants. In 1905 Jensen organized the Playground Association of Chicago, and he and Cowles served on the committee that sponsored the association's Saturday afternoon walks. These trips to the natural areas in and around Chicago were intended to provide the poor with an opportunity to experience natural areas and increase their awareness of these sites. The walks became so popular, especially among the middle class, that Jensen, Cowles, and Chicago reformer Thomas W. Allinson started a new organization called the Prairie Club to administer them. The Prairie Club was primarily a social organization for professionals, but for many years it functioned as the midwestern counterpart to the Sierra Club in the western United States. In 1913, Jensen, Cowles, and Allinson, along with sixteen other prominent citizens, organized Friends of Our Native Landscape, which was a society formed to promote life in the open and to preserve examples of native landscapes that were fast disappearing as a result of industrialization. Jensen was the president, Cowles served as vice president, and Forbes was a member of this group. Friends of Our Native Landscape was foremost among the five other Chicago-area conservation groups that were organized by Jensen, Cowles, and Allinson together or separately.

One of the most significant accomplishments of these conservation organizations was their contribution to the establishment of Indiana Dunes State Park and Indiana Dunes National Lakeshore. The Indiana Dunes, located between Calumet and Michigan City, Indiana, is a unique ecosystem in the Midwest that was threatened by the increasing industrialization and urbanization that was occurring in the early 1900s. The importance of the Indiana Dunes for ecologists internationally is highlighted by the insistence of the members of the 1913 International Phytogeographic Excursion of the United States that they visit this ecosystem. Cowles and Shelford led a tour of the dunes for this group of international scientists, which included famed ecologists Arthur Tansley and Frederic Clements.

The effort to protect the Indiana Dunes began in the early 1900s, when Jensen began traveling through the Chicago area promoting the dunes' importance and beauty. Later, the Prairie Club, Friends of Our Native Landscape, and the National Dunes Park Association, all formed by Jensen, Cowles, and Allinson, assumed the primary role in advocating for the Indiana Dunes. These early conservation efforts to protect the dunes were

unique because they involved prominent individuals from the arts, sciences, and public service. Despite the ecological significance and the public popularity of the Indiana Dunes, it took a decade of effort by numerous individuals and conservation organizations to establish Indiana Dunes State Park in 1925 and then another forty-one years to establish Indiana Dunes National Lakeshore to ensure the protection of this unique ecosystem from urbanization and industrialization.

Friends of Our Native Landscape published a publicity piece titled *Proposed Park Areas in the State of Illinois* in 1921. This publication described the scenic beauty and historical interest of natural areas within Illinois that needed to be preserved. These natural areas were identified by Cowles, Jensen, and Forbes using information compiled through the Illinois State Forestry Survey and fieldwork conducted by Cowles. This significant publication led to the protection and management of many of these natural areas, as they became state parks or forest preserves.

Cowles and Jensen collaborated for at least fifteen years. Cowles contributed to Jensen's understanding of plant ecology, the role of individual species within the larger plant community, and succession within plant communities. Jensen's increased knowledge of plant ecology helped him implement his landscape designs within Chicago-area parks and private residences. Jensen was a noted leader of the prairie style of landscape design and promoted the use of native plants. He used relatively pristine native landscapes as inspiration for his designs, a precursor to today's restoration practice of designing restoration projects based on the physical and biological conditions found at nearby unimpacted reference sites (for more on this reference ecosystem concept, see Chapter 2). Jensen never intended to duplicate nature, but instead he tried to capture the spirit of the native landscapes in his projects. Jensen's design of the Lincoln Memorial Garden in the mid-1930s is reflective of modern-day ecological restoration. Most of the seedlings and transplants predominant in his design were planted by volunteers of all ages, presenting the idea that restoration can be an ecological, social, and educational activity. Jensen intended for succession to occur and for the vegetation to change over time. Even Jensen's work on private estates reflected succession and transformation of existing landscapes to one designed with native landscapes in mind. Specifically, the intent of his designs was to foster a love for the native landscape and ultimately assist with conservation efforts.

In 1907, Cowles became a charter member of the Illinois Academy of Science, and he eventually served on its Committee on Ecological Survey. Stephen Forbes was the chair of this committee, formed to improve the understanding of Illinois forests and to develop policy for public and private forested lands. Cowles was an advocate for responsible forest policy, and as early as 1911 he recommended that "bits of forests here and there gradually be restored to the primitive wilderness and beauty of the forests of pioneer days" (Cassidy 2007). Cowles's involvement with this committee is notable because it represents one of the earliest documented interactions between these two early ecologists. In the summer of 1918, Cowles conducted surveys in northern Illinois documenting the extent and types of forested habitats in the state. The results of these surveys, as well as those conducted by Forbes's Illinois Natural History Survey colleagues, were summarized in two reports published in 1921 and 1923. The 1923 report was used as the impetus to establish a forestry division within the University Experiment Station. The 1923 report also contributed to a 1926 act that authorized the Illinois Department of Conservation to establish state forests as fish and wildlife sanctuaries and public parks, and to develop tree nurseries to support reforestation efforts.

Forbes was a versatile ecologist who worked with birds, terrestrial insects, plankton, aquatic macroinvertebrates, and fish. He conducted pioneering research in economic entomology, economic ornithology, limnology, and ecology, and was an exceptionally productive scientist, writing over 200 publications during his career. As a result of his foresight and efforts, he established the Illinois Natural History Survey, which is one of the premier state natural history surveys in the nation. In 1894, Forbes requested and received funds from the Illinois legislature to establish the Illinois River Biological Field Station in Havana, Illinois. As part of this proposal, he indicated that he would compare the chemical and biological conditions of the river before and after the opening of the Chicago Drainage Canal into the Illinois River. The drainage canal was expected to reverse the flow of the Chicago River and water from Lake Michigan, and transport diluted sewage, stockyard, and industrial wastes from Chicago into the Des Plaines River and then the Illinois River. Forbes's research through the Illinois River Biological Field Station documented the physical, chemical, and biological impacts of the canal. This scientific evidence resulted in required construction of two sewage plants to treat wastewater coming from Chicago prior to its entry into the Illinois River. This represents one of the first applications

of ecology research results to assist with the repair of a degraded river in the United States. Additionally, as part of this research effort Forbes and Robert Richardson developed a water pollution index that used benthic aquatic macroinvertebrates as indicators of the water quality of the river. This was the first water pollution index in the United States and a precursor to widely used quality indexes developed by Illinois scientists, such as the floristic quality index developed by Morton Arboretum scientists in the 1970s (Swink and Wilhem 1979) and the Index of Biotic Integrity developed by a University of Illinois scientist in the 1980s (Karr 1981, see Chapter 2). These types of indices help quantify the quality of remnant ecosystems and serve as criteria for monitoring the impacts of a restoration project.

Victor Shelford was a distinguished ecologist whose work helped set the foundation for modern ecology. Over the course of his career, Shelford conducted field and laboratory research involving community ecology, ecotoxicology, and population ecology in freshwater and marine ecosystems. He obtained his PhD from the University of Chicago, and his dissertation research focused on tiger beetle (subfamily Cincindelinae) life history and larval habitats. Cowles was one of Shelford's graduate school mentors and is credited as the teacher who influenced him the most. Cowles's influence likely inspired Shelford, as a graduate student, to conduct a study of the association of tiger beetles with plants on the Indiana Dunes. After completing his dissertation, he became a professor at the University of Chicago and then later was recruited by Forbes to become a professor at the University of Illinois and a biologist with the Illinois Natural History Survey.

In December 1914, a committee was formed to organize an American ecological society to provide an opportunity for joint gatherings of plant and animal ecologists and to organize summer field trips for its members (Shelford 1917). Shelford was elected president of the organizing committee and Cowles was its treasurer-secretary (Shelford 1917). In December 1915 in Columbus, Ohio, fifty members approved the proposed constitution and the Ecological Society of America (ESA) was formed (Shelford 1917). Shelford was elected ESA's first president. Later, Cowles would serve as president (in 1918), and Forbes was the president in 1921.

In 1917, Shelford proposed the formation of an ESA Committee for the Preservation of Natural Areas and was appointed chair of the committee. Cowles and Forbes were also members of this committee. The committee published a milestone report in 1933 that identified natural areas in the United

States that needed to be preserved and their current condition. This report also provided management recommendations that exhibited exceptional foresight (Grumbine 1994). Remarkably, the report listed modern management recommendations for natural areas such as (1) the importance of protecting individual species and ecosystems; (2) the expansion of natural reserves to match the species' needs; (3) ensuring that preservation efforts protect a representation of ecosystem types; (4) accounting for natural disturbances; (5) and the use of buffers to protect core habitats within natural areas (Grumbine 1994).

Shelford from the beginning felt strongly that ESA needed to be actively involved with conservation of natural habitats, so he contributed time and personal funds to the work of the Committee for the Preservation of Natural Areas. In contrast, many in the leadership of ESA did not think that it was appropriate for a learned scientific society to be actively involved with conservation. This difference in philosophy eventually led to the termination of the preservation committee. In response, Shelford organized the Ecologists' Union in 1946 to continue the committee's work separate from ESA. In four years the Ecologists' Union had grown from 83 members consisting only of ESA members to 294 members consisting of both scientists and nonscientists. In 1950, the Ecologists' Union reorganized and changed its name to The Nature Conservancy and Shelford served on its board of governors. The Nature Conservancy has since become a leader in preserving and restoring terrestrial and aquatic ecosystems throughout the world.

In conclusion, the relationships between Cowles, Jensen, Forbes, and Shelford highlight the beginnings of ecology and ecological restoration in the Midwest. Their individual and joint accomplishments resulted in the protection of important natural areas, the development of a quality index, and the organization of state, national, and international organizations that are currently contributing to modern-day ecology and ecological restoration.

THE HISTORY OF MARIAN UNIVERSITY'S NINA MASON PULLIAM ECOLAB

The Initial Design

The history of Marian University's Nina Mason Pulliam EcoLab illustrates how a precursory restoration effort (i.e., designed landscape) laid the founda-

tion for a modern-day ecological restoration project. In 1910, James Allison, a prominent Indianapolis businessman, purchased farmland in Indianapolis, Indiana, that would become his Riverdale estate (Figure 2). At the time of purchase, the northern portion of this 0.26-kilometer-square property consisted of row crops, with pasture to the south. The property contained a portion of Crooked Creek, located about 1.6 kilometers upstream from the White River. The meandering of Crooked Creek and the postglacial flooding of the White River watershed created an eighteen-meter-high bluff on the southern edge of the property. Construction of Allison's home at the top of this bluff began in 1911 and was completed in three years. After construction, the home, with its modern conveniences, became known as the "House of Wonders."

The same postglacial flooding that carved the bluff also exposed a soil layer impervious to infiltration. Water percolating through the soil hit the impervious layer and then eventually resurfaced within the Riverdale estate and the surrounding area. Just north of the mansion, at the base of the bluff, were several springs and wetlands that were drained by the farmer with subsurface tile drains. The farmer also used the springs to his advantage by building a groundwater-fed livestock watering trough.

Allison hired Jens Jensen in 1910 to design the landscape for his Riverdale estate. Jensen made several scouting trips to Riverdale as he began developing a plan. During these trips, he mapped the site and took photographs to document the existing conditions. Jensen's topographical maps documented the locations of the subsurface tile drains installed by the farmer, and his later design drawings indicated the tiles were used to maintain consistent pond levels. Jensen manipulated the hydrology across a significant portion of the estate. He built three dams within Crooked Creek that were lined with river rock. They contained sluice gates to manipulate the amount of water flowing over the dam to maintain an aesthetically pleasing flow. Jensen also armored a portion of Crooked Creek with concrete sides and created a prairie pool that was 0.3 to 1.2 meters in depth to evoke his idealized image of a wide, shallow prairie river. The retaining wall used moraine rock that probably originated from Crooked Creek itself, rather than the stratified limestone he used in his other projects (Dodson 1998). Jensen also created a series of five shallow spring-fed ponds along the bluff to the south, just below Allison's mansion (Figure 2). Allison's head groundskeeper indicated these ponds were "made the hard way—with teams and slip

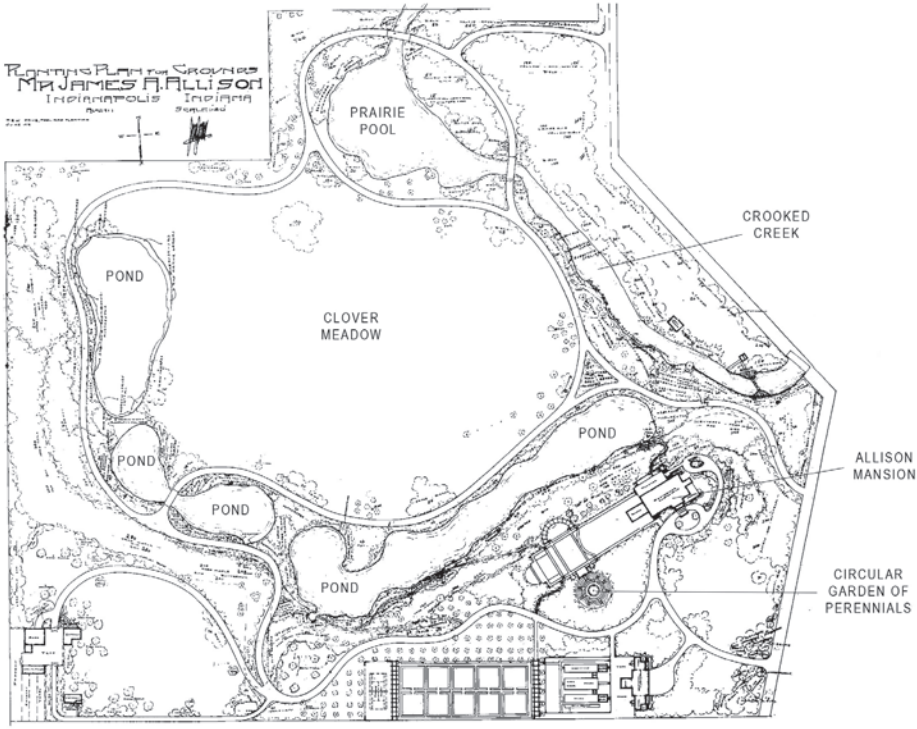

FIGURE 2. Jens Jensen's planting plan for the grounds of the Allison estate in Indianapolis, Indiana. Only key features within the planting plan are highlighted. This site became part of the Nina Mason Pulliam EcoLab at Marian University, a laboratory for ecological restoration.

scoops" (Heidkamp 1952). The ponds were located in areas that would likely have been extremely wet with spring water even in the presence of the subsurface tile drains. Three of the ponds were dredged to a depth of 0.9 to 1.2 meters, while the other two were shallower wetlands located on the western part of the property.

Jensen designed a more formal landscape with distinct groupings and geometric patterns near the mansion. Just west of the mansion, he installed a labyrinthine circular garden of perennials surrounding a fountain (Figure 2). Near this garden was his iconic council ring, which consisted of a seating area around a fire pit within a half-circle stone colonnade and pergola. Jensen built an outdoor amphitheater between the circular garden and the

council ring. The stage was raised and flanked by limestone pedestals with a backdrop of eastern red cedars (*Juniperus virginiana*) and eastern white pine (*Pinus strobus*). A large grove of sugar maples (*Acer saccharum*) was planted west and south of the mansion.

The majority of the plantings near the mansion consisted of native species, although Jensen's source for nursery stock extended beyond the local area. The cedars and pines were brought in from southern Indiana and Wisconsin (Heidkamp 1952). White birch (*Betula papyrifera*) were planted between the maples and the cedars, and were one of the few plantings not native to central Indiana. However, white birch is native to northern Indiana and Illinois, and it occurs in the Chicago area. Jensen also planted privet (*Ligustrum* spp.) in the formal portion of the landscape.

Jensen designed a less formal, more naturalistic portion of the landscape north of the bluff. Here Jensen's skills as a prescient restoration practitioner are most evident. For example, Jensen's plan indicates that 600 sugar maples and 600 red oaks (*Quercus rubra*) were to be planted in a 152-by-23-meter stretch located high on the bluff. Then just downslope, 560 black walnuts (*Juglans nigra*) and 560 butternuts (*Juglans cinerea*) were to be planted in a 107-by-15-meter location. The plantings of enormous numbers of individual plants rather than just a few large specimens is indicative of Jensen's willingness to allow ecological processes such as selection, competition, and succession take place. Jensen also specified the planting of 20 downy hawthorns (*Crataegus mollis*), 100 flowering dogwoods (*Cornus florida*), and 36 pepperidges (*Nyssa sylvatica*) below the walnuts along the shore of one of the shallow ponds. While flowering dogwood is typically found in drier environments, downy hawthorn and pepperidge are common in wet woods and along aquatic habitats.

Jensen did not specify the planting of many forbs or any understory vegetation, except in his plantings around the ponds and in the riparian habitat adjacent to Crooked Creek. Jensen had several common native wetland forbs planted along the wetland edges, such as swamp rose mallow (*Hibiscus moeschettus*), spikerush (*Eleocharis* spp.), northern blue flag (*Iris versicolor*), sweet flag (*Acorus americanus*), and buttercup (*Ranunculus* spp.). Jensen's designs also called for planting narrowleaf cattail (*Typha angustifolia*) along the wetland edge. The planting of narrowleaf cattail as part of a restoration project would be a questionable choice today, but at the time it was considered a relatively uncommon native cattail.

In the sunny riparian habitat of Crooked Creek, Jensen used overlapping flights of wet prairie–type wildflowers such as marsh blazingstar (*Liatris spicata*), New England aster (*Symphyotrichum novae-angliae*), Canada goldenrod (*Solidago canadensis*), sweet black-eyed Susan (*Rudbeckia subtomentosa*), black-eyed Susan (*Rudbeckia hirta*), smooth beggarticks (*Bidens laevis*), purple coneflower (*Echinacea purpurea*), showy black-eyed Susan (*Rudbeckia speciosa* var. sullivantii), summer phlox (*Phlox paniculata*), and goldenrod (*Solidago* spp.). He also specified a few species typically found in drier areas, like smooth blue aster (*Symphyotrichum laeve*), Missouri evening primrose (*Oenothera macrocarpa*), and narrowleaf evening primrose (*Oenothera fruticosa*). New York American aster (*Symphyotrichum novi-belgii*) was also used, although its native range lies east of Indiana. Jensen's designs also specify planting *Lythrum grandiflorum* in the riparian habitat of Crooked Creek. This species name is no longer in use, and it is uncertain which species it represents. Unfortunately, it is suspected that this species is purple loosestrife (*Lythrum salicaria*), which is a nonnative plant brought to the Midwest at the turn of the twentieth century by the horticultural trade. However, *Lythrum grandiflorum* may also have referred to another native *Lythrum* species, such as winged loosestrife (*Lythrum alatum*) (R. Grese, personal communication).

Jensen's plantings within the Clover Meadow in the center of Riverdale (Figure 2) most likely consisted of nonnative turf grasses (family Poaceae) and clover (*Trifolium* spp.). Jensen at this point in his career felt that the illusion of prairie was more important than creating the actual thing. By 1916, Jensen would use prairie grasses and wildflowers in his open spaces and designate them "the prairie" in his landscape drawings (Dodson 1998). Jensen's use of nonnatives in the Clover Meadow may have also been influenced by Allison's plan for the area to be grazed by cattle.

Jensen finished the landscape design in 1912, and the landscape installation was completed shortly after. James Allison and his wife, Sara, moved into their summer estate at Riverdale in 1913, and they used the estate regularly from then until his death in 1928.

Disinterest and Neglect

After Allison's death, Riverdale was in limbo as Allison's mother, his first wife, and his second wife fought over the inheritance. Allison's mother

eventually won the dispute and maintained control of the estate until she died in 1930. Otis J. Clemens began working for Allison as the head groundskeeper and manager of his twenty-two maintenance men in 1921 and lived in a residence at the west edge of the estate (Heidkamp 1952). It is assumed that Clemens continued to maintain Jensen's original plantings through this period.

The Sisters of Saint Francis at Oldenburg purchased Riverdale in 1936. The Sisters then moved Marian College from Oldenberg to Riverdale in 1937 as part of their efforts to provide a college education for women. Marian College was the first Catholic college for women in Indianapolis. In its first year at Riverdale, the entire college, which consisted of twenty-four students and sixteen instructors, was housed within the estate. When the Sisters purchased the property, they retained head groundskeeper Clemens in their service until 1952 (Heidkamp 1952). Due to cost, it is unlikely the Sisters were able to keep as many groundspeople as the Allisons had, and the more naturalistic portion of the property was likely unmanaged.

Ice-skating and rowboating in the ponds and wetlands created by Jensen were major forms of entertainment for students from the 1940s on. The ponds and wetlands were excellent venues for these activities, but they were small. These shallow aquatic habitats were perceived by the students as being clogged and unclean, which reflected the common public perception of wetlands at the time.

In 1946 the Sisters agreed to a plan to dredge the three main ponds to create one larger and deeper lake and then to use the dredge spoil to infill the shallowest two wetland ponds and create a playground area (Bohlen 1946). Ironically, the dredging created drainage problems and may have created more wetland area on the property than the original wetlands that were filled. A substantial portion of Jensen's Clover Meadow became wet and reverted to hardwood swamp over the next several decades. After the dredging and filling of the original wetlands was completed, the December issue of the student newspaper promoted the use of the new lake by encouraging students to include ice skates on their Christmas lists (Anonymous 1946). The new, larger lake was such a success that lights were installed around the lake within a decade to allow for ice-skating at night (Anonymous 1959).

The upper part of campus property underwent major changes as the college expanded. Clare Hall was built in 1949, and Marian Hall was constructed in 1953. To make room for Marian Hall and parking, a large portion

of the estate was dismantled, including a long colonnade, greenhouses, and a portion of the formal gardens. Some of the demolition debris, including the columns of the colonnade, was dumped onto the flat spot located on the western portion of estate where the shallow Jensen wetlands were located. This area became known to the campus community as the Roman Ruins (Yarber 1959). Additionally, when the basements for Marian and Clare Halls were being excavated, their fill was dumped into this same area, further infilling Jensen's wetlands and increasing the ground level three to five meters above its original elevation.

The wetlands and the other habitats located below the bluff were likely used by biology professors as a learning environment for their students as early as 1937. Botany and Taxonomy of the Higher Plants were taught in the early 1940s, followed by Local Flora in the late 1940s and into the 1950s. It is impossible to imagine these classes would not have taken advantage of the variety of vegetation in Riverdale. In the 1960s, Ecology was added to the curriculum and was a required class for biology majors from the 1970s to 2006. The Sisters of Saint Francis undoubtedly used the natural habitats as course materials for their students. The Sisters also used them for their own Franciscan Summer Study, where Sisters engaged in graduate and undergraduate study that included aquatic biology.

In the mid-1950s, the sophomore class created a Campus Conservation Corps to beautify the campus. As part of these beautification activities, the Campus Conservation Corps uncovered old trails around the lake and up to the stone arch bridge. In 1955, 1,650 multiflora rose (*Rosa multiflora*) seedlings were requested through the Indiana Department of Conservation's Living Fence Program (Olivia 1955). Multiflora rose has since become a major invasive species throughout the Midwest. The Campus Conservation Corps also raked leaves and installed plantings, but it is unclear whether they planted within the wetlands and the other habitats located below the bluff (Anonymous 1956).

Renewed Interest

In 1972 Marian College was the recipient of a major grant from the U.S. Department of Health, Education, and Welfare to develop the wetlands of the Riverdale estate into the Marian College Wetlands Ecological Laboratory, which would serve as an outdoor learning environment for Marian College

students and local high school and grade school students (Anonymous 1972). The Minnesota Environmental Sciences Foundation was hired to design the master plan, and they envisioned that the Wetlands Ecological Laboratory would provide unique opportunities for basic research and teacher training in helping people understand their relationship to the surrounding environment (Vogt and Thompson 1973). The master plan included detailed descriptions of twenty-six sites within the Riverdale estate that could be used for teaching topics such as forest understory succession, wildlife observation, long-term ecological studies, and stream studies. The master plan also included a trail designed to depict hardwood forest succession, recommendations for rejuvenating selected springs to enable them to be used for raising fish for restocking and study, clearing Crooked Creek of logs and litter, planting shade-tolerant native understory plants along the bluff for erosion control, and rototilling old trails to loosen soil followed by planting native understory plants. While the site plan was being prepared, students, the Biology Club, and other volunteers removed trash and debris from the site and worked at maintaining water flow through the ponds to the creek.

The Marian College Wetlands Ecological Laboratory was a priority for the college for several years after the 1973 proposal was completed. The laboratory had a director and was used to involve students in learning about their environment and in the development and upkeep of the ecological laboratory itself (Anonymous 1978). The college diverted drainage from parking lots and roadways into culverts and storm sewers to inhibit further erosion. Campus Operations also used telephone poles to block access to the area to prevent dumping. The laboratory produced two books of educational activities to help with environmental education efforts. It is unknown whether these books were ever used. Funds were never secured to complete the plans for the trail system and study sites, and the property underwent a second period of disinterest until the same ideas were resurrected in 2000.

Early in 2000, Marian College students started quietly protesting the dumping that was occurring in the wetlands by Campus Operations and neighbors. The students' interest started a movement to develop the area into a more useable space. Several volunteer days were planned, including one featuring the Marian College president and cabinet. A Conservation Biology class wrote small grant proposals to fund a service-learning project

for 120 third- through seventh-grade students who helped remove debris and plant native plants. These activities attracted public interest, and Indianapolis mayor Bart Peterson visited the campus to see the progress of these efforts.

The local Audubon chapter provided initial funding for habitat improvement, Asian bush honeysuckle (*Lonicera* spp.) removal, and planting a small prairie patch in the former Clover Meadow. This initial effort was followed by major funding from several sources, most notably the Nina Mason Pulliam Charitable Trust. Initial plans were drawn up, loosely following the recommendations from the 1973 Minnesota Environmental Sciences Foundation report (Vogt and Thompson 1973). Smock Fansler Corporation was hired to build the infrastructure of what was then being called the Marian College EcoLab.

The Jensen design for the landscape of Riverdale was rediscovered in a drawer in Marian College Campus Operations. Landscape architect Kevin Parsons, Tom Fansler III, Spencer Goehl from the restoration firm Eco Logic LLC, and biology professor David Benson analyzed the historic plans and found the road system was similar to the planned EcoLab trails. At the time, it was unclear whether the Jensen design had ever been implemented. While scouting out the location for a trail, the large concrete bridge at the west end of the pond was discovered under 0.6 meters of silt. Later, stepping-stones were found in the water along the south edge of the pond. With these finds it became obvious that the Jensen landscape had been built and the direction of the EcoLab project needed to change to include ecological restoration and the restoration of significant historical features.

The approach for historical and ecological restoration of the vegetation in the Jensen-designed area was simple. The Jensen design was followed if the plants specified for a particular area still appeared appropriate when taking the current environment, climate, and knowledge of ecology into account. For example, along the 213 meters of shoreline on the north edge of the main pond, Jensen originally specified the planting of 75 pepperidges, 120 smooth roses (*Rosa blanda*), 140 dogwoods (*Cornus* spp.), 335 crimsoneyed rosemallows (*Hibiscus moscheutos*), 36 hawthorns (*Crataegus* spp.), 42 white birch, and 12 ash (*Fraxinus* spp.). For the dogwood, ash, and hawthorn plantings, pagoda dogwood (*Cornus alternifolia*), green ash (*Fraxinus pennsylvanica*), and downy hawthorn were chosen because all

three were commonly used by Jensen. With the exception of white birch, all of these plants are natives that do well in medium to wet soils and full sun. Although it changed the aesthetics slightly, river birch was used instead of white birch because white birch is not native to central Indiana and would be unlikely to survive the heat. Also, the number of individuals planted in the EcoLab was about ten times fewer than the number specified by Jensen. This may have altered the aesthetics, but the new plantings consisted mostly of 1.5-meter-tall plants, likely much larger than the individuals Jensen planted. The shoreline of the north edge of the main pond was then seeded and planted with a mixture of wetland plant species. Jensen did not always specify plants as understory, but in this case he gave a general list of species to be used along the shorelines of the ponds. The species planted contained all species specified by Jensen and several others to increase the diversity of the community.

Asian bush honeysuckle was noted within the EcoLab area as early as the 1940s, although it is unclear whether these early observations referred to Japanese honeysuckle (*Lonicera japonica*) or Amur honeysuckle (*Lonicera maackii*). By 2000, Amur honeysuckle was the dominant shrub within the EcoLab and was so abundant that it forced those marking the locations of the EcoLab trails to crawl through the shrubs. Other invasive shrubs and vines such as privet, multiflora rose, Japanese honeysuckle, common buckthorn (*Rhamnus cathartica*), Oriental bittersweet (*Celastrus orbiculatus*), and Norway maple (*Acer platanoides*) occupied the areas where Amur honeysuckle coverage was less than complete. Likely the majority of the EcoLab was overrun by invasive shrubs and vines by the turn of the twenty-first century. In 2001, the first major restoration action for the EcoLab was to remove the invasive shrubs and vines. Immediately afterward a mixture of silky wildrye (*Elymus villosus*), Canada wildrye (*Elymus canadensis*), and Virginia wildrye (*Elymus virginicus*) was planted in the newly opened areas, and then tree and shrub seedlings following Jensen's plan as described above were planted.

Restoration of the EcoLab also involved the removal of large quantities of fill to restore the wetlands in their original locations as specified by Jensen. The main pond was recontoured using this fill to more closely match the initial Jensen-designed shape of ponds one, two, and three. The recontouring of the main pond also allowed the trails to be installed in the original conformation of the roads and footpaths at Riverdale.

Prior to implementation of Jensen's landscape design, the Riverdale estate consisted of agricultural land devoid of almost all woody plants. There is no doubt that Jensen was attempting to create a particular aesthetic in his design. Notably, he chose plant species quite similar to those that many restoration practitioners would choose today, and his design called for groupings of native plants as they would be found in nature, fitting the region, microclimate, and soils of the area being planted (Grese 1992).

Of the many thousands of trees that were specified in Jensen's landscape design of 1912, only a small number are present within the EcoLab. A 2002 study documented the presence of only 116 trees of the correct species and approximate location specified in Jensen's original design. Of these trees, only twenty-three oaks (*Quercus* spp.), twenty-three sugar and black maples (*Acer saccharum, Acer nigrum*), fourteen eastern red cedars (*Juniperus virginiana*), and twelve eastern white pines (*Pinus strobus*) were approximately the right age to have been planted by Jensen. Approximately half (thirty-six) of the Jensen-aged trees that remained occurred within the naturalistic portion of Riverdale and therefore were not likely to have been subjected to pruning or trimming by the ground crews. Additionally, twenty-three shrubs were found of the correct species in the correct approximate location.

Much of the loss of Jensen's original plantings may be due to human impacts after the purchase of the property by Marian College in 1937, such as the dumping of fill into one of Jensen's wetlands, the recontouring of the main pond, and extra fill that was pushed over the bluff. These actions would have smothered sensitive root systems and caused stems to rot. Other plants were likely lost to natural ecological processes such as disease, climatic conditions, and succession. For example, it is likely white birch expired due to disease and climatic conditions because it often succumbs to bronze birch borer (*Agrilus anxius*) infestation and the heat. Additionally, the staghorn sumac (*Rhus typhina*) planted alongside sugar maples were probably shaded out by their larger neighbors. Other smaller species of shrubs and trees might have been lost as a result of the invasion of non-native shrubs and vines.

Assuming the landscape was installed as designed, which was not always the case (Grese 1992), only a small percentage of Jensen's original plantings survived (Benson 2004). However, the resulting native plant community

of the EcoLab was in remarkably good shape in 2001 and exhibited a 3.3 mean coefficient of conservatism and a high floristic quality index score (53.5) (based on a recalculation of data obtained by Tungesvick [2003] using Indiana coefficients of conservatism). The EcoLab's floristic quality index score is a good indication of the success of Jensen's design, especially considering what this score was prior to the implementation of the design, when the property was in agricultural production. The property also has high breeding bird and mammal diversity.

Additionally, a five-year evaluation of the plant responses to the 2001 removal of invasive shrubs and vines documented that by 2007, native plant species richness within upland habitats increased by nine species and the percentage cover of native plants increased by 15 percent. Additionally, native plant species richness in the lowland habitats of the EcoLab increased by three species and the percentage cover of native plants increased by 14 percent. Wetlands that had been spared the effects of invasion by Amur honeysuckle exhibited no changes in species richness or percent coverage of native plants during the same time period. Overall, these results highlight the positive impacts that the 2001 removal of invasive shrubs and vines had on native plants within the EcoLab.

Although much of Jensen's design focused on installation of plants within the Riverdale estate, it is notable that his manipulation of hydrology by digging ponds and wetlands and the removal of some of the subsurface drainage tiles may have been some of the most beneficial manipulations he made. Removal of these drainage tiles, plus the accidental clogging of others, led to the restoration of several springs and the reestablishment of a more natural hydrological regime within the EcoLab. Over a long time period, this altered hydrological regime led to the Clover Meadow changing from a plot of nonnative turf grasses and clover into a hardwood swamp. Breeding American woodcock (*Scolopax minor*) and beaver (*Castor canadensis*) have been documented in this location. The presence of beaver is likely another cause of the continued success of the restoration, because their presence has helped maintain a more natural hydrological regime.

The Marian College EcoLab (currently the Marian University Nina Mason Pulliam EcoLab) case study illustrates how Jensen's designed landscape laid the foundation for a modern-day ecological restoration project. At the time Jensen designed the Riverdale estate, plant availability was likely limited, the knowledge of ecology was elementary, and ecological resto-

ration had not been conceptualized. Yet the project was successful in part because Jensen applied the knowledge of ecology and botany learned from Cowles and his other ecologist friends to design landscapes in a way that anticipates the practice of modern-day ecological restoration. In conclusion, we feel Jens Jensen himself would consider his historical efforts and the current Marian University restoration efforts to be important because the site provides refuge from modern life for the people of a large urban city and an educational center that promotes the beauty and value of natural habitats in the Midwest.

CONCLUSIONS

Our syntheses of the relationships among pioneers in ecology and landscape architecture and the history of the Marian University Nina Mason Pulliam EcoLab highlight how historical precursory restoration efforts lacking an ecocentric approach laid the foundations for ecological restoration in the Midwest. The relationships between these pioneers also highlight the strong historical link between ecology and ecological restoration in the region, and they bring to the forefront the contributions that Chicago- and Illinois-based individuals and institutions made toward the development of both fields. The history of the EcoLab illustrates how a precursory restoration effort lacking an ecocentric approach provided the foundation from which ecological restoration could emerge as the discipline of ecology matured. In conclusion, the lessons learned from these precursory restoration efforts highlight the shared heritage of the science of ecology and its application to ecological restoration, which in turn confirms the importance of integrating science and practice within ecological restoration in the Midwest.