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From the Ground Up: Natural History Education in an Urban Campus Restoration

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Abstract - We discuss the first phase of development of the Volusia Sandhill Ecosystem, a teaching landscape on the grounds of the Gillespie Museum, on the DeLand, FL, campus of Stetson University. Since its initiation in 2011 with the planting of a canopy of 80 trees, undergraduates and community volunteers have contributed to the site's development as an urban-habitat fragment of the *Pinus palustris* (Longleaf Pine) forests that once dominated the sandy ridges of Central Florida. In the first 5 years since its establishment, the site has provided hundreds of undergraduate students opportunities to participate in site development and interpretation, including the design of new outdoor activities that have been incorporated into the museum's K–6 programming. The Volusia Sandhill Ecosystem is a case study for how, with volunteer labor and modest funding, a small but visible corner of a university campus has been developed as a community-based environmental project, a research site for the undergraduate curriculum, and an urban forest with environmental benefits.

Background

The Volusia Sandhill Ecosystem provides an outdoor classroom and demonstration site on the grounds of Stetson University's Gillespie Museum of Minerals and adjacent environmental learning center in DeLand, FL. In its 5th year of development, the landscape is a 0.5-ha, ongoing restoration of the *Pinus palustris* Mill. (Longleaf Pine) sandhill habitat that was native to western Volusia County before the area's agricultural and residential transformation began in the 1880s. The campus is situated within the historic sandhills of the DeLand Ridge, an area typified by rolling topography and well-drained sandy soils (German 2009). Like other areas throughout the coastal plain of the southeastern US prior to European settlement, the pine uplands on the ridge were dominated by Longleaf Pine and characterized by a diverse herbaceous understory (Peet 2006). Over the last 150 years, these forests have been reduced to roughly 3% of their historic range, lost largely to urbanization, citrus agriculture, lumbering, and fire suppression (Frost 1993). Within the city of DeLand, and on Stetson's campus, most Longleaf Pines have been removed and replaced by *Quercus* (oak). As a result of city beautification projects in the mid-1920s and again in the early 1970s, Longleaf Pine ecosystems have not only been fragmented, but the pines themselves were removed.

Our restoration project began in 2011, when the opening of a new environmental learning center created a need and an opportunity to create a landscape that embodied a commitment to native habitat and sustainable practices. Through this

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restoration, we have developed a small, urban ecosystem similar to the habitat that once occupied the site, demonstrating the benefits of restoring even a fragment of a natural system (Fig. 1). In the first 5 years, over 1500 volunteers at all levels of expertise (including ecologists, undergraduates, K–12 students, and community gardeners) have engaged in planting, research, and interpretation at the site. We utilized a modest budget and thousands of volunteer hours to transform the site from an open, neglected field to a young forest of more than 80 trees and over 1000 understory plants representing 49 species associated with the sandhill habitat. Support from the university has taken several forms, including funding for a walking path, and the freedom to allow the project to grow under its own momentum and the fluid interests of participants. Now seen by over 11,000 museum visitors and uncounted numbers of campus pedestrians and community cyclists on the nearby multi-use trail, the teaching landscape has a broad reach. Here we describe the benefits of using a small tract of campus land to educate and engage the community, to provide a convenient and visible research site for undergraduates, and to develop and maintain an ecosystem with intrinsic value.

A Community-based Project at an Earth Science Museum

As the university's earth science museum, the Gillespie has for the last 5 decades fulfilled an environmental mission to (1) provide the community a highly accessible area for studying natural history through collections and environmental projects (Fleischner 2011, Hampton and Wheeler 2012); (2) offer the museum and grounds as an instrument for change (Weil 2012); and (3) promote community participation in exhibits, interpretations, and, with the current project, ecosystem restoration (Simon 2010).

The landscape surrounding the museum provides opportunities to educate visitors about Florida's natural history. Indoors, the museum features mineral collections and earth science displays on Florida minerals and fossils and a gallery devoted to Florida's natural communities, where small, temporary exhibits connect earth science and the state's environmental legacy. As part of a broader university commitment to environmental responsibility made in the mid-1990s, the museum grounds were landscaped with 240 trees and shrubs native to Florida. The project inspired development of a native-tree policy for the campus, which is now designated by the Arbor Day Foundation as a Tree Campus USA.

The opening of the Rinker Environmental Learning Center in 2009 was the impetus for a new native landscape, this one featuring an imperiled ecosystem. Unlike the museum's earlier initiative, which created a sense of place more broadly, we conceived the Volusia Sandhill Ecosystem as place-based—a project that reflected the natural history of the specific site (Davenport and Anderson 2005).

A Research Site to Support the Undergraduate Curriculum

The Volusia Sandhill on Stetson's campus provides undergraduates with opportunities to apply scientific knowledge to real-world ecological situations; the

experience increases their scientific literacy (Reynolds and Lowman 2013) and strengthens student commitment to conservation (McFall 2011). On the southeastern

Figure 1. The Volusia Sandhill Ecosystem was initiated on a neglected field adjacent to Stetson University's Rinker Environmental Learning Center in 2011. (A) The first Longleaf Pine tree was planted to commemorate Arbor Day that year. (B) Five years later, the site has nearly 80 trees and a developing understory.

corner of campus, the site is accessible for outdoor classroom and laboratory exercises for undergraduate courses in the natural sciences (including plant ecology, geography, environmental sciences, and introductory biology for both majors and non-majors) as well as instruction and self-directed study for students in the humanities and social sciences (such as nature writing, environmental policy, and museum studies). The restoration area is situated on the campus periphery; thus, it was less managed and manicured than the center of campus. The more natural conditions at the site created opportunities for student engagement in restoration, including individual research projects related to the ecology and natural history of Florida's sandhills.

An Urban Forest

The Sandhill Ecosystem project has introduced elements of the historic landscape, and recreated some of the habitat and services of intact sandhills on a plot with highly altered soil covered in turfgrass and weeds. Home to many locally rare and endemic species, sandhills and other Longleaf Pine ecosystems that once dominated the North American Coastal Plain are recognized as a hotspot for biodiversity (Noss et al. 2015). This rich diversity has been threatened, however, as Longleaf Pine ecosystems have been reduced by human exploitation over the last 150 years (Jose et al. 2006). The dry, upland sites occupied by sandhills in Florida are gravely imperiled because they continue to attract new land development for residential, commercial, and even recreational uses (particularly golf courses) (Noss 2012).

In Florida, the largest remaining tracts of Longleaf Pine occur on federal and state lands. While management of large national forests and other protected land is centrally important to modern conservation efforts (e.g., Hodgson et al. 2011), small urban/suburban fragments of native habitat can also play a role in conserving biodiversity (e.g., Alvey 2006, Baldock et al. 2015) and providing ecosystem services (Niemelä et al. 2010). Given the small size and recent origin of the Volusia Sandhill Ecosystem, the soil characteristics, vegetation structure, and total plant diversity differ from protected tracts of undisturbed sandhill habitat. As a result, the plant and animal assemblages are likely to remain a novel mixture of species, not completely reflective of those found in large sandhill occurrences (e.g., van Nuland and Whitlow 2014). We expect, however, that with intentional management designed to mitigate those differences (e.g., the introduction of fire and continued removal of turfgrass), generalist species common to sandhill habitats, particularly those at lower trophic levels (e.g., Gibb and Hochuli 2002), will populate the site. Importantly, this 0.5-ha area will ultimately offer a home for pollinators, other arthropods, birds, reptiles, and amphibians that would otherwise be absent from our 51-ha campus.

Approach

In every sense, this project has developed from the ground up. The site was made available with the opening of a new environmental center and consensus that the landscape should extend the museum's native plant initiative; the geologic history

and notable slope of the site shaped our plan to establish a Longleaf Pine sandhill ecosystem. From the start, that plan has been informal and flexible, beginning with a brief mission statement (to establish a native ecosystem as a teaching landscape), a list of species to plant, and a schematic site plan. Plants have been added and lost, small areas have been designated for uses not originally conceived, and the project has gained partners. While expediency, funding, and volunteer commitment have driven various stages of site development, the central narrative for interpretation has remained the same and is guided by an early proposal for 10 "teaching stations" related to the cultural and natural history of sandhills.

We have measured progress informally and by the academic calendar. Typically, changes are most noticeable during fall and spring semesters, when trees, understory plants, and seedlings are introduced and educational programming and interpretation are developed (Table 1). Maintenance and some outdoor programming occur in summer months.

The site was first established—environmentally as well as visually—in the summer of 2011, with the installation of a temporary gray-water irrigation system and the planting of 65 Longleaf Pines (from grass stage to 10 years old), 10 *Prunus caroliniana* (Mill.) (Aiton) (Carolina Laurelcherry), 7 *Diospyros virginiana* L. (Common Persimmon), and 6 *Quercus laevis* Walter (Turkey Oak) trees. We purposely planted at a density that is slightly higher than would be found in a mature Longleaf Pine forest (Gilliam and Platt 1999) because it was important to establish a visual impact on the site even in the early stages. We expect some mortality and are prepared to remove mature trees, if necessary, to retain the grassland community structure associated with historic sandhills. We set up and expanded understory plots during a series of community workdays and class projects in the 1st and 2nd years (2011–2013). Each new area provided manageable projects within areas typically 30–40 m^2 in extent, with a visible outcome and a volunteer group to highlight in publicity. In the first years, over 700 volunteers helped to move the project forward.

In year 3 (2013–2014), we clarified our strategies for interpretation. With support from an undergraduate intern, and photographs from a biology faculty colleague, we researched sign companies, sought funding for walking paths, and began an almost 2-year collaboration to design and manufacture trail signs (Fig. 2). In the same period, we were awarded grants from 2 state organizations, which enhanced the project's visibility in the region. We used text and imagery from these grant applications to create webpages on the museum's site.

Years 4 and 5 (2014–2016) brought significant change. We installed a 50 m x 100 m demonstration garden (funded by the Florida Wildflower Foundation) at the southern entrance. This garden doubled the understory plantings of blooming species, and it was installed during a series of well-publicized and well-attended volunteer days. Grant funding also supported 2 new brochures: *Why Plant Native* and *Florida Wildflowers in the Volusia Sandhill Teaching Landscape*. Other undergraduate projects followed, including the development of outdoor classroom activities and a seed library. In the current year, new concrete and gravel walkways and interpretive trail signs were installed and 3 new interpretive areas were completed. The teaching landscape is now a place to visit as well as a place to volunteer (Fig. 1).

Table 1. Timeline for Volusia Sandhill Ecosystem development and interpretation. Interpretive projects are italicized.

Year	Development stage	Campus and community partners
2011–2012	Arbor Day planting, tree 1	Faculty/staff Tree Fund, volunteers
	Reclaimed water irrigation; planting of canopy (full site)	Volusia County environmental grant, Sandhill intern, campus volunteers
	Understory plants (northern entrance)	Volusia County environmental grant, Student volunteers
	Pollination Garden	Biology 305 class project
	Certification as Wildlife Habitat	Biology 305 class project
	Maintenance and plant labeling	Volunteers; Biology 112 students
	Wiregrass plots	Volusia County environmental grant, volunteers, Biology 100 students
	2 *Science Saturday programs*	Biology 305 and 450 class projects
	The Volusia Sandhill Ecosystem (2-pages, with site plan)	Project directors
2012–2013	Expansion of northern entrance plantings	Student volunteers, Stetson Beekeeping
	Wiregrass plots	Campus and community volunteers
	Maintenance and plant labeling	Student volunteers, museum staff, English 305 class project
	Grass-stage Longleaf Pine planting	Florida Department of Forestry
	2 *Science Saturday programs*	Biology 450 class project
	Sandhill Scavenger Hunt	Biology 450 class project
2013–2014	Expansion of northern entrance plantings	Volunteers, Biology 100 students
	Expansion of Pollinator Garden	Biology 305 class project
	Research and development of interpretive signs	Project directors, Sandhill intern, faculty colleague/photographer
	Website development	Sandhill intern
2014–2015	Florida Wildflower Demonstration Garden (southern entrance)	Florida Wildflower Foundation grant, Florida Native Plant Society, student volunteers, Biology 450 class project
	Persimmon Hollow planting	Faculty/staff Tree Fund, student volunteers
	Maintenance and plant labeling	Student volunteers; Biology 112
	Seed library	Honors 102 class project
	Interpretive sign for Wildflower Garden	Biology 450 class project
	Why Plant Native? (brochure)	Florida Exotic and Pest Plant Council grant, Sandhill intern
	Website maintenance	Sandhill intern
	Engaged Learning activities for K–6 fieldtrips	Independent study project
2015–2016	Wildflower seed collecting and sowing	Stetson seed library, campus volunteers
	Native Orchid Garden installation	Biology 375 class project
	Wildflower Teaching Circle	Biology 375 class project
	Florida Botanical Explorers Garden installation	Biology 450 class project
	Maintenance and plant labeling	Student volunteers, Biology 450 class project
	Arbor Day planting and working	Biological Honor Society Beta Beta Beta
	Installation of walking paths and interpretive signs	Stetson University facilities, museum staff, student volunteers
	Native Florida Wildflowers in the Volusia Sandhill Ecosystem (brochure)	Florida Wildflower Foundation grant, Sandhill intern
	Storyboard interpretive signs	Biology 375 and 450 class projects

Outcomes: The First 5 Years

Museum programming

The Volusia Sandhill Ecosystem has provided opportunities to move museum activities outdoors, for new hands-on and participatory environmental education and self-guided tours (Figs. 3, 4). It has allowed for a new menu of field-trip activities including Florida Ecosystems—a curriculum for K–6 science classes. Each of the 4 options (Native Plant Scavenger Hunt, Soil Profile, Pollination Study, and Leaf Transpiration Lab, available at http://www.stetson.edu/other/gillespie-museum/index.php) allows students the freedom to roam outdoors, collecting, testing, reporting, and collaborating with museum guides (Tal and Morag 2007).

In the museum's monthly Science Saturdays and Summer Outdoor Classrooms**,** young scientists and their families are regularly engaged in planting or seed sowing, as well as observation and experimentation in or interpretation of the site. For these weekend programs, undergraduates (as volunteers or through class projects) create informal activities at various learning stations; children choose activities and their level of engagement. Free-choice childhood experiences contribute significantly to science literacy (Falk and Dierking 2010).

The walkways and interpretive signs through the ecosystem enable self-guided discovery, for visitors of all ages (Figs. 3, 4). To date, we have assessed visitors' and volunteers' impressions informally, mostly through open inquiry and anecdote. Written responses to questions asked of over 150 undergraduate volunteers and

Figure 2. The 4 types of signs used in the Volusia Sandhill Ecosystem are: (A) interpretive trail, (B) informational species, (C) storyboard, and (D) plant identification signs (listed in descending order of cost and permanence).

visitors demonstrate that they had learned to recognize and appreciate important key features of the ecosystem including that it is pyrogenic, the sandy soils are nutrient-poor, and why and how its plant community is adapted to dry conditions. In addition, the answers indicated an awareness of the loss of Longleaf Pine Sandhill habitat and its impact on native plant diversity. One student offered this remark: "Though I've lived in Volusia County for my entire life and have been surrounded by Longleaf Pines, I'd not recognized the importance of this ecosystem."

Undergraduate education and research

Over the last 5 years, more than 500 students, with a broad range of interests and talents, have developed the Volusia Sandhill Ecosystem by participating in semester-long projects in a class or collecting data in a laboratory course as part of an independent research project (Table 2). Class projects, which have included the installation of several water features, a pollination garden, and bird houses, resulted in the site's being certified by the National Wildlife Federation as wildlife habitat. Recent student research investigating the effects of pH and native soil biota has produced results that will inform our continued restoration efforts and lead to additional research questions. Similarly, data collected on Longleaf Pine tree height and diameter, as well as bird and insect diversity and abundance will be used as a

Figure 3. On a Sandhill scavenger hunt (site-specific and free-roaming), Science Saturday visitors can learn as they go.

Figure 4. A museum without walls, the teaching landscape offers a place for the campus and community to learn about and recreate a native ecosystem. Undergraduates drive the project.

point of comparison for future research as the site continues to mature. Descriptions of methodology and results for several of these projects are available at http://www.stetson.edu/other/gillespie-museum/vse/research.php.

Students introduced to the site through a class activity have responded positively, often continuing to volunteer long after their graded work has ended. They provide physical labor by planting, mulching, and weeding on workdays, and contribute intellectual and creative energy to Science Saturday events. Students have also raised awareness of the site by creating a site logo, emblazoned on t-shirts worn proudly by volunteers; contributing to a website and Facebook page, which now features a Wildflower Wednesday post each week; and creating Storyboard signs of 15 to 20 words, that explain a variety of features of the landscape (Fig. 2).

Table 2. Data collection and research projects conducted in the Volusia Sandhill Ecosystem.

Research title	Project type*
Calculating growth rate of Longleaf Pine (*Pinus palustris*)	Lab component in plant ecology course (n = 16 students)
The effect of biotic and abiotic factors on the germination and establishment of several understory species common on Florida sandhills	Lab component in plant ecology course (n = 16 students)
Comparing the abundance and diversity of insect pollinators between the Volusia Sandhill Ecosystem and a mature sandhill site	Lab component in plant ecology course (n = 18 students)
Survey of insect biodiversity in the Volusia Sandhill Ecosystem teaching landscape	Independent study project
The effects of small-scale, young-growth, restored sandhill on avian diversity of Stetson University's campus	Independent study project
Acidic soils benefit seedling growth in 2 perennial plant species native to Florida sandhills.	Independent study project
A vanishing ecosystem: Longleaf Pine decline in West Volusia County	Senior research project (Environmental Science)
Herbicide effectiveness on weeds in a restored Florida sandhill and its effect on germination of *Aristida stricta* (Wiregrass)	Senior research project (Environmental Science)
The effect of seed density of an aggressive weed (*Bidens alba*) on the germination of 3 native, perennial sandhill species	Senior research project (Biology)
Restoration of sandhill ecosystems: The importance of soil fungi on the growth of a native perennial, *Liatris tenuifolia* Nutt.	Senior research project (Biology)
The effect of soil pH and fungi on the growth of a native sandhill perennial.	Senior research project (Biology)
The effect of priority in competition between an aggressive weed (*Bidens alba*) and a native perennial (*Asclepias tuberosa*).	Senior research project (Biology)

*Each of the independent study projects was initiated by a student, introduced to the Volusia Sandhill in their coursework, prior to their senior year. Senior research projects fulfilled the capstone requirement in a student's major and were conducted by students who were initially introduced to the site through their coursework.

Ecosystem development

The landscape currently hosts more than 80 trees, mostly Longleaf Pine. We continue to incrementally remove turfgrass and weeds chemically and manually (hoeing and solarization) from small (~30–40 m^2) areas designated for a particular planting scheme (e.g., *Aristida stricta* Michx. [Wiregrass] plots, wildflower seed beds). Before plants are installed in a new area, the ground is covered by paper and overlain with landscape cloth and pine-straw mulch to control undesirable species. These sites, combined with defined garden areas that are more formally defined (i.e., Pollinator Garden, Wildflower Demonstration Garden, and Wildflower Study Site), contribute nearly 50 species of annual and perennial forbs to the landscape, significantly increasing plant diversity relative to the rest of our traditionally landscaped campus.

To increase understory diversity beyond species that are readily available commercially, we are also increasing our efforts at propagation of plants from field-collected seeds (e.g., *Asclepias humistrata* Walter [Pinewoods Milkweed], *Arnoglossum floridanum* (A.Gray) H. Rob. [Florida Indian Plantain], and *Froelichia floridana* (Nutt.) Moq. [Cottonweed]). With the exception of *Chamaecrista fasciculata* (Michx.) Greene (Partridge Pea), direct seeding has produced few adult plants. In order to improve germination and seedling success in the future, the site also includes an unplanted area designated for student investigation, where research projects will be conducted, in situ, for direct application to future management plans.

The time scale for measuring success for a project like this likely exceeds our lifespans. However, one indication of success comes from reproduction of established plants. In the spring of 2016, more than half of the Longleaf Pine trees produced male cones and several are currently maturing female cones. Similarly, the Common Persimmons have produced copious flowers each year and even some self-sown seedlings that established on the site. Likewise, several understory species have been exceptionally successful at spreading through the landscape, including *Pityopsis graminifolia* (Michx.) Nutt. (Narrowleaf Silkgrass), *Vernonia angustifolia* Michx. (Ironweed), *Coreopsis* spp. (tickseed), and *Solidago odora* Aiton (Sweet Goldenrod). Ongoing measurement of pollinator diversity and abundance will allow us to determine the effect this expanding plant community has on the local insect community and, eventually, higher trophic levels.

Conclusion

Development of the Volusia Sandhill Ecosystem began with a broad vision, which has been realized through continual volunteer support and small, purpose-driven projects often embedded in semester-long coursework. Its presence on a college campus, adjacent to an earth science museum with a long history of outreach, makes this site ideal for education focused on the upland Longleaf Pine forests within which so many southeastern towns have developed (Heuberger and Putz 2003). As a modest, developing fragment of this native community, the site provides an accessible place for experiential natural history education at a time when interest in field studies is waning (e.g., Noss 1996, Tewksbury et al. 2014), and

when increasingly large segments of society receive their natural history education through electronic encounters with vast remote areas and dramatic landscapes. The small, personal scale of the site, intended to reflect a historic landscape, brings a natural system to a place where people live, study, and work. A notably succinct student response to the question "Would you recommend the Volusia Sandhill as a place for fellow students or family members to learn about native ecosystems?" was "Yes, because it is and is not wild." With the development of the biological community and the infrastructure to lead visitors through informed engagement with the restoration, we can begin to more rigorously assess the effectiveness of both formal and informal science education in the site (e.g., greater awareness of the benefits of native pollinators, or the relationship between the mineral and biological components of the ecosystem).

Small urban/suburban fragments of native habitat such as the Volusia Sandhill Ecosystem also contribute to the vision of a "humane metropolis" (Pickett et al. 2011) where at least some of the biodiversity and ecosystem services of natural systems can be maintained in a human-dominated landscape. The degree to which the site meets these goals is under continual study, and the possibilities for future projects seem endless. In the next 5-year phase, we will develop the Teaching Landscape as we have done with the site's other areas: through small, flexible, and inexpensive projects which can be completed in a few weeks' or, at most, a few months' time. We hope to find a balance between research into and experimentation with management practices (e.g., introduction of fire, soil amendments, seed and seedling propagation) and development of educational programming and additional interpretative signs and strategies (e.g., a fossil dig site, a soil-profile station, additional trail signs about native pollinators, Florida geology, and plant diversity). As a participatory, outdoor museum, the site will continue to promote formal and informal scientific research as well as community engagement.

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