Chapter 9
Art to Capture Learning About the Longleaf Pine Ecosystem – Why a Picture Is Worth a Thousand Words

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> the sustainable ecological knowledge that youth gain from experiences goes beyond comparison with those gained by mere expressions and written words – (Mitchell and Mueller 2011, p. 219)

Nestled within 48,000 acres of privately owned conservation lands in the Florida Panhandle is an oasis for environmental learning – The E.O. Wilson Biophilia Center at Nokuse Plantation. The Center is the capstone to an ambitious environmental stewardship project, Nokuse Plantation, conceived and implemented by M.C. Davis, with the mission to create a model that connects the large-scale preservation of lands with experiential learning. The center serves as a catalyst for the preservation of nature's biodiversity. Davis believes that the future of biodiversity lies in the combined resources of multiple actors and is best accomplished "by joining the passion of individuals with the resources of the entrepreneur and the power of government, all guided by science" (http://www.nokuse.org/).

Nokuse Plantation (pronounced "no go zee") is the Creek Indian word for black bear. It was during a public presentation on the Florida black bear that Davis began to understand the need for its protection and restoration of bear habitat. He decided to direct his attention and skills as a private businessman to build on existing conservation projects in an effort to provide a large-scale network of conservation lands. The black bear is considered an "umbrella species" because of its wide ranging habitat needs, and by addressing the needs of such a species, protection will be afforded to many other less widely ranging species that comprise the ecosystem (Noss 1991).

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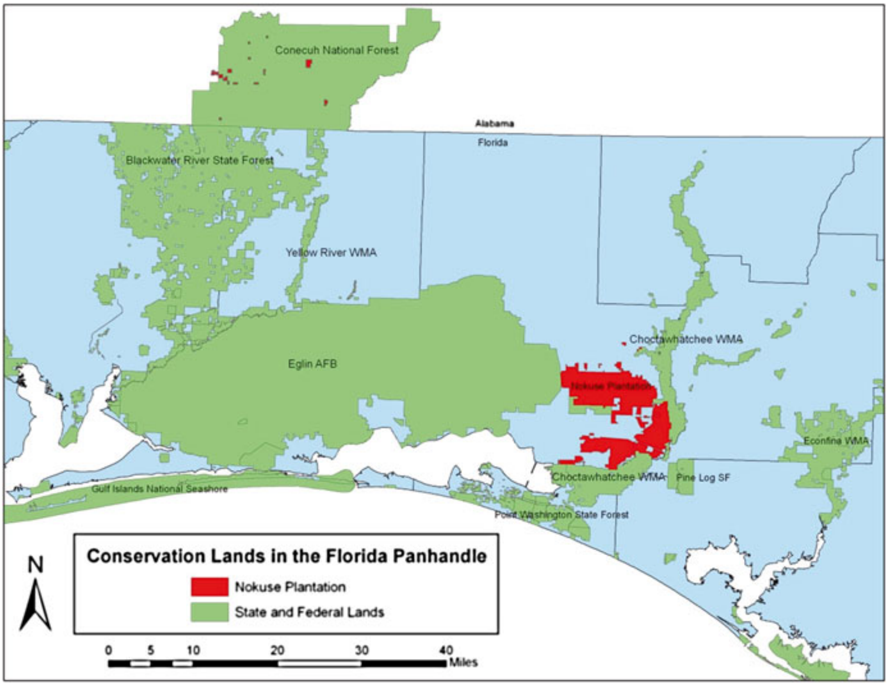

Fig. 9.1 Landscape location of Nokuse Plantation and the greater Panhandle conservation lands

Securing the necessary lands for Nokuse Plantation occurred over many years and was driven by the favorable conditions that allow private interests to work in ways that are not permissible by public entities. Lands could be held in trust out of the public gaze which allowed the piecing together of the essential parcels without unsubstantiated price inflation. It also provided the flexibility to purchase lands, if deemed essential to the project, at prices that sometimes exceeded market value – an option that is generally not available in public acquisitions. This process resulted in the accumulation of those core lands managed and preserved as the Plantation. The Plantation, however, is a cog in a larger conservation project that joins state and federally lands in a virtually contiguous 1,000,000 acres that reaches into Alabama (Fig. 9.1).

The Longleaf Pine Ecosystem

Much of the uplands, and portions of the wetlands, within the larger landscape covered in Fig. 9.1, and specifically within the Plantation, were historically dominated by longleaf pine (*Pinus palustris*). It is estimated that longleaf pine has been eliminated as the dominant tree from 97 % of the lands it once covered prior to European settlement in the area between Virginian and Texas (Frost 1995). The precipitous decline of this community type is attributed to the land use changes that have occurred since early presettlement years, including conversion for agriculture, grazing by livestock and fire suppression (Frost 1995). The single most devastating impact was from logging for the production of ship masts and dwellings throughout the continent and Europe (Whitney et al. 2004). Once logged from its historic range, early foresters documented the inability of this pine species to replace itself. They determined that the destruction of seedlings by free ranging hogs and fire were the primary causes (Ashe 1894a as cited in Frost 1993). While hogs indeed impact longleaf seedling survival, fire is not the enemy as once thought, and in fact, is a required disturbance for the maintenance of longleaf ecosystems and species. The necessary conditions for survival and perpetuation of the greater longleaf pine ecosystem and its integrated micro-communities is the focus for the curriculum, facilities and exhibits of the E.O. Wilson Biophilia Center.

Goals of the Center

The mission of the Center "is to educate visitors on the importance of biodiversity, to promote sustainable balanced ecosystems, and to encourage conservation, preservation and restoration" (http://www.nokuse.org/). The Center involves the local public school system in an active partnership to engage students with ecological issues. Multiple grades are afforded the opportunity to come to the Center, however we focus on the experience of grade 4 students for this chapter.

The exhibit hall combines both free exploration and some guided learning. Stations include longleaf pine ecosystem dioramas, frog biome, bird window, gopher tortoise burrow replica suitable for students to crawl through, snake and aquatic turtle exhibits, photosynthesis model, animal sounds "piano", and multiple taxidermies of typical and iconic inhabitants of the ecosystem (Fig. 9.2). Trails through remnant and recovering longleaf pine forest, embedded wetland communities, and upland bluffs that transition into hardwood wetlands, provide direct contact with the ecosystem. Students have guided learning opportunities with gopher tortoises, animal tracks, embedded microcommunities, specific plants, predator-prey relationships, and various vertebrate and invertebrate species collected by stationary pre-set traps nearby.

How important are such experiences with the natural world? Consider the notion of ecological literacy that has been that has been proffered by David Orr (1989, p. 334):

> To become ecologically literate one must certainly be able to read, and I think even like to read. Ecological literacy also presumes the ability to use numbers, and the ability to know what's countable and what's not, that is, to know the limits of numbers. But these are indoor skills. Ecological literacy requires the more demanding capacity to distinguish between health and disease in natural systems and to understand their relation to health and disease in human ones; knowledge of this sort is best acquired out-of-doors.

Fig. 9.2 View of the exhibit hall of the E.O. Wilson Biophilia Center showing the gopher tortoise burrow and dioramas

In order to engender ecological literacy we must immerse students in the study of nature and provide a sense of ownership to the issues and the power to make a difference (Mitchell and Mueller 2011). This supports the core goal of the American Association for the Advancement of Science (Rutherford and Ahlgren 1989, p. xiii), which states that science education "should help students to develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves and to face life head on". Ecological literacy supports the holistic development of a well-rounded citizen.

The Outdoors as a Classroom

Varied research suggests that field-based lessons and curriculum generate greater cognitive understanding than when those same concepts are imparted in the classroom exclusively. Nigerian students that have first hand experiences with organisms in their natural habitats have increased performance on ecological assessments when compared to those exposed to the content only in the classroom setting (Hamilton-Ekeke 2007). Focusing on potential gender differences, the gains for

4th and 5th grade boys are especially high for an environmental education curriculum that incorporates lessons out of doors when compared to only traditional classroom instruction (Carrier 2009). Experienced-based strategies in the natural environment are more effective than complimentary traditional strategies in encouraging student learning for sustainability in Queensland (Ballantyne and Packer 2009), and residential programs are shown to be "influential in forming long-term memories and knowledge" among 5th grade participants in Idaho (Knapp and Benton 2006). Isabel Ruiz-Mallen et al. (2009) note that school students who participated in a local outdoor environmental education program have greater ecological knowledge based upon a combination of qualitative and quantitative assessments than those who do not participate, even when the control group has compulsory ecological classes. Justin Dillion et al. (2006, p. 107) find "substantial evidence to indicate that fieldwork, properly conceived, adequately planned, well taught and effectively followed up, offers learners opportunities to develop their knowledge and skills in ways that add value to their everyday experiences in the classroom". In a program that focuses on increasing children's everyday perception of local plants and animals on their way to and from schools in Switzerland, participation is shown to increase the identification of common species when compared to a control group (Lindemann-Matthies 2002). Adrienne Cachelin et al. (2009, p. 13) contend that the "rich peripheral signals generated in outdoor contexts actually allow the brain to store the information differently: in spatial memory", ultimately leading to lasting learning. This is consistent with the understanding that memory is enhanced when concepts are stored in "natural, spatial memory" (Knapp 1992, p. 6).

Environmental Education and Broader Educational Goals

One of the earliest definitions provides that "environmental education is aimed at producing a citizenry that is *knowledgeable* concerning the biophysical environment and it associated problems, *aware* of how to help solve these problems, and *motivated* to work toward their solution" (Stapp et al. 1969, p. 54). The literature also suggests that the benefits of environmental education extend beyond the potential to develop environmental responsible behavior and impacts broader educational goals. Wolff-Michael Roth et al. (1996) argue "that traditional science teaching leads to (a) singular and mythical views about science and scientists, (b) scientifically nonliterate citizens, and (c) knowledge that is of little use outside schools" (p. 460). The ability for environmental education to provide a range of perspectives on topics through its multi-disciplinary roots and inclusion of situated learning "offers a conceptual richness that challenges current thinking in science education" (Dillon and Scott 2002, p. 1112). In sum, environmental education has the potential to engage students with issues that extend beyond nature and reach to the fundamental "character of education as a whole" (Bonnett 1997, p. 249).

Contextualizing the Assessment of the Impact

Although strongly linked to the local school districts, the Biophilia center is best characterized as an informal learning environment because of its setting remote from the formal classroom, although it may not truly be considered a "free-choice learning environment" because of the structured activities underlying curriculum. One-way to assess the benefits of learning outside of schools is to consider the impact of the occurrence on the individual. "Impacts depend on personal, physical, social and cultural contexts and may not be evident until sometime after the experience" (Friedman 2008, p. 12). Impact categories that can be used to consider the merits of informal learning include: awareness/knowledge/understanding, engagement/interest, attitude, behavior and skills (Dierking 2008).

The Assessment of Drawings

Since assessment of the impacts of any outreach program is valuable, the authors in consultation with the leadership of the Center sought a metric that would provide information without detracting from the experience for the student. The option to consider the use of student drawings rose from the literature as a potentially rich source of information since art and learning have been considered to be closely linked (Vygotsky 1971). Drawings can be an "efficient and effective method" in assessing children's learning, often providing an understanding that may be hidden in other assessment types (White and Gunstone 1992, p. 105). Drawings are very open assessments with few limitations placed on responses, and as a result, they may be complimentary to more generally accepted closed assessments and may "tap different aspects of understanding" (p. 105). Some scholars suggest that drawing analysis as a means of assessing children's understanding is reliable and "among the most accurate obtained through any means of assessment" (Lewis and Greene 1983, p. 23), and that the act of drawing to be significant because it is "a cognitively complex activity which many children find absorbing and practise extensively" (Thomas and Silk 1990, p. 159). Marilys Guillemin (2004) argues, "that drawings offer a means of gaining further insight into the ways in which participants interpret and understand their world" (p. 287). When used a research tool, drawings "focus a person's response" and lead to "honesty and parsimony" (Nossiter and Biberman 1990, p. 15).

The linkage between drawings and learning has been explored in literacy strategies. Suzanne McConnell (1992; 1993) developed an approach called "talking drawings" whereby "translating mental images into simple drawings helps students at all levels bridge the gap to better comprehension and learning" (p. 260). Susan Fello et al. (2006) extend this to science education finding the process "enables children to combine their prior knowledge about a topic with new information derived from expository text" (p. 80).

Drawings have been used to visualize and characterize children's perceptions of the environment and scientific concepts (e.g., Shepardson et al. 2011). Rob Bowker

(2007) establishes that the pre and post drawings of 9–11 year olds after a visit to a tropical rainforest exhibit provide insight to the understanding and learning of the experience. Drawings are used as representations of student understanding of the concept of the environment (Shepardson et al. 2007), and as 4th and 7th grade students' mental models of the desert environment (Judson 2011)

Demographics of the Fourth Graders

The participants for this study included 406, 4th grade students from nine schools in two school districts in the region. Classes attending the Biophilia Center did so for either 2 days or 5 days depending upon the interest and resources of the individual school. For evaluation purposes, the experience was separated into two groups – 2 days over 2 weeks and 5 days over 5 weeks. A total of 201 students comprise the sample for the 5-day experience while 205 individuals represent the 2-day experience.

Of course, students attending the center for 5 days had more time to interact with more activities than those students attending for only 2 days. Table 9.1 provides a list of the activities and learning modules provided at the Center and the frequency that each was taught for the nine schools. As evident from the table the following activities were consistently offered to all 2-day and 5-day participants: Exhibit Hall Exploration,

Table 9.1 Specific activities completed at center by each individual school referenced to the duration of their experience

	5-Day Schools						2-Day Schools		
	A	B	C	D	E	F	G	H	I
Exhibit Hall	√	√	√	√	√	√	√	√	√
Longleaf Pine Hike	√	√	√	√	√	√	√	√	√
Harvest Ant Activity	√	√	√	√	√	√			
Video Introducing Dr. Wilson/Center Intro	√	√	√	√	√	√	√	√	√
Estimating the Height of a Tree	√	√	√	√	√	√			
Wetland Fauna Collecting	√	√	√	√	√	√			
Tortoise Exploration	√	√	√	√	√	√	√	√	√
Measuring Students Pace	√	√	√	√	√	√			
Tortoise Home Range	√	√	√	√	√	√			
Tortoise Carrying Capacity SIM	√	√	√	√	√	√	√		√
Prescribed Fire PowerPoint	√	√	√	√	√	√	√	√	
***Remnants of a Forest* – Video**	√	√	√	√	√	√	√		
Analysis of Burn Plots	√	√	√	√	√	√	√		√
Forest Understory Exploration	√	√	√	√	√	√	√		
Exhibit Hall Diorama and Snakes	√	√	√	√	√	√			
Bird Video	√	√	√	√	√	√			
Turtle Trail Hike	√	√	√	√	√	√	√	√	√
Exhibit Hall Bird Exploration	√	√	√	√	√	√			

Longleaf Pine Hike, Video of the Center, Tortoise Exploration, and the Turtle Trail Hike. A brief description of each activity/module is provided in Appendix I.

Prior to attending the Center, and then again after their last visit, students were asked to draw what they believed a longleaf pine forest from north Florida looked like, and to include the plants, animals and the processes that occur in the ecosystem. All of these activities were completed at the individual schools, under the direction of the classroom teacher, and occasionally as a project for art class. The authors had no contact with the students, nor did we have any control over the explanation of the assessment, or the medium utilized for the drawings (although instructions were provided to the teachers).

How We Evaluated the Drawings

The review of the drawings began with the identification of the presence or absence of 20 key concepts of the longleaf pine ecosystem, and dealt with appropriate fauna, flora, community structure, habitat components, species interactions, abiotic characteristics and dominant processes, such as how fire shapes the community. These concepts formed the basis of a rubric that was developed and validated for the program (Dentzau and Gallard 2014), which has been adopted by the center to evaluate future program effectiveness.

Drawings were reviewed in an iterative manner using a modified content analysis that allowed additional themes not encapsulated by the key concepts to emerge. Content analysis is "a research technique for the objective, systematic, and quantitative descriptions of manifest content of communications (Berelson 1952, p. 74). Robert Bogdan and Sari Biklen (1982) consider the process as "working with data, organizing it, breaking it into manageable units, synthesizing it, searching for patterns, discovering what is important and what is to be learned" (p. 145).

The Sense We Made of the Drawings

During the content analysis of the pre and post drawings themes emerged that in some cases overlapped the items of the rubric and in others that extended beyond the scope of rubric. All themes and patterns emerged without consideration of the length of the respective experiences; however, data is explored both as an aggregate and by length of experience. While several themes emerge, we highlight the students' focus on animals for this chapter, including:

- Changes in biodiversity representation;
- The propensity of a student to attempt to draw and define specific animals;
- Unique animals highlighted by instruction and activities; and
- Animal alternative conceptions.

Changes in Biodiversity Representations

Biodiversity is classically defined as "[t]he variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera, families and still higher taxonomic levels" (Wilson 1992, p. 393); in other words, the variety of life forms or species. Here, biodiversity represented by the students is determined through changes in number of animal species and in the frequency of representation by animal categories. In the simplest metric biodiversity increased as represented by a reduction in the number of drawings including only plants. Approximately 26.8 % of the pre drawings in this study contained no animals, while this percentage dropped to 14.8 % in the post drawings**.** A representative pre and post example from a single student is provided in Fig. 9.3.

Another way to consider biodiversity is to look at the change in the number of distinct animal species represented by students from the pre to post drawings. To achieve this, each drawing is evaluated to determine the number of distinct species being represented by the student. Obviously this requires some interpretation, and certain assumptions are made. Animals deemed to represent gross alternative conceptions of the forest ecosystem, for example monkeys, are not included in the analysis. Animals with four legs that are otherwise uncharacterizable are assumed to be mammals. Birds of different colors are assumed different species, unless a parental or offspring relationship is suggested.

Fig. 9.3 Example showing drawings from a single student with the pre drawing (*left*) with no animals and post drawing (*right*) with some animal diversity

Table 9.2 Statistics for changes in distinct number of animal species with experiences combined

Drawings	Mean (*M*)	Change in *M*	*N*	*SD*	*t*	*df*	*p*
Pre	2.42	1.01	406	2.26	−7.43	405	<0.001
Post	3.43			2.66			

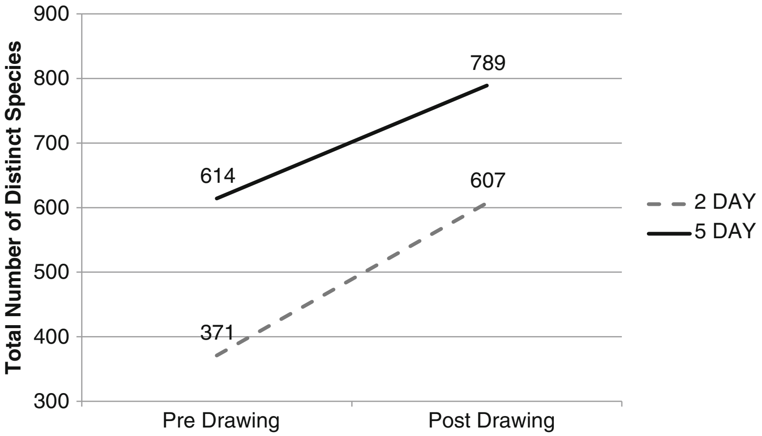

Fig. 9.4 Change in total number of distinct species in the pre and post drawings by duration of experience

Table 9.2 provides the mean number of distinct animal species in all pre and post drawings. When the experiences are combined, these data show a significant increase in the mean number of species being represented from the pre to post drawings. While there is a significant difference in the mean starting points and ending points of the 2-day versus 5-day experiences ($t = -5.81$ (404), $p = <.001$, and $t = -3.65$ (403.58), $p = <.001$, respectively), there is no statistically significant difference in the change of the mean between the 2-day and 5-day experiences ($t = 1.12$ (403.98), $p = .262$). Therefore, as expressed in terms of biodiversity growth, increases are similar for both 2 and 5 day experiences when considering the change in absolute number of distinct species being represented (Fig. 9.4).

Another way to look at biodiversity shifts is to consider the shift in frequency when drawings are assigned to discrete species numbers categories. To facilitate this, categories representing 0 species, 1 species, 2 species, 3 species, 4 species, 5 species, 6 species and >6 species, are established, and each drawing is assigned to a single category. Figure 9.5 shows the pre and post data for both treatments combined, and demonstrates a significant pre-post shift in the distribution of species ($X^2 = 143.64$, df = 7, $p < 0.001$), with a general trend of the post drawings to reflect more species. Figures 9.6 and 9.7 demonstrate a pre/post example from an individual student.

Examination of these data by length of experience does provide additional information masked by the combined data. Figure 9.8 represents the relative percentages of each of the categories in both the pre drawings and post drawings for the 2-day experience. The pre drawing distribution is strongly, positively skewed

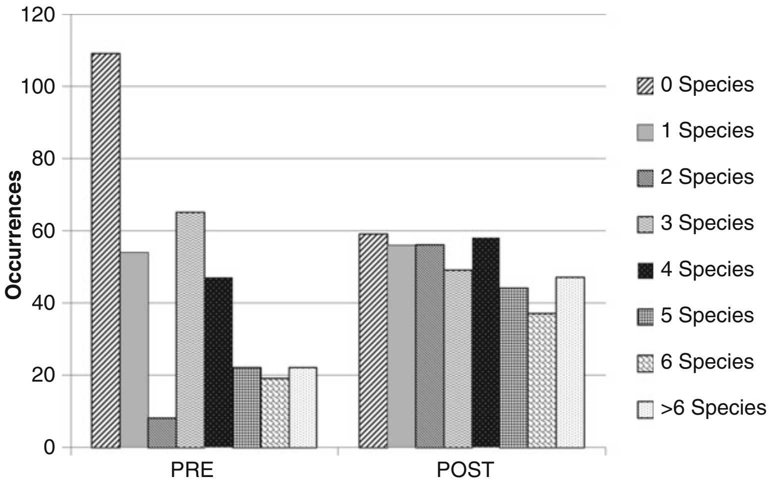

Fig. 9.5 Frequency of drawings for all treatments combined classified into numbers of animal species represented (n students = 406)

Fig. 9.6 Pre drawing of student showing low biodiversity associated with the ecosystem

with over ½ of the drawings including either one or no animals. As evident the distribution changes in the post drawings to approximate a more even distribution across the categories. In the 5-day data (Fig. 9.9), however, there is a more equal distribution among all of the categories in the pre drawings and this trend continues with the post drawings, with shifts towards more species per drawing however clearly evident.

Fig. 9.7 Post drawing from same student showing increased biodiversity

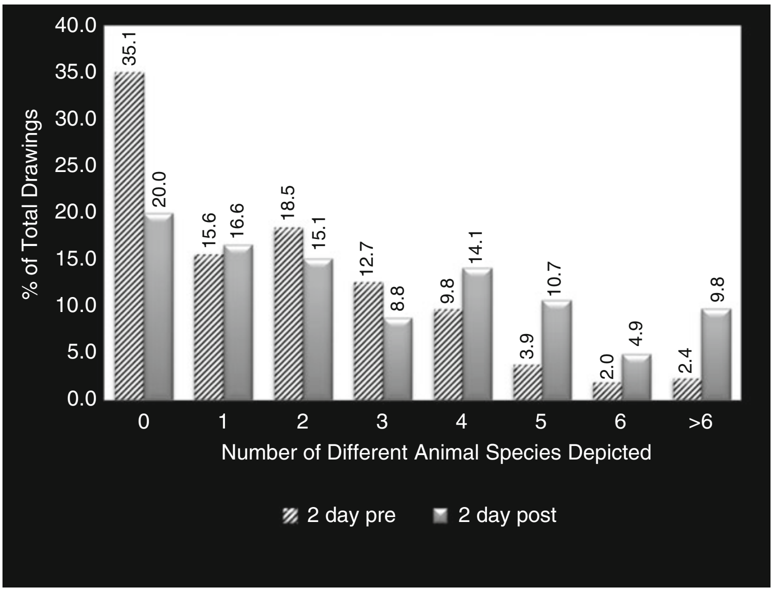

Fig. 9.8 Percentage of drawings in the 2 day experience for the pre and post drawings within each category

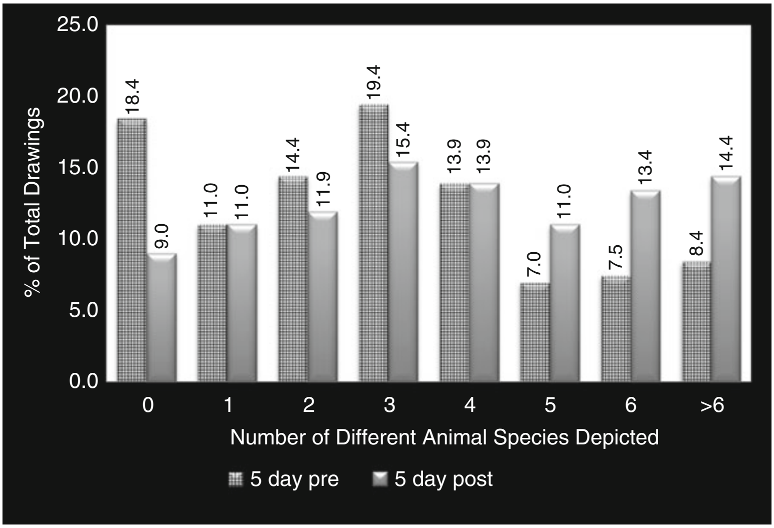

Fig. 9.9 Percentage of drawings in the 5 DI for the pre and post drawings within each numerical species class

Table 9.3 Specific animal categories images to which images are assigned

Mammals	Birds	Reptiles
Amphibians	Fish	Invertebrates
Unknown Class		

Finally, content analysis also indicates a shift in the proportions of categories or groupings of animals between the pre and the post drawings, which may be yet another measure of animal biodiversity. To arrive at these data all images of animals in each drawing are placed into a single category as referenced in Table 9.3. The same subjectivity in accurate classification of images to distinct species also applies for category class, and must be considered in interpreting the results.

Figure 9.10 shows the change in distinct species numbers in each of the 7 categories when the data for both treatments are combined. These data show substantial increases in the number of bird, reptile and insect species represent in the post drawings when compared to the pre drawings for all students combined. Also evident is a decrease in the number of mammal species represented in the post drawings when compared to the pre. Little change is evident for amphibians, fish and images that could not be classified into a category. Figures 9.11 and 9.12 provide an example demonstrating this from an individual student.

These data provide another example where differences in the length of the experience appear insightful; Table 9.4 provides the category data separated by experience length. Although the occurrence of mammal species declined drastically with the experiences combined, it is clear that this result is driven by the changes for the 5-day and not the 2-day experience. When the data are converted to represent the

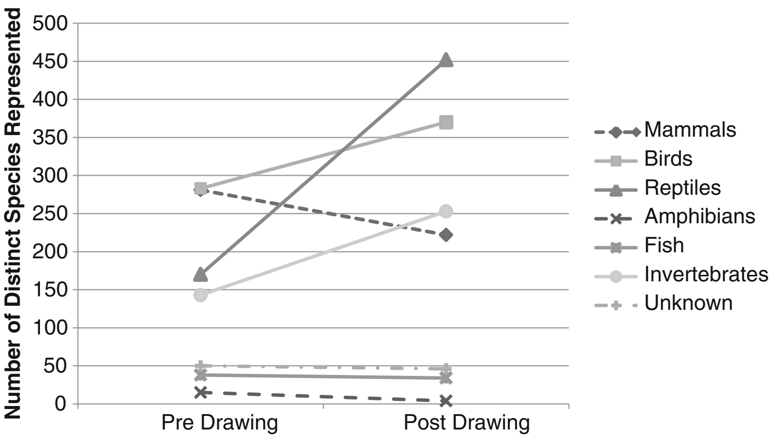

Fig. 9.10 Number of distinct animal species by categories for pre and post drawings of all 406 students

Fig. 9.11 Pre drawing from a student showing dominance by mammals

mean number of mammals depicted pre-post, there is a significant decrease for the 5-day experience (t=3.446 (200), p=.001), but not for the 2-day experience (t=.071 (204), p=.944). The increases in the bird, reptiles and insects noted above, however, are still evident when the data is parsed into different lengths of experience.

Fig. 9.12 Post drawing from the same student as shown in Fig. 9.11 showing increases in reptiles, birds and invertebrates

Table 9.4 Number of occurrences of distinct species by animal category for pre and post drawings for each experience

	5 day experience		2 day experience	
Category	Pre	Post	Pre	Post
Mammals	183	124	99	98
Birds	155	203	128	167
Reptiles	108	250	62	202
Amphibians	11	11	4	3
Fish	25	23	13	11
Invertebrates	93	147	50	106
Non-Descript	38	27	12	19
TOTAL	**613**	**785**	**368**	**606**

Animal Specificity

Animal specificity, or the propensity of a student to attempt to draw and define a specific animal, increases from the pre to post drawings (as demonstrated in Figs. 9.13 and 9.14). With a few notable exceptions (e.g., gopher tortoise, red-cockaded woodpecker) animals in the pre drawings are predominately common or generic representations (e.g. deer, red bird, unidentified snake, butterfly). While these

Fig. 9.13 Pre drawing showing unspecified animals from a student

same species are often referenced in the post drawings, there is also an increase of specific species (e.g. gopher frog instead of simply frog), and species that are otherwise "inconspicuous" (e.g., insects). Table 9.5 provides a listing of those animals that are only found in the post drawings when both of the experiences are combined. A few instances of species specificity, such as red-cockaded woodpecker, eagle, gopher tortoise, harvester ants and red fire ants, are documented in at least some pre-drawings. Another example of increases in animal specificity is observed in a pre and post comparison represented by Figs. 9.15 and 9.16. Often in either the pre or the post drawings, specific species were designated as such with labels or the use of characteristic community references (e.g. burrow associated with a tortoise or bands of round drill holes to represent a yellow-bellied sapsucker).

A review of the frequency of representations of the gopher tortoise, a key component of the Biophilia Center's instruction and a keystone species of the longleaf ecosystem, provides another insightful comparison (Table 9.6). When looking at the experiences combined the gopher tortoise is represented in 3.7 % of the pre drawings (15 students), and 36.0 % of the post drawings (146 students). Many of these post

Fig. 9.14 Post drawing of same student as referenced in Fig. 9.13 showing specificity of animal species

Table 9.5 Animals referenced only in student post drawings for experiences combined

Gray Fox	Fox Squirrel	Coyote
Panther	Bat	Chipmunk
Red-Headed Woodpecker	Blue Jay	Sparrow
Cardinal	Barn Owl	Barred Owl
Bobwhite Quail	Yellow-Bellied Sapsucker	Sparrow
Blue Heron	Soft Shelled Turtle	Box Turtle
Red Tailed Hawk	Pine Snake	Indigo Snake
Red Rat Snake	Pigmy Rattlesnake	Water Moccasin
Corn Snake	King Snake	Wolf Spider
Purse Spider	Ant Lion	Crawfish
Flea	Fly	Gopher Frog

drawings show not only the gopher tortoise but also reference the burrow of the tortoise, which is a valuable habitat component of healthy longleaf pine upland (Fig. 9.17).

Post increases are demonstrated for other specialized or unique species, but not to the degree represented by the gopher tortoise (Table 9.7). These species are considered either unlikely to be known by the student population prior to engagement at the Biophilia Center (e.g. harvester ant) or those that had a prominent position in the instruction at the center (e.g. red-cockaded woodpecker).

Fig. 9.15 Pre drawing showing generic and commonplace animals

Fig. 9.16 Post drawing from same student represented in Fig. 9.15 showing animal specificity

Table 9.6 References to Gopher tortoise and Gopher tortoise burrows in the drawings

	2 Day Pre	2 Day Post	5 Day Pre	5 Day Post	Combined Pre	Combined Post
Number	4	58	14	88	15	146

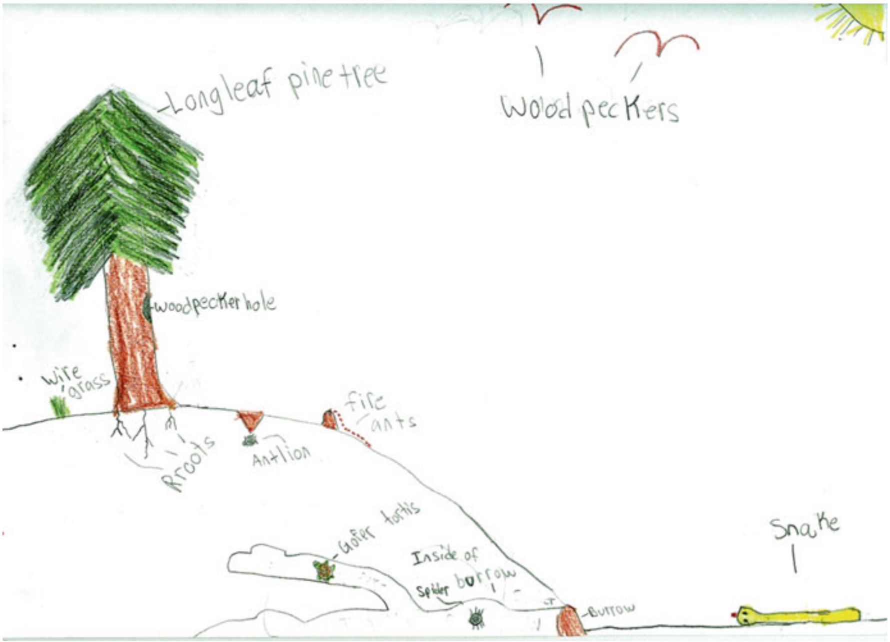

Fig. 9.17 Post drawing showing a gopher tortoise and detailed burrow system

Table 9.7 Frequency of occurrence (n = 406) of specialized or unique animal species

Species	Pre	Post
Harvester Ant	1	14
Fire Ant	2	8
Indigo Snake	0	6
Red-Cockaded Woodpecker and RCW References	2	43
Yellow-Bellied Sapsucker/Foraging Holes	0	17
Beaver and Beaver Dam	1	24
Pine Snake	0	4
Fox squirrel	0	3
Bear	1	4

Animal Alternative Conceptions

The animal alternative conceptions in the drawings are almost exclusively related to the pre drawings and were relatively few in occurrence. A total of 17 obvious animal alternative conceptions are represented by 10 students (2.5 % of sample population), and are evenly distributed between the two experiences (Table 9.8). Figure 9.18 shows an example where both appropriate animals and alternative conceptions (flamingo and koala) are depicted, while in Fig. 9.19 inappropriate species dominate (monkey and reindeer).

Table 9.8 Animal alternative conceptions reflected in the drawings

Student	Animal	Experience
A	Panda Bear	2 Day Pre
B	Flamingo; Koala	2 Day Pre
C	King Cobra; King Anaconda; Grizzly Bear	2 Day Pre
D	Monkey	2 Day Pre
E	Reindeer; Monkey	5 Day Pre
F	Monkey	5 Day Pre
G	Ostrich	5 Day Pre
H	Lion; Anteater	5 Day Pre
I	Ant Lion; Monkey	5 Day Pre
J	Large Cat in Zoo	5 Day Pre
K	Cheetah on Branch	5 Day Post

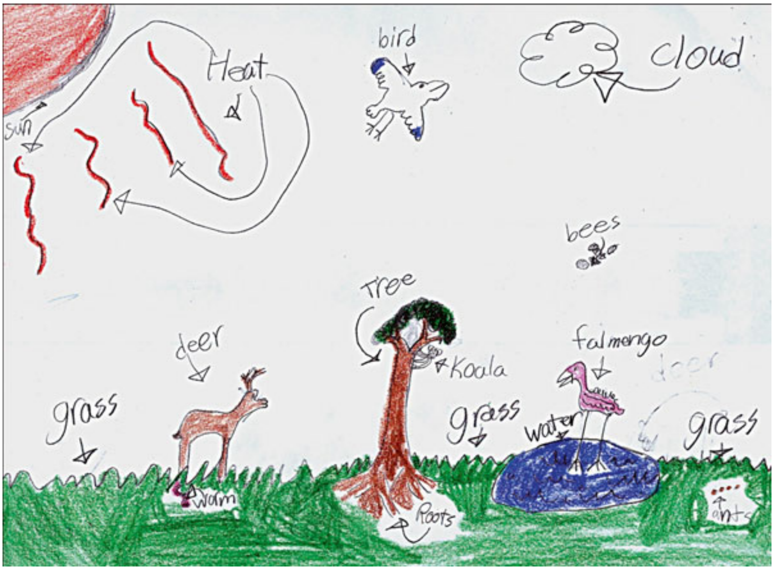

Fig. 9.18 Pre drawing showing animal alternative conceptions – flamingo and koala

Fig. 9.19 Pre drawing dominated by animal alternative conceptions (monkey and "rain" deer)

Students Make Connections to Biodiversity

Experience with the Biophilia Center substantially increases the number of students, that when prompted, associate animals instead of only plants, with the longleaf pine ecosystem. Strommen (1995), when dealing with a sample of 40 1st grade students, finds that 21 % include no animals in their drawings when asked to draw their understanding of a forest ecosystem; this corresponds closely to the 26.8 % of pre drawings in this study that includes only trees and no animals. Our study benefits from the ability to look at these changes over a period of instruction, which shows a substantial decrease to 14.8 % in the number of students failing to connect animal life to the ecosystem. This is an important point to consider if one of the objectives is to help students learn science informally and also to help make sense of their surroundings in a scientific manner. Ron Wagler (2010, p. 372) offers:

> It is essential that students are exposed to a K-4 science curriculum which incorporates reptiles, amphibians and invertebrates; represents all animals in a scientifically accurate way; and conveys the interconnected life-sustaining relationship animals have to one another and to the environment.

Our pre data indicates that students in this study substantially overestimate the contribution of large mammals and underestimate the role of arthropods to ecosystem function and dynamics. This finding agrees with those of Strommen who concludes, “children appeared to overestimate the number and type of large carnivores to be found in forests” (p. 694). More recently, Jake Snaddon et al. (2008) find similar results in a sample of 167 primary aged children in the United Kingdom. These children when asked to express their “ideal rainforest”, display an understanding of an ecosystem that they have likely not visited, and at the same time, seem to lack a perception of the importance of social insects and annelids.

Our post data, however, demonstrating a shift from charismatic megafauna towards more inconspicuous animals, offers some encouraging results. A curriculum, therefore, that highlights and celebrates such species, especially in their native context, may be effective in providing alternative conceptions that are more in line with ecological reality. Hopefully this curriculum serves as one component that drives the development of their appropriate mental models of ecosystems. Although shifts in the right direction are evident in the current data, we assume that lasting benefits will come from the continued reinforcement of the proportional contributions of invertebrates and vertebrates in ecosystem functions throughout the learning process.

The post data, while suggesting that an experience such as that offered by the Biophilia Center may be able to assist students in changing their initial perception of biodiversity of the longleaf pine forest, is mixed with respect to the impact of duration on this understanding. While a shift to increased invertebrates (insects) is established in both the 2 and 5-day data, a decrease in mammals is only observed in the 5-day program. It is unclear if this is an anomaly of the data or in some way reflects the impact of the different lengths of the instruction in the two experiences.

Students Make Sense of Animal Specificity

The data show a clear increase in the specificity of animals proceeding from commonplace, undifferentiated animals to keystone, rare, emblematic and specifically referenced or labeled animals. According to Linda Cronin-Jones (2005), “[g]enerally drawings by elementary students include more details and realistic representations for subjects they know more about” (p. 228). Therefore, the increase in specificity implies an increased understanding (learning) about the longleaf ecosystem. While this might seem intuitive and is hopefully expected from any curriculum, it does not diminish the importance of such data when it comes to engendering both an understanding and respect for ecological systems. As an example, one study involving 4,000 Swiss students ages 8–16 finds that the more plants and animals students are cognizant of and familiar with in the local environment “*the more did they appreciate these organisms* (emphasis added)” (Lindemann-Matthies 2005, p. 655). After all, enhanced appreciation of the nature world that surrounds us is considered necessary for long-term environmental sustainability.

While the deficit model of pro-environmental behavior where environmental knowledge leads to environmental attitude and ultimately pro-environmental behavior (Burgess et al. 1998), is arguably over simplistic (Hines et al. 1986), it has be suggested "that nature experience is one central foundation for the development of knowledge and values in relation to the environment" (Bögeholz 2006, p. 65). Numerous researchers have proposed such a knowledge linkage as a precondition of attitude (e.g., Kellert 1996). Monroe (2003), using a summary of the literature concludes that environmental literacy can be promoted through education based on environmental issues and through significant life experiences. Any increase in environmental understanding and hopefully awareness is therefore movement in the right direction.

What Students Did Not Understand or Were Confused About

While only 2.5 % of the students expressed alternative conceptions with fauna, the pre-post design is able to show that in all cases the students corrected the alternative conceptions to eliminate non-native animals. The restructuring of existing knowledge and the concomitant change in students' conceptual frameworks is essential in the progression towards a well-defined conceptual model. This idea is also supported by,

> Children's drawings often reveal misconceptions, which if undetected may otherwise act as barriers to further learning. If stereotypical images are not indentified and challenged, children will fail to recognize other examples in different settings. Failure to acknowledge that children perceive concepts form preferred perspectives may hinder their understanding when these topics are first introduced. (Dove et al. 1999, p. 496)

Our Path to Understanding Today and Tomorrow Through Informal Science Education

The understanding of biodiversity is foundational knowledge for elementary-aged children. The National Research Council (1996) notes that students in grades K-4 should be exposed to a diverse array of animals and that "[m]aking sense of the way organisms live in their environments will develop some understanding of the diversity of life and how all living organisms depend on the living and nonliving environment for survival" (p. 128). Taken in the context of global extinction rates, which have been estimated at 27,000 species/year (Wilson 1992), the influence of human activities is unmistakable (Pimm and Raven 2000), and the need for increased understanding is genuinely significant. But how effective are science educators in conveying this message? In one study involving 109 UK students between four and 11, children that are eight and older are able to identify "Pokémon 'species' substantially better than organisms such as oak trees or badgers" (Balmford et al. 2002, p. 2367). Are we in fact presenting the wonders of nature to students in a way that is less exciting than a role playing game based upon fictional species? This finding may not surprise those who understand and value the necessity of learning through doing and the constraints placed upon learning through the neoliberal model of education. Perhaps in the larger societal scope of things, if UK students had been afforded the opportunities to dedicate as much time to their surroundings as they did to Pokémon, the results of Balmford et al. would have been different. Yet another possibility is that learning Pokémon 'species' is viewed as critical knowledge to have because this knowledge enhances their everyday life by helping them win at this game. In other words, the knowledge is useful and applicable to a game players' life. If so, instead of simply bemoaning this apparent disconnect, maybe we as educators should work within the culture, and with the tools of the culture, to attempt to increase the relevance of biodiversity to our youth.

Mark Rickinson (2001) concludes that "the general message stemming from recent evidence is that the factual environmental knowledge among secondary age students is lower than might be hoped" (p. 227). Further, the understanding of environmental issues of young people "is very focused on the science of global environmental issues" (p. 243). What do we need to do to change this? Martin Braund and Michael Reiss (2006) explain that

> when pupils visit or are taught in places that explain science in often new and exciting ways, they frequently seem to be more enthused. There is, we believe, something about these contexts and places that brings about a change through increasing the desire in people to find out and understand more. (p. 1378).

Connecting children to their local environment in a manner that makes understanding of the natural world useful and applicable to students' lives, as in the example of Pokémon, may be the missing catalyst that is engendering this knowledge deficit. The example of the learning opportunities afforded by a facility such as the E.O. Wilson Biophilia Center may be able to provide the engagement needed to make biodiversity relevant and help our youth develop a connection to their local environment. While clearly an opportunity like the center cannot be reproduced in every community, its model is worthy of replication regionally wherever possible. In the absence of such opportunities, however, simple connections with nature in the immediate surroundings of a child, both in formal and informal settings, may provide some of the same cognitive and affective benefits at a nominal expense. These can include native plant gardens, backyard ponds, bird feeders, community plant and animal identification guides…the list goes on.

It all depends upon what we privilege as a society. Do we want students to understand the natural world and be "compassionate human beings able to think for themselves and to face life head on" (Rutherford and Ahlgrens 1989, p. xiii.)? Until we as a collective group embrace the need to provide opportunities that afford real-life and life-long connections of ecologically accurate information in education, we fail to achieve this greater goal. We believe that, as stated earlier, ecological literacy supports the development of a well-rounded citizen. When exposed to such a transformative experience as we have documented herein, it remains to be seen if these students become knowledge advocates imparting the excitement to their peers and parents. That would be truly rewarding.

Appendix I

Introductory Video on Dr. Wilson and the Biophilia Center

This video is presented in the Center's Theater and introduces students to the namesake of the facility, Dr. E. O. Wilson and the mission and importance behind the development of the Biophilia Center at Nokuse Plantation.

Exhibit Hall Exploration

This activity is a combination of free exploration and guided discovery where staff of the Center introduce students to various stations in the exhibit hall. The hall has the following stations/exhibits for student interaction:

- Large sculptures of animals including, gopher tortoise, harvester ant and indigo bunting.
- A cast/mold of a harvester ant mound showing the intricacies of the tunnel.
- Display of historic and archeological artifacts.
- Frog biome that shows live frogs and plays the call of each.
- Bird window with placards identifying bird species that may be visible.
- Molded gopher tortoise burrow suitable for students to crawl in one end and out the other.
- Longleaf pine diorama that shows the various stages of the longleaf pine from seedling to mature tree with a depiction of prescribed fire.
- Active beehive contained in plexiglass that has a connection to the outside.
- Large interactive schematic of a leaf and photosynthesis.
- Diorama of a transition from an upland ridge into a wetland community showing pitcher plants and other flowering species that are not easily seen during all times of the year.
- Aquatic exhibit with live turtles.
- Snake exhibit with several different species.
- Exhibit demonstrating heat sensing ability of predatory snakes.
- Musical exhibit substituting animal calls for notes.
- Taxidermies of beaver, feral hog, black bear, Florida panther, bobcat, quail, wading birds, woodpeckers and other typical species.

Longleaf Pine Hike

The Longleaf Pine Hike is completed on a blazed trail that loops around some mature remnant longleaf pine uplands and through several embedded wetland drains. Through this excursion students often see the various stages of the longleaf pine (grass stage, bottle-brush and mature), turkey oak, yaupon holly (*Ilex vomitoria*), purse web spiders/spider webs, evidence of yellow-bellied sapsucker foraging, harvester ant mounds, the microcommunity developed when a tree falls and the roots form a vertical substrate, a red bellied woodpecker cavity, a tree that was struck by lightning, different fungi and lichens, a shell from a box turtle and deer antlers. Students are also shown the differences between the slash pine and longleaf pine with respect to cone size, needles, growth forms, etc.

Tortoise Exploration

During this activity one of the staff that is expert with turtles and tortoises introduces students to the gopher tortoise and its life cycle. This is based primarily within the exhibit hall and uses the diorama and tortoise shells and skulls that the students can hold and examine. Occasionally live gopher tortoises are available, but not all classes have the opportunity to interact with live animals. Staff explains the gopher tortoise relocation plan that is being conducted on other parts of Nokuse Plantation and how biologist mark and number the tortoises for later identification.

Turtle Trail Hike

This hike takes students along a wetland finger adjacent to a high upland where they can see the elevation change from uplands to wetlands and the change in vegetation that occurs. Students also often see the characteristics indications of yellow-bellied sapsucker foraging and the microcommunity that develops when a tree falls and the roots form a vertical substrate. The students are also introduced to beavers and their role in the ecosystem as well as a discussion of various aquatic wildlife that is collected in traps pre-set along the trail. Species encountered in the traps include crawfish, spotted sunfish, pirate perch, pickerel, warmouth, lesser siren, two toed amphiuma, loggerhead musk turtle, largemouth bass, tadpole madtom, river frog, bronze frog, and others.

Tortoise Carrying Capacity SIM

This exercise is designed to demonstrate how populations might fluctuate over time through the introduction of the concept of carrying capacity. Carrying capacity is the highest number of organisms that can be supported by an area or habitat without the numbers resulting in damage to the area. The SIM activity estimates how gopher tortoise populations can change from year to year and how many tortoises a simulated habitat can support.

Analysis of Burn Plots

The Center maintains 4 contiguous plots approximately 1/2 acre each which are provided different treatments. One is an unthinned and unburned slash pine plantation – this represents the conditions on site before any environmental restoration was completed by Nokuse Plantation. The other three have been thinned of slash pine and have been burned during different seasons and frequencies. The students are asked to compare burned plots from unburned plots and to collect observations in their field journals.

Prescribed Fire PowerPoint

This brief powerpoint is shown in the theater at the center and provides information about the value of prescribed fire for the longleaf pine ecosystem and the natural fire regime of the system.

"Remnants of a Forest" – Video

This multimedia presentation discusses the longleaf pine ecosystem and its decline in the southeastern United States. Students are provided with a brief history of the longleaf pine ecosystem, the role of fire in maintaining the community and its diverse groundcover, and some of the prototypical species of the ecosystem, including red-cockcaded woodpecker, pitcher plants, gopher tortoise, quail, indigo snake, burrows, flatwoods salamander, gopher frog, pine snake and rattlesnake. The value of the gopher tortoise as a keystone species of longleaf pine is introduced.

Understory Exploration

During this activity the students return to the forest burn plots to look specifically at the understory of the longleaf pine ecosystem. The students are asked to write down the plants (using general descriptive terms or drawings) they see at ground level, one foot above ground level, and then those even taller but still within the understory. This is designed to emphasize the vertical structure of the longleaf pine forest and forests that are managed/shaped by fire. Depending upon the effort expended on looking at the plants some groups also engaged in a food web game. Students sit in a circle with a ball of string and one individual names an animal and extends the string ball to another student who needed to either name an animal that would be either a prey or predator to the first animal. This engagement continued until a “food web” was created.

Jeopardy

Fashioned after the popular game show, this version uses a similar format of providing the answer with the students needing to provide the response in a form of a question. Topics focus on the experiences the students have both in the exhibit hall and on the trails at the center.

Harvester Any Activity

In this activity the students investigate the foraging behavior of the Florida harvester ant, which is common to the longleaf pine forest upland communities. As the name implies, these insects gather food and store it in chambers underground. Food sources consist of seeds, which are collected from the ground or off of plants, with the chaff from husked seeds deposited around the main entrance to the chamber. Students working in teams examine harvester ant mounds in the field, and conduct guided inquiry on preferred food types through several simple experiments.

Estimating the Height of a Tree

This activity involves the students in the application of simple measurements that are used as one technique to solve a real world problem, in this case, the height of a large pine tree. Although foresters and ecologists often have sophisticated equipment to estimate tree height, a simple technique involving pairs of students, a 1-foot ruler, and a 100-foot tape measure are used to provide a very good estimate of height.

Field Measurement Techniques

In this activity, students learn a technique to measure their own pace, or the distance covered by one normal step, to be able to measure distance and calculate area. This technique is often used by field biologists as a simple and fairly reliable measure.

Wetland Fauna Collecting and Identification

This activity takes place in the artificially created wetlands and pond that straddles the entrance boardwalk to the center. The students follow the instructors as they use dip nets to collect predominately aquatic invertebrates and occasionally small fish or amphibians for transfer to small containers for observation as they use identification cards to attempt to determine the different kinds of animals collected.

Tortoise Home Range

The students are introduced to the concept of home range, defined as the area in which an animal lives, using the gopher tortoise. While the ecologists at Nokuse Plantation use transmitters attached to tortoises and incorporate data over many months, the students are given representative locations and a simulated burrow and use their field measurement skills to estimate the maximum distance the tortoise travels from the burrow and the approximate area it covers based upon a minimum of 5 measurements.

Exhibit Hall Diorama and Snakes

For some students this represents a second visit to the Exhibit Hall and this focuses on the live snakes and characteristics of snakes.

Bird Video

This video is narrated by a young girl and provides video of birds in different habitats, including the beach, marshes, ponds, fields and forests. Individual species are discussed with identification features and some specializations provided.

Exhibit Hall Bird Exploration

During this activity the students are provided with a scavenger hunt list of birds that they are to locate in the Exhibit Hall. Students are to identify several species of birds and fill out characteristics such as size, color, beak size, etc.

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