Development of an Undergraduate Plant Science Course Promoting Environmental Awareness, Native Flora and Critical Thinking Skills

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ABSTRACT: Students now have the opportunity to pursue a B.S. degree in Horticultural Sciences or Agribusiness Management offered by the University of Florida at a satellite campus located on the Treasure Coast. With only two majors and a limited number of distance education courses available, faculty decided to create several elective courses including a 3000 level course entitled South Florida Flora and Ecosystems (SFFE). This course was designed to give horticulture students background knowledge in the area of native plants and ecology in order to better prepare them for a professional future working in an atmosphere of increased environmental regulation and public concern. Additionally, the unique and diverse ecosystems in Florida provided a rich setting for experiential learning in the course. The instructors also designed the course to promote and develop student critical thinking skills using controversial, environmental issues. These examples of teaching exercises and techniques could be easily adapted as a component in many plant science curriculums and be adapted for the local ecosystems in many geographical regions in the U.S. or the world.

INTRODUCTION

South Florida contains a variety of ecosystems not found elsewhere in the United States. Biota found in Florida are very similar to what is expected for an island chain, since the southern third of the peninsula, or the "habitat island", is bounded by water on three sides and by frost on the fourth (Simberloff, 1994). Ecosystems in this part of Florida typically contain impoverished native flora and fauna, as well as lower species diversity relative to mainland systems (Simberloff, 1994). Typical South Florida Ecosystems include: pine flatwoods, scrub and high pine, rockland, swamps, marshes, lakes, rivers, dunes, salt marshes, mangroves, and in-shore marine habitats. Each of these systems differs markedly in the numbers and types of flora and fauna associated with them. Plant vegetation (structure and composition) within and surrounding ecosystems influences invertebrate, avian, and mammalian diversity and species richness (Webb, 1989; Stout and Corey, 1990; Hagan et al., 1996; Pearlstine et al., 1997). Structure and composition of plant communities are quickly impacted by human activities. Large areas of nearly all ecosystem types have been lost or impacted by human-related activities such as urban development, agriculture, and land management strategies (i.e. altered fire regimes, etc.). These ecosystems also have been impacted by the introduction of invasive, exotic species into the landscape for agricultural and ornamental purposes.

Preservation of Florida's remaining intact habitats and habitat fragments is a priority for many agencies such as the water management districts, state and federal agencies, local county governments, and private organizations. However, perhaps even more essential is the creation of awareness among people of the value of the different ecosystems and ecosystem components. Once people understand the resource, they are much more likely to consider how their activities might impact ecosystems. In order to increase the environmental awareness and critical thinking skills of undergraduate students, a multidisciplinary group of faculty (citriculturalist, environmental horticulturalist, and agroecologist) undertook the design and implementation of an upper-division horticultural science course. This course introduced environmental concepts relevant to students' future employment in horticulture or other related industries, using the diverse and unique ecosystems of south Florida as a backdrop.

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TEACHING METHODS

The development of the SFFE course had three educational goals. The primary objective of the course was to provide students with a basic understanding of the ecosystem concept and survey the ecosystems that are present in South Florida. A secondary goal of SFFE was to expose horticulture students to a variety of plant materials in their native habitats. Finally, the instructors used current environmental concerns in agriculture as the framework to teach and promote critical thinking skills. The following article presents the teaching methods that were utilized to attain these goals. All of the following teaching methods discussed are specific to South Florida, but could easily be adapted to other geographical regions to highlight local ecosystems and environmental concerns.

ECOSYSTEM EXPOSURE

The Horticulture Science and Environmental Horticulture Departments at the University of Florida have developed educational programs that cover the scientific and production-oriented aspects of commercial horticulture. However, more emphasis on environmental sciences would be beneficial to students who will graduate and enter a business climate where such issues are critical and economically important. For example, 'wildlife watchers' spent in excess of 1.6 billion dollars in Florida (Guzman, 2000) during a single year. In comparison, the on-tree sales value of citrus in Florida has averaged about a billion dollars annually for the last decade (Florida Agricultural Statistics Service. U.S. Dept. of Agriculture, 2000).

Early during the semester, students in this course received a lecture covering the basic fundamentals of ecology including cycling of nutrients, biomes, trophic levels, and the development of communities and ecosystems. Issues of climate and human settlement, framed in the historical biogeography of Florida, were also discussed early in the course giving the students a 'feel' for the manmade changes in the landscape.

South Florida is an ecologically diverse area facilitating the teaching of this ecosystems course. Ecosystems covered in the course are shown in Table 1. Additionally, students toured disturbed sites and restoration projects to observe the impact of invasive exotics and the work and costs involved with removing them. For example, when the class visited the South Florida Rocklands (roughly Lat 25.398, Long –80.590), they toured the Everglades and

Table 1. Ecosystems covered in *South Florida Flora and Ecosystems.*[z]

Topic status[y]	Ecosystem[x]	Field trip[w]
Covered	Scrub	Savanna State Reserve
	Pine Flatwoods	St. Lucie West Managed Natural Area, Archbold Biological Station
	Coastal Ecosystems	Fort Pierce Inlet State Recreation Area
	South Florida Rocklands	Everglades Restoration Project
	Salt Marshes and Mangroves	Bear Point Sanctuary Mosquito Impoundment
Proposed	Lakes, Rivers, and Springs	Kissimmee River Restoration Project
	Inshore Marine Habitats and Coral Reefs	Bathtub Reef, Lou Key
	Dunes and Maritime Forests	

[z]ORH 4932; course offered at the Indian River Research and Education Center (Fort Pierce, FL) through the University of Florida's Department of Environmental Horticulture.

[y]Covered ecosystems have been field tested in the course. Proposed ecosystems are lectures and field laboratories to be added during the next offering of the course.

[x]Ecosystem names come directly from the text utilized for the course (Myers and Ewel, 1990).

[w]Field laboratories were mandatory and conducted either in the late afternoon or on overnight weekend trips.

received a guest lecture on the impact of agriculture on the area, the history of failed and successful restoration projects, and estimates on the cost and time involved in restoring the area. Students were shown aerial photographs of native vegetation in the Everglades to compare to current thick canopies of Brazilian pepper (*Schinus terebinthifolius* Raddi.) in areas that had been disturbed by the use of agricultural rock-plows in the 1930's and 40's. The students went out to several sites in various stages of restoration.

During another laboratory, students were given a roving lecture at the MacArthur Agroecology Reserve Center (Lat 27.150, Long –81.198), a division of the Archbold Research Station, where they observed the environmentally sound management practices of agricultural and natural areas. Additionally, the natural landscape at the Station allowed for students to see the subtle transitions between several ecosystems from Live-Oak hammocks to wetlands. The speaker pointed out how these ecosystems are integrated components in a larger ecosystem and how careless land development of one area can have detrimental effects on others. Additionally, visiting a variety of ecosystems under various management practices reinforced the potential landscape use of native plant materials the students were learning. These examples of experiential learning are viewed as a very important component of learning by the American Association for Higher Education, the American College Personnel Association, and The National Association of Student Personnel Administrators who jointly stated: "Learning is enhanced by *taking place* in the context of a *compelling situation* that balances challenge and opportunity" (American Association for Higher Education, American College Personnel Association., and National. Association of Student Personnel Administrators, 1998).

NATIVE FLORA

Invasive exotic plant species have collectively disrupted thousands of acres of natural ecosystems throughout Florida by forming dense, monospecific stands, altering ecological processes that lead to a loss of native biodiversity (Langeland and Burks, 1998). Many of the invasive plants that have escaped cultivation were originally introduced as ornamentals and prized by the producers and consumers for their brightly colored flowers or fruit, fast growth, and relatively carefree requirements (Schmitz et al., 1997). The State of Florida is the second largest producer of ornamental plants in the U.S. with an estimated value of sales by the environmental horticulture industry of 5.9 billion dollars (Hodges and Haydu, 1999). Florida's nursery industry is largely driven by consumer demand. The devastation caused by Melaleuca (*Melaleuca quinquenervia* (Cav.) S.T. Blake) and Brazilian Pepper, is an example of the impact trees that were introduced as ornamentals can have. Invasive species damage natural areas, alter ecosystem processes, displace native species, hybridize with natives, and support other potentially damaging plants, animals, and pathogens (Randall and Marinelli, 1996). *Melaleuca* and *Schinus* alone currently invade well over 350,000 hectares (865,000 acres) in South Florida (Schmitz et al., 1997) and the State spends millions of dollars annually for control. Aside from being the second largest ornamental plant producer in the U.S., the geographical features of Florida such as highly disturbed habitat, large tourism and population, absence of freezes, and abundance of lakes, streams and wetlands, predispose it to great invasibility (Simberloff, 1994).

Increased industry and public awareness of invasive exotics has led to the increased need for undergraduate education about native plants and the consequences of introductions of exotic species. Fortunately, Florida has the third highest number of native plant species of any state in the country (Haehle and Brookwell, 1999). Students are taught the advantages to using native plants including, but not limited to, resistance to pests and pathogens, adaptation to local soil types and climates, more efficient utilization of water and nutrients, and physiological mechanisms to cope with many of the environmental stresses associated with Florida's climate (Haehle and Brookwell, 1999). However, it is also explained in class that most exotic plants are not bad. Only a small portion of exotic plants introduced to Florida actually become invasive. Students were taken to natural areas to learn to identify native and invasive plant materials *in situ*. Students were expected to memorize Latin names for the plants and be able to identify them from habitat descriptions, plant material samples, or pictures. In order to facilitate learning, digital images of plants were placed on a website that students could access at their convenience. A sample listing of plant materials in the lab covering "scrub" ecosystems is shown in Table 2.

By showing plants in their native habitats, students began to synthesize the potential uses and value of native plants for landscaping. For example, native cacti can thrive in deep sand pockets, both providing beauty to the landscape with little land preparation and reduced irrigation costs. Many native plants are also adapted to Florida soils that are naturally low in organic matter. These plants have reduced nutrient requirements, thus lowering fertilization costs and limiting the chance that excess nutrients will contaminate groundwater supply. Students need to be made aware of plant material selections that reduce water consumption. The authors hope that the next generation of trained horticultural professionals will see that native plants in the landscape coexist nicely with well-chosen exotics, thus offering an economically and environ-

Table 2. Plant materials list for the scrub ecosystems lecture and field laboratory.[z]

Origin	Botanical name[y]	Common name	Family
Native	*Bidens alba*	Spanish Needles	Asteraceae
	Carya floridana	Scrub Hickory	Juglandaceae
	Cassia chamaecrista	Cassia/ Partridge Pea	Fabaceae
	Cassytha filiformis	Love Vine	Lauraceae
	Chrysopsis sp.	Golden Aster	Asteraceae
	Cnidoscolus stimulosus	Stinging Nettle	Euphorbiaceae
	Commelina erecta	Dayflower	Commelinaceae
	Conradina grandiflora	Scrub Mint	Lamiaceae
	Ficus aurea	Strangler fig	Moraceae
	Galactia volubilis	Milk Pea	Fabaceae
	Harrisia eriphorus var. *fragrans*	Fragrant Wooly Cactus	Cactaceae
	Licania michauxii	Gopher Apple	Chrysobalanaceae
	Opuntia compressa	Prickly Pear Cactus	Cactaceae
	Palafoxia sp.	Palafoxia	Asteraceae
	Pinus clausa	Sand Pine	Pinaceae
	Polygonella sp.	Jointweed	Polygonaceae
	Quercus chapmanii	Chapman's Oak	Fagaceae
	Quercus geminata	Sand Live Oak	Fagaceae
	Quercus minima	Runner Oak	Fagaceae
	Quercus myrtifolia	Myrtle Oak	Fagaceae
	Sabal palmetto	Sabal/ Cabbage Palm	Arecaceae
	Selaginella arenicola	Spike moss	Selaginellaceae
	Serenoa repens	Saw Palmetto	Arecaceae
	Smilax sp.	Smilax/ Greenbrier	Smilacaceae
	Stylisma patens	Coastal Plain Dawnflower	Convolvulaceae
	Tillandsia recurvata	Ball Moss	Bromeliaceae
	Tillandsia utriculata	Wild Pineapple	Bromeliaceae
	Tillandsia usneoides	Spanish Moss	Bromeliaceae
	Vaccinium myrsinites	Huckleberry	Ericaceae
	Vitis rotundifolia	Muscadine Grape	Vitaceae
	Zanthoxylum clava-herculis	Hercules' Club	Rutaceae
Exotic	*Abrus precatorius*	Crab's Eye/ Rosary Pea	Fabaceae
	Albizia lebbeck	Woman's Tongue	Fabaceae
	Catharanthus roseus	Madagascar Periwinkle	Apocynaceae
	Cereus undatus	Night-blooming Cactus	Cactaceae
	Eugenia uniflora	Surinam Cherry	Myrtaceae
	Schinus terebinthifolius	Brazilian Pepper	Anacardiaceae

[z]Field laboratory was conducted with permission at the Savannas State Reserve, 9551 Gumbo Limbo Lane, Jensen Beach, FL 34957. (A mostly-undisturbed 5000-acre tract of land on the Atlantic Ridge which houses at least eight discernible ecosystems.

[y]Botanical authorities not shown.

mentally sound alternative to landscaping with potentially invasive plant materials.

CRITICAL THINKING SKILLS FOR POST-GRADUATION SUCCESS

Wildman and Preston (1999) reported that prior to college most tasks competed by students are teacher specified, cognitively simple, and performed alone or with a teacher's instructions. However, once students graduate from college, professional tasks are complex, often self designed, and may often have to be completed utilizing teamwork skills. It is up to instructors in higher education to provide students critical thinking skills to compete in the professional job market, enhance the application of knowledge from their chosen field of study, and experience post graduation success. The promotion of higher-order thinking skills is a principle emphasized by the Presidential Task Force on Psychology in Education (Amer. Psychological Assoc. Presidential Task Force on Psychology in Education, 1997).

In addition, instructors have to be aware that the content information they are presenting will have varying half-lives as factually correct information. For example, the Laws of Thermodynamics, will in all likelihood be permanently unchallenged, but economic research on the current marketing trends in ornamental landscape plants may be out of date by the time it is published. In contrast, the critical thinking skills we help students develop will be the foundation for a lifetime of learning. There has been an educational movement afoot to increase critical thinking exercises in schools. Additionally, critical thinking skills should be honed and developed in the new paradigm of "learning as cultural participation" (as reviewed by Wildman and Preston (1999)). The authors support this paradigm shift and believe the addition of critical thinking exercises to the undergraduate curriculum, where possible, will aid students in becoming 'society-ready' graduates.

In order to teach critical thinking skills a series of 'reaction' exercises were incorporated into the SFFE course. The results of one of the critical thinking exercises are shown in Table 3. In this exercise, students were asked to review an excerpt from the required text that discussed the role of citrus production's impact on the decline of native habitats and species on the central ridge of Florida. Students were then asked to write a response to the passage using the voice of an individual chosen from a pre-determined list. All of the responses were posted on the course website for students to read so that an overall discussion of the topic could take place in class. It was clear from the writing samples that students were accustomed to the general arguments for and against agriculture espoused by various groups and organizations. Occasionally, this resulted in a humorous look at our own society, as displayed by the writing sample from a student role-playing a South Florida politician (Table 3). However, following class discussions most students still had their own "correct" opinion, but saw the value in understanding opposing viewpoints, even if only to gain an advantage in refuting an argument. This was an important observation to the authors, providing evidence that the students were learning the value of critical thinking. In subsequent critical thinking exercises students were forced to assume new roles maintaining the requirement for new creative thoughts. Additionally, critical thinking exercises were included on the final exam to continue the emphasis on the importance of these skills.

Browne and Keely (1998) state that critical thinking skills are useful to students for reading comprehension, information evaluation and class participation. Likewise, critical thinking skills are important to society participants in making every day decisions (Browne and Keely, 1998). The addition of critical thinking skill exercises to the course should put students one step closer to becoming a successful 'society-ready' graduates.

LESSONS LEARNED

The authors feel that the educational tools used to meet the objectives of this course were successful, but that does not mean they were without difficulties or room for improvement. For instance, some students had relatively weak backgrounds in fundamental ecology. An introductory lecture was provided for students, but even more background information will be provided in the future. Early during the course, it also became apparent that critical thinking exercises were foreign to most students. As a result, a brief introduction to critical thinking and its importance in education will be provided to students in one of the first few lectures in the course. We also tested for critical thinking skills on the final exam by giving the students four essay questions which were graded based on scientific logic, proper support of conclusions, approach to answer, clarity of arguments, and resources listed to solve an individual problem.

The initial offering of this course also occurred during a shortened summer session (6 weeks instead of 16). The authors and students found this short time to be a limiting constraint on the amount of information that could be effectively covered. In subsequent offerings the course will be offered during a 16-week semester and the credit hours have been increased from 2 to 3. In addition, students had some problems associated with taking the course at a satellite campus. The following concern was reiterated on student course evaluations: "limited access to library and research materials" and "need better library access." The authors plan to have a short Internet library resource training session in the future to help students better access resource materials. Most of the students

Table 3. Student writing samples from a critical thinking assignment designed to utilize role-playing as a mechanism to understand opposing arguments.[z]

Student's assigned role	Excerpts from student compositions[y]
Ridge citrus grower	"My family spent many years of hard work clearing the useless scrub off of our land. Now, the so-called environmentalists complain about the loss of scrub. If they wanted to protect the scrub so much why didn't they buy it and put the kind of work into saving it that we put into developing productive groves. We are good environmentalists too. We only fertilized and sprayed as much as we had to and we always followed the Extension Agent's recommendations. After all it is our land that we would be damaging and our soil that would be eroding away."
Passionate environmentalist	"If this keeps up, our native Florida stands of vegetation will be lost forever. These agriculturists insist upon tromping in and plowing over our natural wonders. Don't they have enough orange and grapefruit trees already? Why do I see so many abandoned groves left to wither when they could reuse some of these groves instead of mowing down my children's indigenous heritage? Why do I see so many piles of perfectly good grapefruit dumped to rot in the blazing sun in pastures when we have so many hungry people in the world?"
Chemical company spokesperson	"Today's citrus grower uses resources, chemical and natural, with increasingly more conservation and precision than growers of previous generations. Much of this improved technology is the result of research and education sponsored by WOW and companies like ours. WOW also supports legislation currently in place to preserve and regenerate the longleaf pine and related plant communities. The future is here regarding common goals in agricultural chemical research and environmental concerns."
Florida homeowner with children	"As a homeowner with children I want to know if this is true...and if it is what kind of fertilizers and pesticides are being used? Have these fertilizers and pesticides been tested for side effects that can cause disease? Are there any known diseases that can occur from these fertilizers and pesticides? If there are I believe the public should be made aware of the possible health hazards and research efforts to find fertilizers and pesticides that are not hazardous to our health."
South Florida politician	"While we're on the subject, I'd like to propose we re-commission our original study on fertilizer and pesticide run-off from citrus groves into the watershed. The insufficient findings of the previous study are.....insufficient. I'm convinced that if we study this situation long enough and closely enough that we'll eventually have the answers to what we are looking for."

[z]In this assignment students were given an excerpt from the required text discussing the role of citrus production on the decline of native habitats and species on the central ridge of Florida.

[y]Full-length student compositions online at http://www.irrec.ifas.ufl.edu/SFFE/index.htm

found the materials handed out in class adequate, but reviews were mixed on the text. Most thought the text was a thorough and complete review of the ecosystems in Florida, but at least one found the content to be overkill stating, "personally I found the text more technical than necessary for the course" on the student evaluation. This problem may relate to a lack of background in the subject matter, as mentioned previously.

Finally, we received several positive student comments including "valuable, educational, important for anyone who intends to live in Florida" and "...make it a requirement for all majors." Our course is designed to accomplish this via the concurrent exposure of students to flora identification exercises, *in situ* ecosystem lectures by experts, and critical thinking exercises related to current environmental issues related to the horticultural industry. The course received at 4.57 (out of 5) overall evaluation by students. Courses offered the same term in the Department of Environmental Horticulture and across the College of Agriculture and Life Sciences at the University of Florida received mean student evaluation ratings of 4.50 and 4.22 respectively. The three modules presented here could all be readily adapted for local ecosystems and environmental concerns in the context of a variety of plant science curriculums. The authors hope that the teaching methods and observations reported here will benefit plant science educators seeking to add an environmental awareness and/or critical thinking component to their curriculum.

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