Field-based and hands-on ecology labs increase undergraduate interest in the natural world

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Courses with field components and emphasis on natural history have been fading from college curricula. Interest among young people in observing the natural world has also widely been observed to be declining. Here, I measured whether participation in a college-level general ecology lab (with hands-on and field-based labs) increases student interest in natural history. I created a scoring system to assess students' interest in natural history ("naturalist score"), and students used this system in self-evaluation before and after completing the course. During the semester, students participated in labs rooted in ecological theory and natural history including two field-based labs, one experiment using live plants and animals, and independent projects on topics of their choice. Naturalist scores increased significantly post-course. This pattern was apparent in students across a wide range of career interests.

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Engaging children and young adults in natural history is an important challenge. Natural history—"a practice of intentional focused attentiveness and receptivity to the more-than-human world, guided by honesty and accuracy"—(Fleischner 2001, 2005) may be beneficial to earth stewardship, human societies, and personal well-being (Fleischner 2011). In their daily lives, children and young adults are often largely disconnected from nature (Louv 2005, Allard 2008, Hofferth 2009). In classroom settings, natural history has increasingly disappeared from curricula in biology education at all levels (Noss 1996, Wilcove and Eisner 2000, Dayton 2003). Even among biologists, natural history is often viewed as a luxury or even negatively (Futuyma 1998). Such attitudes are worrying in the face of ecological crises (Trombulak and Fleischner 2007) since conservation and natural history are intertwined (Dayton 2003, Fleischner and Noss 2013). Biology educators are in a position to support the reintroduction of natural history into curricula. Here, I aimed to quantify whether field-based and hands-on ecology labs increased undergraduate students' interest in natural history.

In the fall and spring semester of 2012-13, I taught four sections (two per semester) of general ecology lab at the University of Florida. This lab is designed to complement the lecture component of an ecology course. The purpose of the lab is to provide students hands-on experience in ecological research. This includes learning the natural history of local ecosystems, applying field methods, and testing ecological hypotheses.

Among the four sections, I had 41 students. At the beginning of the semester, I asked students to write their names, what they wanted to do professionally, and to rate themselves on a scale of 1 (low) - 10 (high) as naturalists or in their interest in observing the natural world (henceforth "naturalist score"). Throughout the semester, students participated in hands-on exercises in the field and lab. At the end of the semester, I again asked students to report their naturalist score.

The average score increased (Fig. 1) from 6.2 before the class to 7.6 (paired t-test; $t = -6.88$, $df = 40$, $P < 0.001$). Of the 41 students, 31 (76%) increased in their naturalist score between the beginning and end of the semester, 9 did not change (22%), and one student decreased (2%). Students whose naturalist scores did not change largely already had high scores (8.4 ± 1.1 SD).

I identified six groups based on responses to what students wanted to do professionally: ecology (research), medicine, veterinary medicine, wildlife/fisheries (management), don't know, and other (for career paths that did not fit into other groups). The largest group (n = 16) was interested in pursuing careers in medicine, followed by ecology and wildlife/fisheries (n = 7 each), and veterinary medicine (n = 6), and "don't know" and "other" (n = 4 each).

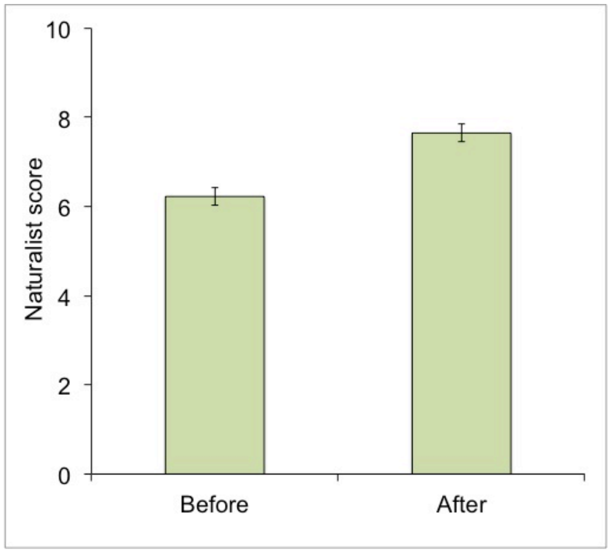

Figure 1. Student (n = 41) self-identification as naturalists and their interest in observing the natural world (naturalist score) at the beginning of the semester (before) and the end of the semester (after) of the general ecology lab. Bars indicate average scores and error bar indicate within subject 95% CI (Cousineau 2005).

Naturalist scores for students trended towards increases across career interests (although replication was low for some groups; Fig. 2): those with career interests in ecology showed a 22% increase (t = -3.7, df = 6, *P* = 0.01), wildlife/fisheries 11% increase (t = -2.3, df = 6, *P* = 0.07), veterinary 13% increase (t = -1.3, df = 4, *P* = 0.26), other 28% increase (t = -2.5, df = 2, *P* =0.13), don't know 21% increase (t = -2.6, df = 3, *P* = 0.08), and medical 37% increase (t = -4.4, df = 14, *P* = 0.001). Notably, the naturalist score of students interested in ecology was over 9.5 after completion of the lab section.

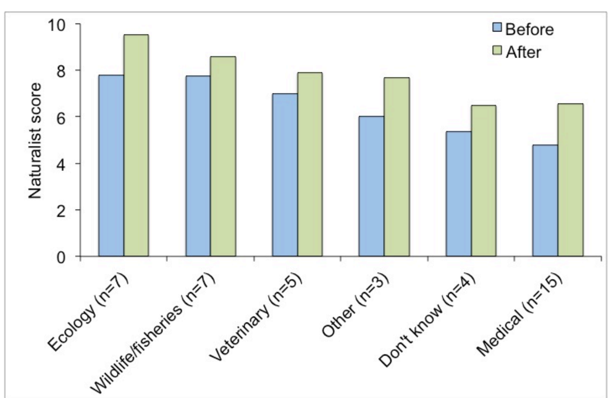

Figure 2. Students' naturalist score at the beginning of the semester (green) and the end of the semester (blue) grouped by career interests. Bars indicate average scores.

After receiving their final responses, I shared the results with the students via email and asked what it was about the course that increased their interest in natural history. Eight students responded; some students gave more than one reason. The reasons given (summarized and in no particular order) for the increased naturalist score were (1) tying ecological concepts to observations in nature, (2) working with live animals in independent projects and in lab, (3) spending time outside and exploring new natural areas, (4) demystifying ecological research, and (5) hearing stories from the field.

These results, although anecdotal, support the view that biology education through hands-on and field-based labs can be a promising avenue for promoting natural history to students with diverse interests. Future studies to quantify the effects of field and hands-on labs on interest in natural history could replicate the study described here and improve on it by making surveys anonymous, adding additional pre- and post-course questions, and including controls (for example, students taking only the lecture component of the course).

Instructors may under-estimate the impact that field trips and hands-on activities have on students. These impacts may last long after the course. For example, Falk and Dierking (1997) interviewed children and adults about their recollection of field trips during elementary school and found that nearly all of them recalled field trips, especially field trips to natural areas. I believe that college-level field trips and hands-on labs can have similar impact. Personally, I will long remember field experiences that I had as an undergraduate, such as trapping small mammals and bats in a mammalogy class and observing ants at bait stations in ecology class. These experiences were formative in my love of ecology and natural history.

Below, I briefly describe the labs and independent projects. Full descriptions are available from the author on request. The labs and manual were developed by Ted Schuur, Caitlin Hicks-Pries, Jordan Mayor, Michelle Mack, Craig Osenberg, and Brian Silliman.

Labs and Independent Projects

Forest tree community structure lab. The objective of this two-week lab was to compare tree species composition between two forest types at a local natural area. During the first week, students collected data in the field, and the following week they visualized and analyzed the data. As a class, we visited San Felasco Hammock Preserve State Park (http://www.floridastateparks.org/sanfelascohammock/), a large (28,000 ha) protected area a 20-minute drive from campus. Students compared two iconic Florida forest types, longleaf pine sandhills and a mixed hardwood forest. They first made observations about the differences in the forest types (e.g., number of trees species, species richness, tree heights, canopy cover) and what could be driving those differences (e.g., topography, soil, fire). They then laid out transects through each of the two forests. Along these transect students collected data on trees and identified them using dichotomous keys provided in the lab manual, field guides, and tips and tricks that I taught them.

Terrestrial ecosystem function lab. The objective of this lab was to compare carbon flux and biomass in areas of different human land uses at a natural area on the University of Florida campus (http://natl.ifas.ufl.edu/). Again, the first week of the lab consisted of data collection in the field and the second week of data visualization and analysis. In the field, students laid out transects through four land cover types: a forest, two early successional fields of different ages, and a lawn. Along each of these transects, they collected data on above ground biomass and measured soil respiration using an infrared gas analyzer respiration chamber. In the forest ecosystem students collected data from trees on their diameter at breast height (DBH) to estimate the carbon pool from allometric equations.

Trophic cascade lab. The objective of this lab was to test the top-down effect of predators on herbivores and plants. In this lab, the predator was the razor-backed musk turtle (*Sternotherus carinatus*), a turtle native to Florida. The herbivorous prey were crayfish (*Procambarus clarkii*), which are also locally common. The plant was hydrilla (*Hydrilla verticillata*), a problematic invasive species in Florida. Students set up the experiment by devising aquaria with different combinations of hydrilla, crayfish, and musk turtles, including a treatment of non-consumptive predator effects. The following week, students broke down the experiment and weighed the hydrilla, crayfish, and musk turtles. They then visualized and analyzed the data to reveal the results of the experiment.

Population dynamics lab. This was a MS Excel lab that simulated stage structured population growth in a charismatic local species, the loggerhead sea turtle (*Caretta caretta*). This lab was modified from Donovan and Welden (2002). The objectives of this lab were to build a model of population growth with stage structure and explore how a population responds to changes in model parameters. Students first simulated and graphed population growth over for a population of sea turtles structured by stages (hatchlings, small juveniles, large juveniles, small adults, and adults). Parameters for the transition matrix were derived from Crowder et al. (1994). Students then tested the effects of making changes to the model such as introducing density dependence and changing the initial abundances and transition parameters (to simulate the introduction of Turtle Exclusion Device fishing nets).

Independent projects. Independent projects were a major component of lab. They were devised and carried out by students in small groups (2-3 students). Students were encouraged to begin thinking purposefully about their projects from the beginning of the semester. Half-way through the semester, we spent 30-40 minutes of a class period in a forested area on campus discussing ideas and making observations. Once groups were formed, students discussed ideas and made plans to make observational studies to get familiar with their study system. The following week, students presented observational data, their research questions, hypotheses, and an outline of their study plan. Students worked independently with my guidance for the remaining seven weeks of class. Class time in four of those weeks was devoted entirely to independent projects. Projects culminated in a ten-minute PowerPoint presentation and a written lab report. Independent project topics included trait-mediated effects of avian predators on foraging by song birds, effects of abiotic variables on bat emergence, floral color effects on pollinator visitation, variables affecting Spanish moss cover on trees, abundance of fire ants along a disturbance gradient, and microbial biodiversity among local bodies of water.

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