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Discovering Sustainability in New York City: An Interdisciplinary Framework for Teaching in Urban Institutions

Karyn Pilgrim
Kevin L. Woo
State University of New York Empire State College, USA

ABSTRACT

Ecological learning is enriched when students can apply course content to their own communities and gain an understanding and experience for deploying sustainable practices. Such merging of content, application, and place requires an interdisciplinary approach to grapple with the ecological and cultural issues more holistically that sustainability education explores. Guided by the ecological pedagogy of David Orr, founder of the Oberlin Project, we devised a pilot study that combines course content in environmental science, cultural studies, and writing with place-based, experiential, and hands-on learning to empower students to critically analyze their lifestyles and engage in activism for change.

Keywords: activism, experiential learning, interdisciplinary, place-based, sustainability education

INTRODUCTION

The application of student learning outside the classroom promotes academic understanding of content. Students can enhance their learning when they put into practice new skills, test theories, and think in

interdisciplinary and multifaceted ways (Barth et al., 2007; Grabinger & Dunlap, 1995). When students test their learning within their local communities, they can see firsthand how their knowledge applies to their own lives, which may foster an ethic of caring along with a greater depth of understanding. For example, it is one thing to learn about the effects of climate change and water resources and quite another to see how it affects the local watershed. Merging what happens in the classroom with experiences outside the classroom is a strategy for making higher education more meaningful and applicable to our students' everyday lives.

Another noteworthy trend in higher education is the growing presence of interdisciplinary approaches to learning and thinking in higher education. Interdisciplinary learning allows students to investigate ideas broadly, gain multiple perspectives on how cultures incorporate and implement knowledge and values, and teaches students about the interconnectedness of all things. The walls of the classroom are becoming more transparent and the artificial boundaries between disciplines are being revaluated; these are welcome developments for educators working to advance sustainability studies, which require of students an understanding of the natural environment and humanity's place in it, as well as how human attitudes and behaviors impact the health of the natural environment. Sustainability itself is a cross-disciplinary area of study (Robinson, 2008), as much a science as a cultural perspective that can, and probably should, be integrated into virtually every discipline. Indeed, it has been argued that sustainability is an important component to incorporate into core institutional degrees and should be widely implemented across curricula (Rowe, 2002; Warburton, 2003).

Initially, the drive to necessitate sustainability into the curricula was instigated primarily by academics and instructors (Klein, 2009). Functionally, successful implementation of these programs required institutional cooperation and input, such that administrators, faculty, and stakeholders collaborate to recognize sustainability's academic importance for inclusion into dynamic curricula (Krizek et al., 2012). Jointly, the desire to create courses that incorporated aspects of cultural, environmental, and social sustainability was an attractive tool academically and professionally for students. It was recognized early in consideration that content and dialogue often originated with topical areas of academic expertise (Scholz et al., 2006). While there were clear and important overlapping themes, early implementation drew narrowly from single streams of content with the attempt to identify common corridors for bridging knowledge (Redman, 2013). This led to a common tapering, sometimes exclusively segregated, of

courses that were limited in scope that failed to account for a much wider consideration of issues and approaches (Welsh & Murray, 2003).

As further institutions created more courses thematically under a sustainability umbrella, it became increasingly evident that sustainability is inherently interdisciplinary and benefits most from the cross-pollination of institutional faculty and their respective areas of expertise (Caviglia-Harris & Hatley, 2004). Consequently, this epiphany unearthed new pedagogical philosophies regarding instruction and curricular design approaches while also generating new avenues for consideration and new complexities. Historical approaches to classroom delivery also relied heavily on traditional instructional models of mere discussions of content and theory (O'Byrne et al., 2015). The most seemingly logical approach to injecting sustainability into interdisciplinary studies was to identify two core disciplines and merge the capitol subject areas while infusing aspects of how sustainability impacts the fields of study. In essence, subject area content was essentially presented within traditional academic silos and failed to integrate cross-disciplinary ideas effectively (Kurland et al., 2010; Ward et al., 2016). Some courses in sustainability appear to have an obvious relationship to the subject, such as those in the natural or physical sciences (Barth & Michelsen, 2013; Biedenweg et al., 2013; Burns, 2011). In contrast, for example, with the overarching theme of sustainability in a wider context, several interdisciplinary courses with more disparate disciplines seemed to have successfully been crafted to pair areas like agriculture and policy (Karsten & O'Connor, 2002), geography and education (Widener et al., 2016), foreign language and environmental studies (Ter Horst & Pearce, 2010) and human services and environmental sciences (Schmitz et al., 2010), to identify a brief list of studies. Consequently, the scope of future interdisciplinary courses in sustainability, such as the one presented here, ought to consider a wider breadth of pedagogical diversity.

And yet, one of the great ironies of teaching sustainability in academia is that most, if not all, of the learning outcomes for our courses are directed at the outside world and our students' interactions with society (Lélé & Norgaard, 2005), while the learning itself takes place within an artificially manipulated environment of perfect climate control. While we teach students to think critically about the complex interplay of human culture and behavior and natural environments and ecological systems, the seemingly stable and controllable physical environments of our classrooms suggest, in a background white-noise kind of way, that we can adjust the environment most satisfactorily to suit our desired comfort levels.

One obvious disconnect between humans and nature is the overwhelming social science literature that suggests a significant portion of

the population believes that they are sensitive to environmental issues but fail to act in socially responsible ways (Jensen, 2002; Kennedy et al., 2009; Kollmuss & Agyeman, 2002). A challenge for teaching sustainability related coursework in the classroom is to discover and implement modes of teaching and learning that both transcend and bridge the classroom with the far more dynamic and volatile landscapes of the world outside the classroom. Precisely because the classroom is not an ideal environment for learning how to merge knowledge with practice in sustainability—in other words, how to gain hands on practice of the concepts students learn in the classroom—it becomes imperative as educators that we build bridges between knowledge and practice into our curriculum. This is neither a new idea nor an easy one to implement. The ease of implementation depends upon the setting where one teaches (Sampson & Smith, 1957; Kehl & Morris, 2008; Rowan-Kenyon & Niehaus, 2011; Younes & Asay, 2002). Many scholars of sustainability pedagogy have called for the dissolution of the boundaries between the classroom and the world, in one form or another (Brundiers et al, 2010; Remington-Doucette et al., 2013). One known barrier is that professors and students alike often contend with a lack of space or equipment, or lack of funding to procure new resources (Klein & Newell, 1997; Summers et al., 2005). However, the main challenge, as sustainability pedagogy becomes more widespread and interdisciplinary, is in many ways a mirror image of the challenge of culture change for sustainability itself: how to adapt and implement such pedagogy across a wide range of classroom structures and educational landscapes, many of which present significant obstacles for the cultivation of hands-on learning experiences.

As an inherently interdisciplinary field, the premier difficulty is to ensure that the diversity across perspectives is adequately captured and meaningfully delivered (Johnston, 2013). As a persistent conflict in its pedagogical implementation, many instructors have genuine intentions for disseminating content, but there is no real consensus on best practices for delivery and facilitation of instruction (Feng, 2012; Vincent et al., 2016). More seemingly successful approaches seem to engage students by employing active learning strategies (Levintova & Mueller, 2015). In one example, Brundiers and Wiek (2013) have noted that one of the fundamental issues is the disconnect between problem-based and project-based learning (PPBL) activities that are meant to bridge the theoretical content and practice. Central to this notion is the inclusion of case-based examples that may encourage student innovation as they consider pragmatic solutions for problem solving (Sprain & Timpson, 2012). As such, the emphasis here is not merely to ensure that content areas are addressed, but that applied learning opportunities provide a more comprehensive and holistically

fundamental approach for engagement. Another interesting approach by Ranaswami et al. (2012) employed a novel social-ecological-infrastructural systems (SEIS) framework for an engineering curriculum. Here, the model developed two subsystems (biophysical and social) that integrated sustainability theory and legal policies with the disciplines of environmental sciences/climatology, infrastructure engineering, industrial ecology, architecture, urban planning, behavioral sciences, public health, and public affairs. The interaction of these models appeared to generate two highly successful outcomes: 1) that students overall felt the integration of these disciplines was central for understanding sustainability on a graduate level that may lead to actualized application, and 2) allowed for cross-disciplinary faculty collaboration (Wood, Cornforth, Beals, Taylor, & Tallon, 2016).

College and university campuses serve as an excellent environment in which to engage in interdisciplinary instruction for sustainability. Evans et al. (2015) suggested that the university environment serves as an opportune example of a 'living-laboratory', in which the notion of theory and practice ought to be seamlessly disseminated throughout the collegiate community. For example, Gosselin et al. (2016) examined the effectiveness of place-based learning at three distinctly different colleges in the United States that teach courses in sustainability and link geoscience concepts with societal challenges. Here, Gosselin et al. (2016) further suggested that the college campus, and surrounding geographical and environmental communities, offer immense opportunities for students to engage in real-world issues that may have a direct impact. Thus, the likelihood for engagement increases with familiarity and the perception of impacts to one's immediate locale. As with most foundational studies, the introduction of sustainability curricula is often focused on undergraduate populations, both in terms of reaching a larger number of students as well as the likely impressionability (Aktas, 2015; Coops et al., 2015). However, sustainability curricula are also becoming more commonplace in graduate programs, particularly as students seek post-graduate degrees that may focus on areas pertaining to environmental or social change (Lee et al., 2013).

As the nature of pedagogical delivery and the rapidity of the discipline evolve, so does the mode in which students can engage in courses. For example, Knowlton et al. (2014) devised a graduate course where the central focus was to develop interdisciplinary sustainability science teamwork skills. Given the personal and professional demands on graduate populations, Knowlton et al. (2014) sought to design in-person and web-based interactions that provided both a flexible and complementary experience for ensuring that students had access to the course content, but continued to engage with the course and class on a fairly regular basis.

Deviating from traditional models of instruction, curricula in sustainability are inherently interdisciplinary, which is both attractive for developing creative pedagogical tools, yet notoriously difficult to design a 'one-size-fits-all' model. Rau et al. (2018) noted the difficulty and increasing challenge for students, academics, and practitioners to solve 'real-world' issues from merely classical content and instruction alone. They advocate an embrace of the diverse perspectives in sustainability, from academic to experiential, and employ similar project-, place-, and problem-based approaches in sustainability research to assist short- and long-term goals. Thus, it seems likely that the approach for sustainability instruction is to continue to validate nontraditional 'outside-the-box' paradigms than enable instructors and students to be both creative and innovative.

Sustainability education should be a study of humans within nature, with the aim of fostering healthy, mutually sustaining ways of being. In order to foster such mutually nurturing practices, students need to feel empowered to act sustainably, experiment with sustainability practices, and implement such practices in their communities. The example of the classroom without windows on a campus without access to outdoor space demonstrates yet another important aspect of the need for integration in sustainable education; in this case, the integrative factors are the linkage of environmental concepts with cultural frameworks. Residents of large urban centers spend much of their time in controlled environments, which can create a perceptual distance between human culture and the wider natural environment (Gehl, 2011; Grahn, & Stigsdotter, 2010). It is all too easy to ignore or be unaware of the mounting problems associated with climate change and environmental degradation or simply to lack any experience with natural environments that humans have not designed. The complex interactions between humans and our ecosystems often go unnoticed. For these reasons, sustainability education must connect the perceptual gap between nature and culture. Students need to develop an understanding of how their own actions and beliefs and the actions and beliefs of their communities are engaged in a dynamic exchange with natural systems that are not immediately evident to the untrained eye. It is imperative that students see how behavior at the personal and local level connects with wider regional, national, and international systems that impact and alter the natural environment. Furthermore, they need to become aware of how human culture is not separate from nature but co-existing within nature, a part of it that is altered by as much as it alters nature.

For these reasons, we—a cultural studies professor and a biology professor—have developed a course entitled "Green Pens and Thumbs: Discovering Urban Sustainability in New York City" that combines learning

in ecology, cultural studies, and writing to teach principles of ecology, sustainability, and civic engagement to undergraduate students at our public university. In this paper, we explain how we deploy hands-on learning within and outside the classroom, share the successes and failures of our course, and consider strategies for revising and repeating this course in the future. Finally, we reflect on the relevance of interdisciplinary, experiential learning for educators in sustainability studies, broadly conceived as such, and propose some best practices which have emerged from our experiences for designing and implementing our course.

Pedagogical Model

For a theoretical framework for teaching sustainability, we draw on the pedagogical model developed by David W. Orr, a leading expert in sustainability education, professor of environmental studies and politics, and founder of the internationally renowned Oberlin Project, which envisions "full spectrum sustainability": a joint venture by the town and College of Oberlin to create a thriving, sustainable and environmentally friendly community. Orr (2004) advocates a form of environmental education that is integrative and transformative, that puts into practice the principles of sustainability in a holistic and place-based approach to learning. It is holistic in the sense that he believes that "all education is environmental education" (Chapter 1, "Rethinking Education," para. 2); this is the first principle for rethinking education that he espouses in his foundational text, *Earth in Mind: Education, Environment, and the Human Prospect*. By this, he means that it is essential for students to learn the interconnectedness of things and that sustainability is not just about science and nature but how we live. Furthermore, he argues that "The goal is not mastery of subject matter but mastery of self" (Chapter 1, "Rethinking Education," para. 3), his second principle for rethinking education. This is an inherently holistic approach for it involves the student as a citizen with responsibilities to self and others, and it considers the integrity of the whole person. He opposes a learning model that severs knowledge from its value to people and each individual's personal growth. In fact, his sixth principle for rethinking education is that delivery and content are equally important for student learning. Orr (2004) argues that we instruct our students in silent yet significant ways by the nature of the classrooms we teach in and how we structure our classrooms and curriculum. A scenario wherein the professor lectures and the students take notes is, as we know, experienced quite differently by students and engages them differently than a classroom discussion would. Considering the example above of the windowless classroom, the lack of connection to the exterior world, and the enormous amount of energy consumed in its

operation, also sends a powerful message to students that sustainability is abstract or "out there."

Instead, Orr (2004) asserts that learning that is truly liberal and fosters citizenship and sustainable growth must be interdisciplinary and include experiential learning. He advocates "that we seek out ways to situate disciplinary knowledge within more profound experiences of the natural world while making it more relevant to the great quandaries of our age" (Chapter 14, para 14). In this way, critical and creative thinking processes could be freed from disciplinary constraints to engage in transdisciplinary problem solving and far more comprehensive understandings and explorations of the issues we face on global and local scales. It could further remove boundaries between the classroom and the lived world. This kind of learning is place-based and intends to nurture student connections from the classroom to their individual communities; it is a combination of both theoretical and applied learning in action that transitions these concepts from abstractions to purpose. One example Orr sets forth is that we should dedicate a part of the curriculum to the study of natural systems in the same manner that the students experience them. To study a polluted water canal in Brooklyn, for example, students should visit the canal and conduct experiments or observations onsite. This type of learning aims to create an ethos of caring and an experience of connection. Orr calls for all introductory level courses, in all disciplines, to include extended place-based education so that students are introduced to the wonders and mysteries of the world around them as lived experiences first, before their induction into more abstract forms of learning.

Joining Interdepartmental Forces between Humanities and the Natural Sciences: A nontraditional public campus in New York City

The course development for an integrative study of sustainability set forth in this paper takes place at a large public institution, with approximately 22,000 students statewide. The institution consists of 12 regional locations with one or more affiliated, smaller units. The number of faculty and students enrolled at each location varies. We work for the Metropolitan location, situated in Manhattan, but teach at the downtown Brooklyn unit, which rents one floor of a multi-story office building, and so rental conditions disallow any opportunity of cultivating outdoor green spaces on surrounding lands, the relatively few parking lots, or the rooftop. Furthermore, the floor plan of this campus is such that faculty offices surround the classroom space, leaving the classrooms in the interior without windows or natural lighting. The atmosphere is starkly office-like, and the small student lounge is also windowless. In such an environment, the

seeming separation between humans and the natural environment could not be starker. At the same time, the need to figure out how to "let the wilderness back in" as William Cronon once asserted, or at least some greenery and sunlight, provides a most instructive challenge for faculty and student advocates of sustainability. Compounding this situation is that many of the students live in similar environments, lacking significant access to natural light or green space. Despite our institution's physical and structural constraints, we aimed to create hands-on learning experiences and a learning environment that supported sustainable thinking.

Our Course

We are scholars in the disciplines of cultural studies (literature, critical theory, and writing) and natural science (biology, ecology, and animal behavior), who are active in developing the college's learning goal of integrating sustainability concepts across the curriculum. With this in mind, we decided to team-teach a course that satisfies two State University of New York general education requirements—one in the sciences and the other in basic communication—that explains ecological concepts of sustainability and then explores the various ways that these concepts are expressed in cultural systems, in this case the urban systems of Brooklyn, NY. Social, ecological, economic, and political factors of sustainability are all critically analyzed throughout the course.

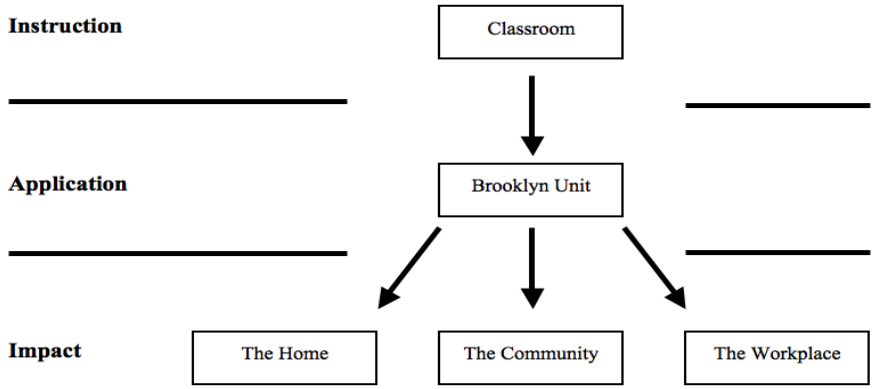
Because the course integrates learning in the ecological sciences and communications, we named the course "Green Pens and Thumbs: Discovering Urban Sustainability in New York City." We included the following description of the course purpose on the syllabus handed out to students:

> This study intends to immerse students in urban sustainability, from an ecological, cultural, and activist standpoint. Students will explore definitions of sustainability and consider the means by which a community can work together to implement sustainable practices for the good of all. Since the best way to learn about sustainability is to practice it, students will apply their reading and classroom learning to hands-on experiences in urban agriculture field trips, visits to museums, and other sites across the city. And because sustainability and democratic principles are intertwined, students will take on the role of citizen journalists, interviewing people involved in urban sustainability, researching the goings-on across the city, and reporting on them in creative essays.

Conceptually, we approached the course as a flowchart with "Instruction" leading into "Application" and then the "Impact" on "Home," "Community," and "Workplace" (Figure 1). In our model, the proposed purpose was to deliver both the theoretical instruction and applied activities in learning environments that were both indoors and in the field. In consideration of Orr's (2004) pedagogical model, and also due to the lack of green space at our campus, a primary goal of this study was to make use of the students' communities, envisioned on a walkable neighborhood scope, to immerse themselves in hands-on learning and thereby apply the instructional components of the course to its application at the level of home, campus, and community.

Figure 1

Our Conceptual Model for Engaging Students to Think and Act Sustainably



Note. We intended to deliver theoretical content that is complemented by hands-on learning experiences in the classroom. However, the 'classroom' was both our literal indoor space at the Brooklyn Unit and field trips that we experienced with organizations based in New York City. From this learning, students were then asked to create sustainable initiatives for implementation at the Brooklyn unit, which would allow their efforts to be publicized. This display and their knowledge would encourage the students to engage in sustainable actions in the home, the community, and the workplace.

Instruction

The instructional material of the course was organized into six units of study, with each unit representing a week of the 8-weeklong accelerated summer term, excluding the first meeting and the last meeting. The first unit covered a broad overview of environmental sustainability and fundamentals

of good writing; the second, general ecology principles, hydroponics and agroecology, and basic research and interviewing techniques; the third, conservation principles and writing for social media; the fourth, the development of team projects for greening the workplace (in this case, the campus) and approaches to revision; the fifth, urban sustainability practices, food security, and the economic approaches to urban sustainability; and the sixth, urban sustainability and social activism (see Table 1; see Appendix A for a copy of our syllabus). Students completed the term by presenting their team projects and their work on an on-site hydroponics system to the college community, who were invited to observe their presentations.

While the purpose of this study was to combine interdisciplinary learning in environmental sustainability and cultural studies with basic skill development in the sciences and communications, as well as to implement hands-on learning experiences to empower students to critically analyze their lifestyles and engage in activism for change, the learning objectives for the course were as follows:

1. ***General ecology principles and conservation***. The basic science behind ecological principles and the need for sustainability, with a special focus on urban sustainability, will provide foundational knowledge for their work in the course (see Appendix B for a copy of our 'Measuring Biodiversity' exercise).

2. ***Sustainability principles and the challenges practitioners face***. Students will be introduced to a range of urban sustainability practices, food and urban sustainability issues, climate change, and the impacts of environmental degradation on life systems.

3. ***The cultural significance of urban sustainability and social activism***. Students will, by comparing and connecting their learning of sustainability and ecological principles to cultural practices and beliefs, understand how and why societies may fail to implement sustainable practices, and even actively work against them.

Table 1

A course outline that identifies the theoretical and applied content covered during the term.

Week	Theme	Interdisciplinary Topics	Activities
1	Introduction	- Foundational concepts in cultural and environmental sustainability - Environmental literacy	- Start blogs and initial entries
2	General Ecology	- Biological levels of organization - Impact of population dynamics - Abiotic-biotic interactions and landscape evolution	- Research information on plant species for improving indoor environmental health - Research on different plant systems (e.g., hydroponics, aquaponics, aeroponics) for implementation during the term
3	Individual Writing Projects	- Environmental advocacy and social activism - Investigative journalism and reporting	- Field observation report on urban wildlife and plant species within student's neighborhood posted on class blog -Interviews with members of student's local community on attitudes to sustainability posted on class blog -Individual research projects on topics such as food sustainability, urban agriculture, waste disposal, and wildlife, posted on class blog
4	Conservation Team Projects	- Conservation biology and science - Climate change and global warming	- How to measure biodiversity using the Simpson's Diversity Index - Consider nonprofit environmental management
5	Sustainability	- Social attitudes towards sustainability - Anthropogenic impacts on urban environments	- Field trip to urban farm for hands-on experience in agricultural - Discuss operational missions, goals, achievements with staff
6	NYC Initiatives	- Interdisciplinary approaches in urban sustainability	- Comprehensive review of innovative operations specific to New York City and the urban environment (i.e., farms, beekeeping, aquaculture, alternative energy, advocacy groups)
7	Food Systems	- Urban agroecology	- Relate work on innovative agroecological operations to food insecurities in urban environments - Opportunity to finish design and construction of group plant systems
8	Conclusion	- Future of urban ecosystems	- Presentation of group projects - Unveil plant systems - Reflect on term content, activities, and projects

Note. Summer term courses were eight weeks.

Further, they will learn about the ways that grass-roots political action and consciousness raising have historically fostered community empowerment.

4. ***Research and writing as a form of social activism***. Students will learn about and engage in citizen journalism, including identifying a social problem that pertains to sustainability in their communities, engaging in research and interviewing local residents, and writing entries for a class blog, Urban Investigators.

Application

Through a combination of an instructor-led team project, a student-led team project, a field trip to an urban farm, and individualized research and writing assignments, students engaged in experiential learning. The syllabus included a faculty-led class project that involved the entire class researching and building an on-site hydroponics system in one of the classrooms, with the goal of the college community maintaining the system in perpetuity.

For the student-led team project, the class was asked to develop their own on-site project with two criteria: that it would remain a permanent installation and advance a sustainability principle. As a viable project with an immediate deliverable, the practicality for creating indoor spaces has several advantages. First, green indoor spaces improve general air quality (Allen et al., 2015), particularly in office-like environments regulated by air-conditioned and heating units. Secondly, select indoor flora significantly reduces the amount of common indoor pollutants and acts like a natural air purifier or biofilter (Cetin & Sevik, 2016; Wolverton & Wolverton, 1993). Thirdly, green indoor spaces have also been shown to improve workplace conditions, collegiality, and satisfaction (Nieuwenhuis et al., 2014). Lastly, green spaces have also been suggested to improve general workplace productivity (Miller et al., 2009). The class chose to advance sustainability principles through a twofold approach of greening the campus and educating the college community. With financial support from two grants, our students were able to conceive sustainable projects within a prescribed budget. The students purchased plant species whose maintenance required no outdoor light and infrequent watering to green the campus, and that was easily propagated to create seedlings for future distribution. The students created a stand for the plant and placed it in the reception area. Attached to the stand was a pair of scissors on a string and a poster that explained their goal of having faculty, staff, and students cut off branches and spread the plant throughout the campus.

To educate the college community, the students made professional posters with tips for everyday sustainability and hung them around the campus in hallways, the student lounge, and outside the restrooms. For the field trip, the students made one afternoon visit to an urban farm, Youth

Farm at the High School for Public Service (Brooklyn, NY), which operated on-site at a public charter school not far from the college. Going into its fourth year in production when we first launched the class, and now in its eighth year, the farm operates a Community Supported Agriculture program and intensive internships for interested college students and adults. Further, as part of its mission, it engages in educational workshops and provides a place for community members to gain hands-on experience in gardening. Our class worked at the farm for four hours, first tilling and weeding the garden beds and planting lettuce seedlings. As they worked, a farmhand instructed them about gardening with beneficial weeds and insects, compositing principles, and the labor intensiveness of the farm operation.

The individualized research and writing projects focused on instilling a layman's understanding of the power of communication for social activism. These projects drew on the philosophy of citizen journalism, which states that everyday people who are not professional journalists create their own news, including gathering information, reporting, analyzing, and disseminating it digitally, to democratize information within our otherwise highly concentrated and top-down media culture. The students were asked to investigate and photo-document their neighborhoods and local communities with the intent to analyze issues of food security. They researched the demographics of their local communities, interviewed residents about what sustainability means to them, and what their greatest concerns are regarding issues of sustainability, and then blogged about their findings on a class blog, 'Urban Investigators: Writing for Change' (https://urbaninvestigators.wordpress.com/). Their research, interviews, and photo documentation culminated in a critical essay by each student that considered the affordability and accessibility of healthy food for all residents in their communities, including the most vulnerable residents who may rely on charitable organizations to survive.

Potential for Impact

While it was not feasible for us to realize our goal to engage in the macrocosmic mobilization of an entire community to participate in sustainability, in a far more modest and limited way, we worked to connect the ranges of scale—from home to campus and the greater community—into scaffolded series of assignments and projects so that the impact of their learning was rooted in personal ways in their communities and personal lives. In this way, we attempted to model the concept of sustainability understood at its most basic as that which can be sustained in the design of the curriculum itself. Sustainable learning, that is, ongoing learning, needs

to cross the classroom boundaries to be integrated into the student's life, over time that endures beyond the limits of the term.

At the level of the home, students were asked to investigate by observation, interviewing, and online research, both the level of awareness about sustainability of residents in their immediate neighborhoods, which often included their family and roommates, as well as close friends and then to carefully consider the way their own lifestyles and the lifestyles of their neighbors were impacting the health of their neighborhood ecosystems. In this way, as they were studying general principles of ecology and sustainability, they began to see how their own behaviors and lifestyles were working to undermine or to impact their health and the health of the neighborhoods where they lived. Furthermore, the interviews they conducted generatednew conversations surrounding sustainability with the people with whom they lived.

At the campus level, the student projects made visible some sustainable practices by creating a hydroponics system that was left intact to be maintained by other students, staff, and faculty—a loosely campus-wide endeavor—after the term had ended. The posters offering tips for sustainability made—and continue to make—sustainability a topic at the campus. Although we helped guide the first iteration of the study with projects aimed at the food system and food security, it became rather clear that community interactions with food systems were more important to our students.

Students engaged their learning at the level of the community, interpreted for the most part as the community districts where they lived, by investigating the question of food security and the availability of healthy food for all members of their communities, including the most vulnerable. Students visited community farms, stores and marketplaces, food pantries and soup kitchens, homeless shelters, public schools, and churches, among other institutions. Some students interviewed homeless people and learned about the best prospects for "dumpster diving", meaning salvaging for food that stores throw out after it reaches its expiration date. Furthermore, students deployed their learning for the online community by publishing their investigative reports on food security on the class blog. While the readership of the blog is, by virtue of a lack of promotion, mostly limited to the college community, the students were very conscious of the public nature of their writing and the responsibility and power they thus had to instigate important public conversations about sustainability and to educate and dialogue with other interested people around the world. Finally, the field trip to a community farm allowed students to travel out of their own

communities and observe firsthand how urban spaces can become important sites of agricultural production and sustainability education.

Potential for Successes

We collected students' responses to test their understanding of the relationship between the community and the environment from their blog entries. Moreover, we were interested in the information contained within the entries that would directly connect the cultural and environmental association and whether students would feel compelled to disseminate their understanding beyond the confines of the classroom. Methodologically, these entries provided the qualitative basis for initial feedback and impressions for the likelihood that the model may have been impactful. Given that our pilot course consisted of a relatively small class size (<10 students), which is typical for our classroom courses at our institution, it, therefore, did not provide sufficient initial data for thorough qualitative or quantitative analyses. Consequently, our measure was implicit and therefore provided us with an initial baseline of data that can be used to compare to the feedback from future students. However, based on their blog entries, it seemed relatively straightforward that students could articulate favorable impressions of the course, content, and activities (see Table 2) and employ strategies of investigative journalism in their reflection of anthropogenic activity in contrast or concert with the urban environment.

In order to gauge the effectiveness of the course, we need to compare the anticipated learning outcomes with actual outcomes for student learning:

1. ***General ecology principles and conservation.*** While the students may have been aware of some principles of general ecology and sustainability before the course, by its end, they had come to see these principles manifest in their own communities. On the first day of class, we asked students to discuss what sustainability meant to them. Most of them mentioned recycling and vague concepts such as "not buying more than you need." By the course's end, their understanding of everyday sustainability practices was greatly expanded, as evidenced by their production of posters encouraging urban composting with practical tips that they posted around

Table 2.

Sample quotations from students' blog assignments, which supports positive attitudes towards sustainability and the environment.

Theme:	Quotations:
On sustainability:	"So I've learned firsthand if we can just make better use of what we have in front of us we can extend our precious resources for the next generation. In short, sustainability means life for our future by governing what we use in the present." "I like to keep it simple and I think sustainability is pretty much like it says; the ability to sustain. This is in reference to some sort of ecosystem that uses resources to keep itself going. Resources can be anything money, food, labor or even something simple like clean water. What is our ability to keep these resources from drying up? Are we using too much? I think sustainability is about identifying these factors and coming up with solutions to sustain our environment." "I am starting to realize that perhaps [sustainability is] not so much about reducing my overall footprint as it is changing the footprint all together. What I mean by that is unless we radically change how we go about living day to day, there won't be much living to go about – perhaps sooner than any of us realize."
On course projects:	"I don't know about anyone else, but for me, thinking that this area's ecosystems once rivaled today's Yellowstone Park makes me want to work so much harder to protect what we do have, and to create more green spaces. If there is anything we can learn from New York City's cultural richness, it's that our ecological richness is just as important. So start composting." "I love learning about sustainable neighborhoods. This article, especially the interviews, gave me new ways of seeing sustainability." "The garden in East New York provides vegetables for those individuals from Puerto Rico who miss home and encourage a healthy diet. For now the gardens are used as safe havens and the pride of the community. I am sure that given time, with more information being disseminated related to healthier lifestyles, the idea of sustainability will take hold. The love of growing, gardening and a positive neighborhood life already exist. It is not too much of a leap." "…even just these few simple changes could really help reduce the environmental impact dogs are having on the world. After all, I know I personally couldn't imagine a life without dogs, and I wouldn't want to. Besides, we're not just trying to save the planet for us, we're saving it for them too."
On community influence:	"Talk to your neighbors about composting, and what they think of your hood. Look around for trees on your street that need to be taken better care of. NYC's 311 call center is a great resource to use if you identify a tree that needs some love." "I believe that as long as the awareness and education continue into the long term effects of eating healthy vs. non-healthy then we are on the right track." "This dilemma [to radically overhaul the system] is something I have come up against a lot in my studies and beliefs, because I do believe that radical change is needed on many fronts in our system, in order for humans to thrive as a whole; however, I want to work for things that are actually possible." "In my report, I recall my conversation with this one man, in which I asked him whether or not he thought that people might eat healthier if the bodegas offered healthier options. To echo his point, accessibility is only part of the solution. Education plays a huge role in motivating people to choose the apple over the candy bar when the options are there right in front of them." " The change is being energized by education about the health risks and benefits of foods, local availability and local participation by organic farmers. It is essential that the organic foods are affordable and accessible." "… the largest common factor I noticed was that all of these problems required a personal investment from the members of the affected communities. When a neighborhood keeps an eye out for a senior living alone, there is support to prevent hunger, with compassion. When an assistant principal drives around to deliver food for needy students in order to protect their privacy, there is support to prevent hunger, with dignity. The stores we buy our food in don't feed us, the work of human hands and minds do. With strong communities working together, hunger can be overcome."

Note. Complete excerpts can be found at https://urbaninvestigators.wordpress.com/.

the college. The information they included covered a spectrum of issues pertaining to composting, from ecological to economic and social benefits:

"Composting decreases the amount of garbage in landfills, therefore reducing global warming emissions."

"Composting saves $$$ on garbage removal."

"Composting eliminates the use of chemicals."

"Composting turns waste into gold by yielding nutrient rich soil."

The students created Facebook, Twitter, and Instagram accounts and invited their colleagues to share their composting photos and stories. By this, they sought to involve the college community and further spread information about sustainability practices.

2. ***Sustainability principles and the challenges practitioners face.*** Students learned firsthand from their own observations and individual and team projects about the many difficulties that practitioners of sustainable food production face. They experienced the labor intensiveness of urban farming, for instance, through their own labor at the urban farm. That the weather transitioned from well over 90 degrees Fahrenheit to a drenching, hour-long downpour as they worked, drove home the significance of climate in ways that a textbook may not have. Here, students were able to appreciate the link between theoretical and applied applications in agroecology.

3. ***The cultural significance of urban sustainability and social activism.*** As the students analyzed their own communities' sources for food and demographic research on the economic status of people in their communities, they learned that sustainable practices surrounding food include far more than growing vegetables organically, but also finding means to sustain all the people in the community with organic produce, and not just the affluent. Furthermore, in their interviews with community residents, they learned that sustainability invariably means different things to different people. They also realized that economic insecurity is a sustainability issue as people struggle to achieve physical security in an unequal society. With this understanding, students realized that social activism and environmental sustainability are intertwined.

4. ***Research and writing as a form of social activism*****.** This learning outcome is the most readily assessed, as each student produced two blog posts of some length (800-1500 words) that incorporated their research, excerpts from the interviews they conducted, their observations, and analysis. The nature of blogging implies a kind of outreach for an audience; it is a practice that is integral to social activism. It aims to engage and communicate with others and has the potential to connect with a wide international audience (a potential not yet realized in this case). Furthermore, the content of the students' blog posts was focused on their communities and the social-sustainable challenges they faced, particularly regarding economic insecurity and access to food. The transition from writing for class, or writing for the professor, was thus made to writing for the public, and in the public's interest. Comments such as these indicate the empowerment students may feel when their writing is turned outwards, for a community, rather than contained within strictly pedagogical frameworks.

We found that the design of the course curriculum and activities did accomplish, in large part, its overarching goals of cultivating awareness and cultivating skill-building for sustainable practices through experiential learning. In some ways, the course achieved its greatest success at the level of the community, for by the course's completion, the students had learned to see themselves as advocates for sustainable practices in their communities, thereby gaining a renewed sense of connectedness to their local environments. Furthermore, they learned to see some social and human ramifications of thinking and acting sustainably by exploring sustainability practitioners' fundamental challenges when attempting to promote food security in their communities. Foremost, the students realized, was the question of access: economic access to healthy food (or any food), geographical access to healthy food, access to green space, and access to education.

Limitations and Future Considerations

We can conclude that the level of student engagement in projects, assignments, attendance, and participation in the discussion was high. We also feel confident that the course achieved the following outcomes:

1. Students explored new green areas of NYC
2. Students became more familiar with 'green' terms and initiatives
3. Students actively engaged with issues and people in their communities
4. Many students went on to enroll in independent studies or similar study groups with a focus in sustainability education

Nevertheless, we experienced some setbacks while teaching the course. First, enrollment for the first iteration of the course was eight students, which is relatively low when the maximum class size for the Brooklyn unit is 25 students. This could indicate a lack of awareness about the importance of sustainability education at the college among students and their advisors. We intend to continue our efforts to increase interest in this topic across the college. One initiative we are focusing on is reaching out to new students during our pre-term orientation weeks through workshops on sustainability and integrating sustainability education into their study plans. Another plan is to advertise this study before registration, through student email systems and posters, and by contacting advisors to make sure they are aware of the study and its benefits.

Another setback occurred early in the course when the pump for the hydroponics system broke. As part of our funding, we acquired small-scale hydroponic and aquaponic kits for demonstration purposes within the Brooklyn location. It was not replaced until a week before the term ended. So, while students did engage in creative thinking about ways to get around the broken pump, ultimately, the system was not developed as well as it could have been, had all the materials been in working order. In this instance, we all learned that these kinds of systems might require consistent maintenance and ingenuity to help solve any immediate technical issues as they arise.

Finally, experiential learning provides a direct link between classroom knowledge and application and has been shown to increase learners' understanding of academic concepts in action (Kolb, 2014). As our students gathered information about sustainable food production in their communities, they learned about the complex web of attitudes, opportunities, resource distributions, and the vital role of education and how these things may transform or inhibit awareness and community action. Their own neighborhoods became a part of their curriculum, which nurtured the "ethic of caring along with a greater depth of understanding" cited in the introduction. As they read about some of the obstacles to sustainable practices in the course readings and further discussed them in class, their citizen journalism projects brought them into contact with these obstacles manifest in their own communities. Likewise, working on the urban farm as the weather shifted from extreme heat to a heavy downpour over the course of a few hours opened their eyes to the real hardships of food production within changing climates, thereby undoing the certainty they may have had that human can control the environment to satisfy our needs and whims. The interdisciplinary merging of science, cultural studies, and writing provided this fertile ground for bridging school and community, scholarship and

practice, and demonstrates the power of interdisciplinary knowledge production.

To further enhance these understandings, we would have liked to see more experiential learning take place in an ongoing manner at an urban farm or other sites of a significant urban sustainability project such as wide-scale vermicomposting or tree planting initiatives. Instead, we had to settle for one farm visit due to difficulties in communication with farm managers and scheduling constraints. And while students were enthusiastic about the experience (one student spoke with the farm manager afterward about an internship with them, and another joined a community farm in his own community the following week), they did not benefit from participating in plant production over time. This would have helped integrate ecological concepts more effectively into their learning. Furthermore, because the class lacked continuity beyond the completion of the term, the student's efforts to engage the college community in practices such as composting and blogging, tweeting, and posting to Instagram, were likewise abandoned. A truly successful form of citizen journalism and outreach would address the dilemma of perpetuating community, perhaps by forming an ongoing activity such as a club or student organization that could oversee the maintenance of social media. In future iterations of this course, we intend to allow for ongoing, structured engagement with sustainability projects in the city that commence with the start of the term and offer students participation that continues that continue after the course is concluded. In this way, we hope that at least some students will transition from sustainability learners to practitioners and builders of sustainable culture in New York City and beyond.

CONCLUSION

The impact of student learning at the home and community level was more far-reaching, and in some ways profound, than we had anticipated. Perhaps the most surprising outcome was that although the original model intended to merely instruct, the combination of theory and application genuinely encouraged students to impart their knowledge outside the classroom. However, in our third iteration of the course, we have observed that the student learning and actions feedback into the classroom. What our students have learned about being citizen journalists has informed our content for future instruction. Hence, our original model can be modified to include a positive feedback loop, which links what students could impart and learn from the home, community, and workplace back to the classroom. In this mode, students are best able to inform us, the

instructors, and future students about current trends in urban sustainability. This is particularly important as it allows us to identify salient issues in sustainability as they become focal points for the community. As issues in sustainability evolve, it is even more important that we learn about them and impart concerns pertaining to environmental, cultural, and social issues to future students. Our goal was to create opportunities for nontraditional students enrolled at an institution with an urban campus and to encourage them to learn about sustainability through their own interactions with the urban environment. Moreover, the model employed to empower students to engage in environmentally responsible ways may be replicated in other urban areas for instructors and their students.

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KARYN PILGRIM, PhD, is an Associate Professor in the division of Arts & Humanities, State University of New York Empire State College. Her major research interests lie in the areas of environmental humanities, literary theory, and creative writing. Email: karyn.pilgrim@esc.edu.

KEVIN L. WOO, PhD, is an Associate Professor in the School of Science, Mathematics, & Technology and the Department of Natural Sciences at the State University of New York Empire State College. His major research interests lie in the area of animal behavior, animal cognition, ecology, and conservation biology. Email: Kevin.Woo@esc.edu

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Appendix A

Green Pens and Thumbs: Discovering Urban Sustainability in New York City

Instructor(s): _____

Purpose:

This study intends to immerse students in urban sustainability, from an ecological, cultural, and activist standpoint. Students will explore definitions of sustainability and consider the means by which a community can work together to implement sustainable practices for the good of all. Since the best way to learn about sustainability is to practice it, students will apply their reading and classroom learning to hands-on experiences in urban agriculture field trips, visits to museums, and other sites across the city. And because sustainability and democratic principles are intertwined, students will take on the role of citizen journalists, interviewing people involved in

urban sustainability, researching the goings-on across the city, and reporting on them in creative essays.

Learning Objectives:

Students will learn to articulate in discussion and writing:

1. A range of urban sustainability practices
2. Challenges practitioners of sustainable practices face
3. The basic science behind ecological principles, and the need for urban sustainability
4. An awareness of the impacts of climate change and environmental degradation on life systems
5. The cultural significance of urban sustainability
6. Best practices for clear writing and research
7. An understanding of social activism

Required Texts:

Callenbach, E. (2008). *Ecology: A pocket guide, revised and expanded*. Berkeley, CA:
University of California Press.

Klein, N. (2014). *This changes everything: Capitalism vs. the climate*. NY: Simon & Schuster.

Kolbert, E. (2015). *The sixth extinction: An unnatural history*. NY: Picador.

Suggested text(s):

Green, T. (2013). *The dictionary of global sustainability*. New York: McGraw-Hill.

Sage, C. (2012). *Environment and food*. New York: Routledge.

Assignments & Meetings:

Assignment Module #1:

Date Assigned: _____

1) Callenbach A-C and D-F
2) Klein, chapters 1, 2, 3; Kolbert, chapters I, II, III
3) Do Writing Assignment#1: Part A (Research)
4) Listen:

Hidden Kitchens (http://www.npr.org/series/91851784/hidden-kitchens-the-kitchen-sisters)

Assignment Module #1 is due: _____

Meeting #1: Location: *Classroom

For the first meeting, we will cover an introduction of the study, and discuss the broader topics in environmental sustainability. Here, we will discuss the intent of the study, the assignments, activities, and the term. . We will also cover some basics of good writing style, and discuss the term length individual writing projects that students will engage in.

Meeting #2:

For the second meeting, we will talk about general ecology and begin working on the plant systems.

Meeting #3

For the third meeting we will discuss what we have learned in Klein's This Changes Everything, Kolbert's The Sixth Extinction, and the individual writing projects you will be engaging in. The discussion will be led by presenters (individuals to be grouped):

Chapter 1 of Klein and Kolbert:

_____

Chapter 2 of Klein and Kolbert:_____

Chapter 3 of Klein and Kolbert:_____

Assignment Module #2:

Date Assigned: _____; Due: _____

1) Callenbach G-I, J-L, M-O
2) Klein,chapters 6, 7, 8; Kolbert, chapters VI, VII, VIII
3) Writing Assignment #1B; Due on _____

Assignment Module #2 is due: _____

Meeting #4:

For the fourth meeting, we will begin work on our team projects. Don't be absent!

In addition, we will discuss the basics of biological conservation, and how to measure biodiversity. Inclusive of our discussing a project to be paired with your writing assignments that will have you measure some aspect of biodiversity in your own community.

Meeting #5: Field Trip to Community Garden

Details for the trip will be announced in class.

Writing Assignment #1B Due (email:

Assignment Series #3:

1) Date Assigned: _____; Due: _____

2) Read Callenbach P-R, S-U, W-Z
3) Writing Assignment #2; Due on _____

Assignment Series #3 is due: _____

Meeting #6:

For the sixth meeting, we will Klein's chapters 6, 7, 8, and Kolbert's chapters VI, VII, and VIII. We will also discuss how to begin Writing Assignment #2. The discussion will be led by presenters (individuals to be grouped):

Chapter 6 in Klein and Kolbert:_____

Chapter 7 in Klein and Kolbert:_____

Chapter 8 in Klein and Kolbert:_____

Meeting #7:

For the seventh meeting, we will discuss Klein's chapters 9, 10, 13 and Kolbert's chapters IX, X, and XIII. The discussion will be led by presenters (individuals to be grouped):

Chapter 9 in Klein and Kolbert:_____

Chapter 10 in Klein and Kolbert:_____

Chapter 11 in Klein and Kolbert:_____

Meeting #8:

For the final meeting, we will showcase our final individual, group, and writing projects for the term. It is an opportunity for us to share the investment of our own work that was achieved during the term.

Writing Assignment #2 Due (email:

Measuring Biodiversity

Along with your writing assignments that will take you into the community, you will have a chance learn about biodiversity, and how to measure levels of local biodiversity. We will use a basic calculation, the Simpsons Diversity Index (D), to compare the level of diversity in your community. During our meeting, we will discuss the importance of biodiversity, and how it is integral for the success of local ecosystems. You

will have the opportunity to choose your focus. *Note: Example worksheet and actual activity sheet will be posted online.

Term Assignment and Final Meeting

As a term-long project, students will be divided into two groups to develop a sustainable project that will be housed in the Brooklyn unit. These two teams will be provided with a small budget (supported by internal and external grant funding), and they are to work collectively to research, develop, and initiate this project. Some examples include greening indoor spaces, reducing water waste, and creating information literacy on green initiatives. The groups are to assign duties among each member, and the project is to be completed and presented on the final day of class. Here, we will also host a party in which each team will showcase their project. This event will be public, and all students, staff, and faculty of the Metropolitan Center will be invited. The overall goal is to empower our students to think creatively and innovatively, and develop small models that may be implemented in the greater community.

Plant Systems

To get everyone integrated with a single issue in sustainability, we will be examining the nature of agricultural methods. To do this, each student will be provided with a growing tray. We will supply each person with any other basic materials.

You may wish to leave your tray at the Brooklyn unit. We will provide you with access to one of our offices to retrieve your tray. Hence, you can work on it while at the Brooklyn unit, but it is advised that you continue to work on the trays independent of class time.

Team Projects & Showcase

As the plant systems project aims to provide an initial idea, and innovative way to look at a problem in food systems and sustainability, you and your group will have the opportunity then to exam a specific challenge that faces the urban environment, and design a sustainable project.

This is a team project, and you will need to coordinate time and schedules with your to work on your final project. However, unlike the plant systems, there will be no kits provided to you or your group. You are to conduct extensive research on your issue, and with your team, create an innovative way to address this issue.

The project aims to empower students to develop a small-scale project, and one that may be adapted to the community. Hence, the project that your group creates will be available for the Brooklyn unit community to see/use/interact.

In addition, it is likely that you and your team may need to invest personal funds into the project. As we have severely reduced the initial cost

for acquire texts (i.e., selected relatively inexpensive material) and supplemented each group with acquired funding, there is no minimum or maximum that each team may wish to allocate to this project. However, we also understand that it may not be feasible for select individuals to contribute equal amounts of funding to the project. If any individual is currently experiencing financial hardship that does not allow them to contribute monetary funds to the project, please see Professor Pilgrim or Professor Woo privately. The exercise is not designed for individuals to spend an exorbitant amount of money, which would put you in any financial hardship, but is to manage a socially responsible project while realizing the likely investments that may be needed for projects in sustainability.

Field Trip

During the term, we will have the opportunity to visit an organization that is engaged in sustainable activities. In New York City, there are many innovative groups that are engaged in a wide range of sustainable missions from food systems, alternative energy, water, and to environmental justice. These organizations can be linked to larger corporations or non-profit. Here, we intend to pair what we learn and discuss in the classroom with the opportunity to see the concepts that we learn come into action. *Note: The date, location, and timing of the field trip will be announced during the term.

Schedule of Assignments

This schedule is designed to keep you on pace to complete all prescribed assignments for this study. You are expected to engage in excellent time management skills, and thus not fall behind on your studies.

Week	Date	Theme	Topic(s)	Klein and Kolbert Chapter(s)	Callenbach Chapter(s)	Activity(ies)
1	_____ _____	Introduction	Foundational Concepts		A-C	
2	_____ _____	General Ecology	Agroecology		D-F	Start Plant Systems
3	_____ _____	Individual Writing Projects		Kl: 1,2,3 Ko: I, II, III	G-I	

4	_____ _____	Conservation Team Projects	Biodiversity Guidelines for brainstorming		J-L	-Discuss Team: Projects/Guidelines/Get Started! -Writing Assignment #1A due
5	_____ _____ FIELD TRIP	Sustainable Actions in NYC	Urban Agriculture Alternative Energy	Kl: 6,7,8 Ko: VI, VII, VIII		Writing Assignment #1B due
6	_____ _____				M-O and P-R	
7	_____ _____	Assessing Food Sustainability		Kl: 9,10,13 Ko: IX, X, XIII	S-U	Finish Plant Systems
8	_____ _____		Showcase		W-Z	-Writing Assignment #2 due -Biodiversity Project -Finish Team Projects & Showcase!

Appendix B

Biodiversity Exercise

Discovering sustainability in New York City:
An interdisciplinary framework for teaching in urban institutions

Instructor(s): _____

Purpose:

The natural world is a complex theater. Over time, biological and physical factors have likely shaped the composition of ecological communities around the globe. However, to better understand the nature of communities, and how multiple species interact with each other, scientists have developed assays to measure the abundance of individuals and the number of species found within various ecosystems. Moreover, effective sampling techniques allow us to compare the relative diversity between multiple communities. The difference in biodiversity between comparable ecosystems helps

scientists to generate models that are potentially reflected in communities across all biomes. As scientists employ the scientific method to study ecological interactions, they may develop more questions, hypotheses, and theories about the natural world. In particular, assessing relative biodiversity may provide useful information for us to consider the health of communities.

Key Terms:
Abundance: number of individuals in a species that are found in a given area (measured by population size or density)
Richness: number of species in a community
Evenness: relative abundance of species in a community compared with one another
Diversity: a measure the combines the number of species (richness) in a community and their relative abundances compared with one another (evenness)

Activity:
Our objective is to measure and quantify the level of fauna diversity in two locations at in New York City, and to compare the relative biodiversity between the two communities. Students will be divided into one of two groups, and led on a nature walk to fauna species and record their frequency, as they are found in their respective location. Both teams will use a systematic approach. Students will record how many types of fauna (e.g., may wish to identify group/clade) they are able to identify either by their common name, scientific name, or descriptors used to identify the species from other fauna. Students will also record the frequency of occurrence. Upon completion of the field survey, students will return to the 'lab' and calculate the relative biodiversity using the Simpson's Diversity Index (D).

Location Map:

Equipment:
Writing instrument(s)
Data sheet(s)/worksheet(s)
Transects
Calculators
Photo/Video recording devices (cameras, mobile phones, tablets)
Simpson's Diversity Index (D):

$$D = \frac{\Sigma\, n(n-1)}{N(N-1)}$$

n = the total number of organisms of a particular species
N = the total number of organisms of all species
Then…
Simpson's Index of Diversity: **1-D**

→ The value of this index ranges between 0 and 1. Here, the greater the value represents the greater the sample diversity. The index represents the probability that two individuals randomly selected from a sample will belong to different species.
or…
Simpsons Reciprocal Index: **1/D**

→ The value of this index starts with 1 as the lowest possible figure, as it would represent a community containing only one species. The higher the value represents the greater the diversity. The maximum value is the number of species in the sample.

Example & Calculations:

Location #1: Lower Hudson Bay, NY

Species	Number (n)	n(n-1)
Bottlenosed dolphin (*Tursiops truncatus*)	5	20
Minke whale (*Balaenoptera acutorostrata*)	1	0
Harbor seal (*Phoca vitulina*)	22	420
Grey seal (*Halichoerus grypus*)	3	6
Hooded seal (*Cystophora cristata*)	2	2
Common dolphin (*Delphinus delphis*)	5	20
Total (N):	38	468

Calculations #1:

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

$$= \frac{468}{38(37)}$$

$$= \frac{468}{1406}$$

$$= 0.33$$

1-D = **0.66**

Location #2: Ipswich Bay, MA

Species	Number (n)	n(n-1)
Common dolphin (*Delphinus delphis*)	21	420
Minke whale (*Balaenoptera acutorostrata*)	6	30
Humpback whale (*Megaptera novaeangliae*)	6	30
Harbor seal (*Phoca vitulina*)	44	1892
Grey seal (*Halichoerus grypus*)	7	42
Bottlenose dolphin (*Tursiops truncatus*)	9	72
North Atlantic right whale (*Eubalaena glacialis*)	3	6
Total (N):	96	2492

Calculations #2:

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

$$= \frac{2492}{96(95)}$$

$$= \frac{2492}{9120}$$

$$= 0.27$$

1-D = **0.73**

Worksheet (Field):

Your Location: _____

Species/Descriptor **Frequency**

Calculations (Lab):

Question/Hypothesis

Observation(s):

Result(s):

Conclusion(s):

Limitation(s):

Future Question(s):

Additional Data Sheet:

Species/Descriptor **Frequency**