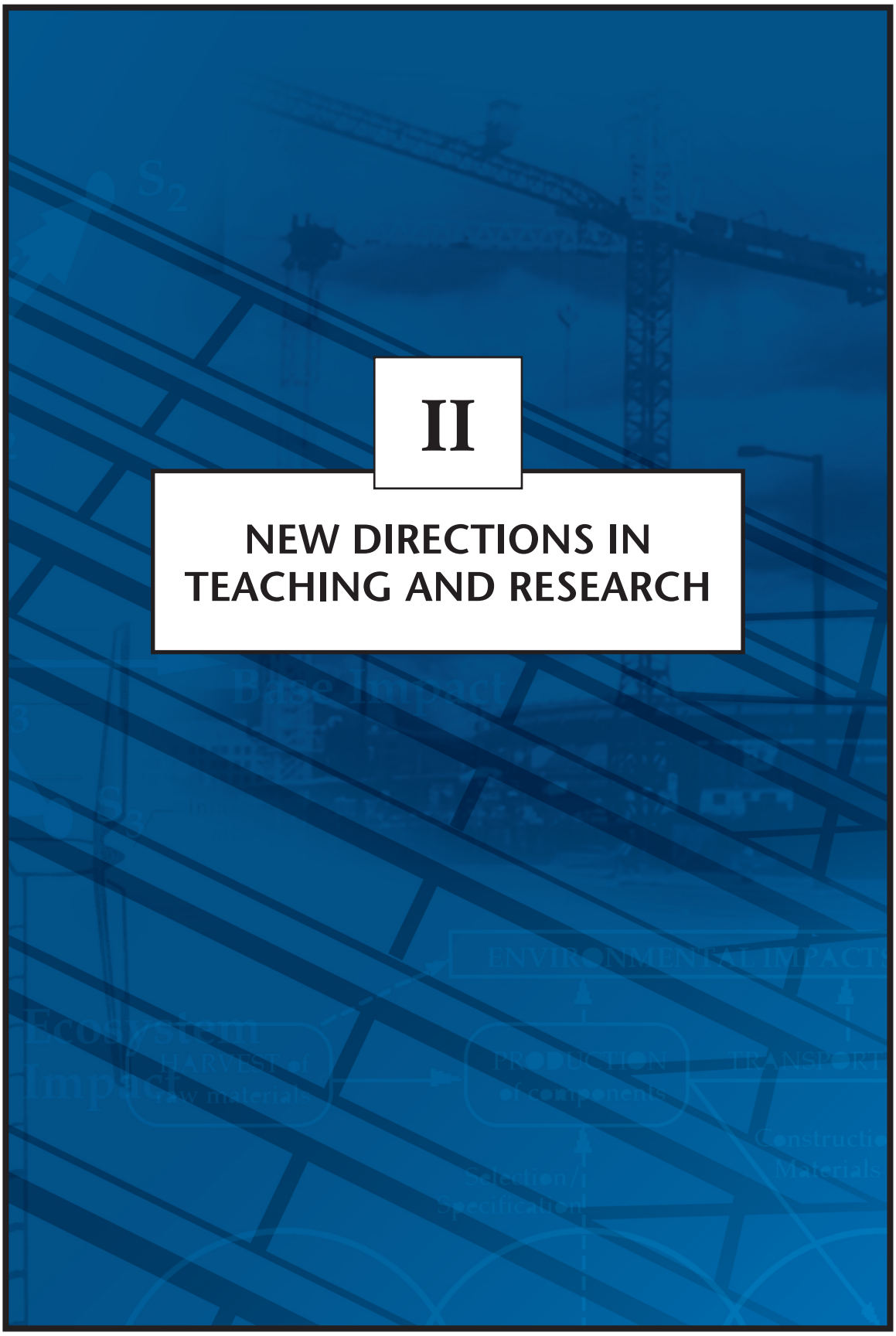

II

NEW DIRECTIONS IN TEACHING AND RESEARCH

GREEN INFRASTRUCTURE PLANNING ON CAMPUS

CASE STUDIES FROM UNIVERSITY OF MASSACHUSETTS–AMHERST

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INTRODUCTION

College campuses pride themselves in being leaders in promoting innovation in both technical and theoretical aspects of all fields of study, including sustainability. The drive for sustainability in higher education has become institutionalized in many college campuses in the form of offices of sustainability, as well as membership in the American Association for Sustainability in Higher Education (AASHE). In parallel, but not always in concert, are more grass-roots efforts by students to promote sustainability through recycling programs, urban agriculture, and similar initiatives. Students are often frustrated between the classroom lessons they learn about sustainability and the slow adoption of sustainable practices in the "real-world," including on campus. In order to address this issue, faculty have begun to engage students in the sustainability challenges facing their own campuses. The *Journal of Green Building* showcases these projects in the *New Directions in Teaching and Research* section of the journal. As part of this series, this article will highlight a course at the University of Massachusetts–Amherst in which students engage in green infrastructure planning projects for the campus.

KEYWORDS

green infrastructure, sustainable campus planning, curriculum design, student projects

The course, Sustainable Green Infrastructure Planning and Design (Regional Planning 591I/ Landscape Architecture 591I) is a graduate-level course that is also open to upper-division undergraduates. In a department with many studio-based courses, this course is designed as a seminar course with an applied project that is designed to serve as an entre for both design and non-design students to learn about green infrastructure. Reflecting the need to take an interdisciplinary approach to sustainability, the course attracts students from a range of fields, including landscape architecture, regional planning, sustainable community development, architecture, building construction technology, sustainability science and natural resources. The course has been offered for five years and averages 20–25 students per semester.

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This course introduces students to the concepts, theories, and applications of green infrastructure planning at multiple scales, including the site-level, neighborhood, and region. Students learn about green infrastructure with readings from two course textbooks: Austin (2014) and Benedict and McMahon (2006), as well as a series of additional weekly readings. (See course syllabus at https://scholarworks.umass.edu/sustainableumass_educationresources/1/ for more information). The class begins with an historic overview of how green infrastructure developed and how the term has been defined in different contexts. The course then focuses on one of its major themes, the application of green infrastructure to address climate change and resiliency. The course then introduces students to a series of topics that are central to green infrastructure planning including hydrology and water quality, transportation and complete streets, living buildings and wastewater treatment, human health and well-being, urban heat island and micro-climate planning. Students are also introduced to the idea that public perceptions of sustainable innovations, such as green infrastructure are critical to promote the adoption of these techniques, whether by government agencies and institutions, or by private corporations and homeowners.

To encourage students to do the course readings for our discussions, they are required to upload their reading notes ahead of time on the course digital platform in Moodle. This prepares them for the course discussions and exams. However, it is critical that they learn to apply this new knowledge to a "real-world" problem. Thus, the final project in this course gives students the opportunity to apply the knowledge learned on their course readings and lectures and apply it to a "real-world" sustainable planning issue on the University of Massachusetts-Amherst campus.

Defining Green Infrastructure: It is important to review some of the definitions of green infrastructure when discussing this course. In the classic book by Benedict and MacMahon (2006, p. 1), green infrastructure is defined as an "*Interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife…in short, our natural life-support systems.*" Other planners have expanded this definition to describe green infrastructure as "*all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales*" (Tzoulas et al., 2007, p. 169). In my course, we look at important characteristics that green infrastructure replaces grey infrastructure that typically has one function, such as road runoff removal in a stormwater system with underground pipes, with multi-functional green infrastructure that uses a systems approach at multiple scales, such as bio-swales and water treatment wetlands.

Researching Green Infrastructure: A couple years after teaching the class, I was fortunate to be chosen for a Sustainability Curriculum Fellowship from the University that allowed me to work with librarian Madeleine Charney to incorporate more research into the course. She developed a course guide (http://guides.library.umass.edu/aecontent.php?pid=529204&sid=4354134) with extensive resources on green infrastructure to augment the course readings. In addition, as part of the fellowship, I developed an assignment in which students use the library's digital resources to research innovative campus planning projects and later, cutting-edge-research and applications for their respective final projects. This phase of the class begins with a librarian led workshop that teaches students about search techniques and resources related to green infrastructure.

CAMPUS PLANNING CASE STUDIES—LOOKING FOR INNOVATION: Prior to the library workshop, students are given their first assignment to develop a brief case study of innovative sustainability planning at other college campuses that might be transferrable to

our own campus. The objective of this assignment is to broaden the students' understanding of sustainable campus planning strategies, while at the same time building their skills in using the treasure trove of sustainability resources available through the library data bases, the course guide, and to help them build a research collaboration with university librarians in sustainability subject matter that is essential for their final project, as well as future studies. The assignment also introduces them to the Association for the Advancement of Sustainability in Higher Education (AASHE) program and member schools, like UMass that are involved in the STARS program.

The final product for this assignment is a PowerPoint slide that students present to the class, as well as a brief 2-page paper. The assignment's objective, in addition to learning about campus planning, is to teach students how to synthesize a large amount of information into a few key insights. I tell them they have only a few minutes to make their case for why these initiatives might be useful for our own campus. This assignment helps build their skills in oral communication and graphic skills that will be useful in their final assignment. The class uses this new "library" of campus case studies as a resource for the next phase of the course.

Learning about Campus Planning: This course would not succeed without the generous collaboration with the professional staff at the University of Massachusetts–Amherst, Campus Planning division, including the sustainability manager. Early in the semester, the class meets at the University campus planning offices. Students are required to read the campus master plan to become familiar with the overall vision for the campus. This master plan is brought to life by a presentation with campus planners and sustainability manager of the campus. Students get to see first-hand how planning is conducted on campus, learn about current initiatives, and future plans. The goal of this meeting is for students to learn what sustainability topics and geographic locations are most important and useful for the focus of their final projects. My goal is to ensure that the class projects are not hypothetical, academic exercises, but thoughtful explorations of how green infrastructure can further sustainability efforts on campus. The campus planning staff become the clients for the class, providing site information and data, formal and informal feedback, including serving as critics for the final class presentation. In this manner, the campus becomes a real-world learning laboratory for innovation.

Developing Green Infrastructure Plans for the University of Massachusetts-Amherst: The final project gives students the opportunity to apply the knowledge learned in course

TABLE 1. Example of Resources for Campus Planning and Green Infrastructure Case Studies.

Digital Resources and Data Bases	
The Association for the Advancement of Sustainability in Higher Education (AASHE)	https://www.aashe.org/
GREENR (Global Reference on the Environment, Energy, and Natural Resources)	Gale Publishing: Subscription service https://www.cengage.com
Journal of Green Building	http://www.journalofgreenbuilding.com/
Landscape Architecture Foundation Landscape Performance Series: Case Study Briefs	https://landscapeperformance.org/case-study-briefs
Sustainable Sites Initiative	http://www.sustainablesites.org/

readings and lectures to a "real-world" planning issue on campus. This project has the following learning objectives:

1. To teach students how to apply green infrastructure knowledge to "real-world" problems.
2. To learn how to develop persuasive arguments based on research to support students' sustainability ideas/proposals.
3. To develop skills in inter-disciplinary collaboration.
4. To expand students' research skills.

This is a team-based project. Students are organized in interdisciplinary teams of 3 students from different majors at the same class level (graduate/undergraduate), so that they can benefit from having a variety of experience/expertise that is necessary to work on a sustainability project. Each team develops a scope of work that describes their topic and project extent along with a project timeline and work tasks for each team member. This scope of work is reviewed and modified with feedback from the instructor to create a realistic project within the time constraints of a nine-week class project. Excerpts from the final scope of work are often used to write the introduction section for their final report.

The final projects often focus on physical planning for a specific area of campus, such as improving bicycle and pedestrian circulation along a busy campus street; stormwater management and other green infrastructure improvements to a campus plaza or parking lot. Other projects are campus-wide and focus on a green infrastructure topic, such as creating a bicycle network for campus, urban forest plan, or urban agriculture.

In order to avoid procrastination and stress at the end of the semester, the project is broken down into sub-assignments and deadlines: 1) literature review, 2) university planning-to-date, 3) green infrastructure plan, 4) project poster and presentation, and 5) final report.

1. *Literature review:* After completing their scope of work, the teams develop a literature review that synthesizes the state-of-the art planning and design literature as it relates to their green infrastructure topic. The idea is to draw from their previous research in the campus case studies, as well as to find new literature that goes beyond the course readings. Students are required to have at least one meeting with our University sustainability librarian to help them with their research. Students begin their work by describing the major findings of each article in bullet point form to create an annotated bibliography. They then write a literature review essay that will be included in their final report along with a reference list. Surprisingly, for many of the students, especially undergraduates, this is the first time they have had to do a literature review, so I provide examples for them to follow. By having this part of the project submitted early in the semester, students get feedback and revise their literature review for the final report.
2. *University planning to date:* For many of their projects, students work on areas or topics that have already received attention from campus planners or other student projects. In this next phase, students research the planning work to date on their particular green infrastructure topic and/or geographic area of campus. They also meet and correspond with University campus planning and sustainability experts to learn what issues still need to be explored. The teams gather relevant plans from previous University reports (with proper credit/references) to include in their final report. This section includes a review of campus planning efforts and the University's current AASHE STARS rating

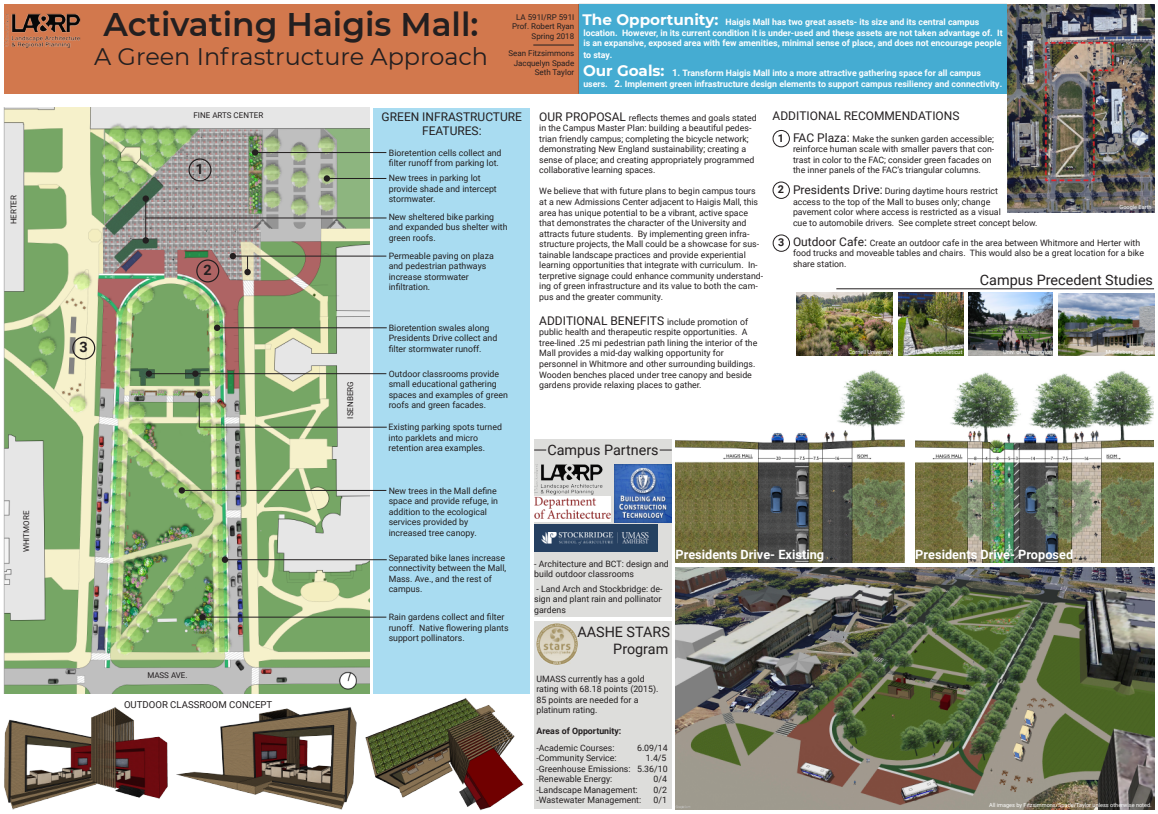
for this topic. A critical aspect of this project phase is a site analysis of the existing site including gathering relevant base maps and other site information.

3. *Green infrastructure plan:* Each team develops a green infrastructure plan for a particular area of campus, or in some cases, campus-wide. This plan includes a written narrative description of their proposals using green infrastructure to address existing issues, such as stormwater, urban heat island, and circulation. The teams support their recommendations by describing the environmental, economic, and social benefits to the campus by implementing their ideas. The goal here is to convince the campus planning staff and higher administration about the efficacy of their project. Teams are asked to include statistics or quantifiable numbers based on course readings or research to support their project. For example, the carbon sequestration for the proposed tree plantings in their project. The plans also include a description about how their proposal will impact the University's efforts to increase its STARS ratings and achieve its climate mitigation/adaptation goals. The plans include maps and/or illustrations showing where these proposals would occur on campus and what it would look like. Since many of the students are non-design majors, they are allowed to use other project images (with proper credit) as inspiration to illustrate their points (e.g., photos of a "complete" street that they think would work well on the UMass campus).
4. *Project poster and presentation:* The students develop their preliminary ideas for their green infrastructure plan into a poster for presentation. They present a draft poster in digital form to the class to get feedback prior to final presentation. Credit for the poster assignment goes to my co-instructor, Michele Wick, a lecturer at Smith College who worked with me in 2015 during a 5-College Mellon grant to promote collaboration in teaching sustainability within the liberal arts colleges and UMass as part of the Five College Consortium. This poster presentation replaced an end of the semester PowerPoint presentation. This phase allows students to synthesize their ideas into one graphic poster board that they present to campus planners, sustainability managers, and other planning experts. By having these presentations two weeks before the end of the semester, students are able to incorporate some of the clients' suggestions into their final report. For two years in a row, students have also presented their green infrastructure projects at the University of Massachusetts–Amherst, Earth Day event organized by the School of Earth and Sustainability (SES). The 2018 event was held in conjunction with the Massachusetts Climate Change Leadership Summit that brought together climate change experts, leaders, advocates, and the general public. (See poster examples in Figures 2, 3, and 4).
5. *Final report:* The student teams compile their work in a final 12–15 page report that includes an introduction to the project, campus planning to date, green infrastructure plan, and in some cases, phasing for implementation. This report describes the project poster and plans in more detail and is useful for the campus planning clients in future work.

Green Infrastructure Plan Examples: The final projects span a range of locations on campus as well as topics, including redesigning a campus plaza, transforming a busy street into a complete street with multi-modal transportation, and developing an urban forestry plan for carbon sequestration and energy savings.

1. *Reimagining a Campus Plaza:* The first project example is from a graduate team that included master's students in landscape architecture, sustainability science, and regional planning, respectively (Sean Fitzsimmons, Jacquelyn Spade, and Seth Taylor). The team looked at Haigis Mall which is the ceremonial heart of the campus that includes the main administration building, the modernist Fine Art Center at its northern end, and campus visitor's center across the street at the southern end (Figure 1). As noted by the team, however, the plaza in front of the Fine Art Center is underutilized with large areas of paving and the traffic circulation enclosing the ceremonial lawn deters people from using it. This team proposed to improve campus sustainability while "transforming Haigis Mall into a more attractive gathering space for all users" (Fitzsimmons et al., 2018.) New shade tree plantings were proposed to create shaded alleys along the ceremonial Presidents Drive loop. Other ornamental trees were also added to reduce the scale of this large-scale space to a more human-scale. Green infrastructure to capture stormwater runoff was proposed along pedestrian walks and a newly redesigned pedestrian plaza. Bio-swales were designed to capture road runoff, allow filtering of pollutants, and infiltration.

FIGURE 1. Redesign of a major campus plaza at the University of Massachusetts–Amherst, Haigis Mall enhances a multi-modal transportation hub and creates human-scaled areas with an outdoor classroom, café, and seating areas. Urban stormwater is treated in a series of bioswales along tree lined walkways. (Image Credit: Sean Fitzsimmons, Jacquelyn Spade, and Seth Taylor, 2018).



The plaza is a busy hub for the regional bus system that serves the campus and surrounding colleges and communities, yet there is limited seating with a small bus-shelter. The team proposed to limit the upper part of the circulation loop to buses only to avoid current conflicts between buses, automobile, and pedestrian traffic. A larger more attractive bus shelter was also proposed. To encourage multi-modal transportation, bike lanes were added to the loop road along with covered bike parking. A quarter-mile pedestrian path that encircles the plaza allows lunch-time employees to get some exercise, as well as serves the busy student population going between classroom buildings.

To increase use of the plaza, a café was designed near the main administration building for outdoor eating. An outdoor classroom building using green technology was also proposed to increase use and take advantage of the open space. The large plaza in front of the Fine Art Center which serves as a forecourt to the building and large event space was retained with new porous paving and additional tree plantings.

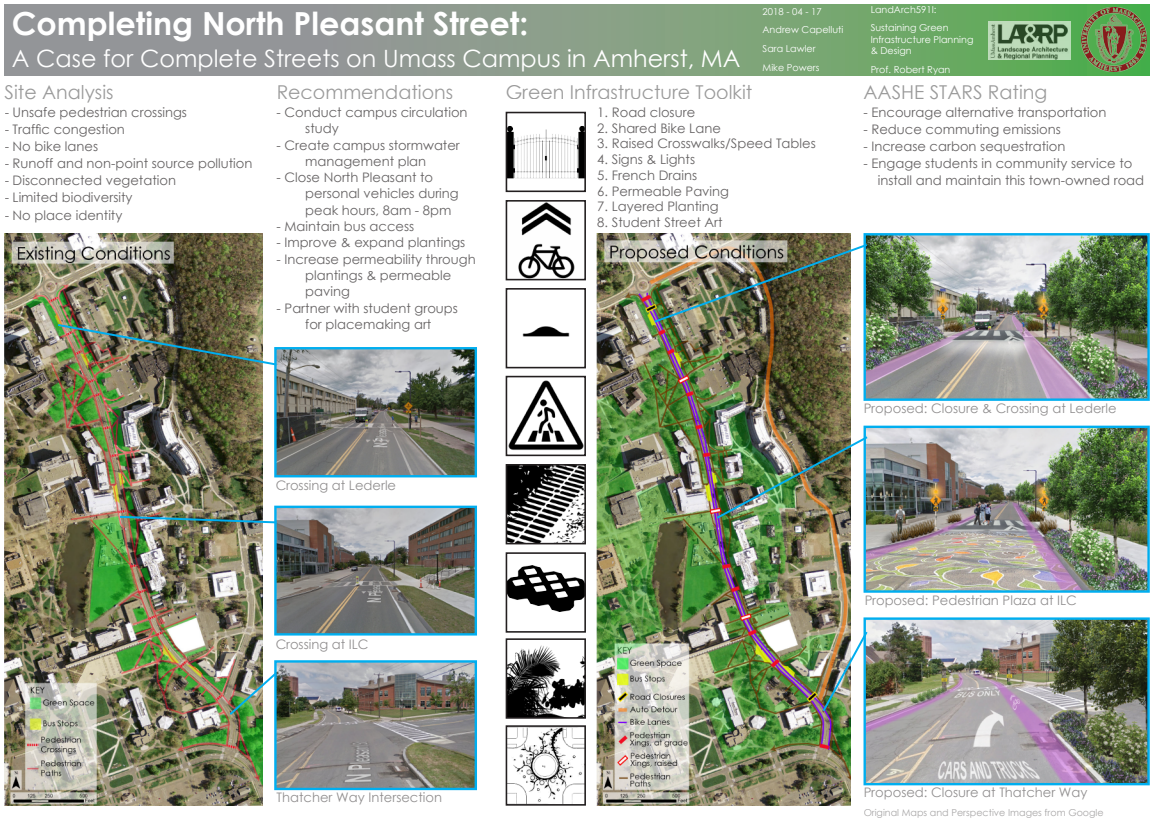
The team proposed engaging students in landscape architecture, architecture, and green building technology to help develop conceptual designs for the outdoor classroom building, bus shelter, and landscape areas. The goal here is to increase sustainability education as part of the AASHE STARS rating through improved stormwater and landscape management.

2. *Creating Complete Streets:* The next project example was a complete street project (Capelluti et al., 2018). North Pleasant Street is a busy two-lane street that bisects the University of Massachusetts-Amherst campus. This graduate team included two landscape architecture students (Sara Lawler and Andrew Capelluti) and a sustainability science student (Mike Powers). The existing challenges on this street include heavy bus and automobile traffic that creates traffic congestion and unsafe pedestrian crossings for students and staff going between different parts of campus. In addition, the narrow drive lanes and minimal bike lanes make biking unsafe. The street has traditional stormwater management without any treatment. Despite being a major spine through campus, this corridor lacks any consistent design vocabulary, street trees or sense of place.

   Building on the campus master plan, this team proposed transforming North Pleasant Street into a complete street that creates a multi-modal pedestrian and bike-friendly corridor (Figure 2). Public transportation is given precedence in this proposal for bus-only use during the busy day-time hours when classes are in session. Automobile traffic would be re-routed to the ring roads around the campus at the north and south campus gateways. To create more pedestrian friendly crossings, raised crosswalks using speed tables were proposed at five key nodes. In addition, bike lanes are widened and made more visually prominent through colorful road paint. As in the previous project, this team also proposed partnering with student groups, in this instance, to design street artwork to create a sense of place and highlight key crossings.

   This team proposed using a green infrastructure tool-kit of approaches that included traffic calming and pedestrian enhancements as well as ecological enhancements to improve water quality and reduce flooding, including permeable paving and linear plantings to capture and infiltrate stormwater in rain gardens and bio-retention swales. Street tree plantings were proposed to unify the street, increase carbon sequestration, and provide shade for the busy sidewalks.

FIGURE 2. Complete street design for North Pleasant Street, a major transportation corridor at the University of Massachusetts–Amherst proposes bus-only vehicular access to allow for improved bike lanes, pedestrian sidewalks, and creative crossings using vibrant artwork created by students. Street trees and bio-swales improve walkability and ecological health (Image: Andrew Capelluti, Sara Lawler, and Michael Powers, 2018).

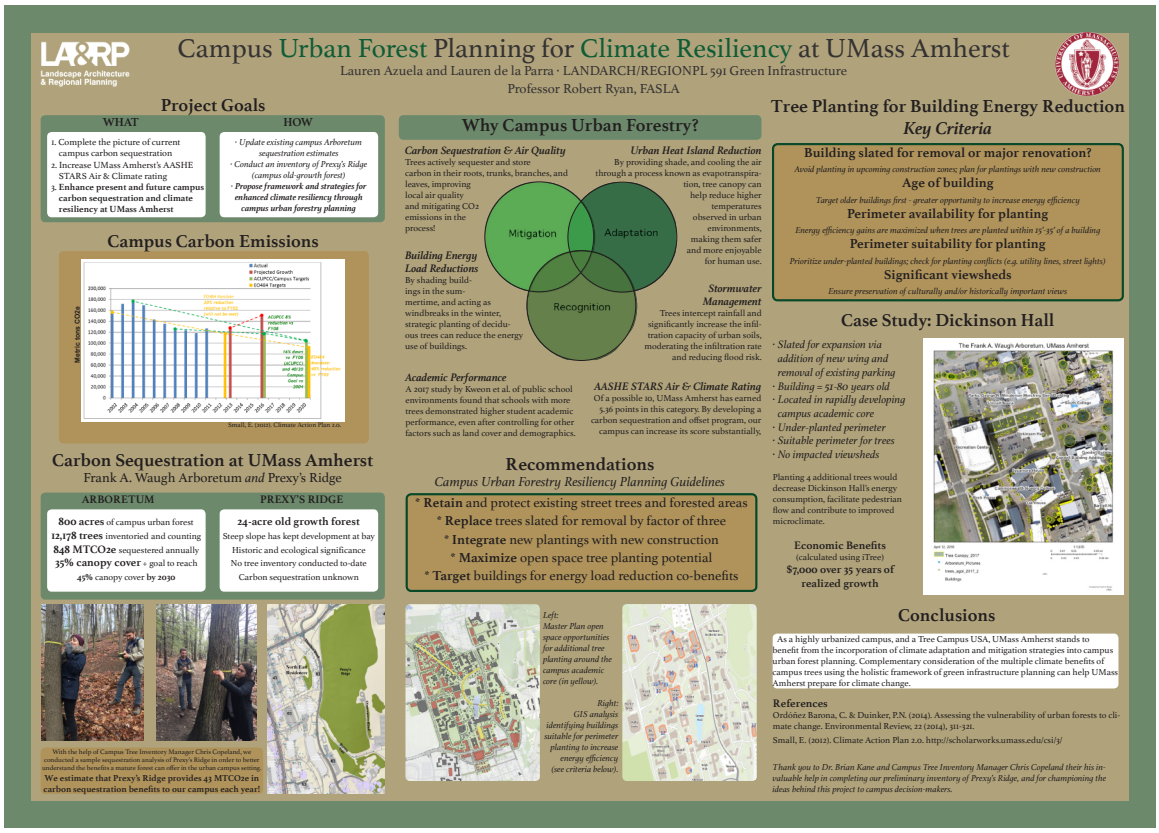


One intriguing aspect of this project is that it could be tested out on a trial basis with simple road paint and signage to determine the effects of temporary road closures on surrounding traffic, as well as improved pedestrian safety. These efforts could be part of the larger campus circulation study that is recommended by this project team

3. *Urban Forestry for Carbon Sequestration and Energy Savings:* This final project example took a topical approach with a focus on the campus urban forestry planning as a means to improve carbon sequestration and climate change resiliency (Azuela and de la Parra, 2018). This team of two students, included a graduate student in sustainable science (Lauren de la Parra) and undergraduate natural resource conservation student (Lauren Azuela). This project proposed to improve the campus's AASHE STARS score in the air and climate category and help achieve the campus goal of reducing and mitigating carbon emissions (Figure 3).

The existing core campus urban forest as part of the Frank A. Waugh Arboretum had already been inventoried and found to have an existing 35% canopy cover with a goal of 45% canopy cover by 2030. The team noted that to achieve this goal, the campus must protect existing trees, limit removal of trees during campus construction, and replace trees by a factor of

FIGURE 3. Urban forestry plan for the University of Massachusetts-Amherst improves carbon sequestration and identifies buildings for tree plantings to reduce energy use. (Image: Lauren Azuela and Lauren de la Parra, 2018).



three since new trees are much smaller than existing trees. Moreover, the students undertook a forest inventory of the 24 acre Prexy's Ridge forest on a wooded hillside on the east side of the campus. Their analysis showed that this existing forest could sequester 43 metric tons of carbon per year. Protection of this mature forest needs to be part of future campus planning efforts.

This team also looked at opportunities to use urban trees to reduce energy use in existing buildings, therefore reducing carbon output and saving money. They used a GIS analysis and the campus master plan to identify older existing buildings that were likely to remain and be renovated rather than removed. Older buildings were targeted, since they were likely to be the least energy efficient. They also identified buildings with minimal existing plantings. Once they had developed a plan that identified campus buildings that met these criteria, they took one building as an example project, Dickinson Hall. Dickinson Hall is slated for a future addition and removal of an existing parking lot. Using the I-Tree calculator, the team showed that planting four new trees would potentially save $7,000 over a 35-year period (REF).

This urban forestry project is a great example of a multi-scalar approach to green infrastructure that looked at the entire university campus for potential buildings that could benefit from tree plantings for energy savings, then focusing down to the site scale with an individual building study to demonstrate this application. The project is unique in that it combines carbon sequestration work with an urban forestry initiative for energy savings.

CONCLUSION: LESSONS LEARNED

This course provides several lessons for others engaged in teaching sustainability and green building courses. The first is the need to apply classroom lectures and readings in a project with real-world applications. The campus setting is a ready-made laboratory as it is easily accessible and familiar to students, saving time in having to learn and/or travel to a more distant site. The second is the need for collaboration with campus planners and other staff members. The projects in this class would not be possible without the wholehearted support of campus planners. Thus, exploring these connections is critical before embarking on a similar class project. In some cases, instructors may find allies in the surrounding community and instead focus on projects in the neighborhoods around their academic institution. Clients' willingness is needed in several key aspects, including having time to meet with the class and students, having the necessary data and base maps, and having staff time to answer student questions. One way to avoid overtaxing these professional contacts is to gather student questions and make requests in a more organized format rather than many individual requests. These projects are aided by the University having an updated campus master plan which gives students some guidance about larger University goals and priorities. Without such a plan, these projects could have the potential to lack the focus or usefulness to campus staff.

Since this is a one-semester class that focuses more on planning and design rather than implementation, there is not a focus on building projects. Other class projects that are smaller in scale could focus on actual implementation or have a longer term focus on particular areas of campus, so that subsequent years lead toward implementation. More advanced courses than the one described here could allow students to delve deeper into the technical aspects of green infrastructure implementation that is challenging for non-design students. From my perspective, the value of these final projects is that students engage in creative explorations that bring in new innovations. These projects spark ideas for professional staff who can take them further and refine them in light of required codes, guidelines and contract procedures. In addition, professional staff have the long-term commitment to these projects that follow a much longer timeline to implementation than the academic semester.

Another aspect of this project is that students choose projects that allow them to explore a particular aspect of green infrastructure and develop new skills, while at the same time partnering with students from other disciplines, opening their eyes to the benefits of interdisciplinary collaboration. This project hopefully becomes a model for the type of interdisciplinary work that is necessary to address the sustainability challenges facing campuses and the larger world as a whole.

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