



Arboriculture & Urban Forestry 2022. 48(2):74–94
<https://doi.org/10.48044/jauf.2022.XXX>



Indiana University's Woodland Campus: A Case Study of Urban Forest Patch Sustainability

By Stephanie Freeman-Day and Burnell C. Fischer, PhD

Abstract. Background: Urban green spaces are increasingly seen as vital resources contributing to ecological and social health. The ecological concept of patch dynamics over space, scale, and time applies to patches in urban settings and is important in understanding the complexity of relationships between and within the ecological and social spheres interacting in urban settings. Methods: This case study investigates forested and natural patches on Indiana University's Bloomington (IUB) campus. Data gathered through university archives includes historical maps and campus plans for a study period beginning in 1884 with the university's relocation to its current area. Documents were reviewed for evidence of patches being labeled or left blank. Historic aerial photos were compared with present satellite imagery using geographic information software (GIS). Results: Findings include patterns where patches were indicated on maps (1902 to early 1940s), followed by a period where natural/forested areas were unindicated on maps (post-WWII to 1960s), followed by patches reappearing on maps and being suggested for preservation (1960s to present). Although some natural patches were "lost" during the study period, others persisted. Patches that endured may be defined as Commons: shared resources protected by formal/informal rule processes. Conclusions: This novel framework for the IUB patch project serves as a template for use in investigating green patches in the city of Bloomington. The Bloomington project builds upon the IUB framework, expanding GIS analysis of current patches and historical imagery, and assessing current ecological patch condition. Additional considerations reflect complexity of municipal settings and include patch ownership, socio-demographics, and equitability in access.

Keywords. GIS; Historical Ecology; Patch Theory; Pilot Project; Urban Ecosystems.

INTRODUCTION

Background—Indiana University Bloomington Campus

Since relocating in 1884 to its current site, Indiana University's Bloomington (IUB) campus has been identified as having an emphasis on natural surroundings with the presence of forested patches. As discussed in the Indiana University (IU) brochure "The Woodland Campus" (Robeson et al. 2018), the oldest portion of campus, the 20-acre Dunn's Woods, was purchased from a local farmer in 1884 and opened to students in the fall of 1885. It is also emphasized (Robeson et al. 2018) that early faculty strongly advocated for maintaining the natural beauty of the campus and protecting trees growing on university grounds. Advocates included Dr. David Mottier in the early 1900s and influential Chancellor and President Herman B. Wells (President 1937–1962, Chancellor 1962–2000). Reflecting a continued commitment to

valuing natural surroundings, Indiana University's Bloomington campus has been designated a Tree Campus USA by the Arbor Day Foundation since the first year the program began in 2009 by meeting its 5 standards: (1) establish a tree advisory committee; (2) develop a tree care plan; (3) include verification of dedicated annual expenditures on the Campus Tree Plan; (4) be involved in an Arbor Day observance; and (5) include a student service-learning component (Indiana University 2009).

Research Context

While historical analysis of urban forests has not frequently been done, writers have addressed the history of US urban forests, an example being Jill Jonnes (2017) and her examination of 200 years of urban forests and the interactions urban residents have had with city trees. Some research has investigated historic drivers of current urban forest conditions, although a clear gap exists in analysis at the patch level. Nowak

(1993) examined historic aerial imagery, photographs, and documents to investigate changes in Oakland, California's urban forest canopy cover beginning in 1850 and found drivers, including earthquakes, the Gold Rush, fires, urbanization, afforestation, and trends in favored species, that impacted the urban forest as they occurred but also left legacy effects evident during the study period 140 years later. McPherson and Luttinger (1998) combined analysis of historical documents with interviews of local residents to investigate natural and social forces driving changes in Sacramento's urban forest, finding urban forest management and public investment in the urban forest to be instrumental in the city's afforestation and also in response to challenges such as Dutch elm disease. Roman et al. (2018) called for interdisciplinary approaches that consider the role of history in shaping institutions and patterns of urban forest conditions, stating, "historical processes must be considered...to explain how urban forest structure and spatial patterns emerged within a given city, or across multiple cities." Roman et al. (2017) explored canopy cover change over time on the University of Pennsylvania's Philadelphia campus by reviewing historical documents and quantifying canopy cover from aerial imagery, finding that institutional support and intentional landscape planning is needed for increasing canopy cover, but that change needs to be framed over a period of generations rather than years due to the slow nature of tree and forest growth.

Johnson et al. (2020) examined urban forested patches from a historical perspective, citing the influences of past land use and planning decisions as important in their effects, direct and indirect, on current forest patches. The authors emphasize the need to analyze urban forested patches from a socioecological perspective and offer a conceptual model for application in future research. Additionally, they offer a list of research questions that are yet uninvestigated or have been explored minimally. These questions weave together concepts of change over time, future challenges such as environmental change, socioecological drivers of patch condition and sustainability, governance and management, and residents' interactions with and valuing of urban forested patches.

For our case study, we seek to address the research gap delineated above—that little historical analysis of urban forests has been done at the patch level and that any analysis done should be approached from a

social-ecological systems perspective. For this reason, this case study examines the history of the designation and protection of forested and other green patches on Indiana University Bloomington's (IUB) campus from 1884 to present. We identify patterns in patch sustainability, reviewing patches that have been sustained, added, or recognized throughout the growth of the IUB campus, as well as patches that have been removed because of campus development projects. Additionally, we are interested in situating natural patches within the social-ecological sphere in which they interact with biophysical and social/institutional conditions. Finally, we investigate whether some natural patches can be considered a Commons, or a shared resource governed and potentially protected by formal and informal rule processes. Our investigation relates closely to a knowledge gap cited by Johnson et al. (2020), "How do differing stewardship, management, and governance impact the condition of urban forest patches?" and takes the concept into further depth by viewing the problem from a historical perspective.

With this work, a major goal has been to develop a case study methodology for studying historical, social, and ecological conditions related to forested patches in a campus setting that can be applied to the study of forested patches in more complex urban areas. This methodology can then be used to answer research questions related to the social and ecological drivers impacting past, present, and future sustainability of urban forested patches. We are adapting work done here for our current study of forested patches in the city of Bloomington as a whole.

Urban and University Forests: Sustainability, Resilience, and Institutional Planning

Grove et al. (2015) discussed 3 major criteria that serve to define and specify urban patches: physical (human-built or natural abiotic), biological, and social factors. Additionally, they acknowledged the importance of historical and temporal factors in determining ecological outcomes, because flow of genetic material, pollutants, etc. occurs between patches in urban settings, and because historic conditions impact, for example, vegetation present in a location. The definition of an urban patch broadly applies to a focal area of a setting where humans and the biophysical world interact (Grove et al. 2015) and is inclusive of university campus settings. Presence and density

of forest cover is one variable that can be considered in the investigation of urban forested patches and is of particular interest for this project.

Beyond the natural beauty forested patches lend to urban settings, forested patches on campus provide valuable ecosystem services, benefits that are well-documented in literature (Nowak et al. 2008; Dobbs et al. 2011; Ulmer et al. 2016), and furthermore, a recent study (Nordman et al. 2018) showed that preserved urban forest patches provide the highest net economic value of any type of urban green infrastructure. Research conducted in Berlin (Kowarik 2019) further demonstrates the value of preserving urban forested patches, finding that even when alien species are present, these coexist with native species with the outcome being that the forested patches continue to provide ecosystem services for the surrounding area and habitats for species living in urbanized settings.

The current Indiana University Bloomington Master Plan (Indiana University Bloomington and Smithgroup JJR 2010), regarding environmental sustainability, states, "Natural resources should be leveraged to improve their inherent effectiveness and enhance environmental quality... Campus woodland areas and native habitats should be improved and expanded to increase shaded tree canopies and promote indigenous wildlife." This plan reflects trends in sustainability leading up to its creation; the period between the 1990s and 2010 saw growth in campus sustainability initiatives throughout the United States, leading into a period where universities increasingly have intentionally implemented sustainability into policy while serving as contextual models for sustainable practice (Washington-Ottombre et al. 2018). Interestingly, the researchers find that despite the upward trend in awareness of university sustainability, student stewardship of natural areas has not been emphasized in sustainability ranking systems for higher education institutions, such as the Sustainability Tracking, Assessment, and Rating System (STARS). However, students do often engage in volunteer stewardship of natural areas on their campuses, an action which not only directly affects the natural environment, but which is also associated with human mental health benefits for the stewards (Krasny and Delia 2015).

In addition to consideration of environmental sustainability, attention has been increasingly directed to maintaining and increasing biophysical, social, and

institutional resilience in urban environments. Holling (1996) described biophysical resilience as the amount of disturbance an ecosystem can absorb before it can no longer function in its present state. This definition can broadly be applied to the social and institutional spheres, all of which interact within settings over space and through time and as such shape urban ecological patches. With expected climate change impacts for Indiana, including hotter summers, increased storms and flooding, and increases in drought periods, planning for resilient ecosystems is important in mitigating or reducing the impacts (Reynolds et al. 2018). Ordóñez and Duinker (2014) delineate multiple urban forest characteristics, including patch connectivity, equitable distribution of canopy cover, public engagement, and diversity of institutions as contributing factors in resilience to climate change. Forested patches in campus areas contribute to overall urban forest resilience and can be targets of efforts for preservation but can also be considered as prime areas for development expansion, depending considerably on campus planning efforts. As we have found in our analysis of historic documents, it appears there is a tension between the need to expand campuses to accommodate growing student populations while also conserving the elements (in many cases natural elements) that attract students to a campus. Additionally, when looking at university actions over a historic period, we see decisions are made reflecting the societal needs of the time. In the mid-20th century, growth and development was emphasized, but more recently attention has been paid to environmental sustainability. In fact, there has been a recent call for universities to emerge as leaders in increasing resilience by including campus resilience in their master plans and also by contributing to community and regional resilience (Storms et al. 2019).

With the complex ties between social and ecological conditions and outcomes in urban settings, including many college campuses, examination of social and historical conditions and their potential connections with preservation of forested patches can inform future efforts to protect this valued resource. In this project, we explored social and historical factors related to campus planning and how they relate to the IUB campus setting for time period of over 100 years. We included multiple types of "green" patches (i.e., forest patches, lawns, quad areas, and gardens) in our analysis, but paid particular attention to forested

patches, which in its 2010 Master Plan, IU categorized into 3 types: High Quality Mature Deciduous Forest—Few Invasives, Mature Deciduous Forest—Substantial Invasives, and Scrub-Shrub/Immature Deciduous Forest (Figure 1).

This investigation was approached as a case study, with the intention that findings gathered here and methodology used to achieve the research goals could be applied to broader settings in near future work. Baxter and Jack (2008) delineate research situations as defined in Yin (2003) as appropriate for using case studies as a strategy when researchers, “want to cover contextual conditions because [they] believe they are relevant to the phenomenon under study.” We seek the historical and social contexts that may serve as drivers to campus forested patch sustainability or persistence through time and will apply these findings to broader settings where additional drivers are certainly present.

MATERIALS AND METHODS

Research for the case study was supported by librarians at IU Archives, where we were assisted in accessing historical maps and documents as well as campus plans and drawings dating back to the early 1900s. We were aware of planning consultations done shortly after IUB’s move to the Dunn’s Woods area, but physical documentation of any plans drawn has been lost (J. Capshew, personal communication, 2021 January 22). We chose to use a broad array of maps, planning documents, and consultant drawings to analyze for this work. While IU did work with a series of landscape architects who served as consultants in planning, the university did not necessarily follow every aspect of these plans (J. Capshew, personal communication, 2021 January 22). A notable example is the 1902 Ulrich plan, which included the addition of manmade lakes and a cave entrance to the

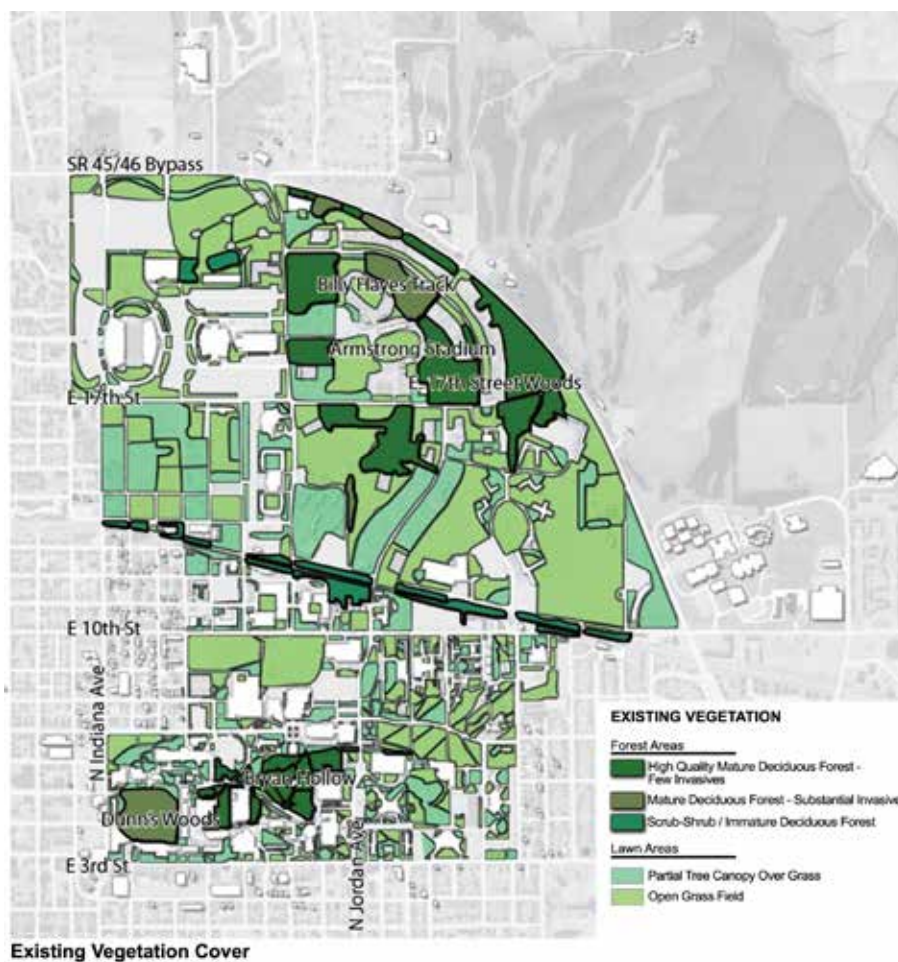


Figure 1. Vegetation typology of IUB Campus from 2010 Master Plan, page 53. Image used with permission from the Indiana University Archives.

campus. These plans never came to fruition but did reflect considerations included in campus planning. Other maps include those designed to orient people to campus, some of which include green spaces as destinations. We began with the first available planning map (Ulrich, 1902, shown in Figure 2) and proceeded through available plans and maps, tracking all patches evident in the maps and documents up until present time (see Figures 3 and 6 in text and Figures S1–S6 in Appendix). From each document, we determined whether the patch appeared labeled as a green space. Additionally, when we were aware of action being taken to either develop upon or protect a patch, records were searched for references of these in meeting notes, official correspondence, and news stories, which were retrieved for us by IU Archives librarians (Figure 4). From these records we documented in a database (Table 1) whether a patch appeared in the planning maps during each decade, whether it had been named or designated for protection, whether the patch had

been cleared due to development (i.e., a “lost patch” as Jordan Field was lost due to the construction of the Union Building), or whether it was left unlabeled/not designated on maps during a particular period. Additionally, we noted evidence of common knowledge of any green space as indicated by existence of photographs of the green spaces.

A portion of the research was done entirely through online archives. The archives database was searched year by year for maps of the campus. Maps found were downloaded and analyzed using the same methods delineated above, where it was determined whether a patch was labeled by name, visually by trees or green areas, or completely unlabeled.

A final visit to the Archives was made to photograph large planning maps that were not present during the first visits to the Archives or available in the online Archives. These photographed maps were then uploaded and analyzed for the presence/absence of patch labels or visual designations. After data was collected, all

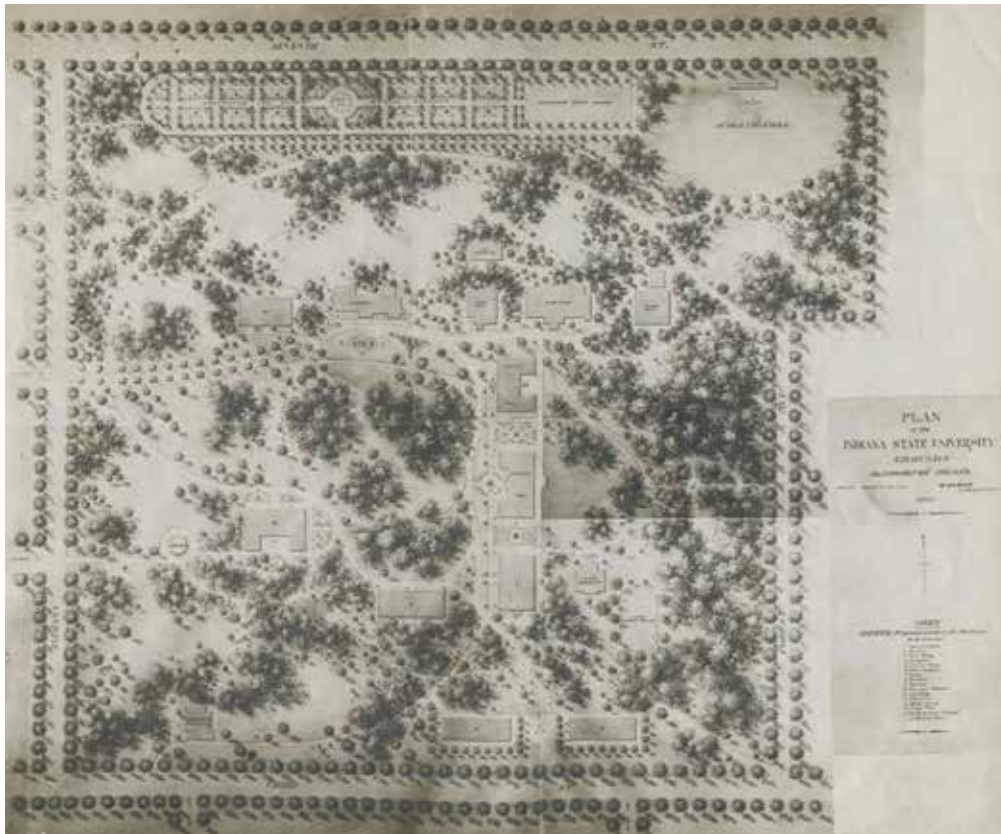


Figure 2. The 1902 planning map of IU Campus with proposed locations of future buildings, walkways, etc., was created by Rudolph Ulrich and shows trees among buildings in the Old Crescent area. The lower left of the map is the location of Dunn's Woods. Image number P0029898. Photograph used with permission from the Indiana University Archives.

documents were compiled into chronological order to be considered as a single timeline depicting changes in campus natural areas from 1902–2010.

An additional component of this case study included use of Geographic Information Software (GIS) to envision changes in tree canopy cover throughout as much of our study period as possible. Aerial imagery is available for the Bloomington area for the years 1939, 1946, 1954, 1958, 1968, 1975, and 1980. Imagery from the years 1939 and 1967 were chosen for comparative analysis of forested patches on campus. These years had high-enough quality images and best represented changes in campus tree cover over the past 82 years. The images from 1939 and 1967 were accessed on the Indiana Geological and Water Survey's "Indiana Historical Aerial Photo Index" (IHAPI), where screen shots were taken of the relevant area (Indiana Spatial Data Portal 2021b). The screen shots were then uploaded to Arc GIS Pro and georeferenced using building edges and street corners as guides. A 1998 aerial image was also accessed through the IU Spatial Data Portal as a Digital Orthophoto Quadrangle (DOQ) that had been georeferenced before being accessed. Forested patches evident in the imagery were then traced using Arc GIS Pro and recorded as a feature class for each year, allowing them to be viewed along with and compared to 2018 satellite imagery of the campus.

One challenge of doing research dependent upon historical imagery is that there is variation in quality

of the images available. This can occur because of the capabilities of the technology at the time or of the quality of material scanned into a digital repository. While variation in image quality did not impact our findings, some figures shown here do show some degree of graininess or blur. Low resolution in aerial imagery was accounted for by comparison with current imagery and with land use category maps.

RESULTS

Overall, findings included oscillating patterns of campus development and the emphasis on conserving natural areas. Occasionally, development was contested and coupled with efforts to protect specific patches. Tracking each patch sequentially by decade (Table 1) provided a more detailed assessment of historical factors related to each of the forested patches studied. The early 1900s showed a clear focus on the natural features of IUB's Campus. A 1902 map included several lakes and an entrance to a cave. Although Dunn's Woods was not specifically labeled on the planning map, trees were drawn in its location as well as throughout the image. The "Woodland Campus" concept arose from these early plans and was echoed in the campus plans made by the Olmsted firm in the 1920s and 1930s. Campus maps from the 1930s showed labeled green spaces, including Dunn Meadow, Woodlawn Field (then called both Drill Field and Parade Ground), and Jordan Field. Also, in the 1930s came the first known contested development planned



Figure 3. The 1950 planning map by E.P. Bardwell shows post-WWII campus expansion. Note: previously identified patches are now blank areas on the map. Image number P0031716. Photograph used with permission from the Indiana University Archives.

to take place in Dunn's Woods. In 1935, university planners identified the center of Dunn's Woods as the ideal location for a new administration building, but when students heard of the plans, they wrote a concerned letter to the student newspaper, and after some

debate the administration changed plans, moving the building to an unwooded area of campus (J. Capshew, personal communication, 2021 January 22). Labeling of green spaces continued into the mid-1940s, where the Jordan River was clearly labeled on campus maps,

Table 1. Labeling/acknowledgment of campus green spaces on maps and planning documents. Patches begin being tracked when campus boundaries include their spatial location.

Patch name	Years labeled with name	Years labeled symbolically (green space or trees)	Years unlabeled
Beech Grove	2010	1902, 1930, 1935, 1944, 1999, 2001	1917, 1940, 1950, 1953, 1962, 1976, 1986, 1989, 1994
Bryan Hollow/Bryan Woods	2010	1902, 1930, 1935, 1944, 1999, 2001	1917, 1940, 1950, 1953, 1962, 1976, 1986, 1989, 1994
Collins Quad	2010	1999, 2001	1917, 1930, 1935, 1940, 1950, 1953, 1962, 1976, 1986, 1989, 1994
Cox Arboretum	1989, 1994, 1999, 2001, 2010	1930, 1944	1940, 1950, 1953, 1962, 1976, 1986
Dunn Cemetery	2010	1902, 1930, 1935, 1944	1917, 1940, 1950, 1953, 1962, 1976, 1986, 1989, 1994, 1999, 2001
Dunn Meadow	1935, 1940, 1976, 1986, 1989, 1994, 1999, 2001, 2010	1902, 1930, 1944	1917, 1950, 1953, 1962
Dunn's Woods	1994, 1999, 2001, 2010	1902, 1930, 1935, 1944	1917, 1935, 1940, 1950, 1953, 1962, 1976, 1986, 1989
East 17th Street Woods	2010	1994, 1999, 2001	1962, 1976, 1986, 1989
Fine Arts Plaza	2010	1944	1917, 1930, 1940, 1950, 1953, 1962, 1976, 1986, 1989, 1994, 1999, 2001
Godfrey Courtyard	2010	1986	1953, 1962, 1976, 1991, 1994, 1999, 2001
Hilltop Garden	1994, 1999, 2001, 2010		1950, 1953, 1962, 1976, 1986, 1989
Jordan Field	1902, 1917, 1930, 1935, 1940, 1944		1950, 1953, 1962, 1976, 1986, 1989, 1999, 2001, 2010
Rogers Fee Lane Cemetery	2010		1950, 1953, 1962, 1976, 1986, 1989, 1994, 1999, 2001
SPEA Grove	2010	1994, 1999, 2001	1950, 1953, 1962, 1976, 1986, 1989
Sunken Garden	2010	1902, 1930, 1935, 1944, 1994, 1999, 2001	1917, 1940, 1950, 1953, 1962, 1976, 1986, 1989
Wells Plaza	2010	1902, 1930, 1935, 1944	1917, 1940, 1950, 1953, 1962, 1976, 1986, 1989, 1994
Wells Quad	2010	1930, 1935, 1944, 1994, 1999, 2001	1917, 1940, 1950, 1953, 1962, 1989
Woodlawn Field/Parade Ground/Drill Field	1930, 1935, 1940, 1944, 1976, 1986, 1989, 1994, 1999, 2001		1917, 1950, 1953, 1962, 2010

and the Dunn's Woods area was indicated as "Wooded Campus." However, by this time campus expansion had changed the status of some previously labeled campus green spaces. Woodlawn Field/Drill Field still appeared on a 1944 planning map, but Dunn Meadow was no longer indicated, and the Indiana Memorial Union, constructed in the 1930s, was built upon what had been Jordan Field.

In the postwar era of the 1950s, IUB planned large-scale expansion, with maps indicating a focus on built infrastructure rather than natural areas. A 1950 plan (Figure 3) indicated no green spaces at all; instead, former green spaces are indicated as empty, unlabeled areas between buildings, presumably as opportunities to accommodate the growing student body with additional classroom and residential buildings. Also, in the postwar period came large-scale campus area expansion, from a little over 100 acres in the 1930s to over 1,900 acres in the late 1960s. This expansion came to the northeast of the original Dunn's Woods site and was then where the majority of building projects took place (J. Capshaw, personal communication, 2021 January 22). After this period, green spaces were slow to appear (or reappear) on maps. In 1968, amid a period of growing student activism, Dunn Meadow reemerged as a labeled green space, with one section of the meadow being indicated by Indiana University trustees as an "Assembly Ground," or sanctioned area for

rallies and demonstrations (Office of the Vice Provost for Faculty and Academic Affairs 1969). This usage of Dunn Meadow continues today, such as when a Climate Action rally was held in the Assembly Grounds location in Fall 2019.

The 1970s began with both Woodlawn Field and Dunn Meadow being indicated by name on maps. With the 1980s again came contentious development in the Dunn's Woods area. A Law School expansion was met with resistance from university faculty and students. Activists formed a group called "Save the Woods" (Figure 4) when it was found that a portion of the woods would be cut down to accommodate the new construction. After months of negotiations, the expansion plans were changed to reduce impacts on and tree loss in the Dunn's Woods area. However, Dunn's Woods was not consistently labeled on campus maps or plans until the 1990s (Figure 5). This period also saw the addition of a new greenspace to campus maps. The Campus Arboretum was designated in the early 1980s and dedicated as the Cox Arboretum in 1997 (Robeson et al. 2018).

The most current (2010) Master Plan (Figure 6) for the IUB campus includes a list of 17 green spaces (forest patches, green lawn spaces with trees, historical green spaces) deemed "preservation areas." Among them are Dunn's Woods, Dunn Meadow, and Cox Arboretum. These 17 spaces fall into 4 categories:



Figure 4. News story about contested campus development impacting Dunn's Woods (Indiana Daily Student, 1982 February 5). The group was formed in opposition to a planned expansion of the Law School that would have involved the removal of a portion of Dunn's Woods. Photograph used with permission from the Indiana University Archives.



Figure 5. 1999 campus map with buildings, forested spaces, and other green spaces. Photograph used with permission from the Indiana University Archives.

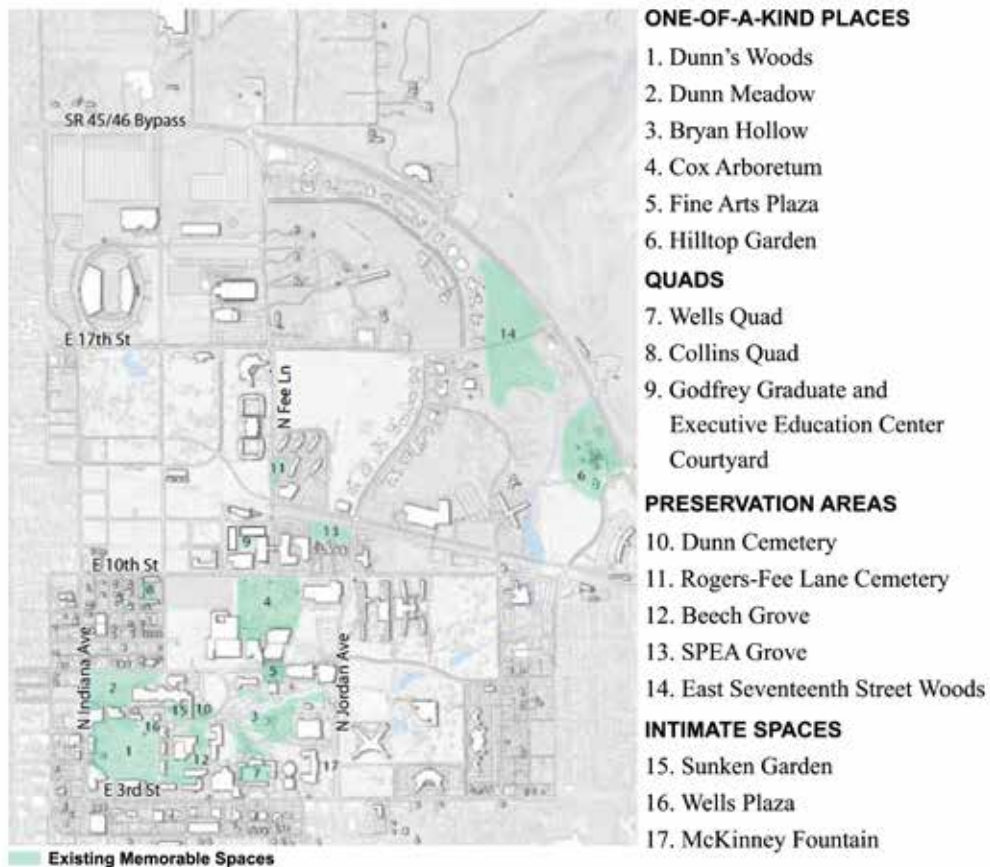


Figure 6. Designated preservation as indicated in the 2010 Master Plan. Photograph used with permission from the Indiana University Archives.

One-of-a-Kind Places, Quads, Preservation Areas, or Intimate Spaces (Indiana University Bloomington and Smithgroup JJR 2010). The list includes green spaces not included on any previous maps and plans, including SPEA Grove, Beech Grove, and the East 17th Street Woods. It is worth noting that the plan did not actually create new green spaces, but instead chose to recognize natural areas on campus that had existed but were not formally recognized, noted, or labeled on maps.

This most recent plan incorporated the ecological health of the campus, including a goal to double the campus tree canopy area from 20% to 40%. The most current data (Davey Resource Group 2019) indicates canopy cover remaining at 20%. This pattern echoes Roman et al. (2017) in finding that appreciable changes in canopy cover would be expected to occur over generations rather than years.

Since the 2010 Master Plan was written, notable changes have been made to natural spaces on IUB's campus. First, and perhaps the most visually striking, was the moving in 2019 of the campus Carillon from its prior location to Cox Arboretum. This added a new structure to the green space, potentially changing the use of the space and encouraging the addition of future infrastructure to the area. Additionally, the wooded area near Bryan House has also been altered with the 2017 addition of the Conrad Prebys amphitheater to the area. Also, the university dedicated its newest official green space, The Ostrom Commons, in honor of Nobel Prize laureate, IU faculty member, and Ostrom Workshop cofounder Elinor Ostrom. This green space is an area at the edge of Bryan Woods, so its designation seems to change its status from Woods to more of a gathering space. Finally, the university announced in late 2020 plans to convert a current parking lot on the north side of campus into a new greenspace that will include tree patches as well as an open lawn (Feickert 2020).

Although forest and other green patches have persisted at IUB for over 100 years, there have been noticeable changes within patches, some more than others. Dunn Meadow remains mostly intact as a mowed, grassy "meeting ground," with merely the addition or removal of bordering trees over time. Dunn's Woods has undergone much more significant changes. Because the woodland was meant to be developed as a campus, University Place (J. Capshaw, personal communication, 2021 January 22), the original

20 acres were eventually developed along each side with buildings, and only about 8 interior acres remain. Besides the removal of a small piece of the woodlands in the 1960's for the Law School expansion, the green patch has changed from a formerly open, grazed woodland in the early 1900s (Figure 7) to a more fully stocked forested area later in the century. More recent changes to the woodland (learned via personal communication in 2020 with IU Landscape Architect's office) have been the widespread infestation and removal campaigns of invasive wintercreeper (*Euonymus fortunei*), tornado damage in May 2012 (around 30 trees lost), and the expansion of built infrastructure (paved trails, lighting, and seating areas). These types of changes can probably be expected in any study of urban forest patches. A cataloguing and ranking of the importance of such changes (ecological and otherwise) should be developed in future studies of urban forest patches in the City of Bloomington and beyond.

DISCUSSION

Context of Findings

Our historical analysis of green patches on the Indiana University Bloomington campus revealed temporal patterns of planning for preservation or removal



Figure 7. Dunn's Woods as seen in the early 1900s, much more open than currently with rows of planted trees. Campus from Indiana Avenue well before Bryan Hall was built (circa 1908). Photograph by Floy Underwood. Image number P0078307. Photograph used with permission from the Indiana University Archives.

of green spaces. Table 1 shows that patches identified early in the campus history, from 1900 until around 1940, were included on maps during this time. These maps were created following when the campus became known as the Campus in Dunn's Woods, a term that may in itself have allowed for the campus itself to be considered a green space by officials and others affiliated with the university. After World War II, when the campus expanded considerably, green spaces were notably absent from planning maps. As conservation of nature became more prevalent in practice during the 1960s, green spaces were once again included. In fact, it was in 1966 when Paul Weatherwax published his pamphlet *The Woodland Campus of Indiana University* that the IUB campus began being known by some as The Woodland Campus (J. Capshew, personal communication, 2021 January 22). Furthermore, direct public pressure led to a portion Dunn's Woods being protected from removal and the entire forested area being designated as a named historical site.

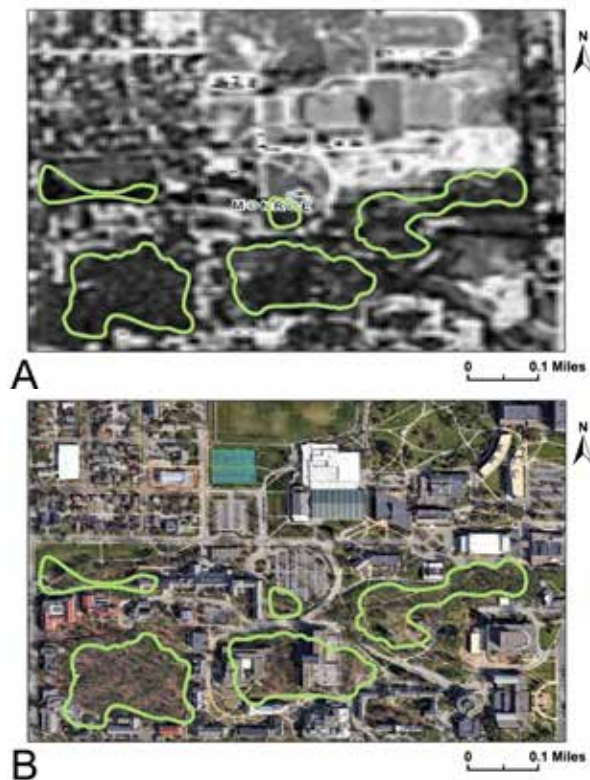


Figure 8. (A) 1939 aerial imagery of IUB Campus with forested patches circled in light green. Forested patches were confirmed using comparison to current aerial imagery and land use categorization maps. Aerial imagery retrieved from the Indiana Historical Aerial Photo Index (IHAPI). (B) IUB Campus with 1939 forested patches (circled in light green) shown on 2018 Google Earth satellite imagery.

Trends specific to forested areas on campus can be seen in the results from the GIS analysis. There has been a gradual loss of forested patches on the older sections of IUB campus, with much of the change occurring between the 1939 and 1967 images. This finding coincides well with the patterns shown in the planning documents for these time periods. Also of interest is the sustainability of Dunn's Woods over time. The boundaries of this forested patch changed little in the 82-year period for which aerial imagery is available. Figures 8, 9, and 10 show forested patches for 1939, 1967, and 1998 as compared to present Google Earth Imagery.

Planning decisions shown on the historical maps examined are reflective of social realities and are subject to pressures influencing both preservation and development. An example of this is the large-scale land purchases made in the 1950s and 1960s that arguably made it easier for the university to conserve natural areas in the older sections of campus, including Dunn's Woods and Dunn Meadow, as the campus center moved greatly eastward. Naming or dedication of a space may offer it additional protection, an example being that of the Cox Arboretum, which had existed since the early 1980s but was dedicated and formally named in 1997.

The current university Master Plan includes a section on ecological considerations, signifying the institution's commitment to consider natural spaces in its planning. This may reflect the continued concept of IUB's campus as a Woodland Campus and prevailing social attitudes from this period embracing sustainability. The university's goal to double tree canopy and retain the existing forested areas (as shown in Figure 1) remains a powerful tool in meeting objectives to emphasize natural spaces. However, the flat rate of canopy cover at 20% between 2010 and 2019 underscores the difficulty of achieving ambitious goals to increase tree canopy cover, especially within the context of pressure to continue developing and expanding campus infrastructure.

The ecosystem services provided by the preserved green spaces, because of their positive effect on human health and the environment, can be impactful in maintaining or increasing social and biophysical resilience. Environmental resilience, both in social and biophysical considerations, is a goal now included in many municipal and campus plans.

Our findings connect directly to urban forest historical research findings. The university's continual

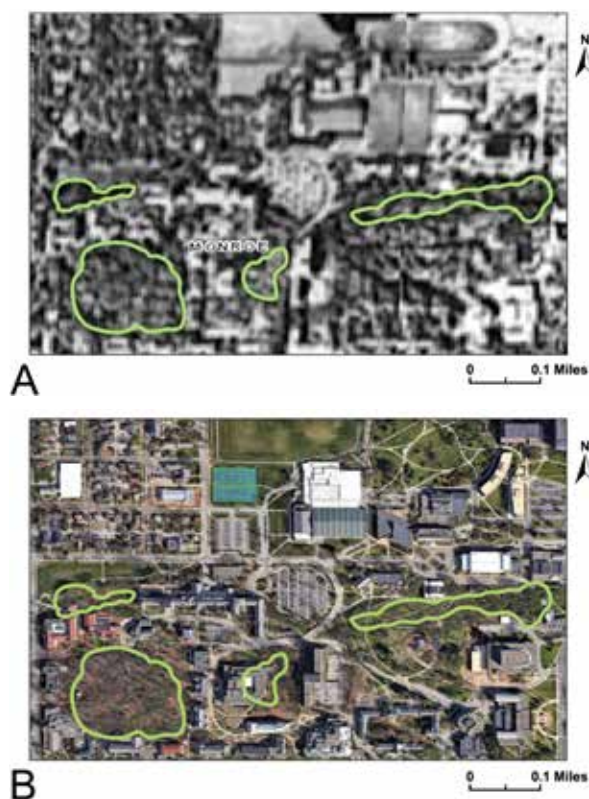


Figure 9. (A) 1967 aerial imagery of IUB Campus with forested patches circled in light green. The original image is of low resolution, but notably clearer than the 1939 image. Forested patches were confirmed using comparison to current aerial imagery and land use categorization maps. Aerial imagery retrieved from the Indiana Historical Aerial Photo Index (IHAPI). (B) IUB Campus with 1967 forested patches (circled in light green) shown on 2018 Google Earth satellite imagery.

investment in the value of green spaces reflects McPherson and Luttinger's (1998) findings that there is need for urban forest management and public investment in urban forested areas for these resources to be sustained over time. Similarly, Indiana University has been most successful in sustaining natural patches when institutional support and intentional landscape planning reflect views embracing the values of these resources, as found in Roman et al. (2017) in the work done in Philadelphia's University of Pennsylvania campus; but changes in the state of forested patches do occur in long periods—generations rather than years.

Green Patches as Commons

Natural Commons, as described by Elinor Ostrom (2008), are resource systems where it is difficult to limit access of use by individuals and groups, and where the use or enjoyment of the resource by one

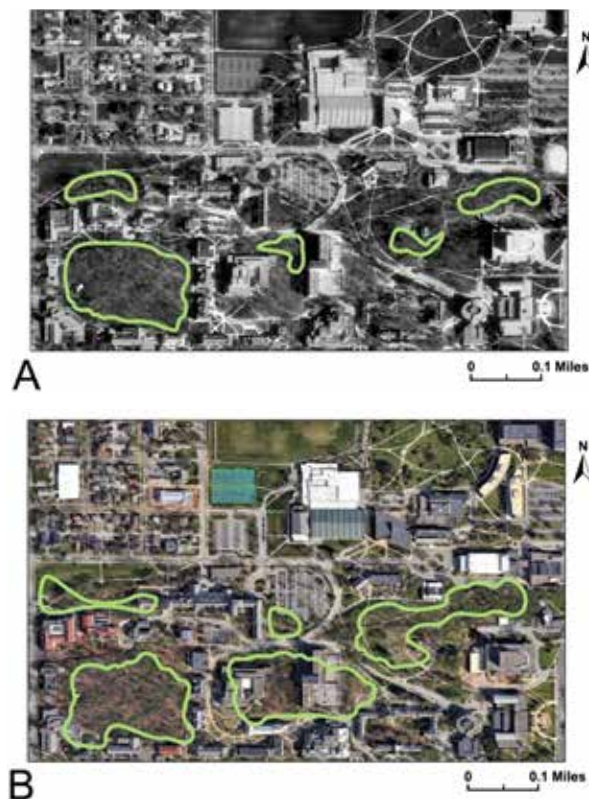


Figure 10. (A) 1998 aerial imagery of IUB Campus with forested patches circled in light green. Aerial imagery retrieved from the Indiana Spatial Data Portal (2021a). (B) IUB Campus with 1998 forested patches (circled in light green) shown on 2018 Google Earth satellite imagery.

party does not preclude the enjoyment of that resource by others. She distinguishes Commons from common-pool resources, where use of the resource does limit the use or enjoyment of the resource by others, a trait termed subtractability. McGinnis (2019) builds on this concept with a slightly different take, defining Commons as resource systems that can be distinguished into 2 categories, both having the trait where access is difficult, in order to limit (1) public goods (not subtractable), and (2) common-pool resources (subtractable). Urban forests, green spaces, and forested patches in urban areas could arguably fit into either category. Fischer and Steed (2008) consider street trees, or public trees in city-owned spaces along streets, along with the spaces where street trees are planted, to be common-pool resources. The ecosystem services they provide are available for all nearby users, and removal of the tree (or use of the tree plot area for another purpose) does subtract from total benefit and can degrade the resource over time (Fischer and Steed 2008).

We argue that preservation (formal or informal) of a green space can transform a common-pool resource (potentially threatened by subtractability by removal for development, etc.) into a Commons. This fits the McGinnis definition of public good along with the Ostrom definition of a Commons because the resource is no longer easily subtractable. Dunn's Woods fits this concept. Before the "Save the Woods" campaign, plans were made to remove part of the forested patch. Afterward, the wooded patch has remained labeled on maps and is listed on the Campus Master Plan as a "Memorable" and "One-of-a Kind" place (Indiana University Bloomington and Smithgroup JJR 2010). If we can define Dunn's Woods as a Commons, then the trees growing within the patch are common-pool resources managed by the university in terms of public safety (removing risky trees, adding lighting, adding walkways and seating) and by university affiliates and the public in terms of maintaining ecological health by group stewardship efforts, including removal of invasive plants and monitoring of woods conditions (Indiana University Office of Sustainability 2020). Dunn Meadow could similarly be considered a natural Commons—it is not easily subtractable (impacted by development), given its history as a meeting space and continued inclusion as a green space on maps and plans. Additionally, it would be extremely difficult to limit public access to the meadow. The Ostrom Commons, dedicated in November 2020, is the first green space on campus to be called by the term. It has long been an open, green area between buildings that could be considered to include the fringes at the edge of Bryan Woods but has not previously been included on maps except as drawings of trees or green space.

CONCLUSION

Methodology from this pilot study will be expanded and applied to more complex settings. The research team has already begun an analysis of forested patches in the city of Bloomington and has planned a patch sample study in Indianapolis, Indiana. Due to increased variability in ownership and land type, additional factors will need to be considered. These include social and institutional variables such as private vs. public land, multiple ownership of patches, and networks of governance including municipalities, nonprofit greening organizations, neighborhood or homeowner associations, and individual property

owners. Ecological conditions will also be considered, including the presence of forest remnants, along with emerging or intentionally planted forests, and mixes of alien and native species within patches. Mapping of all these variables, including changes over time and including these additional considerations within the GIS analysis, will allow for a thorough investigation into multiple interacting factors that may drive urban forest patch sustainability. Additionally, forested patches will be examined through the lens of institutional theory to determine whether they could be considered common-pool resources, and which governance strategies would best be applied to increase the likelihood of patch sustainability into the future.

LITERATURE CITED

- Baxter P, Jack S. 2008. Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report*. 13(4):544-559. <https://doi.org/10.46743/2160-3715/2008.1573>
- Davey Resource Group. 2019. Urban Tree Canopy Assessment Summary Report: City of Bloomington, Indiana. Indianapolis (IN, USA): Davey Resource Group, Inc. https://issuu.com/bloomingtonparks/docs/bloomington_tree_canopy_summary_report_091719
- Dobbs C, Escobedo FJ, Zipperer WC. 2011. A framework for developing urban forest ecosystem services and goods indicators. *Landscape and Urban Planning*. 99(3-4): 196-206. <https://doi.org/10.1016/j.landurbplan.2010.11.004>
- Feickert B. 2020 December 4. IU Board of Trustees approves projects for IUPUI, Bloomington campuses. News at IU. Bloomington (IN, USA): Indiana University, News & Media. <https://news.iu.edu/stories/2020/12/iu/inside/04-construction-projects-approved-for-bloomington-iupui-campus.html>
- Fischer BC, Steed BC. 2008. Street trees—A misunderstood common pool resource. International Society of Arboriculture 84th Annual Conference and Trade Show; 2008 July 26–30; St. Louis, Missouri, USA. Champaign (IL, USA): International Society of Arboriculture. <https://urbanforestry.indiana.edu/doc/publications/2008-street-trees.pdf>
- Grove JM, Cadenasso MI, Pickett STA, Machlis GE, Burch WR Jr. 2015. *The Baltimore school of ecology: Space, scale, and time for the study of cities*. New Haven (CT, USA): Yale University Press. 256 p. <https://doi.org/10.12987/yale/9780300101133.001.0001>
- Holling CS. 1996. Engineering resilience versus ecological resilience. In: Schulze P, editor. *Engineering within ecological constraints*. Washington (DC, USA): The National Academies Press. p. 31-44. <https://doi.org/10.17226/4919>
- Indiana Spatial Data Portal. 2021a. 1998-1999 USGS Digital Orthophoto Quarter Quadrangles. United States Geological Survey and Natural Resources Conservation Service. Bloomington (IN, USA): Indiana University. <https://gis.iu.edu/dataset/statewide/1998doqq.html>

- Indiana Spatial Data Portal. 2021b. Historic Bloomington Aerial Photos. Indiana Geological and Water Survey (IGWS). Bloomington (IN, USA): Indiana University. https://gis.iu.edu/dataset/local/bloomington_historic.html
- Indiana University. 2009 January 27. Indiana University Bloomington named Tree Campus USA by the Arbor Day Foundation. IU News Room. Bloomington (IN, USA): Indiana University, News & Media. <https://newsinfo.iu.edu/news/page/normal/9735.html>
- Indiana University Bloomington, Smithgroup JJR. 2010. Campus Master Plan. Bloomington (IN, USA): Indiana University Bloomington. https://sustain.iu.edu/images/IUB_Master_Plan.pdf
- Indiana University Office of Sustainability. 2020. Promoting healthy forests and reconnecting communities with their woodlands. Bloomington (IN, USA): Indiana University, Sustain IU. <https://sustain.iu.edu/buwp.html>
- Johnson LR, Johnson ML, Aronson MFJ, Campbell LK, Carr ME, Clarke M, D'Amico V, Darling L, Erker T, Fahey RT, King KL, K Lautar, Locke DH, Morzillo AT, Pincetl S, Rhodes L, Schmit JP, Scott L, Sonti, NF. 2020. Conceptualizing social-ecological drivers of change in urban forest patches. *Urban Ecosystems*. 24:633-648. <https://doi.org/10.1007/s11252-020-00977-5>
- Jonnes J. 2017. *Urban forests: A natural history of trees and people in the American cityscape*. London (UK): Penguin Books. 416 p.
- Kowarik I, Hiller A, Planchuelo G, Seitz B, von der Lippe M, Buchholz S. 2019. Emerging urban forests: Opportunities for promoting the wild side of the urban green infrastructure. *Sustainability*. 11(22):6318. <https://doi.org/10.3390/su11226318>
- Krasny ME, Delia J. 2015. Natural area stewardship as part of campus sustainability. *Journal of Cleaner Production*. 106:87-96. <https://doi.org/10.1016/j.jclepro.2014.04.019>
- McGinnis MD. 2019. Connecting commons and the IAD framework. In: Hudson B, Rosenbloom J, Cole D, editors. *Routledge handbook of the study of the commons*. Abingdon-on-Thames (UK): Routledge. p. 50-62.
- McPherson EG, Luttinger N. 1998. From nature to nurture: The history of Sacramento's urban forest. *Journal of Arboriculture*. 24(2):72-88. https://www.fs.fed.us/psw/topics/urban_forestry/products/cufr_20_EM98_19.pdf
- Nordman E, Isely E, Isely P, Denning R. 2018. Benefit-cost analysis of stormwater green infrastructure practices in Grand Rapids, Michigan, USA. *Journal of Cleaner Production*. 200:501-510. <https://doi.org/10.1016/j.jclepro.2018.07.152>
- Nowak DJ. 1993. Historical vegetation change in Oakland and its implications for urban forest management. *Journal of Arboriculture*. 19(5):313-319. https://www.nrs.fs.fed.us/pubs/jrnl/1993/ne_1993_nowak_002.pdf
- Nowak DJ, Crane DE, Stevens JC, Hoehn RE, Walton JT, Bond J. 2008. A ground-based method of assessing urban forest structure and ecosystem services. *Arboriculture & Urban Forestry*. 34(6):347-358. https://www.nrs.fs.fed.us/pubs/jrnl/2008/nrs_2008_nowak_001.pdf
- Office of the Vice Provost for Faculty and Academic Affairs. 1969. Policy for the Use of Indiana University Assembly Ground. Bloomington (IN, USA): Indiana University. BL-ACA-118. <https://vpfaa.indiana.edu/policies/bl-aca-i18-use-assembly-ground/index.html>
- Ordóñez C, Duinker PN. 2014. Assessing the vulnerability of urban forests to climate change. *Environmental Reviews*. 22(3):311-321. <https://doi.org/10.1139/er-2013-0078>
- Ostrom E. 2008. The challenge of common-pool resources. *Environment: Science and Policy for Sustainable Development*. 50(4):8-21. <https://doi.org/10.3200/ENV50.4.8-21>
- Reynolds H, Brandt L, Widhalm M, Fei S, Fischer BC, Hardiman B, Moxley DJ, Sandweiss E, Speer J, Dukes JS. 2018. Maintaining Indiana's Urban Greenspaces: A Report from the Indiana Climate Change Impacts Assessment. West Lafayette (IN, USA): Purdue Climate Change Research Center, Purdue University. 9 p. https://urbanforestry.indiana.edu/doc/iccia_urbangreenreport_2018.pdf
- Robeson SB, Mincey S, Need Z. 2018. The Woodland Campus: Indiana University Bloomington: A Historic Walking Tour. Bloomington (IN, USA): Indiana University Integrated Program in the Environment. <https://oneill.indiana.edu/doc/about/woodland.pdf>
- Roman LA, Fristensky JP, Eisenman TS, Greenfield EJ, Lundgren RE, Cerwinka CE, Hewitt DA, Welsh CC. 2017. Growing canopy on a college campus: Understanding urban forest change through archival records and aerial photography. *Environmental Management*. 60(6):1042-1061. <https://doi.org/10.1007/s00267-017-0934-0>
- Roman LA, Pearsall H, Eisenman TS, Conway TM, Fahey RT, Landry S, Vogt J, van Doorn NS, Grove JM, Locke DH, Bardekjian AC, Battles JJ, Cadenasso ML, Konijnendijk van den Bosch CC, Avolio M, Berland A, Jenerette GD, Mincey SK, Pataki DE, Staudhammer C. 2018. Human and biophysical legacies shape contemporary urban forests: A literature synthesis. *Urban Forestry & Urban Greening*. 31:157-168. <https://doi.org/10.1016/j.ufug.2018.03.004>
- Storms K, Simundza D, Morgan E, Miller S. 2019. Developing a resilience tool for higher education institutions: A must-have in campus master planning. *Journal of Green Building*. 14(1): 187-198. <https://doi.org/10.3992/1943-4618.14.1.187>
- Ulmer JM, Wolf KL, Backman DR, Tretheway RL, Blain CJA, O'Neil-Dunn JPM, Frank LD. 2016. Multiple health benefits of urban tree canopy: The mounting evidence for a green prescription. *Health and Place*. 42:54-62. <https://doi.org/10.1016/j.healthplace.2016.08.011>
- Washington-Ottombre C, Washington GL, Newman J. 2018. Campus sustainability in the US: Environmental management and social change since 1970. *Journal of Cleaner Production*. 196:564-575. <https://doi.org/10.1016/j.jclepro.2018.06.012>
- Yin RK. 2003. *Case study research: Design and methods*. 3rd Ed. Applied Social Research Methods Series, Volume 5. Thousand Oaks (CA, USA): Sage Publications. 179 p.

ACKNOWLEDGMENTS

We would like to thank Dr. Jess Vogt and Gretchen Luchauer for their thoughtful reviews of this manuscript. This project was entirely self-funded with no assistance from outside sources.

Stephanie Freeman-Day (corresponding author)
Indiana University O'Neill School of Public and Environmental Affairs
 1013 E. Chris Lane
 Bloomington, IN, USA
 1-812-606-8453
 stjfreem@iu.edu

Burnell C. Fischer, PhD
Indiana University O'Neill School of Public and Environmental Affairs
 Bloomington, IN, USA

Conflicts of Interest:

The authors reported no conflicts of interest.

Résumé. Contexte: Les espaces verts urbains sont de plus en plus considérés comme des ressources cruciales contribuant à la santé écologique et sociale. Le concept écologique de dynamique des parcelles dans l'espace, selon l'ampleur et dans le temps s'applique aux parcelles en milieu urbain et est important pour comprendre la complexité des relations tant au sein qu'entre les sphères écologiques et sociales qui interagissent en milieu urbain. Méthodes: Cette étude de cas porte sur les parcelles forestières et naturelles du campus de Bloomington de l'Université de l'Indiana (IUB). Les données recueillies dans les archives de l'université comprennent des cartes historiques et des plans du campus couvrant une période d'analyse débutant en 1884 jusqu'à la relocalisation de l'université sur son site actuel. Les documents ont été examinés afin de trouver des preuves que des parcelles avaient été étiquetées ou laissées en blanc. Les photos aériennes historiques ont été comparées aux images satellites actuelles à l'aide d'un logiciel d'information géographique (SIG). Résultats: Les constatations incluent des modèles où des parcelles étaient identifiées sur les cartes (de 1902 jusqu'au début des années 1940), suivi d'une période où les zones naturelles/forestières n'étaient pas indiquées sur les cartes (de l'après-guerre aux années 1960), puis les parcelles réapparaissaient sur les cartes et sont proposées aux fins de préservation (des années 1960 jusqu'à aujourd'hui). Bien que certaines parcelles naturelles aient été "perdues" pendant la période d'étude, d'autres ont persisté. Les parcelles ayant perduré peuvent être définies comme étant d'intérêt public: soit des ressources partagées protégées par des procédés réglementaires formels/informels. Conclusions: Ce nouveau cadre pour le projet de parcelles de l'IUB sert de gabarit pour l'analyse des parcelles vertes dans la ville de Bloomington. Le projet de Bloomington s'appuie sur le cadre de l'IUB, en élargissant l'analyse SIG des parcelles actuelles et de l'imagerie historique et en évaluant l'état actuel des parcelles écologiques. D'autres considérations reflètent la complexité de l'environnement municipal et comprennent la propriété des parcelles, les données sociodémographiques et l'équité d'accès.

Zusammenfassung. Hintergrund: Städtische Grünflächen werden zunehmend als lebenswichtige Ressourcen angesehen, die zur ökologischen und sozialen Gesundheit beitragen. Das ökologische Konzept der Patch-Dynamik über Raum, Skala und Zeit hinweg gilt für Patches im städtischen Umfeld und ist wichtig für das Verständnis der komplexen Beziehungen zwischen

und innerhalb der ökologischen und sozialen Sphären, die im städtischen Umfeld interagieren. Methoden: In dieser Fallstudie werden bewaldete und natürliche Flecken auf dem Campus der Indiana University in Bloomington (IUB) untersucht. Die in den Universitätsarchiven gesammelten Daten umfassen historische Karten und Campus-Pläne für den Untersuchungszeitraum ab 1884, als die Universität an ihren heutigen Standort verlegt wurde. Die Dokumente wurden auf Belege für beschriftete oder leer gelassene Flächen überprüft. Historische Luftaufnahmen wurden mit aktuellen Satellitenbildern unter Verwendung geografischer Informationssoftware (GIS) verglichen. Ergebnisse: Die Ergebnisse zeigen Muster, bei denen Flächen auf Karten eingezeichnet waren (1902 bis Anfang der 1940er Jahre), gefolgt von einem Zeitraum, in dem natürliche/bewaldete Gebiete auf Karten nicht eingezeichnet waren (nach dem Zweiten Weltkrieg bis in die 1960er Jahre), gefolgt von Flächen, die auf Karten wieder auftauchten und für die Erhaltung vorgeschlagen wurden (1960er Jahre bis heute). Obwohl einige natürliche Flächen während des Untersuchungszeitraums "verloren" gingen, blieben andere erhalten. Flächen, die überdauert haben, können als Gemeingüter definiert werden: gemeinsame Ressourcen, die durch formelle/informelle Regelprozesse geschützt werden. Schlussfolgerungen: Dieser neuartige Rahmen für das IUB-Patch-Projekt dient als Vorlage für die Untersuchung von grünen Flecken in der Stadt Bloomington. Das Projekt in Bloomington baut auf dem IUB-Rahmen auf und erweitert die GIS-Analyse aktueller Beete und historischer Bilder sowie die Bewertung des aktuellen ökologischen Zustands der Beete. Zusätzliche Überlegungen spiegeln die Komplexität des städtischen Umfelds wider und umfassen den Besitz von Flächen, soziodemografische Faktoren und die Gleichberechtigung beim Zugang.

Resumen. Antecedentes: Los espacios verdes urbanos son vistos cada vez más como recursos vitales que contribuyen a la salud ecológica y social. El concepto ecológico de la dinámica poblacional sobre el espacio, la escala y el tiempo se aplica a los espacios verdes en entornos urbanos y es importante para comprender la complejidad de las relaciones entre y dentro de las esferas ecológicas y sociales que interactúan en entornos urbanos. Métodos: Este estudio de caso investiga espacios boscosos y naturales en el campus de Bloomington (IUB, por sus siglas en inglés) de la Universidad de Indiana. Los datos recopilados a través de los archivos de la universidad incluyen mapas históricos y planes del campus para un período de estudio que comenzó en 1884 con la reubicación de la universidad a su área actual. Se revisaron los documentos en busca de evidencia de espacios verdes etiquetados o dejados en blanco. Las fotos aéreas históricas se compararon con las imágenes satelitales actuales utilizando software de información geográfica (SIG). Resultados: Los hallazgos incluyen patrones en los que los espacios se indicaron en los mapas (1902 a principios de la década de 1940), seguidos de un período en el que las áreas naturales / boscosas no se indicaron en los mapas (después de la Segunda Guerra Mundial hasta la década de 1960), seguidos de áreas que reaparecen en los mapas y se sugieren para su preservación (1960 hasta el presente). Aunque algunos espacios naturales se "perdieron" durante el período de estudio, otros persistieron. Los espacios que perduraron pueden definirse como Comunes: recursos compartidos protegidos por procesos de reglas formales / informales. Conclusiones:

































Este novedoso marco para el proyecto de espacios IUB sirve como plantilla para su uso en la investigación de espacios verdes en la ciudad de Bloomington. El proyecto Bloomington se basa en el marco de IUB, ampliando el análisis SIG de los espacios





actuales y las imágenes históricas y evaluando la condición actual del espacio ecológico. Las consideraciones adicionales reflejan la complejidad de los entornos municipales e incluyen la propiedad del espacio, la sociodemografía y la equidad en el acceso.

Appendix on following page

Appendix 1.

Table S1. Indiana University Bloomington Campus Green Patches, inclusive of forested patches, less wooded meadows/lawns, quads, cemeteries, and outdoor meeting spaces. Tree icon indicates trees were drawn into the map or plan to indicate an unlabeled/unnamed green space. * indicates the space was not yet IUB property.

Patch name	1902 Ulrich Plan	1917 campus map	1930 campus map	1935 map	1940 map	1944 plan	1950 map of campus, 1953 map, 1962 map	1976 campus guide, 1986 map	1989 map	1994 map	1999 map, 2001 map	2010 Master Plan
Beech Grove		no			no		no	no	no	no		label
Bryan Hollow		no			no		no	no	no	no		label
Collins Quad	*	*	*	*	*	*	no	no	no	no		label
Cox Arboretum	*	*	*	*	*	*	no	no	label	label	label	label
Dunn Cemetery		no			no		no	no	no	no	no	label
Dunn Meadow		no		label	label		no	label	label	label	label	label
Dunn's Woods		no			no		no	no	no	label	label	label
East 17th Street Woods	*	*	*	*	*	*	* /no (1962)	no	no			label
Fine Arts Plaza	*	*	*	*	*	*	*	no	no	no	no	label
Godfrey Courtyard	*	*	*	*	*	*	*	*	*	no	no	label
Hilltop Garden	*	*	*	*	*	*	no	no	no	label	label	label
Jordan Field	label	label	label	label	label	label	no	no	no	no	no	no
Ostrom Commons ¹	*	*	*	*	*	*	*	*	*	*	*	*
Rogers Fee Lane Cemetery	*	*	*	*	*	*	no	no	no	no	no	label
SPEA Grove	*	*	*	*	*	*	no	no	no			label
Sunken Garden		no			no		no	no	no			label
Wells Plaza	*	*	*	*	*	*	*	*	*	*	*	label

Patch name	1902 Ulrich Plan	1917 campus map	1930 campus map	1935 map	1940 map	1944 plan	1950 map of campus, 1953 map, 1962 map	1976 campus guide, 1986 map	1989 map	1994 map	1999 map, 2001 map	2010 Master Plan
Wells Quad	*	*	*		no		no	no	no			label
Woodlawn Field/ Parade Ground/ Drill Field	*	*	*	label	label	yes	no	label	label	label	label	no

¹Ostrom Commons is located at the edge of another campus greenspace, Bryan Woods. Its designation as a Commons then potentially changes its status from that of the edge of a forested green space to that of a gathering space.

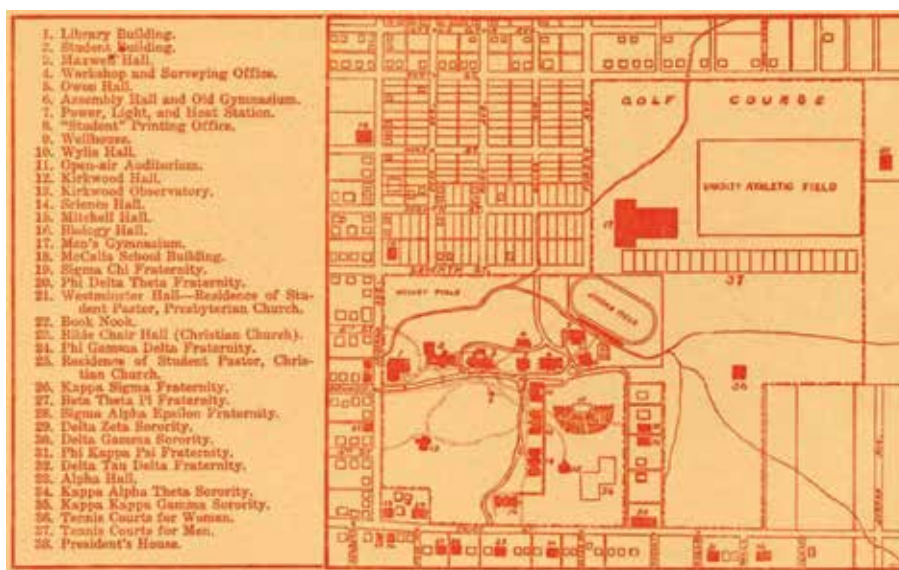


Figure S1. 1917 map of campus and surrounding area includes Dunn Meadow (labeled as "Hockey Field") and Jordan Field. Image number P0093613. Photograph used with permission from the Indiana University Archives.

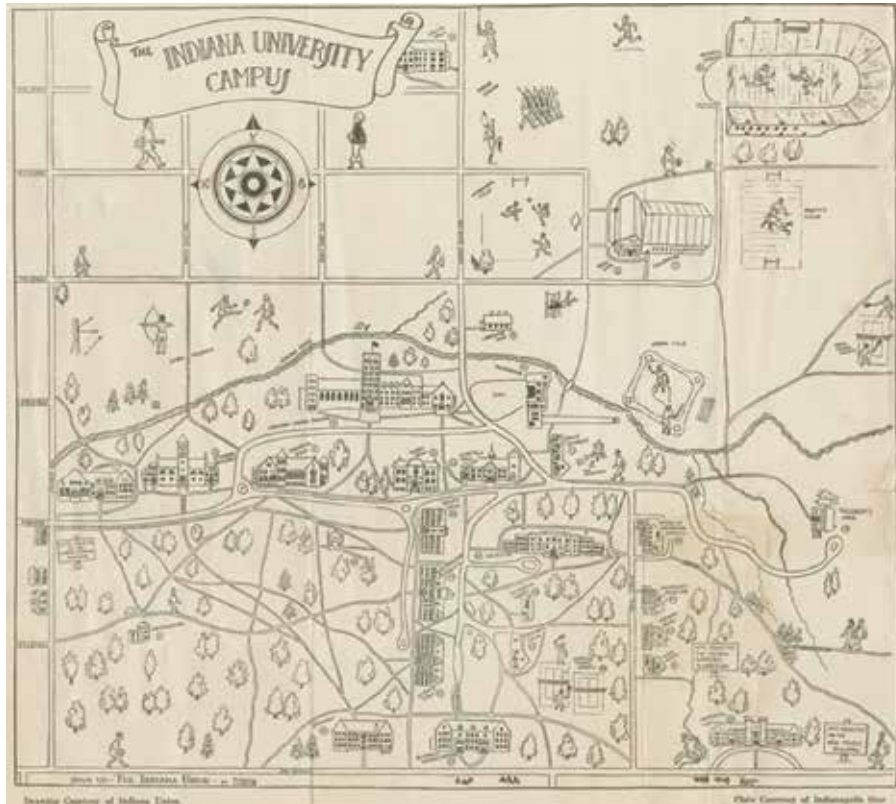


Figure S2. 1935 map drawn by Shannon Johnson includes drawings of trees in known green spaces with labels for Dunn Meadow, Jordan Field, and Woodlawn Field (“Parade Ground”). Image number P0034274. Photograph used with permission from the Indiana University Archives.



Figure S3. The 1944 Eggers and Higgins (photographer/architect) map of planned additions to campus includes drawings of trees and labeling of Woodlawn (“Drill”) Field. Image number P0058496. Photograph used with permission from the Indiana University Archives.

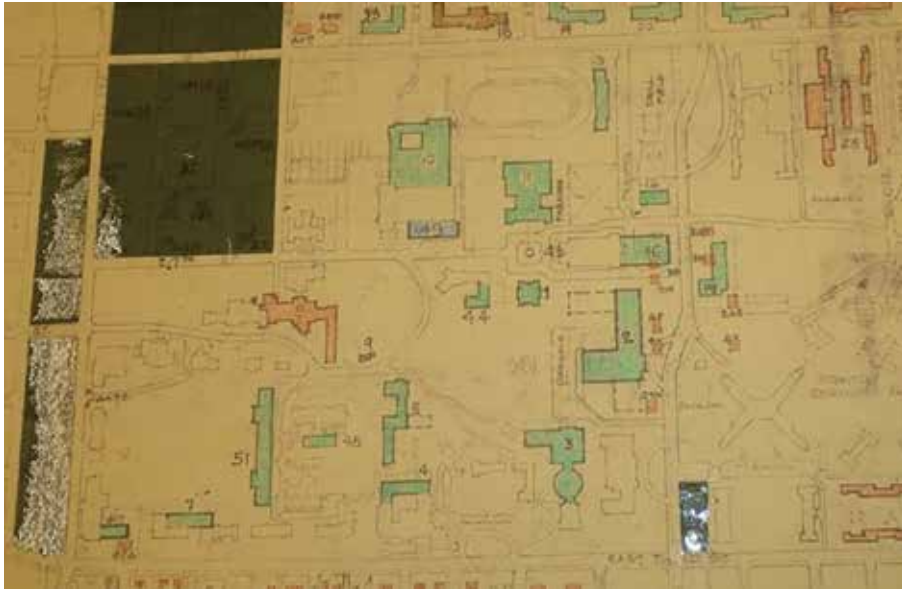


Figure S4. 1956 Eggers and Higgins (photographer/architect) Development Plan for Indiana University Bloomington campus. Drill Field evident, but blank spaces for Dunn Meadow, Dunn's Woods, and Jordan Field. Photograph used with permission from the Indiana University Archives.

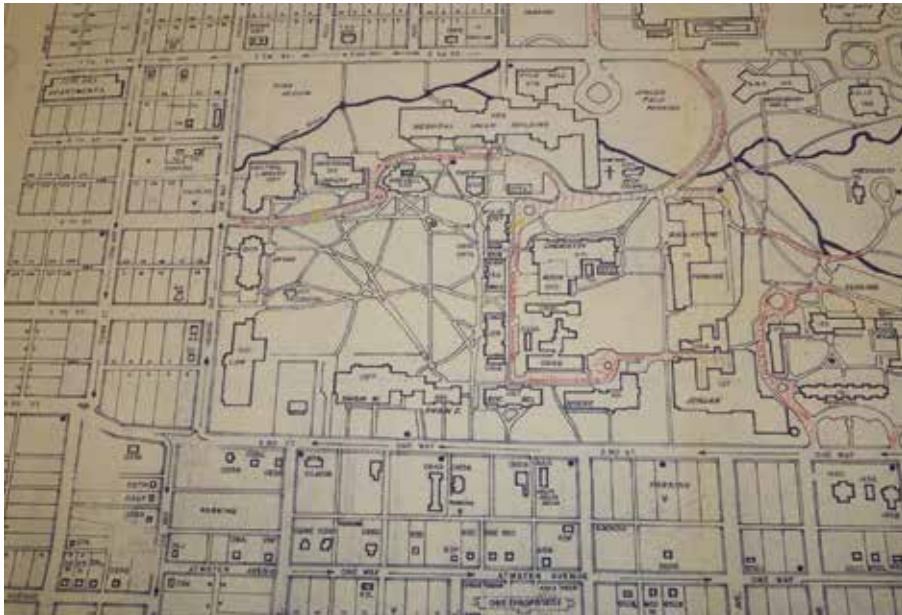


Figure S5. 1966–1967 plan labels Dunn Meadow, with Jordan Field now referred to as Jordan Field Parking. Photograph used with permission from the Indiana University Archives.

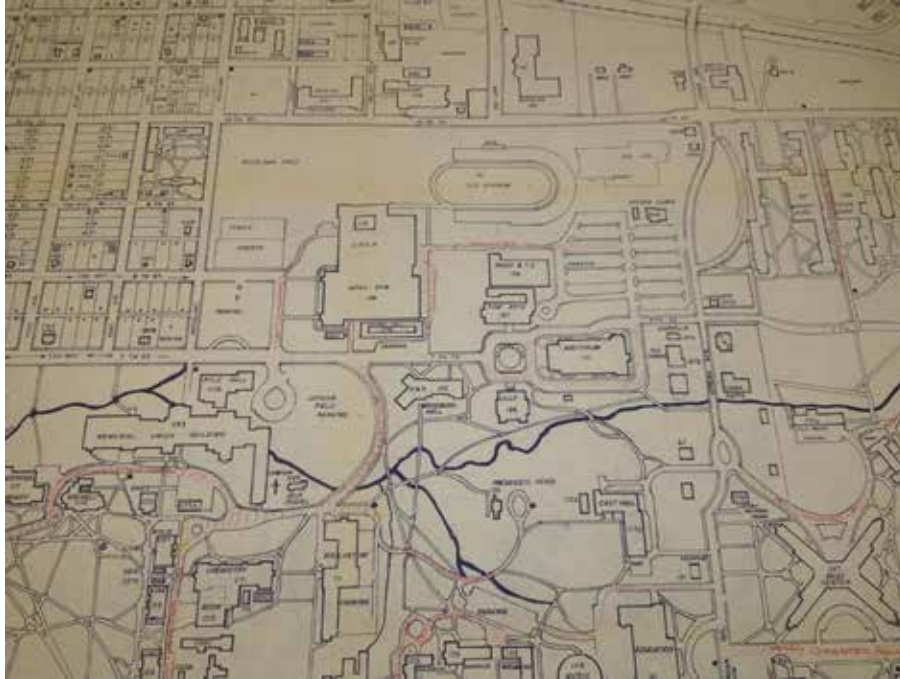


Figure S6. Image from 1966–1967 plan, northeast of Figure S5. Woodlawn Field is labeled. Also evident is a blank space, later indicated as SPEA Woods in the 2010 Master Plan. Photograph used with permission from the Indiana University Archives.