Indiana University's Woodland Campus: A case study of urban forest patch sustainability

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Introduction

Since relocating in 1884 to its current site, Indiana University's Bloomington 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 Fall 1885. 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 considering natural surroundings, Indiana University's Bloomington campus has been designated a Tree Campus USA by the Arbor Day Foundation since the first year (2009) the program began, meeting its five 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).

While historical analysis of urban forests has not been frequently done, writers have addressed the history of U.S. 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 trees in city settings. Some research has taken 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 140 years later at the time of the study. McPherson and Luttinger (1998) combined analysis of historical documents with interviews of local residents to investigate natural and social forces driving changes in Sacramento's urban forest, finding urban forest management and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) call 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" (page 160). 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.

For our case study, we seek to address the gap delineated above- that little historical analysis of urban forests has been done at the patch level. For this reason, the 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 review patches that have been removed because of campus development and building projects as well as patches that have been sustained, added, or recognized throughout the growth of the IUB campus. 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. 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 to urban forested patches.

Urban and university forests- sustainability, resilience, and institutional planning

Grove et al. (2015) discuss three major criteria that serve to define and specify urban patches - physical (human-built or natural abiotic), biological, and social factors. Additionally, they acknowledge the importance of historical and temporal factors in determining ecological outcomes because of 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 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 el. 2011, Ulmer et al. 2016, and furthermore, a recent study (Nordman et al. 2018) showed preserved urban forest patches providing the highest net economic value of any type of urban green infrastructure. Research (Kowarik 2019) conducted in Berlin further demonstrates the value of preserving urban forested patches, finding than 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 (2010), in considering 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." (Indiana University and Smithgroup JJR, 2010, page 12). 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, despite the upward trend in awareness of university sustainability, student stewardship of natural areas has not been emphasized in sustainability ranking systems such as 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), describes 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 of campus (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 acting to increase resilience by including planning in their master plans with regards to campus resilience but also as 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 is informative in 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 over a hundred-year time period. 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 has categorized into three types- High Quality Mature Deciduous Forest- Few Invasives, Mature Deciduous Forest- Substantial Invasives, Scrub-Shrub/Immature Deciduous Forest (Figure 1).
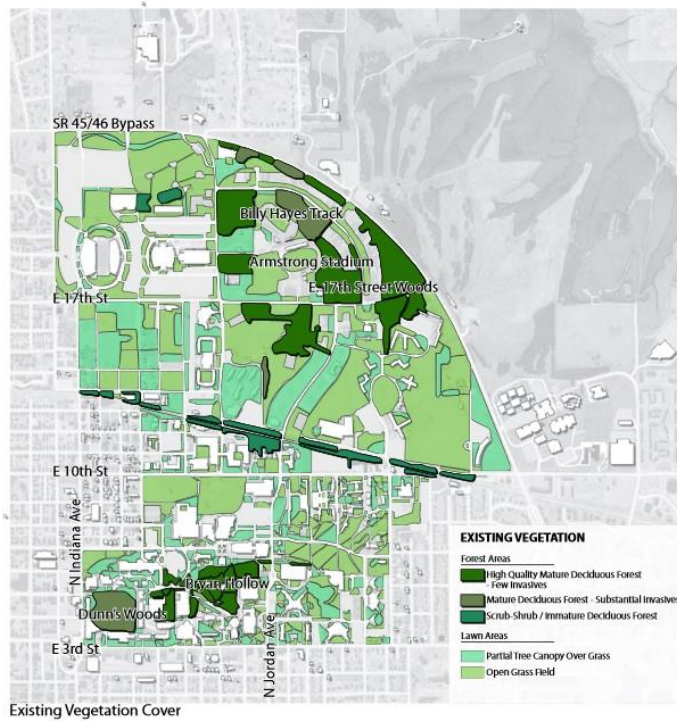
Figure 1 Vegetation Typology of IUB Campus from 2010 Master Plan, page 53

Methodology

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" (page 545). 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.

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 have chosen 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, January 22, 2021). A notable example is the 1902 Ulrich plan which included the addition of manmade lakes and a cave entrance to the 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 known 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 8-13 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 these in meeting notes, official correspondence, and news stories were retrieved for us by Archives librarians (see Figure 5). 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 labelled by name, visually by trees or green areas, or completely unlabeled.

Finally, we visited the Archives to photograph large planning maps that were not present during the first visits to the Archives or available in the online Archives. These maps were photographed and then uploaded and analyzed for the presence/absence of patch labels or visual designation. After data was collected, all documents were compiled into chronological order to be considered as a single timeline depicting changes in campus natural areas from 1902- 2010.
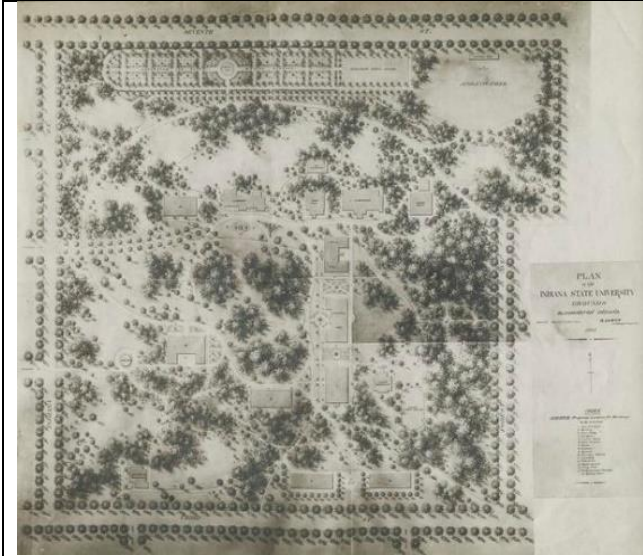
Figure 2-1902 planning map of IU Campus shows trees among buildings in the Old Crescent area. The lower left of the map is the location of Dunn's Woods.
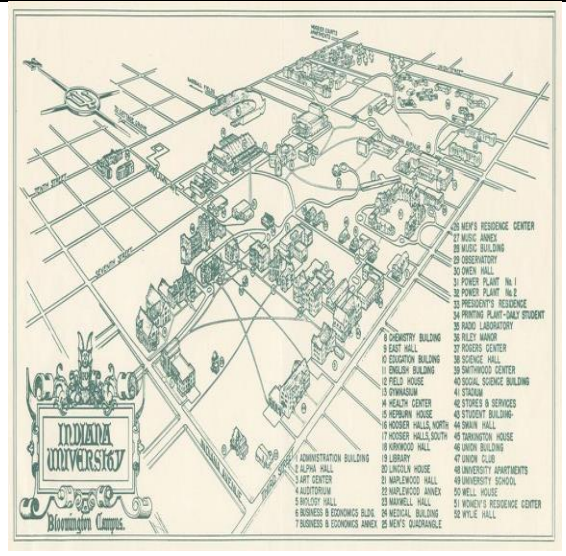

Figure 3- 1950 planning map shows Post WWII campus expansion, note: previously identified patches are merely blank areas on the map.
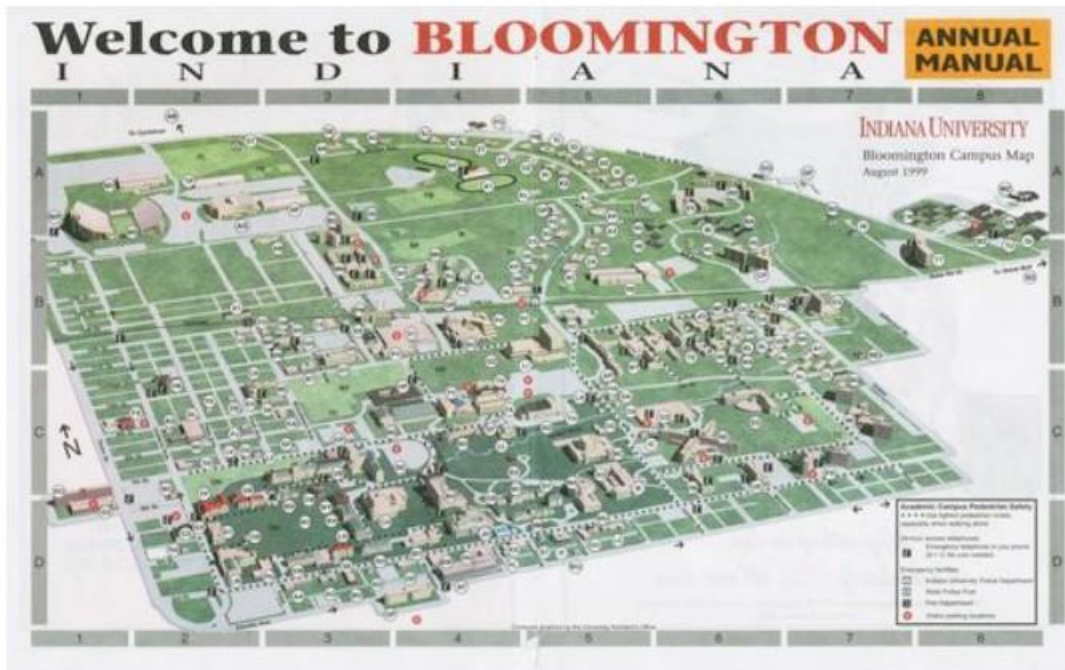

Figure 4- 1999 Campus map with buildings, forested spaces, and other green spaces

Group meets to save woods

By Christopher Cokinos
ids Staff Writer

"We're cutting em' down," a voice bellowed. "Save the woods!"

About seven faces glanced quickly in the voice's direction. They ignored the sarcastic comment, not knowing or seeming to care who the caller was.

Huddled on a path behind the IU School of Law, a few stragglers from Friday's lunchtime Save the Woods ribbon-tying ceremony quietly discussed the demonstration.

"Yeah, it was a success," a smiling Tom Zeller, spokesman for Save the Woods, said as he held green ribbon left over from the demonstration.

The rest of that green ribbon was tied to about 16 trees, and while many demonstrators were leaving, two others tied small ribbons around seven tiny saplings. "We're taking care of the children," said one student as he bound a sapling with a light green strip.

Zeller said not all of the 22 trees slated for removal had ribbons

Save the Woods members cite several environmental reasons for opposing the library expansion plan. One reason is that the area is used for biology classes. And, although the area is not a park, he said, it is a unique urban environment.

attached because "we wanted to make sure we got trees we know are going to be removed."

A large green plastic ribbon also was placed on Kirkwood Observatory's 27-foot-wide dome.

About 50 people took part in the ribbon ceremony, which featured Save the Woods members' talking about the controversial law school project and watching several demonstrators tie ribbon to trees.

Zeller and Douglas Hofstadter,

associate professor of computer science, spoke to participants as the group gathered on the path.

Tongue-in-cheek, Hofstadter called the ceremony an act of "solidaritree."

More serious remarks were made as well. David Frey, professor of biology, cited several environmental reasons for the opposition to the library expansion plan to encroach into the wooded area.

One reason, Frey said, is that the area is used for biology classes. And, although the area is not a park, he said, it is a unique urban environment.

Save the Woods was organized two weeks ago to oppose the law school expansion plan and to seek an alternative plan. Members of the group said they acknowledge the law school's need for more library space but that the current plan would harm the environment.

Currently, the group is working on a letter and petition drive. Members will meet again tonight in Rawles 100.

Staff Photo/Jim Rider

Members of the Save the Woods organization march from the Well House through the Crescent Woods path to the proposed Law Library addition site. They tied green ribbons around the trees, which are scheduled to be cut down, and the Kirkwood Observatory. The organization hopes to keep the library addition from impinging upon the oldest part of campus.

Campus Briefs

Figure 5-- News story about contested Campus development impacting Dunn's Woods. (Indiana Daily Student, February 5, 1982). 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.

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

Patch Name	Years labelled with name	Year labelled 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	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

Results and discussion

Our findings connect directly to urban forest historical research findings as described below. The university's continual 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 that changes in the state of forested patches do occur in long periods- generations rather than years.

Overall, findings include oscillating patterns of campus development and 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) provides 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 includes several lakes and an entrance to a cave. Although Dunn's Woods is not specifically labelled on the planning map, trees are drawn in its location as well as throughout the image. The "Woodland Campus" concept comes from these early plans and is echoed in the campus plans made by the Olmsted firm in the 1920s and 1930s. Campus maps from the 1930s show labelled green spaces including Dunn Meadow, Woodlawn Field (then called Drill Field), and Jordan Field. Also in the 1930s came the first known contested development planned 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 concerned letter to the student newspaper and after some debate the administration changed plans, moving the building to an unwooded area of campus (Capshew, 2021). Labelling of green spaces continues into the mid-1940s, where the Jordan River is clearly labelled on campus maps and the Dunn's Woods area is indicated as "Wooded Campus". However, by this time campus expansion had changed the status of some previously labelled campus green spaces. Woodlawn Field/Drill Field still appears on a 1944 planning map, but Dunn Meadow is 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) indicates 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 to 100 acres in the 1930s to over 1900 acres in the late 1960s- this expansion came to the northeast of the original Dunn's Woods site and was thereafter where the majority of building projects took place (J. Capshew, personal communication, January 22, 2021). Arguably, these large- scale land purchases 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. After this period, green spaces are slow to appear (or reappear on maps). In 1968, amid a period of growing student activism, Dunn Meadow remerged as a labelled 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 (see https://vpfaa.indiana.edu/policies/bl-aca-i18-use-assembly-ground/index.html). This usage of Dunn Meadow continues today, when, for example in Fall 2019, a Climate Action rally was held in the Assembly Grounds location.

The 1970s began with both Woodlawn Field and Dunn Meadow indicated by name on maps. And 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" (see Figure 5) 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 labelled on campus maps or plans until the 1990s. 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). This act has potential to give this green space some protection from development, although the space was modified in 2019 as described below.

The most current (2010) Master Plan (Figure 6) for the IUB campus includes a list of 17 green spaces deemed "preservation areas". Among them are Dunn's Woods, Dunn Meadow, and Cox Arboretum. The list also includes green spaces previously not included on any previous maps and plans, including SPEA Grove, Beech Grove, and the 17th Street Woods. This most recent plan incorporates 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 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. This pattern also 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 being 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 research Workshop cofounder Elinor Ostrom. This green space is in the 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 (see https://news.iu.edu/stories/2020/12/iu/inside/04-construction-projects-approved-for-bloomington-iupui-campuses.html)

ONE-OF-A-KIND PLACES
1. Dunn's Woods
2. Dunn Meadow
3. Bryan Hollow
4. Cox Arboretum
5. Fine Arts Plaza
6. Hilltop Garden

QUADS
7. Wells Quad
8. Collins Quad
9. Godfrey Graduate and
   Executive Education Center
   Courtyard

PRESERVATION AREAS
10. Dunn Cemetery
11. Rogers-Fee Lane Cemetery
12. Beech Grove
13. SPEA Grove
14. East Seventeenth Street Woods

INTIMATE SPACES
15. Sunken Garden
16. Wells Plaza
17. McKinney Fountain

Existing Memorable Spaces

Figure 6- Designated preservation areas as indicated in 2010 Master Plan (Indiana University Bloomington and Smithgroup JJC, 2010)

Although forest and other green patches have persisted at IUB for over 100 years there have been noticeable visible 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, Capshew, 2021), the original 20 acres was developed along each side with buildings and about eight interior acres remains. 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 (see Figure 7) to a more fully stocked forested area later in the century. More recent changes (learned via personal communication, 2020, with IU Landscape Architect's office) to the woodland have been the widespread infestation of invasive wintercreeper (recently greatly reduced by human intervention), 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.

Figure 7-- Dunn's Woods as seen in the early 1900s, much more open than currently with rows of planted trees

Our historical analysis of green patches on the Indiana University Bloomington campus revealed temporal patterns of planning for preservation or removal 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 Two 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* and the IUB campus began being known by some as The Woodland Campus (Capshew, 2021). 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.

Currently, the concept of sustainability has increased in public discourse. There are now recognized 17 areas of various ecological types (forest patches, green lawn spaces with trees, historical green spaces) on campus designated as memorable spaces in the most recent Master Plan (Indiana University Bloomington and Smithgroup JJR, 2010). These memorable spaces fall into four categories, One-of-a-Kind Places, Quads, Preservation Areas, and Intimate Spaces (Indiana University Bloomington and Smithgroup JJR, 2010). It is worth noting that the plan did not actually create new green spaces, instead chose to recognize natural areas on campus that had existed but were not formally recognized, noted, or labelled on maps.

Planning decisions shown on the historical maps examined are reflective of social realities and are subject to pressures both influencing preservation and influencing development. 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. The ecosystems 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.

Green patches as a 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 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 two categories, both having the trait where access is difficult 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 because removing 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 (see https://sustain.iu.edu/buwp.html). 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.

Future research

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 home owners 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.

Works Cited

1917 map of campus and surrounding area. (1917) Indiana University Archives. Image number
    P0093613. Retrieved from http://fedora.dlib.indiana.edu/fedora/get/iudl:2698380/LARGE

1930 Campus Map. (1930) Indiana University Archives. Image number P0034373. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0034273&searchId=
    20&searchResultIndex=1

1935 Campus Map. (1935). Indiana University Archives. Image number P0034274. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0034274&searchId=
    23&searchResultIndex=1

1940 Map of Campus. (1940). Indiana University Archives. Image number P0026037. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0026037&searchId=
    25&searchResultIndex=1

1944 Map of Planned Additions to Campus. (1944) Indiana University Archives. Image number
    P0058496. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0058496&searchId=
    33&searchResultIndex=1

1950 map of campus. (1950). Indiana University Archives. Image number P0031716. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0031716&searchId=
    67&searchResultIndex=1

1953 map with January 12, 1954 updates. (1954). Indiana University Archives. Image number P0051213.
    Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0051213&searchId=
    69&searchResultIndex=2

1976 campus guide. (1976). Indiana University Archives. Image number P0031719. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0031719&searchId=
    1&searchResultIndex=1

A 1962 map of campus. (1962). Indiana University Archives. Image number P0071503. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0071503&searchId=
    85&searchResultIndex=1

A 1986 map of campus. (1986). Indiana University Archives. Image number P0071505. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0071505&searchId=
    6&searchResultIndex=1

A 1994 map of campus. (1994). Indiana University Archives. Image number P0071510. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0071510&searchId=
    3&searchResultIndex=1

A 1999 map of campus. (1999). Indiana University Archives. Image number P0071509. Retrieved from
    http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0071509&searchId=
    4&searchResultIndex=1

A 2001 map of camps. (2001). Indiana University Archives. Image numbers P0071507-P0071508. Retrieved from http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0071508&searchId=6&searchResultIndex=1

A circa 1989 map of campus. (1989). Indiana University Archives. Image number P0071506. Retrieved from http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0071506&searchId=7&searchResultIndex=1

Baxter P, and Jack S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, *13*(4), 544-559.

Campus from Indiana Avenue well before Bryan Hall was built. (circa 1908). Image number P0078307. Retrieved from http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0078307&searchId=24&searchResultIndex=122

Davey Resource Group. (September 2019) Urban Tree Canopy Assessment Summary Report: City of Bloomington, Indiana. Retrieved from 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.

Feickert, B. (4 December 2020) *IU Board of Trustees Approves Projects for IUPUI, Bloomington Campuses. News at IU.* Retrieved from https://news.iu.edu/stories/2020/12/iu/inside/04-construction-projects-approved-for-bloomington-iupui-campuses.html

Fischer BC and Steed BC. (2008, October). Street trees: a misunderstood common pool resource. In *International Society of Arboriculture: 84th Annual Conference and Trade Show, St. Louis, Missouri. International Society of Arboriculture, Champaign, IL*.

Grove JM, Cadenasso MI, Pickett STA, Machlis GE, Burch Jr. WR. (2015) The Baltimore School of Ecology: Space, Scale, and Time for the Study of Cities. Yale University.

Holling CS. (1996) Engineering Resilience Versus Ecological Resilience. In Schulze P. Editor*, Engineering within Ecological Constraints*. (pp. 31-44). The National Academies Press.

Indiana University. (2009, January 27). *Indiana University Bloomington named Tree City USA by Arbor Day Foundation.* INdia News Room. Retrieved from https://newsinfo.iu.edu/news/page/normal/9735.html

Indiana University Bloomington and Smithgroup JJR. (2010) *Campus Master Plan.*

Indiana University Office of Sustainability. (nd) *Promoting healthy forests and reconnecting communities with their woodlands.* Sustain IU. Retrieved from https://sustain.iu.edu/buwp.html

Jonnes, J. (2017). *Urban forests: A natural history of trees and people in the American cityscape*. Penguin.

Krasny ME and Delia J. (2015). Natural area stewardship as part of campus sustainability. *Journal of Cleaner Production*, *106*, 87-96.

Map of planned additions to campus. (1944, June 15). Indiana University Archives. Image number P0058496. Retrieved from http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0058496&searchId=54&searchResultIndex=1

McGinnis, MD. (2019). Connecting commons and the IAD framework. In *Routledge Handbook of the Study of the Commons* (pp. 50-62). Routledge.

McPherson EG and Luttinger N. (1998). From nature to nurture: The history of Sacramento's urban forest. *Journal of arboriculture*, *24*(2), 72-88.

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*. 200:201-510.

Nowak, DJ. (1993). Historical vegetation change in Oakland and its implications for urban forest management. *Journal of Arboriculture. 19 (5): 313-319.*, *19*(5).

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 and Urban Forestry.* 34(6): 347-358.

Office of the Vice Provost for Faculty and Academic Affairs. (1968*). Policy for the Use of Indiana University Assembly Ground.* Retrieved from https://vpfaa.indiana.edu/policies/bl-aca-i18-use-assembly-ground/index.html

Ordóñez C and Duinker, PN. (2014). Assessing the vulnerability of urban forests to climate change. *Environmental Reviews*, *22*(3), 311-321.

Ostrom E. (2008). The challenge of common-pool resources. *Environment: Science and Policy for Sustainable Development*, *50*(4), 8-21.

R. Ulrich plan of campus with proposed locations of future buildings, walkways, etc. (1902). Indiana University Archives. Image number P0029898. Retrieved from http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0029898&searchId=1&searchResultIndex=1

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. Purdue Climate Change Research Center. Purdue University. West Lafayette, Indiana. 9 pages.

Robeson SB, Mincey S, Need Z. (2018) The Woodland Campus: Indiana University Bloomington: A *Historic Walking Tour.* [Brochure] Bloomington, IN, USA. Indiana University Integrated Program in the Environment.

Roman LA, Fristensky JP, Eisenman TS, Greenfield EJ, Lundgren RE, Cerwinka CE., Hewitt DA, & Welsh, C. C. (2017). Growing canopy on a college campus: understanding urban forest change through archival records and aerial photography. *Environmental management*, *60*(6), 1042-1061.

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.

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.

Supplemental Site Plan (supplemental to plan dated June 15, 1944). (1944) Indiana University Archives. Image number P0058497. Retrieved from http://webapp1.dlib.indiana.edu/archivesphotos/results/item.do?itemId=P0058496&searchId=54&searchResultIndex=1

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.

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.

Yin, RK. (2003). Design and methods. *Case study research*, *3*.

Appendix
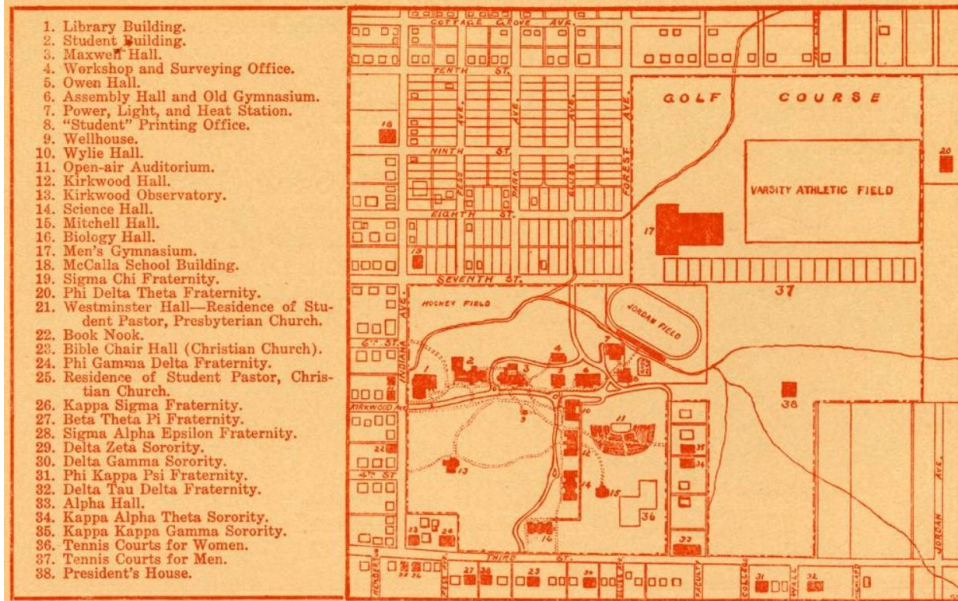
Figure 8- 1917 map includes Dunn Meadow (labeled as "Hockey Field") and Jordan Field
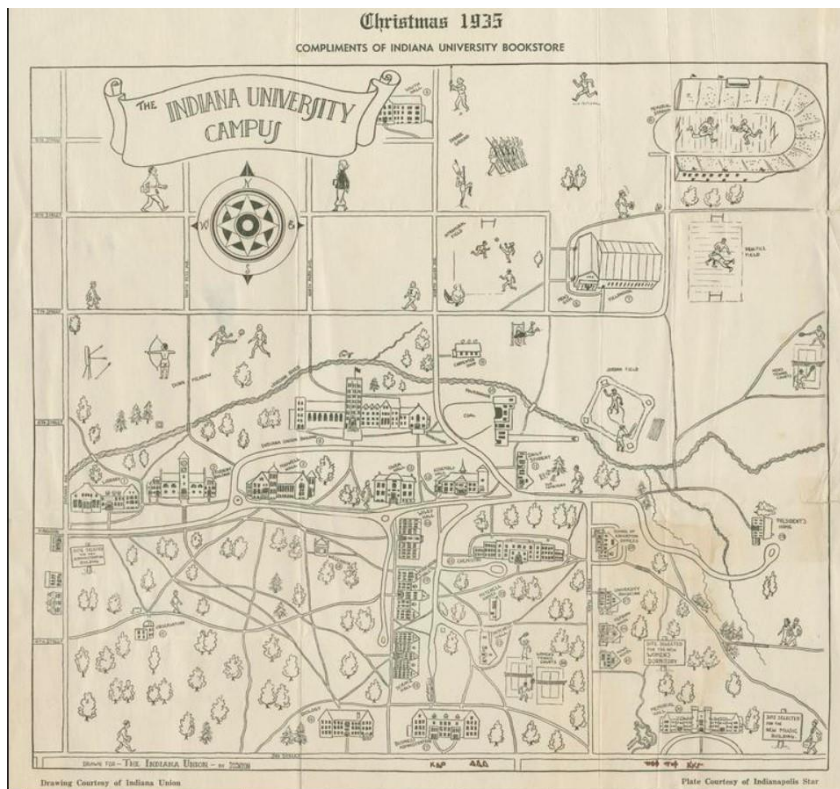
Figure 9- 1935 map includes drawings of trees in known green spaces with labels for Dunn Meadow, Jordan Field, and Woodlawn Field (Parade Ground)
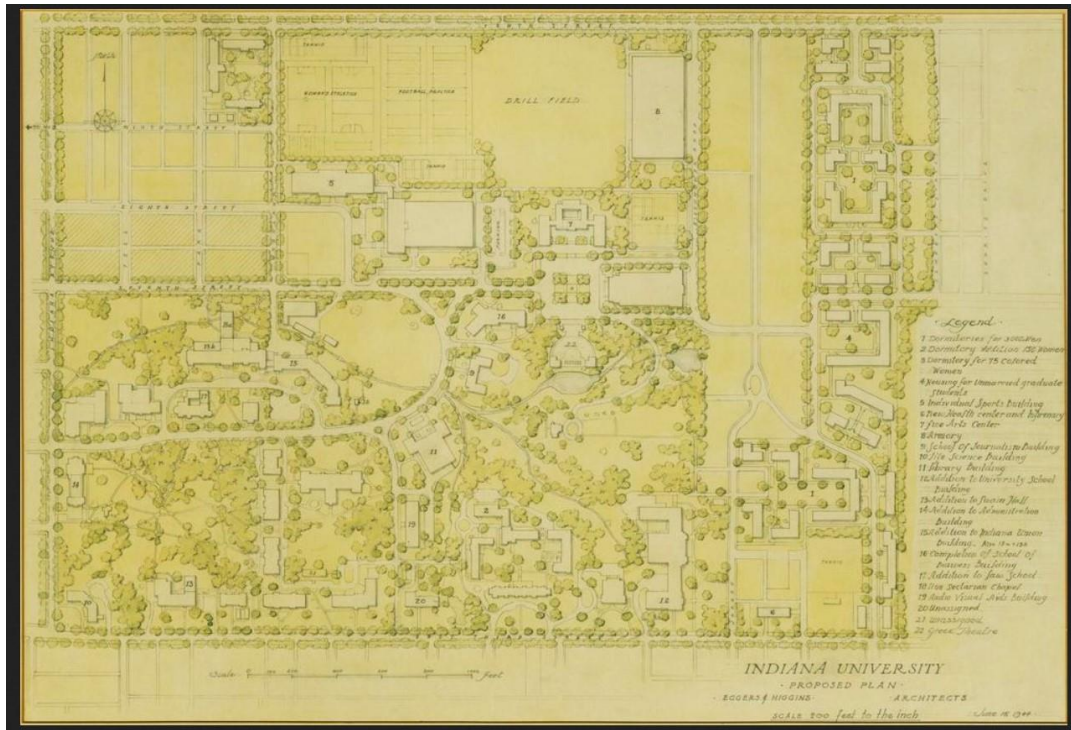
Figure 10- 1944 Eggers and Higgins plan includes drawings of trees and labelling of Woodlawn (Drill) Field
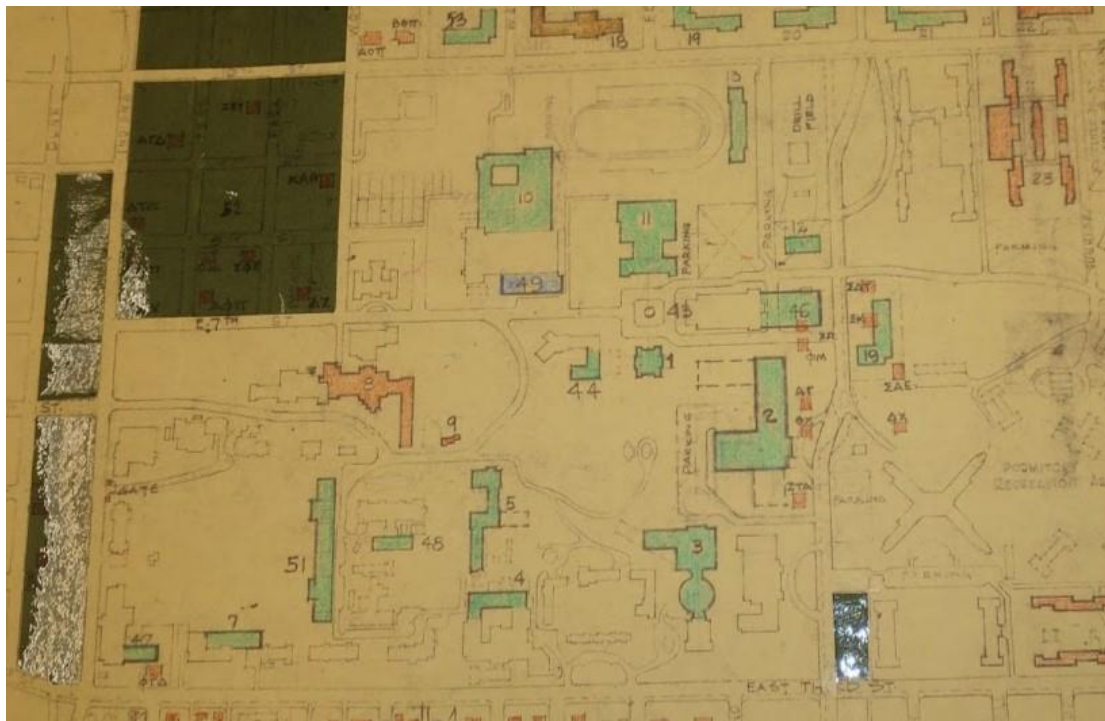
Figure 11- 1956 Eggers and Higgins plan- Drill field evident but blank spaces for Dunn Meadow, Dunn's Woods, and Jordan Field

Figure 12- 1966 plan labels Dunn Meadow, with Jordan Field now being referred to as Jordan Field Parking.
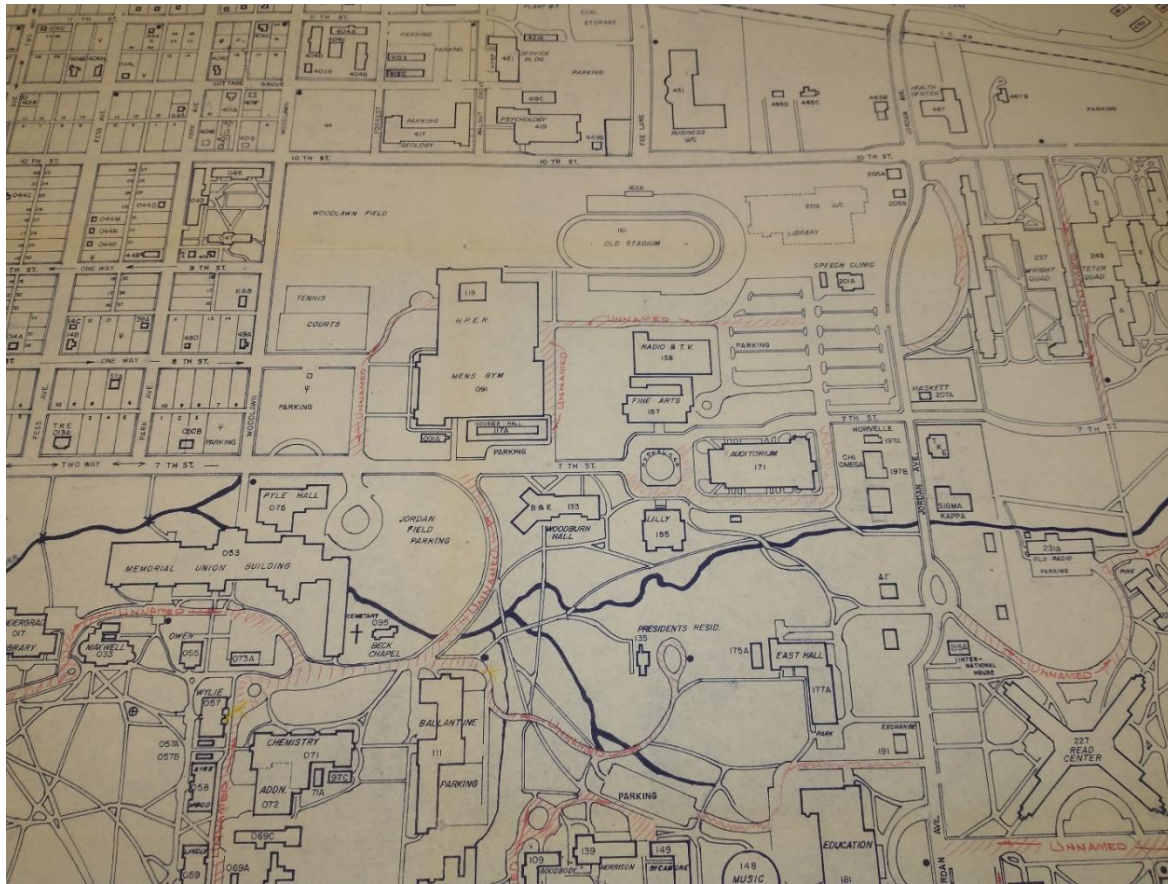
Figure 13- --Image from 1966 plan northeast of Figure 12. Woodlawn Field is labelled. Also evident is a blank space, SPEA Woods in the 2010 Master Plan

*Table 2- IU 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. ***

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
Wells Quad	*	*	*	🌲	no	🌲	no	no	no	🌲	🌲	label
Woodlawn Field/Parade Ground/Drill Field	*	*	*	label	label	yes	no	label	label	label	label	no

[1] Ostrom 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.