2022 Sustainable Urban Ecology

A Framework for Biodiversity, Rewilding and Sustainable Urban Development

Applied research and case study findings

WELLS FARGO

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Introduction

ASU researchers and practitioners are turning to ASU campuses as a living lab to understand the social, economic and environmental impacts of restoring biodiversity to urban spaces. The team includes faculty and researchers across academic disciplines, including landscape architecture and conservation science, as well as knowledgeable practitioners, including those who are managing ASU's facilities and grounds and creating sustainability plans for ASU's campuses. This cross-pollination allows our research-practitioner team to integrate and shape knowledge and practice in ways that are mutually beneficial. Research about Sustainable Urban Ecology (SUE) informs sustainable practice; experiential knowledge and implementation of sustainable practice refines and reshapes research.

Sustainable Urban Ecology (SUE) realizes ecological, social and economic benefits through reintroducing keystone species, preserving biodiversity, fighting climate change, preventing natural disasters, and bolstering local economies. SUE focuses on restoring biodiversity to urban spaces, without an insistence on native-only species. SUE strategies include transforming abandoned shopping centers or golf courses into wetland preserves, removing concrete and revitalizing urban riverbanks, incorporating green spaces into new architecture like Milan’s Bosco Verticale, and rewilding urban areas like the Green Road Project at Walter Reed National Military Medical Center.

Increasing biodiversity in cities benefits ecosystem health and resilience, adds natural capital, and increases human health and wellbeing. Urban rewilding reduces heat-island effects and urban flooding and enhances human experience through access to green spaces. The benefits of this access include better physical and mental health outcomes, greater productivity and reduced burnout, and an enhanced sense of connectedness to the natural world and the community.

Project Team

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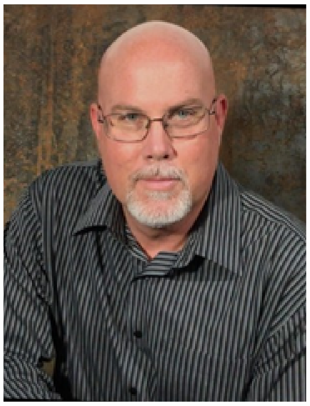

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Sustainable Urban Ecology at ASU

Sustainable Urban Ecology is a plan for ASU's biodiversity management. This plan will help create a multi-functional learning landscape and will be an investment for the future, preserving natural systems of all living and nonliving things at Arizona State University.

This plan will include:

- a desired plant palette to be used around campus,
- tools to adapt the current groundscape to climate change, and
- goals and targets to enhance KBA's (Key Biodiversity Areas).

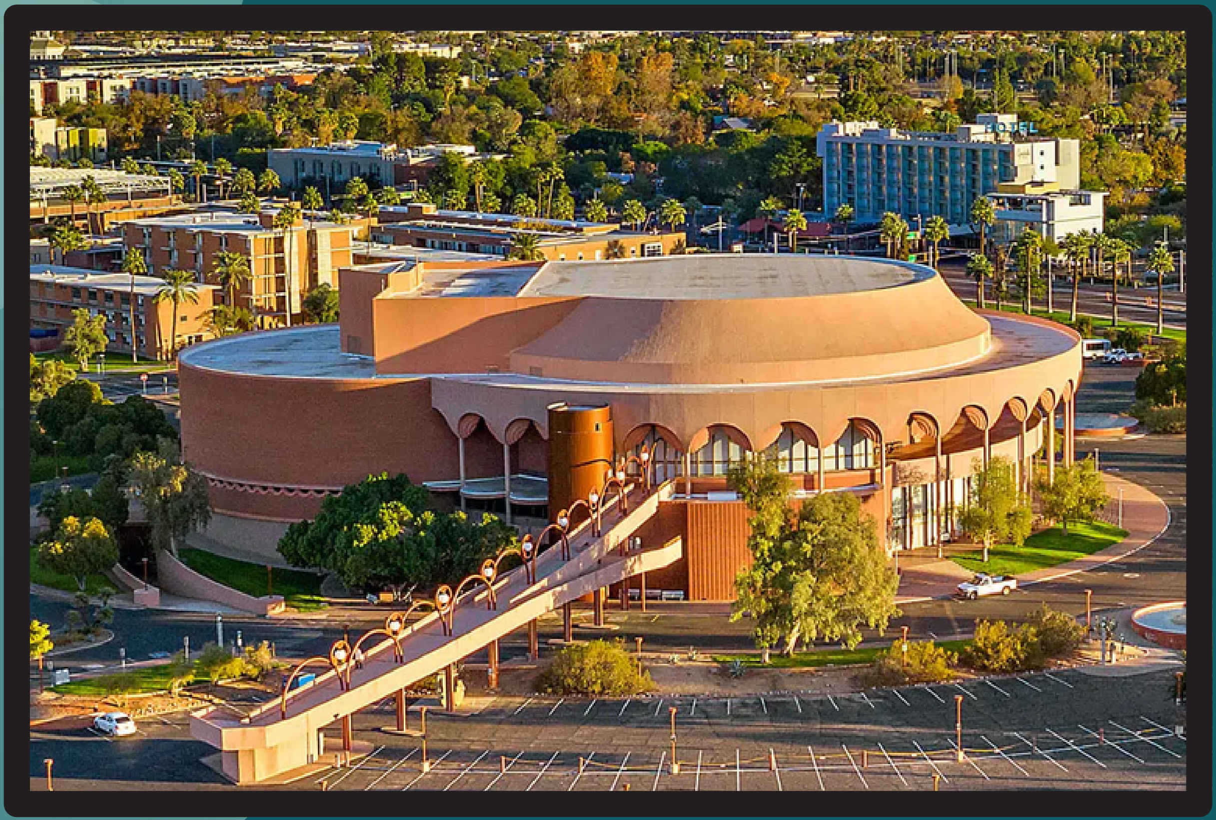
This biodiversity management strategy focuses on ASU campuses in the metro Phoenix region that are in the Sonoran Desert Biome and could be utilized as a platform for measuring Biodiversity and Urban Heat Island in the greater metro Phoenix area.

In this first phase of research our team of ASU researchers and practitioners are turning to ASU campuses as a living lab to understand the environmental impacts of rewilding. The four metro Phoenix campuses of ASU cover 1,989 acres and encompass more than 450 facilities and roughly 150,000 students, faculty and staff. This offers a robust living laboratory in which to examine the interplay of biodiversity, local environmental impacts and human experience.

Research Questions / Framing Concepts

- What type of plan or program needs to be in place to protect or positively impact species, habitats, and/or ecosystems?
- What are the quantifiable benefits and values (environmental/social/economic) of SUE?
- How could ASU become a model for what climate, resilient urban landscapes for humans and nature?
- How can SUE at ASU move from an artifact to ecosystem services model that meaningfully engages the ASU community in the process of design, implementation, and monitoring of sustainability practices?
- How could these benefits be communicated to administration, faculty, staff, and students?

Site Selection



Climate change, impacts from the urban heat island effect, and the forthcoming state water restrictions necessitate a re-evaluation of all existing campus landscapes at ASU. The SUE internal working group identified Grady Gammage Memorial Auditorium (GGMA) as a site of interest to study potential opportunities addressing these changing conditions.

By its placement and design, GGMA is one of Arizona State University's most iconic and recognizable sites. Currently, the building is surrounded by water-intensive landscape plantings and impervious parking lots, indicative of the time period in which it was developed, making it one of the least sustainable areas on campus.

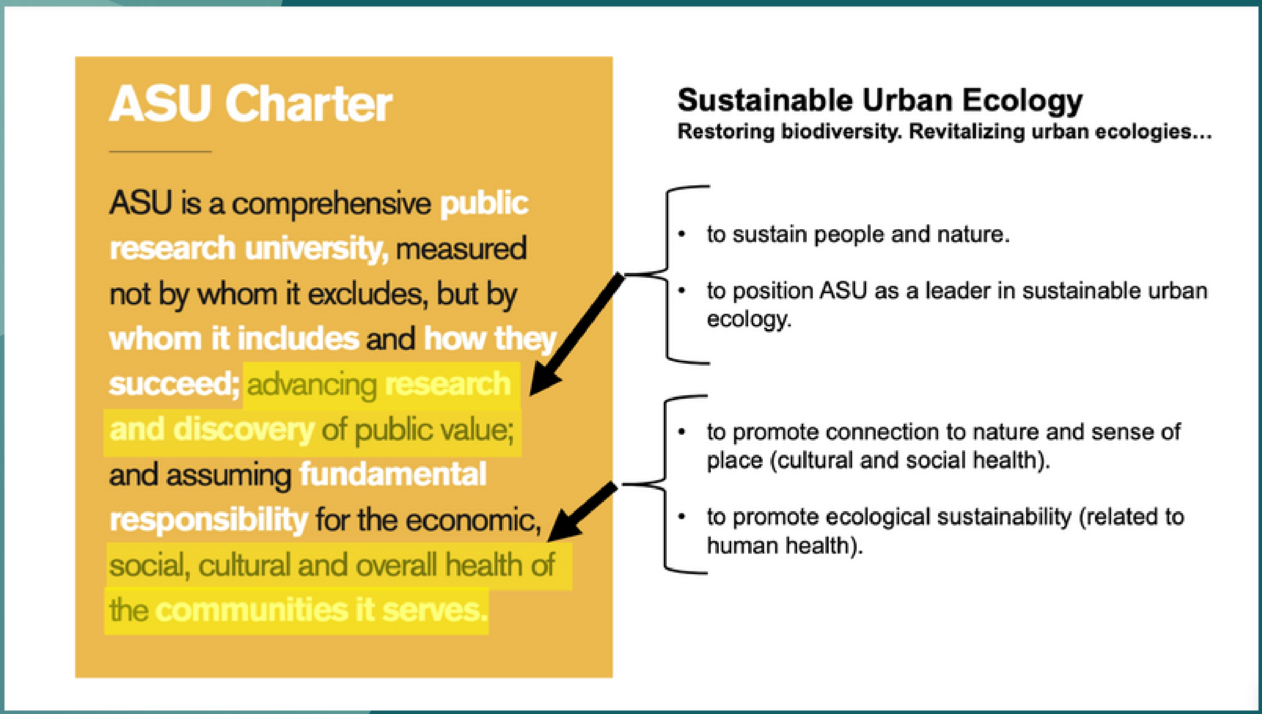
To develop a resource and knowledge base that will enable the university to make sustainable choices around landscape development and land use, the working group designed a study to examine soil profiles, existing water use, urban heat island effect, and biodiversity as well as existing exterior site uses and functions. A key goal of this multi-pronged experimental case study was to develop recommendations that will improve the viability and resilience of the landscape.

Research Design for SUE Experimental Case Study

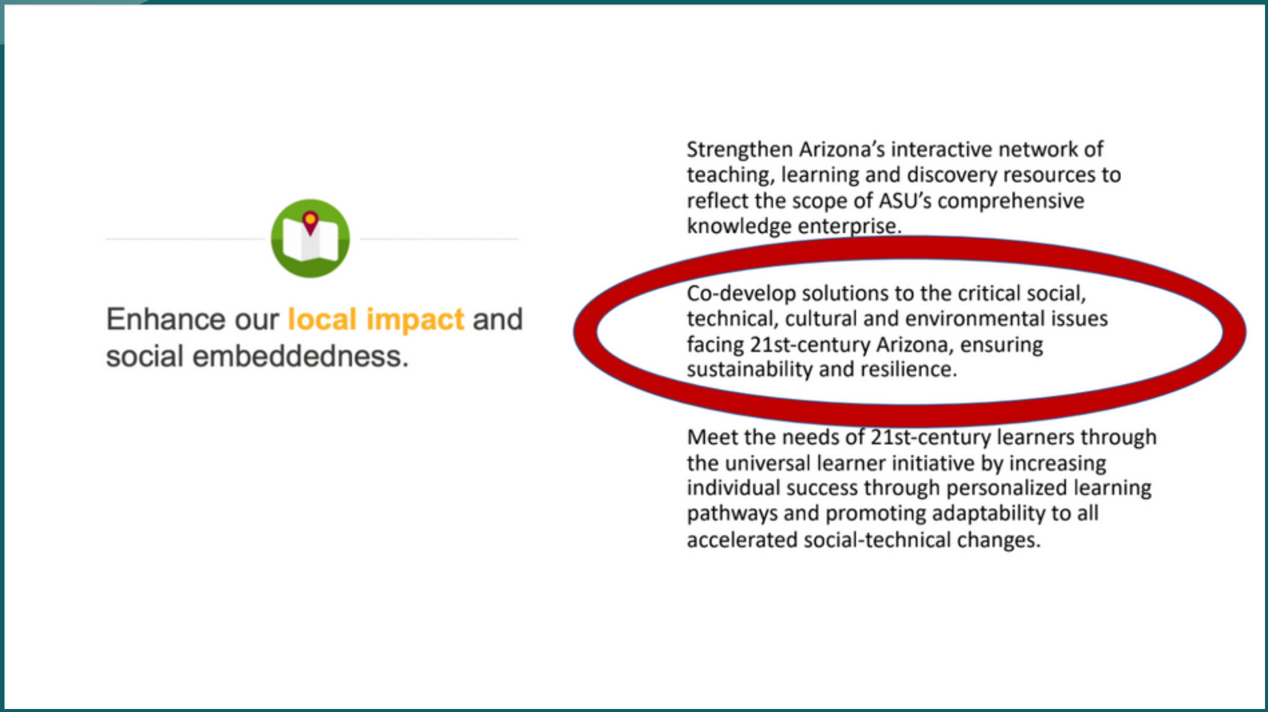
1. Develop a model for what climate-resilient urban landscapes can provide for humans and nature
    - Connections to ASU's charter
    - Indicators for measuring landscape sustainability
2. Assess the current state of the selected site
    - Literature Review: Examination of Frank Lloyd Wright's designs
    - Environmental Analysis
    - Biodiversity Assessment
    - Economic Analysis of Operational Costs
    - Social Analysis
3. Develop a communication plan
    - Stakeholders, goals, content, method
    - ASU Landscape Management
4. Conceptual design and roadmapping techniques for moving toward SUE

A model for climate-resilient urban landscapes

Connections to ASU's charter



While SUE speaks to several of the mission-oriented goals ASU has set for itself, SUE perhaps connects most directly with the goal to "Enhance our local impact and social embeddedness."



Sustainable Urban Ecology

Restoring biodiversity. Revitalizing urban ecologies for people and the planet.

Leverage our place. Enable student success.
Embed the campus form and function (aesthetic) in the full beauty and wonder of the Sonoran desert to provide a unique and important sense of place and thus promoting the social, psychological, and cultural health of the local community.

Transform society. Conduct use-inspired research.
Embody the practice of sustainability in campus landscape design through careful consideration of the impacts of our choices on the triple bottom line – social, ecological, economic.

Value entrepreneurship. Fuse intellectual disciplines.
Model the possibilities of innovation in teaching and research activities around sustainable urban ecology by quantifying the impact of urban landscape choices in terms of both human (aesthetic, health, etc) and ecological (wildlife use and environmental provisioning) benefits.

Be socially embedded. Engage globally.
Consider the needs of all stakeholders (including community members) by collaboratively designing campus spaces that are seen as the cornerstone of our community, while also providing ecological benefits.

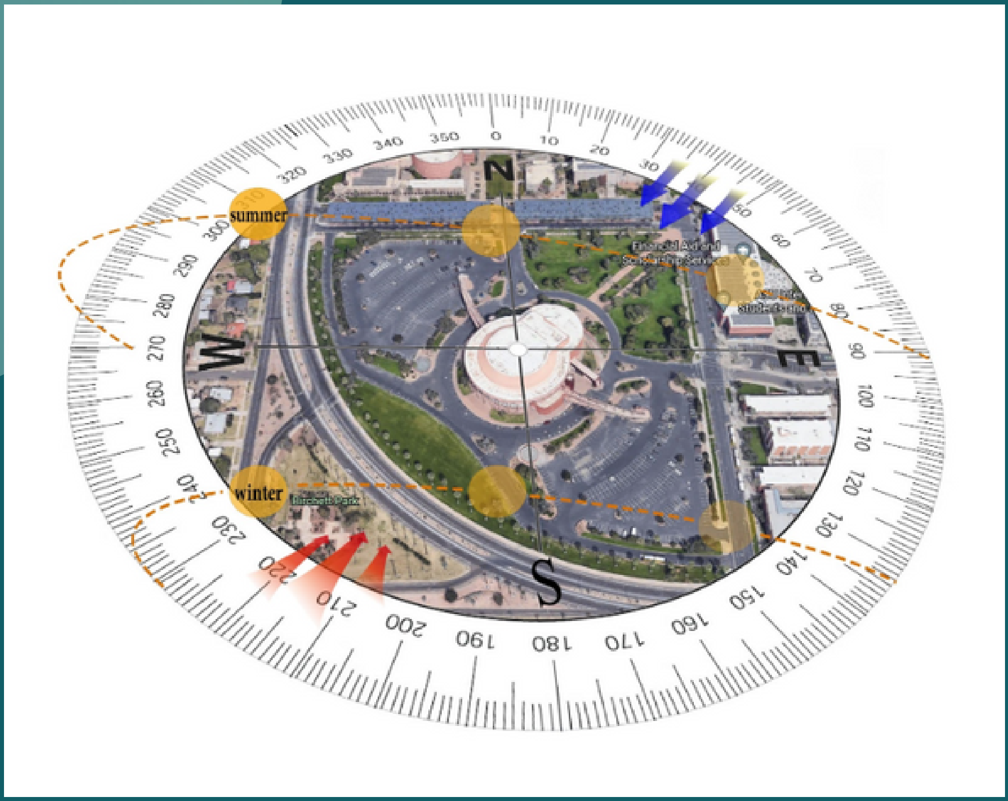
A model for climate-resilient urban landscapes

Socio-ecological indicators for measuring campus landscapes sustainability

We determined several social and ecological metrics for measuring landscape sustainability. Table 1 and Table 2 show general categories and methods along with site-specific questions for social and ecological indicators, respectively.

Some of the methods for assessment, which we later applied to the Gammage site, are outlined in this section following the overview provided by the tables.

Find the full report here.



Social indicators

Table 1: Social indicators

	Indicators	Method	Gammage site proposed research studies and questions
1	Recreational and Social Value	This part requires the use of surveys and site observations. In this purpose, previous Documentation of visitation or use is required,If it is not, time-lapse photography, direct observation, or surveys can be used to determine the extent and type of use. Surveys can gauge frequency and type of use and perceptions related to **quality of life**, **sense of place, safety, and health benefits** (Landscape Architecture Foundation, 2018).	Question: How can we evaluate the recreational and social value of the site? - SUE Interview Questions - Survey Questions
2	Cultural Preservation	Metrics rely on previous documentation of the type, extent, and significance of cultural resources and the measures taken to protect or restore them (Landscape Architecture Foundation, 2018).	Question: How to protect the valuable cultural features of the site? - Protecting Gammage Auditorium Building and **leaving it undisturbed**.
3	Traffic Safety	It relies on collecting traffic incidents or crime data. Field observations can be used to document changes in **traffic speed, jaywalking, or other behaviors that impact safety**. Surveys can yield information about perceptions of safety (Landscape Architecture Foundation, 2018).	Question: What are the main behaviors impacting on safety? - Starting collecting this data soon.
4	Scenic Quality and Views	The main research issue is about **landscape aesthetics** and the best should be used the framework to **integrate quantitative and qualitative data, modeling or image analysis, or user surveys** (Landscape Architecture Foundation, 2018).	What are the primary scenic quality and viewing features of the Gammage site? - Creating some questions in the survey paying attention to the **perceptions of aesthetic quality**. - Paying attention to the **money shot**.
5	Transportation	Metrics rely on **observations, surveys, or previous documentation** of transportation choices. It is useful to employ equipment like a **time-lapse camera or infrared sensors** to facilitate the process, and create **surveys** that can yield information about **modes, travel distances, and changes in transportation choices** (Landscape Architecture Foundation, 2018).	Question: How can we evaluate the transportation of the site? - Creating three different maps (**pedestrian, automobile, and transit maps**). - Creating **questions in the survey**.
6	Access and Equity	**observations and surveys** can be used to collect data on use or perceptions. On-site convenience surveys may not be sufficient to assess access and inclusion, which must take into consideration not only those using the space but also those who are not (Landscape Architecture Foundation, 2018).	Question: How can we evaluate the access and equity of the site? - **Categorizing each entrance** - Finding the **distance** between each entrance to the buildings - Creating a map to show us **critical points** in order to develop access and Equity.

Ecological indicators: Land & Water

Table 2: ecological indicators

	Indicators	Categories	Method	Gammage site proposed research studies and questions
1	Land	Land efficiency and Preservation	Understand the **pre-existing and existing conditions** and the measures taken to **protect sensitive areas** (Landscape Architecture Foundation, 2018).	Question: How should we improve the land efficiency and Preservation of the site? - Area of existing topography preserved (this metric is most applicable on infill sites).
		Soil Creation, Preservation, and Restoration	Soil health is determined through **analysis of physical samples**. Measured values can be compared to a reference soil or to values observed over time in the same location (Landscape Architecture Foundation, 2018).	Should be started in the second phase of the project.
2	Water	Stormwater Management	A system should be designed to find an approach to deal with storm problems, store a given amount of **rainfall**, reduce or maintain **peak flows**, or **treat water** to a certain level (Landscape Architecture Foundation, 2018).	Question: How should we utilize the Stormwater Management to avoid possible crises at the site? - Starting measuring and finding the recorded information - Creating the map in the existing situation (You can find this in the site analysis, Grading and drainage map.
		Water Quality	Water quality can be measured by assessing its **physical, chemical, and biological properties**. An assessment can compare before/after conditions, measure **pollutant removal** from a treatment train, or show a gradual improvement in **water quality of a water body** over time (Landscape Architecture Foundation, 2018).	Should be started in the second phase of the project.
		Water Body/Groundwater Recharge	1- Surface and groundwater levels can be monitored over time to observe trends 2- Data must be correlated with precipitation records 3- Monitoring water levels in a range of locations will lead to more accurate assessments (Landscape Architecture Foundation, 2018).	- Finding the **watershed** and **flood areas** in the existing situation.

Ecological indicators: Carbon, Energy, and Air Quality

3	Carbon, Energy, and Air Quality	Energy Use	This category relies on comparisons to baseline energy use, and it can be estimated from **utility bills** or for different landscape elements using **equations, system parameters, or calculators**. If a site generates energy through renewable sources, system performance information can be used to estimate the **reduction in nonrenewable energy use** (Landscape Architecture Foundation, 2018).	Question: How can we make the energy use more sustainable on the site? - Estimating energy use - Focusing on it during design process - Trying to decrease nonrenewable energy use.
		Air Quality	We need to focus on the estimated **pollutant removal rates** of specific practices, **namely woody vegetation.** (Small Sites: Plant lists are needed. large sites with more extensive vegetation: sampling of vegetation can help (Landscape Architecture Foundation, 2018).	Question: How can we evaluate the air quality of the site? - The Gammage site is located on a small site scale, and we discover each woody vegetation and use i-tree tools (Specific information is in part 3: data collection and assessment)
		Temperature & Urban Heat Island	1- Metrics compare measured **surface or air temperatures** or the solar reflectance index (SRI) of materials used. 2-Since all sites include a **variety of surfaces and microclimates**, a research strategy is needed to ensure that **temperature data and findings are meaningful**. 3- We need to compare the **entire site** to the previous condition or to a conventionally designed site for finding the averages based on the area of a particular surface (Landscape Architecture Foundation, 2018).	Question: How can we evaluate the Temperature & Urban Heat Island of the site? - Measuring the surface and air temperature of the Gammage site in different days - Categorizing the different materials we have
		Carbon Sequestration & Avoidance	Metrics are based on estimates and predictive models. The US Forest Service (USFS) has tools to **estimate carbon storage and annual sequestration in trees and forests**. The US Department of Agriculture (USDA) and others offer carbon calculators for farm and ranchland. Avoidance can be calculated from the measured or estimated **reduction in nonrenewable energy** or **fuel use** (Landscape Architecture Foundation, 2018).	Question: How can we evaluate the Temperature & Urban Heat Island of the site? - Measuring Carbon Sequestration & Avoidance of the Gammage site by i-tree tools (Specific information is in part 3: data collection and assessment).

Ecological indicators: Habitat

4	Habitat	Habitat Creation, Preservation, & Restoration	1- Metrics rely on previous documentation of habitat type and extent by ecologists, biologists, or other experts 2- This information can be found in **environmental impact assessment reports**, site plans, and other project documents 3- Collaboration with **local wildlife experts** may be beneficial (Landscape Architecture Foundation, 2018).	Should be started in the second phase of the project. - Finding **environmental impact assessment reports, and contacting local wildlife experts.**
		Habit Quality	To assess habitat quality more generally, an ecological integrity index can reveal how well an ecosystem is supporting and maintaining natural balance. Several assign a coefficient to each plant species and **require a list of all known plant species** on-site (Landscape Architecture Foundation, 2018).	Question: How can we evaluate the habitat quality of the site? - Creating a list of plant species from the Gammage site, but we need to start estimating species such as birds and terrestrial vertebrates in the next steps of the project.
		Population & Species Richness	1- The assessment technique will depend on the **species** being assessed, **type of habitat**, **time and labor constraints, and level of expertise**. 2- The transect is a commonly used sampling method for estimating species richness or abundance, particularly for **plants**, **birds**, or terrestrial vertebrates (Landscape Architecture Foundation, 2018).	Question: How can we assess the population and species richness of the site? - Creating a list of plant species from the Gammage site, but we need to start estimating species such as birds and terrestrial vertebrates in the next steps of the project.

Weather, microclimate, air quality

On-site weather stations with data loggers are the best method for continuous monitoring of site atmospheric conditions, such as temperature, wind, rainfall, humidity, barometric pressure, and solar radiance. We have 4 tools to measure typical parameters:

Infrared thermometer

Surface Temperature

Thermal camera

Surface Temperature
Air Temperature

Small Wireless Data Loggers

Soil temperature
Dust
Ozone*

Weather Stations

Air temperature
Rainfall
Carbon dioxide*

*Absolute pressure, Air temperature, Air velocity, Barometric pressure, Carbon dioxide, Carbon monoxide, Dew point, Dust, Hydrogen sulfide, Light intensity, Nitrogen dioxide, Ozone, Particles, Rainfall, Relative humidity (RH), Soil temperature, Solar radiation, Sulfur dioxide, Surface temperature, Volatile Organic Compounds (VOCs), Wind speed and direction.

Urban Heat Island Effect

Assessments of secondary effects of urban heat islands should include:

surface albedo (the proportion of light or radiation that is reflected from a surface) with light colors,

vegetated areas (and thus, evapo-transpiration)

water elements

and **shade**, whether it be with trees or structures.

Assessment of smart surfaces to mitigate the UHI effects on the landscape should include:

1. Green roofs and walls, green roof irrigation, and blue roofs
2. Cool pavements (high albedo, smooth texture)
3. Vegetation, including shade trees
4. Shade structures

Other assessments of UHI could include:

- Long-term changes in surface temperature on different material types and shaded surfaces
- Differences in shaded surfaces and high albedo pavements
- Differences in a pavement material's solar reflectance index (SRI) rating and actual performance in the field
- Long-term health of different vegetation types and species for "peak load landscaping" (planting specifically located to provide shade during the time of peak energy demands) (McPherson, 1994)
- Transpiration rates of vegetation and their impact on cooling
- Susceptibility to pests and disease due to changes in temperatures
- Human comfort throughout the seasons
- Building energy consumption, planting strategies, and cost-benefit analyses
- Green roof impacts and variations in green roof types
- Impact of wind tunnels and air movement
- Impact of different architectural glass types and other building materials on UHI
- Tree shading and pollution dispersion along "canyon" streets

Water quality and filtration

In the 21st century, water resource management is one of the most critical issues we face in urban communities, and urban stormwater runoff is one of the causes of water pollution. Gaining site-level knowledge of the measurable performance of water systems in the built environment and how landscape management influences water management is, therefore, critical.

Site-level assessments include:

- **Reuse of stormwater & wastewater onsite**
- **Replication of natural hydrologic conditions**
- **Multi-functionality of stormwater facilities***
- **Functionality of plant selection & soil enhancement**

*treat and conserve water, provide habitat, reduce flooding, mitigate the urban heat island effect, improve air quality, increase groundwater recharge, reduce landscape maintenance costs, etc.

Acoustics

Acoustic data can be collected onsite with handheld meters or modeled-based on predicted sound levels extracted from existing research.

When collecting or modeling sound data, we need to measure the quantity and quality of the sounds.

Human sounds

Physical characteristics*

Natural sounds

Decibel levels

Desirable sounds

Audio frequency

Undesirable sounds

*landforms, solid masses, and weather conditions

Monitoring Set-up

PART 1.
We chose points in four different zones and measure Air temperature, Surface temperature, Real feel Temperature, Humidity, wind speed, etc.

We divided the site in four main parts, and we selected the 38 points according to the distance, type of material, and its placement under direct sunlight or shade before starting the measurement on the 2nd of July and discussed it on the site. Zone A, B, C, and D are located in the North-West, North-East, South-East, and South respectively. Zone A and C are parking lots, Zone B and D are recognized as green areas on the site.

Infrared (IR) thermometer

PART 2.
We used the i-tree tool to estimate four different outputs such as CO2 analysis, Energy analysis, eco analysis, and Air pollution analysis.

We used the i-tree web tool to estimate the benefits of individual trees that we have in five zones. First, we identified the existing woody plants (trees) on the Gammage site, then calculated the DBH (Diameter at Breast Height) of each tree, and put them on the i-tree tool. These data were produced from the i-Tree Planting Calculator version 2.2.0 for Tempe; AZ 85282, and were created on the 26,27, and 30th of June.

From i-tree tools, and we could calculate the CO2 analysis (CO2 Avoided (Pounds and $) and CO2 Sequestered (Pounds and $)), Energy Benefits (Electricity Saved (kWh and $) and Fuel Saved (Millions of British Thermal Units and $)), Ecosystem Services (Tree Biomass (short ton), Rainfall Interception, Runoff Avoided (gallons and $), and Air Benefits (O3, NO2, SO2, VOC, and PM25 Removed and Avoided) for each zone.

Current state of the selected site

This section includes:

- **Examination of Frank Lloyd Wright's designs**
- **Environmental Analysis**
- **Biodiversity Assessment**
- **Economic Analysis of Operational Costs**
- **Social Analysis**

State of the Selected Site

Literature Review:
Examination of Frank Lloyd Wright's designs

Our literature review is an examination of Frank LIoyd Wright's works, attitudes, and approaches he utilized in the design process.

Find the full report here.

Grady Gammage (left) and Frank Lloyd Wright (right) review a drawing of the Auditorium.

Before examining Wright's procedures for the Gammage site, we began by reviewing five of Wright's other works; then we moved on to analyzing the design of the Gammage site. In the literature review, our effort focused on the historical significance of the Gammage site, Frank Lloyd Wright's attitudes and approaches to landscape design, as well as several methods and case studies, which are in the Arizona area or that are appropriate for the environment of this location. See Appendix for complete review.

After Frank LIoyd Wright died, his idea for the Gammage site underwent many modifications. Wright had intended for the site to have more buildings than actually existed. The auditorium, recital hall, music department, art gallery, art department, gardens, and fountains were all planned by him.

Wright's earliest designs also included a broadcasting spire atop the auditorium, so that what was on stage could be transmitted to a much wider audience. Despite Wright's initial plans for additional buildings, the majority of the territory around the auditorium's site became park space or parking spaces (Joseph M. Siry, 2005).

Grady Gammage Memorial Auditorium 1965 (1959 - S.432), (Steiner, 2014).

The placement of the GGMA in Wright's architectural history and criticism is debatable. Firstly, the auditorium was developed between 1962 and 1964 by Taliesin Associated Architects; secondly, the shape of Gammage Auditorium has been critiqued as unworthy of inclusion in the Wrightian canon because of its numerous circular geometries, exterior colonnade, and pedestrian ramps that led to nearby parking; thirdly, Wright frequently asserted that his organic modern architecture was made for unique clients and locations, not similar designs as those of Tempe and Baghdad. Finally, the fountains and water domes are not part of this site's particular historical significance because we can recognize them as a signature element in many of his designs.

In conclusion, we have determined that there are not any historical values specific to Wright's design of the Gammage site. More recently, the landscape and surrounding of the building has moved away from Wright's goals of integrating with nature since the focus of the site is more on cars and unsustainable conditions.

State of the Selected Site

Environmental Analysis

Environmental analysis utilized IOT and sensors to understand the soil, water, air, and temperature implications of the GGMA areas.

The environmental site analysis included the following:

- **land cover analysis;**
- **temperature analysis;**
- **tree canopy map;**
- **wind analysis;**
- **grading and drainage map analysis;**
- **carbon sequestration;**
- **eco analysis;**
- **air pollution and energy analyses;**
- **analysis of critical points in transit, pedestrian, and automobile maps.**

Find the full report here.

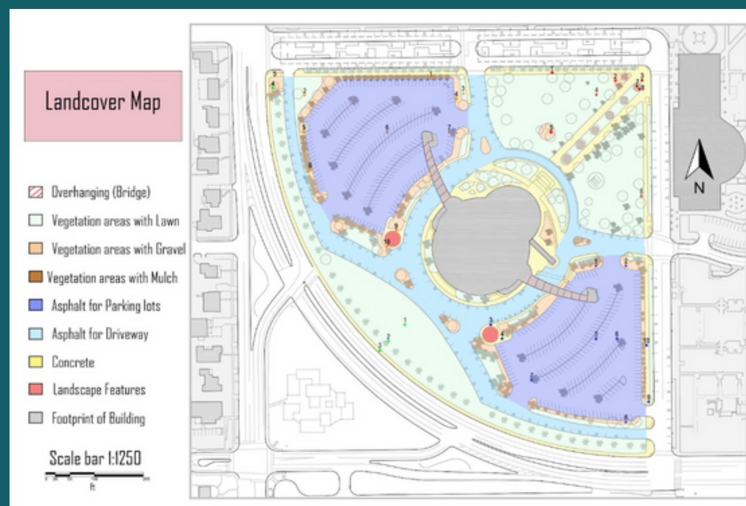
Landcover Analysis

Asphalt areas exceed all other land cover areas at nearly 46%.

Vegetation areas comprise approximately 35% of land cover, most of which is lawn.

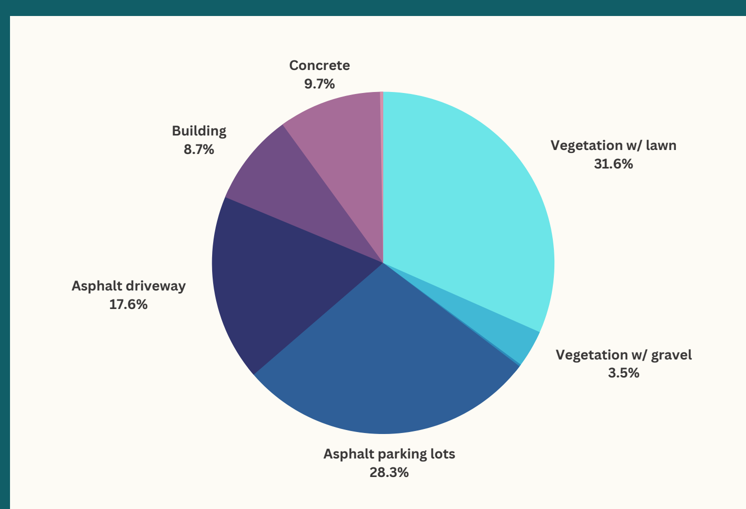
46%
Asphalt areas

28% parking



35%
Vegetation areas

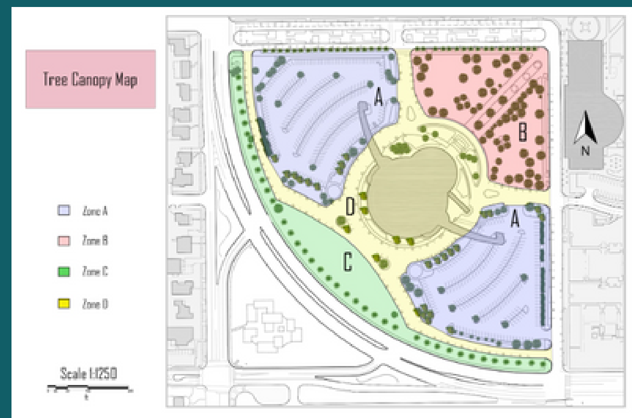
32% lawn



Temperature Analysis

Data demonstrates that all materials have higher surface temperature in the parking lots (Zone A and C) than they are in other zones for the same materials.

In addition the radiant temperature in Zone A and C is higher than other zones respectively.

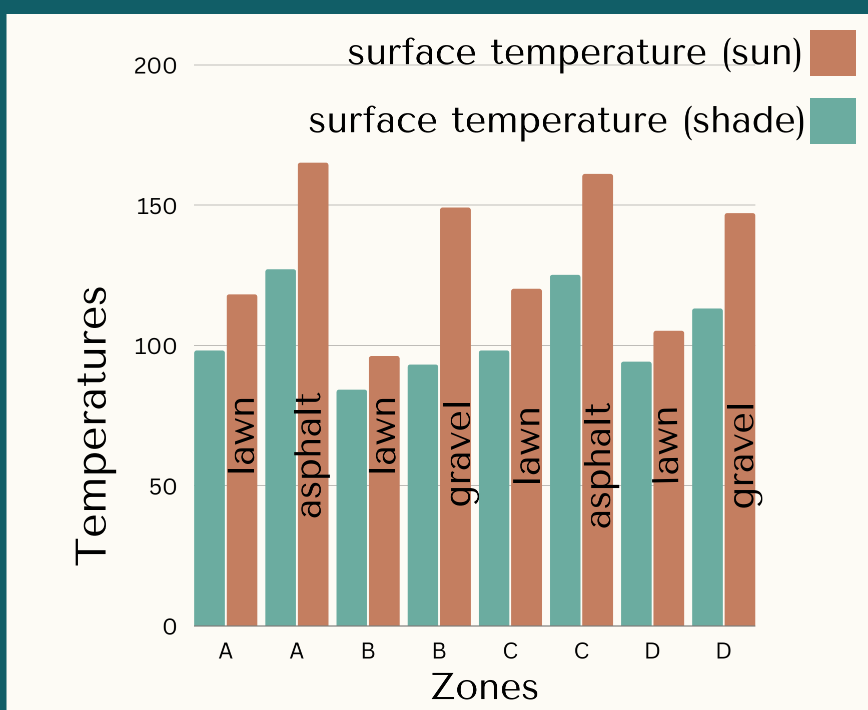


~165 degrees — asphalt areas (sun)

~127 degrees — asphalt areas (shade)

~118 degrees — lawn areas (sun)

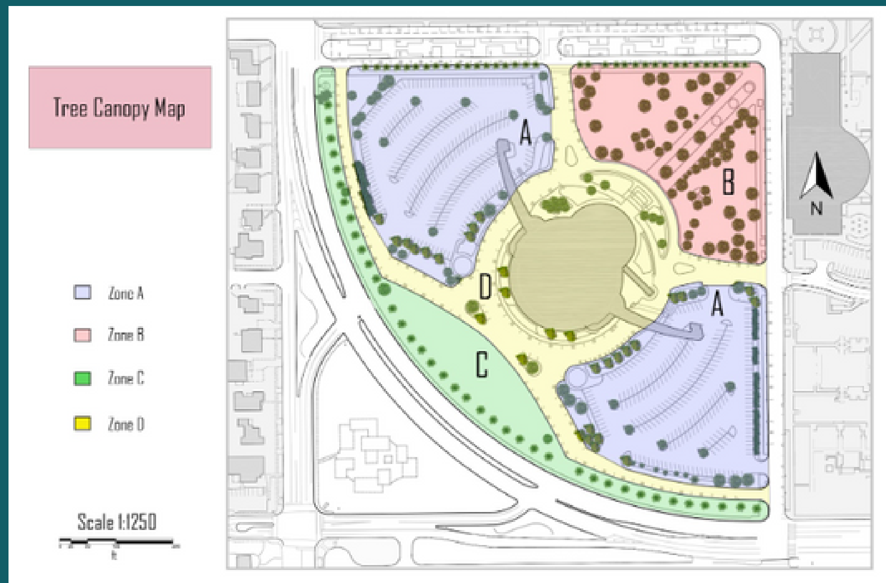
~98 degrees — lawn areas (shade)



Tree Canopy Map

~11%

total
tree canopy cover

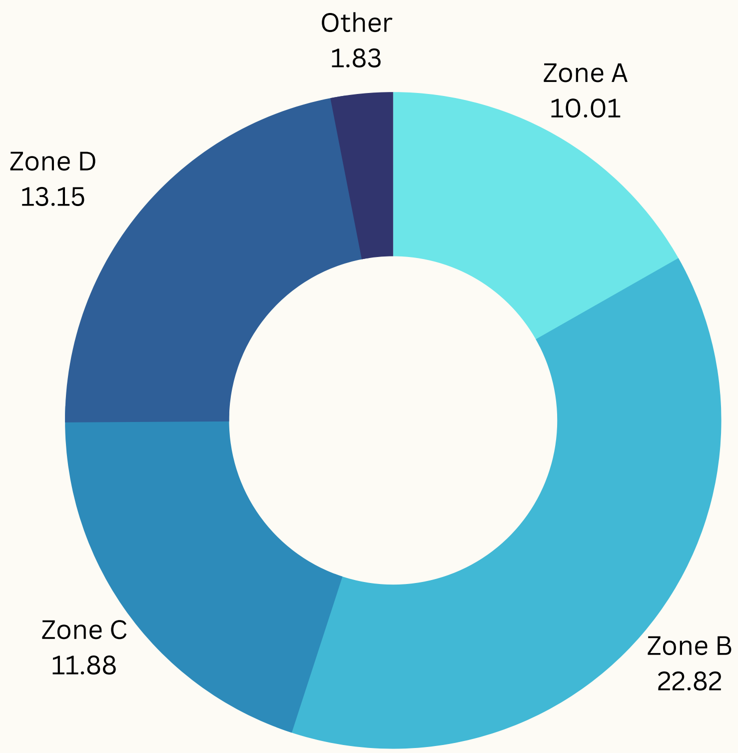


~2%

lowest
tree canopy cover

Zone D

Tree area square footage



Percent of total square footage

~23%

highest
tree canopy cover

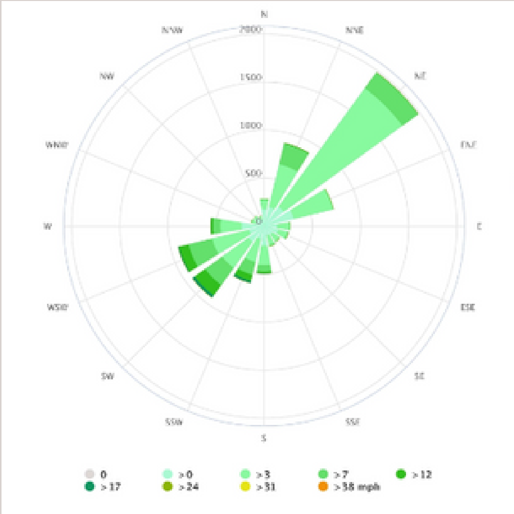
Zone B

Wind Analysis

The wind's direction varies both daily and monthly in this area, but on average, most winds blow from the northeast to the southwest and vice versa. The sun's direction in winter and summer is also displayed in the diagram on the left.

NE - SW

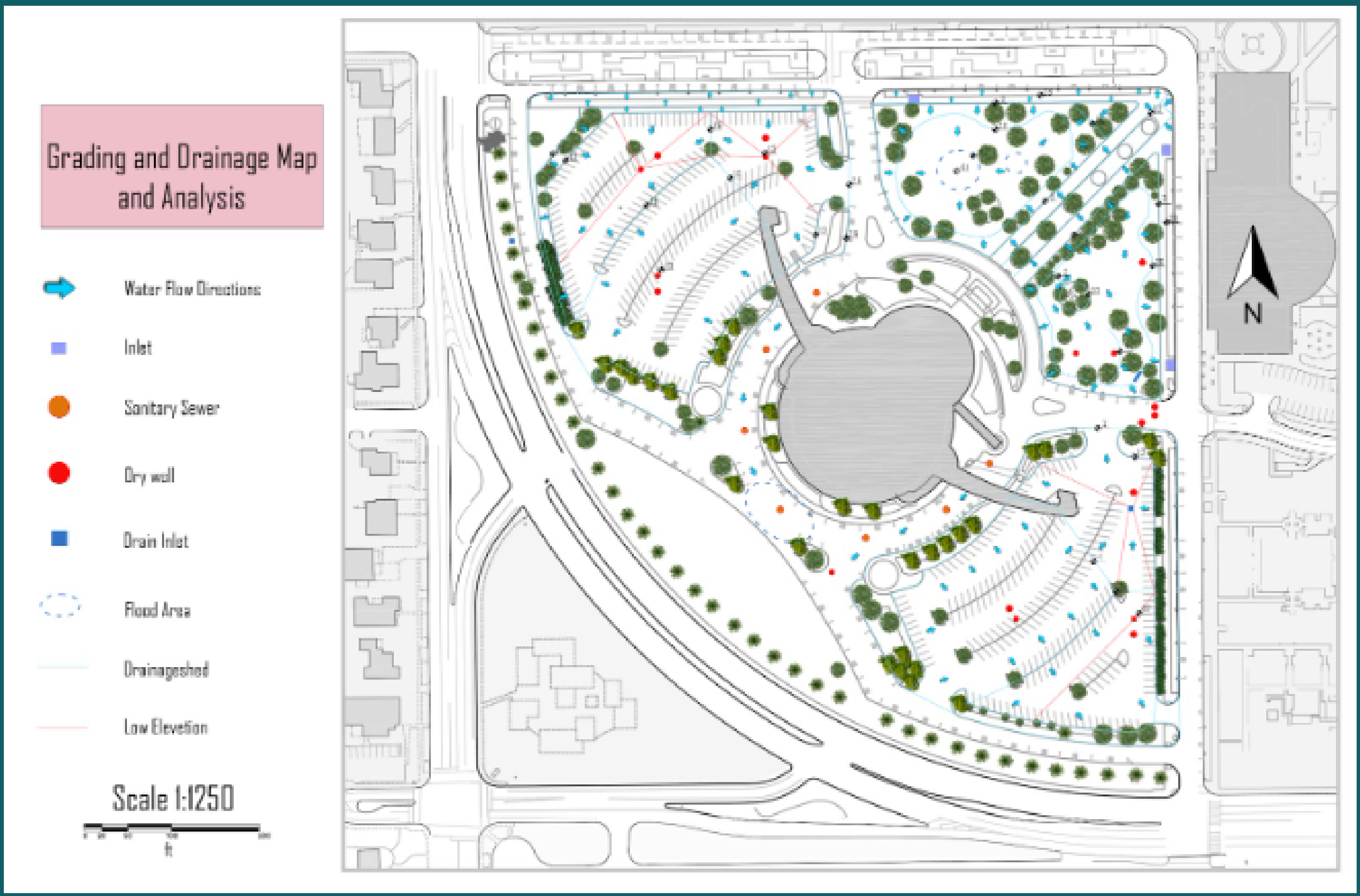
Wind direction



NE - SW

Sun direction

Grading and Drainage Analysis

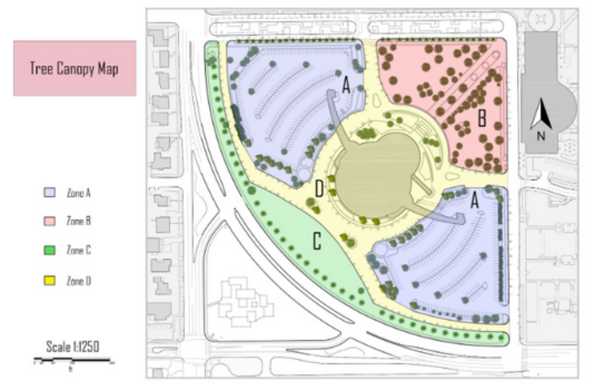


In construction, grading refers to shaping the landscape of the land area, and this is intended to guide the surface runoff away from the building structures on the site (InnoDez, 2021) Moreover, the surface runoff must be directed to a street, lane, or an approved drainage system.

We showed water flow directions, and found the inlets, sanitary sewer, dry well, and drain inlet locations. Finally, we also found the flood Areas and drainage Shed.

These maps ensure that the construction of a new structure is done in a manner that allows proper surface drainage. While preventing any negative impact on the neighboring landowners. Moreover, it provides the builder with specific details for managing or inspecting the grading contractor. As a result, this will help the builder reduce the chances of callbacks.

Carbon Sequestration



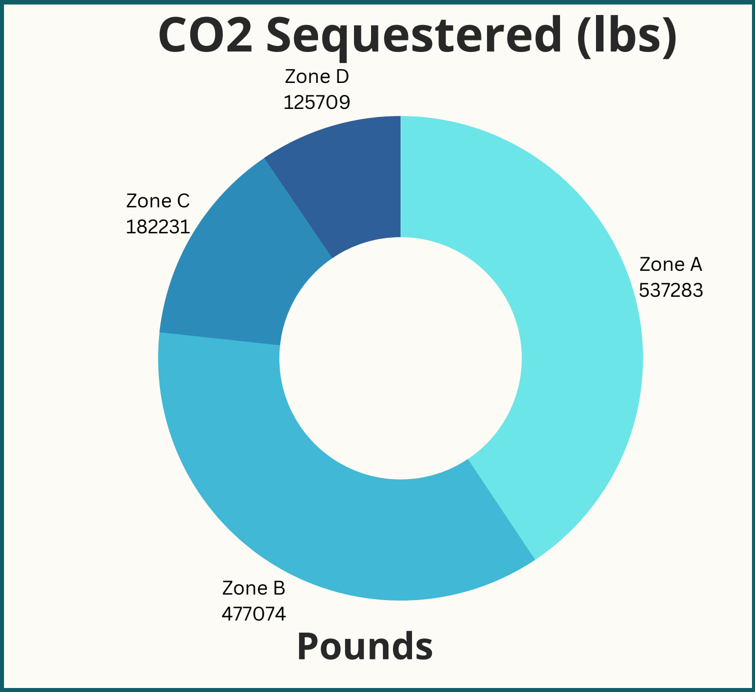
Zone A is higher in CO2 Sequestered and in CO2 Avoided. Although zone B has a higher amount of vegetation in the Gammage site, parking lots are higher in CO2 Sequestered than other zones, and Zone D is the lowest amount of vegetation that is why it is the lowest in CO2, Energy, and Eco analysis.

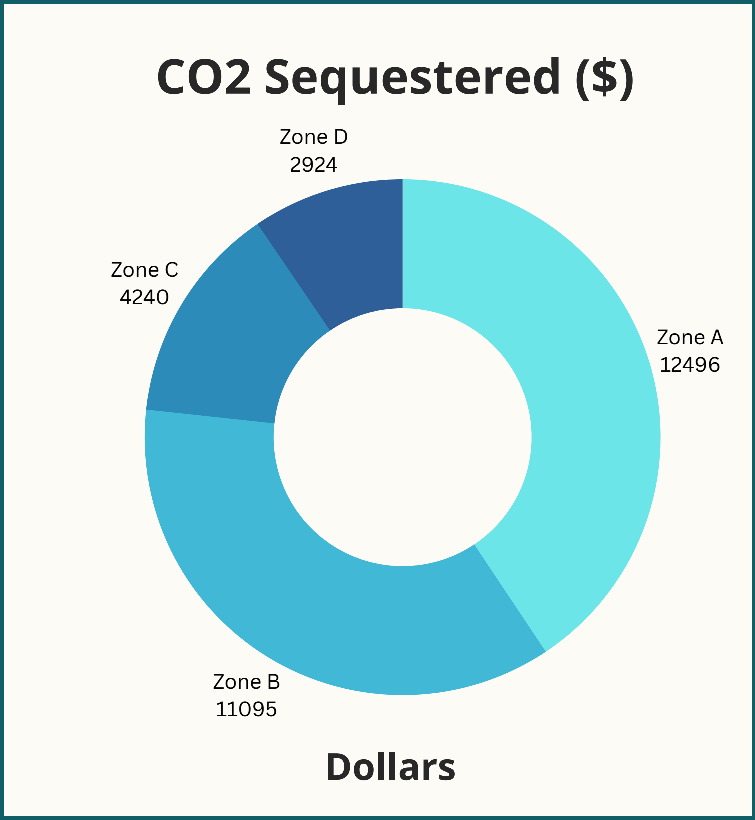
2,776,548
CO2 avoided
Zone A

$64,573
CO2 Avoided
Zone A

537,283 lbs
CO2 Sequestered
Zone A

$12,496
CO2 Sequestered
Zone A





Eco Analysis

Zone A is higher in all Eco parameters than other zones, and Zone D is the lowest.

1,380,992

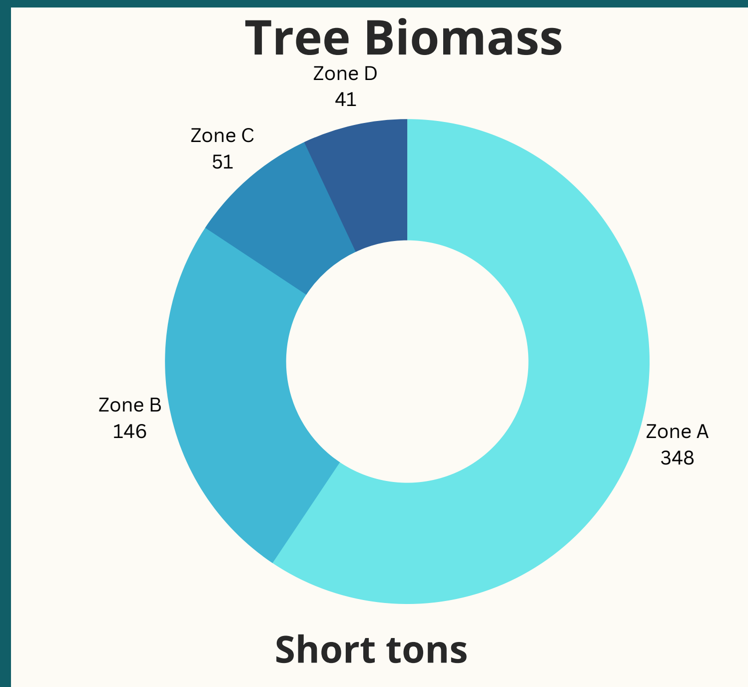
Avoided runoff (gallons)

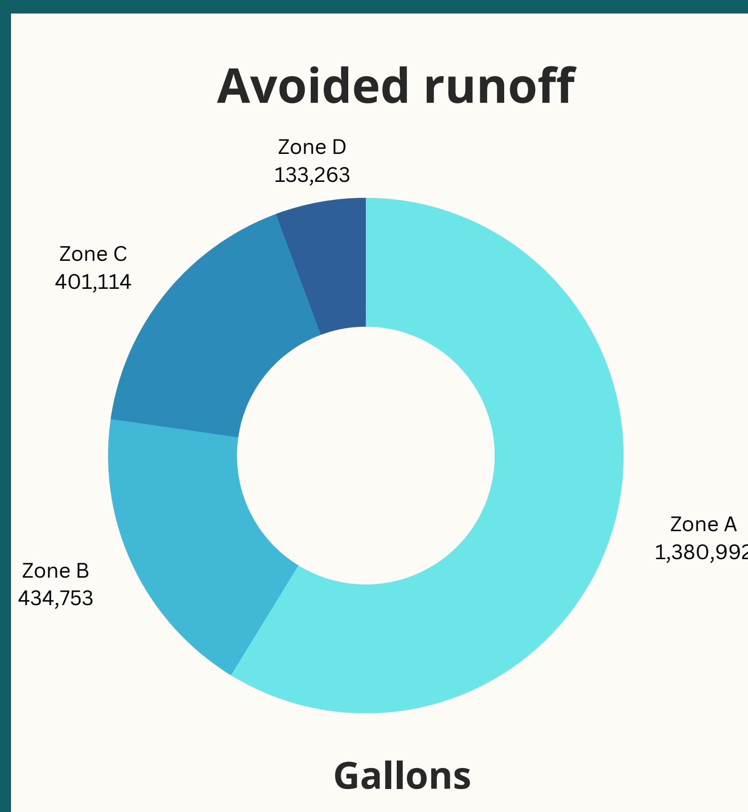
Zone A

$12,341

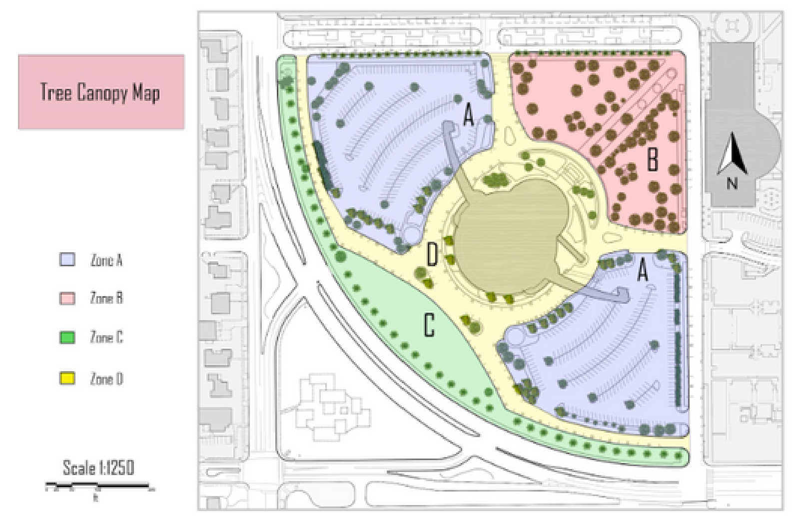
Avoided runoff (dollars)

Zone A





Air Pollution and Energy Analyses



Air Pollution: Data demonstrate that zone A is higher in O3, NO2, SO2, and PM2.5 Removed, NO2, SO2,VOC, and PM2.5 Avoided. Zone D is the lowest one.

Energy: data demonstrate that zone A (parking lots) has a higher amount in all Energy parameters. Electricity saved, and Zone D is Lowest in this section. In addition, it shows us Zone C has a lower amount of Fuel Saved.

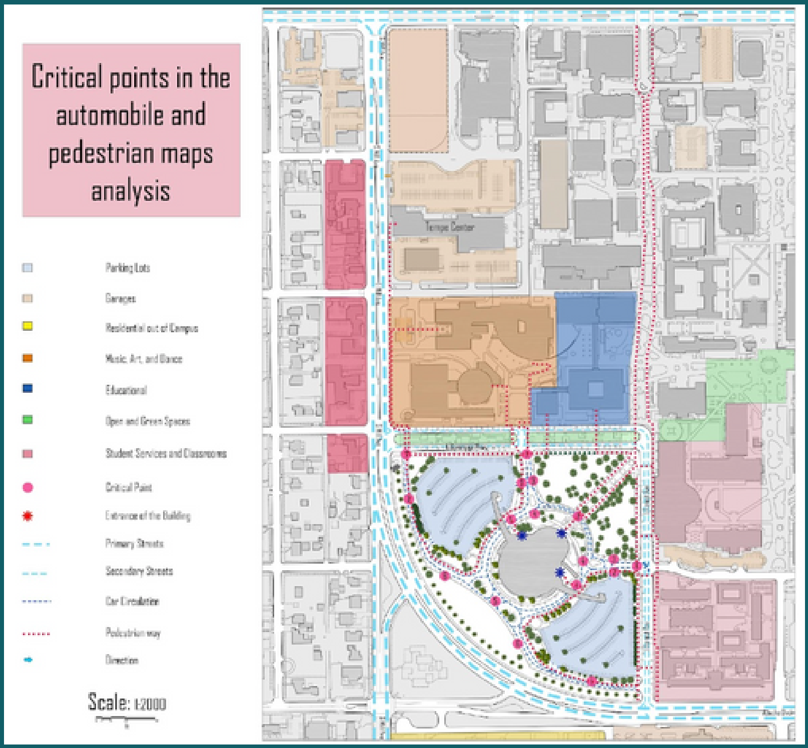
Air Pollution

Zones	O3 Removed (pounds)	NO2 Avoided (pounds)	NO2 Removed (pounds)	SO2 Avoided (pounds)	SO2 Removed (pounds)	VOC Avoided (pounds)	PM2.5 Avoided (pounds)	PM2.5 Removed (pounds)	Note
A	7946.8	608.5	2267.4	1664.3	233.9	36.6	165.3	184.8	High amount
B	2364.1	169.7	677.8	464.1	70.2	10.3	45.4	52	
C	1364.4	73.5	407.5	200.9	43.3	3.7	22.5	23.6	
D	765.2	60.4	218.6	165.4	22.5	3.7	16.4	17.2	Low amount
Total	12458.5	912.1	3571.3	2494.7	369.9	54.3	249.6	277.6	

Energy

Zones	Electricity Saved (kWh)	Electricity Saved ($)	Fuel Saved (MMBtu)	Fuel Saved ($)	Notes
A	**2388972**	305310.6	494.8	8092.22	High amount
B	653885.4	83566.53	220.3	3602.29	
C	327549.9	41860.87	-194.2	-3175.39	Low amount in Fuel Saved
D	237279.5	30324.33	48.4	794.26	Low amount in Electricity Saved
Total	3607686.5	461062.3	569.3	9313.38	

Critical Points in Pedestrian, Automobile, and Transit Maps



Pros

Understandable sidewalks around the site

Shade in main pedestrian entrance

Main pedestrian entrances related to entrances of building

Bus stops near main pedestrian entrance

Cons

Wired sidewalks in the site

Automobile circulation interferes with pedestrian paths.

Limited shade areas by sidewalks

Northern and Eastern entrances have just one-side pedestrian way

No appropriate pedestrian way around parking lots

A lot of asphalt. High temperature walkways surrounding the building

No pedestrian entrances for people using metro

State of the Selected Site

Biodiversity Assessment

The Sustainable Urban Ecology (SUE) project aims to investigate how ASU can model fully sustainable campus landscape design. At its core, sustainable landscape design must consider the three cornerstones of sustainability and promote social, economic and ecological benefit. This study component aims to **quantify the ecological implications** of current landscape design choices in our study area. In particular, we examine aspects of the Gammage landscape that are important for wildlife use and environmental provisioning and explore how these aspects compare to the wider Phoenix area.

A goal of SUE is to demonstrate and promote land use choices that benefit people and nature. Baseline ecological information can help us infer the current status of the site in relation to its benefit to nature (and maybe people).

To determine an ecological baseline for Gammage, we focused on **three organismal categories** to represent the broader ecological status of the site:

Plants

Birds

Pollinators

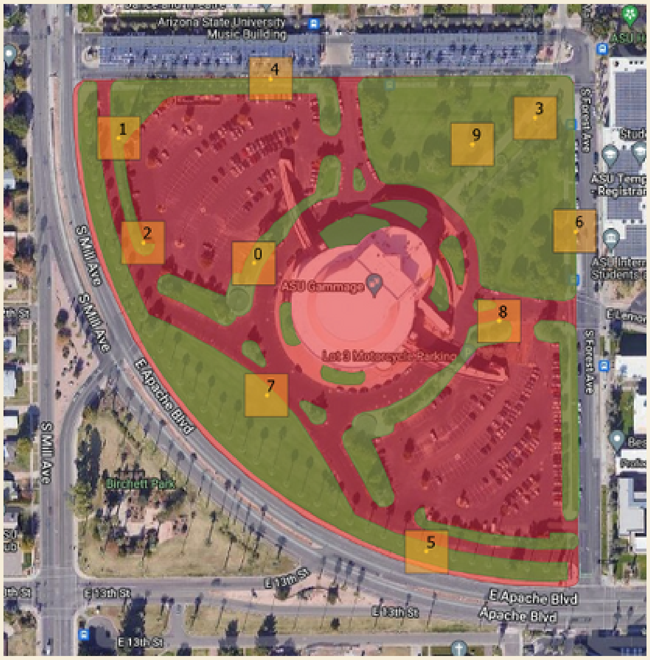
These organisms were ones that we were capable of obtaining meaningful samples of on the site, are **often used as surrogates for broader ecological community composition**, and had recent larger scale sampling efforts in the campus or phoenix region.

Find the full plants report here.

Find the full birds report here.

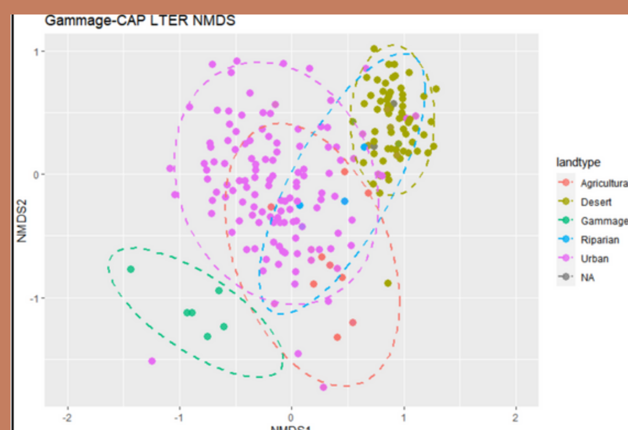
Find the full pollinator report here.

Plants



Map of the sites surveyed at Gammage. The red polygon delineates areas composed of durable surfaces. Green highlights areas of mostly continuous, permeable surfaces.

The orange boxes with numbered points show survey points; data on all plant species occurrences was collected at 1, 2, 3, 5, 6, and 7.



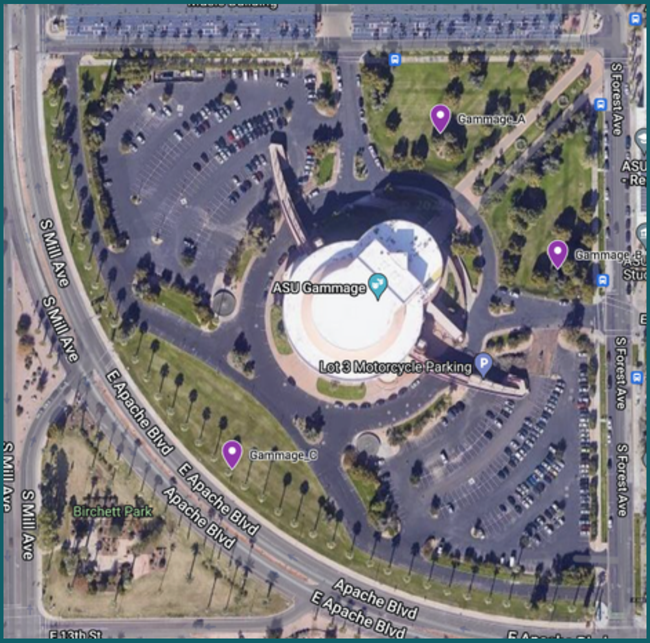
Stage 1: general inventory of all plant species on the property, resulting in a mostly-comprehensive checklist of all vascular plants at Gammage
Stage 2: we surveyed six 30 x 30-meter plots chosen randomly from the greenspace areas

Not including cultivars, **Gammage is home to 68 species of plants**, nearly all horticultural. This makes for a novel plant community with a structure that sets it apart from other land-use categories.

Gammage plant community composition differed from other sites sampled in the Phoenix area (green points). SUE campus plant choices could aim for a resulting community that was closer to the desert site community composition (brown points).

Birds

Map of the sites surveyed at Gammage.



We observed 12 avian species across our 3 sites, with a mean of 8.33 species per site.

Preliminary analysis show that summer avian communities exhibit less species richness in the Phoenix area than winter or spring communities. It also suggests that the site at Gammage exhibits a low species richness in comparison to the overall Phoenix ecology. However, it is not clear whether low species richness at Gammage is a result of an overall decline in species richness across the Phoenix area or a low species richness particular to the Gammage site.

	TOTALS
American Kestrel	2
Anna's Hummingbird	12
European Collared Dove	20
European Starling	30
Gila Woodpecker	12
Great-tailed Grackle	20
House Finch	16
Mourning Dove	180
Northern Mockingbird	2
Rosy-faced Lovebird	36
Rock Pigeon	174
White-winged Dove	4

Pollinators

Map of the sites surveyed.

Four locations containing flowers were observed for approximately 15 minutes each. The visiting pollinators were recorded using a smartphone camera, and the pictures were uploaded to iNaturalist for additional aid in identifying the species. Species that were not capable of being photographed due to distance or their speed were noted and compared to identified species already present within the ASU iNaturalist citizen science project.

	TOTALS
Western Honey Bee	~90 - 115
Fiery Skipper	10
Ceraunus Blue	1
California Digger Bee	1
Thread-Waisted Wasp	1
American Snout	1

Pollinator diversity was observed to be low around Gammage with the most frequently observed species being the non-native Western Honey Bee. Surveys across the Tempe and Polytechnic campus last September provided similar results. This suggests that Gammage plant choices are currently not providing beneficial habitat to the ~700 native bee species that inhabit the Sonoran region.

State of the Selected Site

Economic Analysis of Operational Costs

Operational costs of maintaning the current ecology surrounding Gammage were assessed in terms of **total annual man hours** and **total annual material costs.** Given ASU's commitments to sustainability, Arizona's water crisis, and the city of Phoenix's commitments to Zero Waste, **water use** and **waste disposal** are other important eco-economic indicators.

The following charts show the costs of the **turf care** program as well as the **total maintenance program** at Gammage.

Annual Maintenance Program at Gammage: TURF CARE

TURF CARE	ANNUAL MAN HOURS	ANNUAL MATERIAL
Mowing	832	$3,000
Fertilizer	36	$900
Pre-emergent	6	$600
Post-emergent	52	
Aeration	6	
Sod replacement		
Irrigation monitoring / wet checks	8	
Irrigation programming	12	
Irrigation repairs	226	
Overseed	24	$7,875
Scalping	36	

1,238
TOTAL ANNUAL MAN HOURS

$12,375
TOTAL ANNUAL MATERIAL COST

Annual Maintenance Program at Gammage: TOTAL

	ANNUAL MAN HOURS	ANNUAL MATERIAL COSTS
TURF CARE	1,238	$12,375
IN-HOUSE TREE TRIMMIMG	6	
CONTRACTED TREE TRIMMING		$3,360
BED MAINTENANCE	52	$2,160
FLOWER MAINTENANCE	16	
ROSE CARE	104	
SIDEWALK CARE	52	
WASTE DISPOSAL		$7,500
WATER BUDGET		$40,800
MANAGEMENT	52	
TOTAL ANNUAL LABOR & MATERIAL COSTS	**$151,057**	

10 MILLION GALLONS OF WATER PER YEAR

1,992 TOTAL ANNUAL MAN HOURS

$82,987 ASU LABOR INVESTMENT

$68,070 TOTAL ANNUAL MATERIAL COSTS

State of the Selected Site

Social Analysis

Urban Ecology and Landscape Performance research are critical in providing support for evidence-based design and sustainability practices on ASU campus. This project will collect social and ecological data, engage with stakeholders to co-design alternative landscapes for Gammage site and determine the outcomes and benefits of sustainable campus landscape design through long-term monitoring and research efforts. A questionnaire survey will be conducted online and in-person stakeholders workshops will be conducted to understand users' and ASU community's perspectives on sustainable landscapes and preferences for Gammage redesign.

Interviews

Key stakeholders at ASU and outside ASU who have strong interest in Gammage site were invited to be interviewed. Interviews have been conducted with 10 participants. Our team is analyzing these interviews for themes to carry forward into design charettes this fall. Interviewees will also be invited to participate in the workshops.

SUE Interview Questions

1. Can you tell me any stories about the Gammage Auditorium that you find to be memorable during your time(s) there?
2. What is your current impression of Gammage Auditorium?
   1 → 10
   Not good Neutral Very good
3. How often during a calendar year do you attend functions or events at Gammage?
   0-1 2-4 5 +
4. How often do you visit the Gammage Auditorium site other than an event?
   Never Daily Weekly Monthly Yearly
5. How do you usually approach/get to Gammage Auditorium?
   Walk Drive Rideshare Bike Streetcar Light rail Other
6. How do you feel about getting to the Gammage Auditorium site?
7. What do you like about the landscaped and paved areas immediately surrounding Gammage Auditorium?
8. What are the important features of the Gammage Auditorium site that stand out to you the most?
9. If anything, what would you like to see changed to the Gammage Auditorium site as a whole?
10. In regard to climate change and sustainability, how do you feel about the Gammage site?
11. What is your current status with the University?
   Student Faculty Staff Alumni Patron Donor N/A
12. In regard to gender, how do you identify?
   Female Male Non-binary Prefer not to say
13. What is your ethnicity?
   Asian Black White International Hispanic Indigenous Hawaiian-Pac-Islander
14. What is your age?
   18 - 29 30 - 49 50 - 69 70+ years old

Before concluding our interview today, is there anything else you would like to add or share about the Gammage Auditorium site?

Thank you for your time and have a great day.

Surveys

Survey methods will include ASU communities of students, faculty, and staff on Tempe campus. Surveys may be distributed to 500 or more people, and the participation rate may be at 1% to 2%, 50 to 100 participants. The surveys and methods have been approved by IRB and will be distributed in October. These results will also inform design charettes this fall.

SUE Survey Questions

What are the key historical characteristics of the site to you? Please lists

1. How often during a calendar year do you attend functions or events at Gammage?

   0-1 2-4 5 +

2. How often do you visit the Gammage Auditorium site other than an event?

   Never Daily Weekly Monthly

3. What features of the Gammage site reflect the sustainability goals of ASU? Please lists

4. When you go to the site, what is the typical time you visit the site?

   morning midday afternoon evening

5. How long are you on the site?

   0-15 mins 15 -30 mins 30-45 mins 60 mins or longer

6. How do you find the existing site in terms of aesthetics?

   Unattractive mildly unattractive attractive very attractive

7. As it related to the gammage site area, please rank the following items in order of importance to you (Showing in order of preference with 1 being MOST interested in)

   - Parking and vehicular circulation
   - Pedestrian access to and from the building
   - Views to and from the building
   - Personal safety to and from the building
   - Human comfort

8. When you visit the site, what are your favorite places?

   Building ticket office parking rose walk lawn areas fountains fenced outdoor patio outdoor foyer areas curved elevated walkways other (please list)

9. On average, how long does it take you to walk to Gammage?

   0-10 mins 10-20 mins 20-30 mins 30 mins or longer

10. When you go, how do you typically get to the site?

    Walk Drive Rideshare Bike Streetcar Light rail

Background

1. What is your current status or affiliation with the University?

   Student Faculty Staff Alumni Patron Donor N/A

2. If you are associated with ASU, which unit/department/program you are in?

   ____

3. How do you identify your gender?

   Female Male Non-binary Prefer not to say

4. Which ethnicity are you mostly identified with?

   Asian Black White International Hispanic Indigenous Hawaiian-Pac-Islander

5. What is your age?

   18 - 29 30 - 49 50 - 69 70+ years old

Workshops: Design Charettes

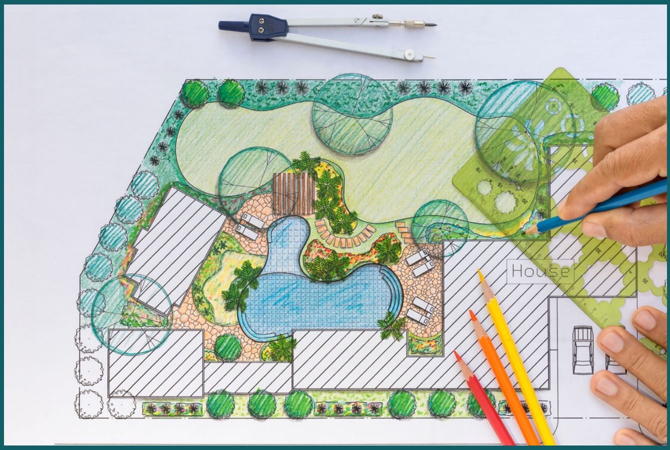
Workshops will include 4 landscape architecture design firms who, along with 15-20 other internal and external stakeholders, participate in a 2-day design charette. The aim is not to produce *THE* final design for Gammage but rather to create a data-driven, community-oriented process and conceptual design for a Sustainable Urban Ecology prototype that could be implemented and piloted at ASU and extended to the broader Phoenix metro area.

Following the workshops, we will create a report / document that outlines process, what we discovered, basis of design, results of workshop, and how we're moving forward.

DAY ONE	*Presentation of project outline, background data, further identification of site issues*			
	WHAT	Introduction	Alicia	Overview
	WHY	What is the WHY??		Objectives
		SUE goals		
		Workshop Goals	Moderators	Sustainability
				Futureproofing the site/campus
				Sense of Place
				Historic Presence
		Workshop Format		Overview
	HOW	Site Review	All	Walk
		Site Analysis Review	Chingwen and Mojtaba	Compiled information
		Bio Diversity Assessment	Gwen?	
		Historical Significance	SHPO or Byron?	Character defining elements
		Survey Responses	Byron and Chingwen	HIDA students and staff
		Interview Responses		Stakeholders
		Gammage Operation Review	Teri?	Pedestrian circulation
				Vehicular circulation
				Parking
				Event loading/unloading
				School tours
				Special outdoor events
				Gammage Season
			PD?	Event Traffic Control, Security
		State Water Reductions	Alex Davis	Implications/ASU water use objectives
		FM Grounds	Eric Houston	Operation overview, Issues
		Landscape Character	Norman	Context, future direction
		Workshop Topic Identification	Topic Stations	Human Comfort
				Landscape Character
				Parking and Vehicular Circulation
				Pedestrian circulation
				Gammage Shows & Events
				Historic Preservation
		Day One Summary	All	What did we learn? What to expect on Day Two
		Resources	OUA	Projector/Screen or Lg Monitor
				Whiteboards
				Inventory/Analysis Exhibits
				Aerial and/or Maps
				Markers, Pens, Post-It Notes, Tape
			Grounds/Zero Waste	Snacks, Drinks, Lunch

DAY TWO	*Development of conceptual ideas, plans, scenarios*			
	WHAT	Concept Development		
	HOW	Day One Review	Moderators	Overview or topics
		Design Charette	Design teams	Rapid concepting
		Preliminary Review	In-house presentations	2 plan options for review
		Concept Distillation	Boiling it down	What is elemental to meeting the goals
		Concensus	How did we meet the goals	Final concept version
		Presentation	Review with Senior Leadership and key stakeholders	

POST WORKSHOP				
	WHAT	Finalize plan based on review comments	Student Team, Moderators	Rendered plan/perspective images
		Design Incubation	Consultant input	Via E-mail, Zoom
		Workshop Summary	Moderators	Written report



Communication Plan

Stakeholder	Goal	Content	Method
ASU President's office / CFO Morgan Olsen	Directly state the value-add in terms of aesthetics and the bottom line, climate resilience, innovation metrics, sustainability rankings, biodiversity, enrollment, mental health resilience, and educational engagement	• SUE's connection to ASU's charter • Site analysis: ecological, economic and social interactions and impacts • SITE and LEEDS certification details for sustainable urban ecology • Case studies • Sustainable campus indicators • Community engagement plan • Conceptual design recommendations	interviews, Gammage final report - slide deck / presentation with quantifiable measures
ASU Faculty, Staff, Students	Convey and enact a broader vision of sustainability innovation and leadership. Communicate the value-add in terms of ecological, psychological and social health and educational usefulness.	• Biodiversity plan • Mental health metrics • Educational opportunities • SUE's connection to ASU's charter	interviews, surveys, website, marketing materials
Gammage	Offer analysis of cultural value of site, programmatic difficulties that could be resolved, and metrics of ecological and economic resilience	• Site analysis: ecological, economic and social interactions and impacts • Frank Lloyd Wright literature review • Case studies • Conceptual design recommendations	interviews, surveys, workshops, final report
State Historical Preservation Office	Identify historical features to be prioritized and maintained	• Frank Lloyd Wright literature review, case studies	interview, tour of site, workshops
City of Tempe	Identify retro-fit priorities of the city	• Frank Lloyd Wright literature review • Case studies • Site analysis: ecological, economic and social interactions and impacts	interview

Communication Plan

ASU Landscape Management

ASU's four Metro Phoenix campuses consist of 28.5 million gross square feet of building space on 1,989 acres of land. This encompasses 1,174 facilities, including 410 buildings and 14 parking structures. Full campus data can be accessed at https://fdm-apps.asu.edu/UFRM/CDS/. Management and allocation of space is dynamic and is managed through the CFO's office: design is managed by the Office of the University Architect (OUA), maintenance and operations is managed by Facilities Development and Management (FDM), and allocation is managed through the Office of Enterprise Planning (OEP).

Responsibility for outdoor space development is jointly managed by the Grounds Department within FDM and the Landscape Architecture program within OUA.

Informed design. ASU uses several avenues to codify design and drive project management. All new construction and renovations follow these documents. Although some of the guidelines tangentially address SUE, there exists ample opportunity to improve.

- Site improvement design guidelines
- Sustainable Design Guidelines
- Project Guidelines
- Plant master list

Space maintenance parameters. The following controls must be taken into account when implementing SUE at ASU.

- Safety - the safety of campus users is paramount. Safety is managed in partnership by Facilities Development and Management, Risk Management, ASU Police and Environmental Health and Safety.
- Labor - to ensure safety, aesthetics and health of the landscaping materials, regular maintenance is required. Limited resources are available for labor and equipment.
- Lifespan of the space - spaces are continually developed at ASU for higher use (i.e. classroom, living lab/research, or community gathering).
- Integrated Pest Management (IPM) - ASU practices IPM in the pursuit of pest control. Grounds is responsible for pest management.
- Usage - how and when spaces are used.
- Building/outdoor interactions (microclimates)

Next Steps

Conceptual Design and roadmapping techniques. Immediate next steps include deploying surveys and hosting design workshops to redesign a conceptual model for the selected site. We will then follow our communication plan to engage top-tier decision makers at ASU and roadmap techniques for moving toward SUE.

Partnering with municipalities and historically redlined communities. A second phase of the research will include partners from local municipalities, like the City of Phoenix, as well as private corporations to continue validating the research. In Phoenix and other desert cities, lack of biodiversity and of ecological infrastructure also coincide with deadly health consequences, disproportionately impacting minority and economically disadvantaged communities in historically redlined areas. With fewer green spaces and fewer resources overall, ecologically-impaired redlined areas are hotter than others, rendering residents more vulnerable to heat-related impacts. Without sustainable ecological interventions, heat-related emergency medical visits, now at $2 million a year, are projected to escalate by $700,000 in 2030 and $1.2 million in 2050; and hospitalizations, now $5.3 million, are projected to rise by $2.6 million in 2030 and $4.7 million in 2050. The cost of additional lost lives alone could reach $1.5 billion on average by 2050, on top of an average figure of $1.3 billion from recent years (Economic Assessment of Heat in Phoenix Area The Nature Conservancy).

Importantly, increasing green spaces and introducing biophilic interventions that connect people to natural ecologies in their everyday lives are documented ways to cool air temperature, combat Urban Heat Island Effect, and help alleviate symptoms of stress and burnout, to great personal, professional, institutional, and economic advantage (Nature Sacred, "Take Burnout From Red to Green"). For example, increasing Phoenix's tree canopy coverage from about 13% now to 25% within a decade would save more than $15 billion over a 40-year period in costs from deaths, hospital visits, road and other repairs and lost labor productivity (Economic Assessment of Heat in Phoenix Area The Nature Conservancy). Coupled with other actions to address systemic issues, Sustainable Urban Ecology (SUE) that supports increased biodiversity and ecological health while also providing biophilic interventions holds great promise for addressing and remediating some of the most harmful and dangerous impacts of ecological degradation.

Developing a decision support tool. The long-term, future goal of this research is to develop a decision support tool that will enable stakeholders to make decisions on where to rewild in a region, understand the impacts rewilding has on a community related to climate and health, biodiversity, and comprehend the financial investments, including return on investment.

Appendix: Reports

Find the full literature review, indicator assessment, and environmental analysis of the site here.

Find the full plants report here.

Find the full birds report here.

Find the full pollinator report here.