

Living Wall Urban Infrastructure: Ecological Care & Post-Occupancy Performance

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Abstract: - This paper revisits the University of Texas at Austin School of Architecture Living Wall (UTLW) pilot project as an operating ecological installation whose significance now lies less in its original Building Information Model (BIM) workflow than in its subsequent intersection of living infrastructure, ecological maintenance, and new environmental sensing. This paper treats earlier developments as project history and examines later changes and data gathered, including a maintenance review, replacement of planting-cell material, soil testing, revised plant recommendations, and thermal observations. Accordingly, the paper interprets maintenance as a form of ecological care and shared architectural stewardship.

Key-Words: - Living Wall, Post-Occupancy Evaluation, Ecological Maintenance, Building Information Modeling

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1 Introduction

How can an existing academic living-wall pilot installation support architectural intelligence through ongoing observation and maintenance? This paper offers a post-occupancy interpretation of the UTSA Living Wall Lab (UTLW), emphasizing adaptation and care as a new form of design practice in architecture, building upon the original BIM workflow and sensor systems. It considers the technical history alongside later plant and material changes, while making explicit the limits of the available performance evidence.

Urban living walls are often evaluated as environmental technologies, but they also depend on repeated acts of observation, repair, and care. In Austin's hot-summer climate and increasingly variable winter conditionsⁱ, a planted façade is not a fixed object: its ecological function depends on species suitability, soil volume, irrigation, exposure, and continued maintenance. The UTLW (10' × 20' × 18" or 304.8cm × 609.6cm × 45.72cm) is considered here a small urban habitat and a site where students, facilities staff, and collaborators can see those dependencies. The project's broader context includes research on urban landscapes that can support biodiversity and human life, including the potential for cities to provide refuge and connectivity for insect pollinators [6]. This research also describes a novel shift in architectural design practice in which the client or user moves beyond human engagement with space and form.

Earlier project stages explored how Building Information Modeling (BIM) could document and analyze plant patterns, organize plant information to track plant survival within an architectural living-wall system, and use low-cost sensors to make selected environmental conditions legible. The BIM also assisted in initial conversations with UT Maintenance and Landscape teams.[5] This workflow established a strong relationship with maintenance priorities and post-construction/planting research. The present analysis

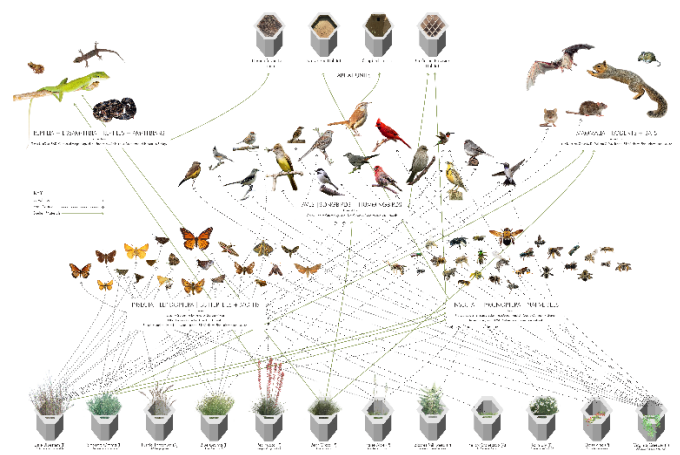


Fig. 1 Living Wall Habitat Web (Credit: Michelle Bright, Lady Bird Johnson Wildflower Center)

asks what we can responsibly learn from the wall's subsequent operations, and what evidence is still needed to evaluate its environmental performance.

This approach treats architectural intelligence as a capacity distributed across a designed system, living organisms, environmental conditions, and the people who maintain and interpret it. Since 2015, the wall's development has raised practical questions about plant viability, material durability, sensor use, and the limits of digital models when confronted with living systems. The research has also introduced a new form of architectural design practice. These questions frame the paper's post-occupancy focus.

2 Background

The installation is located on the west façade of the Goldsmith Hall on the University of Texas at Austin campus in Austin, Texas. The site experiences hot summers, variable (and sometimes extreme) rainfall, and occasional abrupt winter freezes. Although summer heat was the initial primary design concern, the project history described here indicates that cold events have also affected plant viability. These challenging conditions help explain why the wall requires ongoing species selection, irrigation review, and maintenance on several levels; they do not, by themselves, demonstrate a measurable cooling or energy-saving effect.

This work is not unprecedented. Several peer institutions have also engaged in outdoor living wall experiments, providing valuable comparisons. [1][2][3] The growing academic emphasis on sustainability and embedded sensor systems adds value to current workflows; however, few match the UTLW's climatological challenges, habitat inclusion, or long-term pursuit alignment.

Exterior living walls in hot climates must contend with high air and soil temperatures, uneven rainfall, and evapotranspiration. Phase one of the original design installation (2015) identified four considerations for the individual and collective planting cells:

1. Adequate soil volume to ensure plant root health and to reduce desiccation
2. Reduced air volume between vegetation cells to decrease the heat profile
3. Proper soil media that has a low heat capacity
4. Appropriate vegetation that is adapted to local conditions

The post-occupancy research identifies three new priorities:

1. Adequate soil nutrients for plants to establish new roots and to effectively hydrate in extreme weather conditions.
2. Stabilize irrigation systems in the pilot wall and in relation to the university smart system.
3. Continue to pursue information in real time from low-cost sensors.

2.1.1 Initial Data Capture

A variety of initial temperature, humidity and tracking sensors revealed microclimatic variation across the façade, enabling species substitutions and refinements to the irrigation schedule. These sensors were originally simple Arduino pieces (photo transistor, temperature-humidity sensor, sound detector, IR distance sensor (for tracking fauna usage), Arduino Uno R3, and a breadboard). (Fig2) Thermal data showed that the wall not only faced intense solar loading during Austin's extended dry summers but also experienced sharp heat losses during winter cold fronts—conditions increasingly prevalent due to regional climate volatility. The subtle microclimatic readings enabled the substitution of cold-sensitive species in the most exposed areas and informed irrigation strategies that minimized watering during low-uptake winter periods. This way, the wall adapts to the city's broader climatic shifts, serving as a buffer that accommodates extremes rather than averages. Other sensor readings such as proximity of species and hopeful activity near habitat cells were only proven successful through analog monitoring that occurred every three months. Blue Jay feathers were found near the bird habitat and some human encounters were recorded. These were random at best.

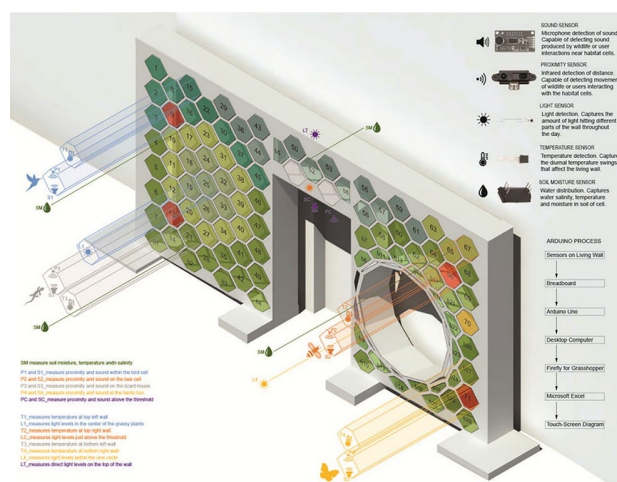


Fig 2. Original sensorial scheme

3 Eco-Maintenance

Changing climate conditions, COVID-related neglect, and irrigation constraints have necessitated full system updates. From 2020 to 2023, the UTLW experienced extreme drought, heat, and winter storm events. The Texas drought during this period is infamous as a severe, multi-year dry spell primarily triggered by a persistent fluctuation in climate pattern that began in late 2021. Often characterized as a "flash drought" due to its periods of rapid intensification [6].ⁱⁱ These events, coupled with limited pandemic access to campus and persistent rodent damage to irrigation, stressed the living wall system and ultimately caused plant failure. The survival rate was assessed again in March 2023 at 26%, excluding the *Opuntia ellisiana* that was added after the initial installation

3.1. Irrigation Updates

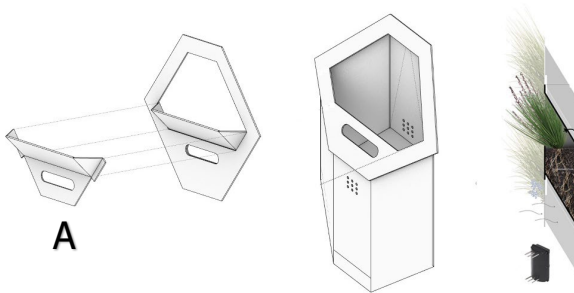


Fig 3. Plant cell updates and performance logic.

We amended the irrigation components and added rainwater collection from fall 2022 to spring 2023. The original dedicated irrigation zone consisted of a flexible swing pipe with microtubing, and drip emitters run to each cell. Because the material is pliable, squirrels and rabbits targeted it as a water source during droughts. The extreme winter weather events of 2021 and 2023 also damaged the water lines as undrained pipes expanded under freezing temperatures. Rainwater contains fewer harsh components of groundwater, such as iron, chlorine, and/or calcium, and was advised by Variance Design, a specialized living wall design studio in Johnson City, TX, as the most critical aspect to revitalize the UTLW. A manageable rainwater collection idea included

adding ABS “petals” to each plant cell to catch individualized rainfall.

The additional ABS “petals” (Fig. 3A identification) were added to every plant cell, be

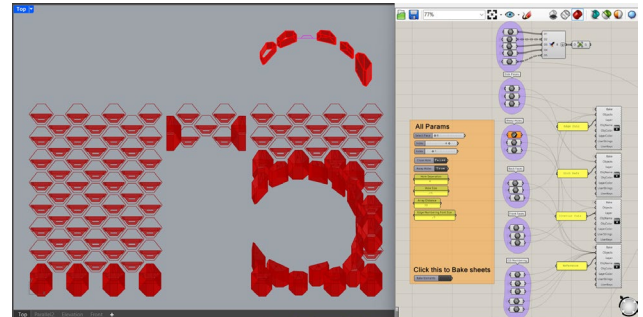


Fig 4. Plant cell updates and performance logic.

it uniform or unique. A Rhino/Grasshopper plug-in script was established as a running fabrication file for future development. The geometry was tested through this parametric programming to improve stormwater capture. These inserts allowed a perpendicular cell to extend beyond the wall. The capture negative volume of XXX would potentially receive X amount of additional rainwater. Potential for façade performance [10].

In addition to the added “petal” drop-ins, the *Kunin Eco-fi® Classicfelt™* atypical cells were replaced with the Acrylonitrile butadiene styrene (ABS) medium. The petal supplement was the only item afforded by the current grant cycle, but the downspout proposal is considered for a phase in 2026-27. Another major consideration is a rainwater harvesting tank connected to a nearby downspout. The downspout located to the left of the living wall is estimated to have a peak runoff of 1,397 gallons during a rain event. With approximate irrigation use of 43.65 gallons of groundwater per week, one 1-inch rain event could supply more than half of the wall's annual volume needs with installed rainwater harvesting. Better drainage holes in these new component cells also improved drainage.

Although the wall provides provisional habitat for pollinators, other insects, and lizards, it was neglected during the pandemic due to proximity constraints. Rodents caused the most damage to the irrigation system. Additional rodent-deterrent measures included adding fencing to the back and base of each wall and

replacing the risers with 18-inch and 24-inch pieces. Additional insulation was added to the microtubing, and Schedule 40 pipe was extended with the same riser-manifold connection, two or more feet above the ground, to service the cells higher on the wall and minimize vulnerable microtubing. This change reduced labor and waste from repeatedly removing and replacing damaged tubing and provided a greater guarantee of irrigation to each cell.

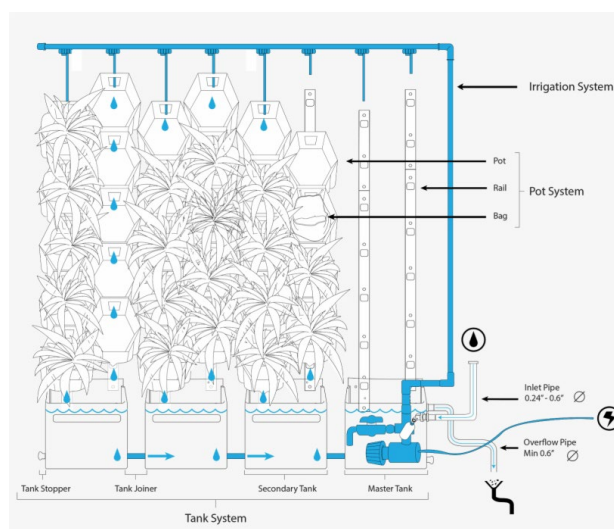


Fig.5 Irrigation System Update

3.2 Plant Selection and Mortality

The project documented plant survival between July 26, 2016, and November 15, 2025, providing an initial record of species performance within the living-wall system. Of the 92 plants with initial and final counts recorded, 70 survived, for an overall survival rate of about 76%. Survival varied substantially by species. Crossvine, Red Yucca, and Virginia Creeper had 100% survival, while *Sideoats Grama* and *Nolina* also demonstrated relatively high survival rates of 93% and 91%, respectively. In contrast, False Aloe and American Five-minute Grass had no surviving plants at the end of the observation period. We excluded Purple Three-awn from the survival calculation because heavy spring rainfall events caused it to rot in the living-wall cells before installation.

The project also demonstrated an important methodological limitation of using BIM to study living systems. Although the Revit model documented the living wall's geometry, planting arrangement, and irrigation infrastructure, the modeled components did not establish the actual

environmental conditions individual plants experienced. A modeled irrigation line did not show that water reached a particular plant; a solar study did not necessarily establish how much light an individual plant received; and the presence of a modeled plant did not establish that it was alive. Similarly, the observation that a plant had died did not, by itself, establish the cause of mortality. Consequently, the BIM model needed to be linked to measured or otherwise validated observations. Under the Plant and Material Take-Off Schedule, the plant-level survival records could be combined with a smaller network of environmental sensors distributed across representative wall zones to document variables such as moisture, temperature, and light. Careful sampling would be necessary to determine

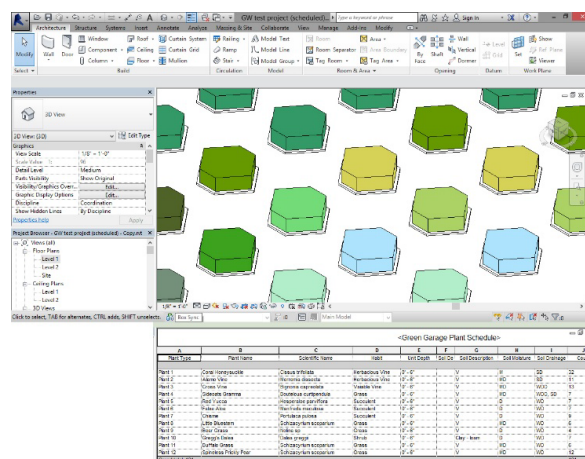


Fig.6 BIM Schedule Updates 2021-23

whether these measurements meaningfully relate to differences in plant survival.

Most of the initial plantings had exceeded their perennial lifespan by the second plant assessment. Therefore, in the 2023 planting, we shifted the focus to managing plant mortality on the wall. The individual cells leave little room for suckers or adventitious roots, and natural germination is difficult because each cell opens only slightly. Collaborator Dr Shalene Jha, Director of Research at the Lady Bird John Wildflower Center, recommended plants that would thrive under these conditions. Overall, we selected plants based on their hardiness in a shallow soil profile, tolerance to extreme heat and drought, and/or ability to self-seed. Several of the selections presented had already been tested in our original 2015 planting scheme. However, we considered the emphasis

on a greater range of *Opuntia* plants (*O. ellisiana*, *O. macrorhiza*, or *O. humifusa*) for application across the wall.

3.3 Soil Health

The existing soil texture was a sandy loam with decomposed crushed granite to allow for water to drain through the soil. The composition was based on the SkySystem™ substrate developed by The Wildflower Center and used in green roof structures around Austin.

However, after years of use and stress, we took a soil sample to assess the original substrate's current health and identify recommended amendments for upcoming plantings. This initial soil sample was taken in February 2023 and sent to the Texas A&M AgriLife Extension Service Soil, Water and Forage Testing Laboratory for macronutrient and organic matter percentage analysis. The test identified “salinity levels are becoming elevated” and “phosphorous is highly elevated”. The organic matter percentage of 17.52% is also higher than expected. No additional nutrient (excluding nitrate-N, sodium, and conductivity) were recommended. It is speculated that the high phosphorus content comes from decomposed

Analysis	unit	2023	2024	2025
pH	none	7	6	6
Conductivity	um/ho/cm	1960	1632	1701
Nitrate-N	ppm	192	190	176
Phosphorus	ppm	339	301	225
Potassium	ppm	584	400	412
Calicium	ppm	9,335	7,256	6570
Magnesium	ppm	877	701	725
Sulfur	ppm	387	340	332
Sodium	ppm	382	400	360
Organic Matter	%	17.52	19.1	23.71

Table 3. Texas A&M AgriLife Extension Soil Analysis Reports Comparison

crushed granite or crushed brick, and the high salinity may result from irrigation use or poor soil drainage. To improve drainage and promote organic matter cycling, the existing soil was amended with one part compost and one part potting soil and drenched with MicroLife Super Seaweed® at planting, according to the manufacturer's application rates, to stimulate

root growth. The project applied compost tea, brewed on-site, in the spring and fall to maintain soil health. The project also followed the recommendation to repeat the same soil test by March 2024.

Lowered salinity (registered by high conductivity) has improved root strength and hydration. Organic matter from *Opuntia* leaves in the cell has increased soil viability. Critical sodium levels have remained relatively the same.

4 Performance Measures_V2

BIM representations cannot simulate measured heat absorption, water-use efficiency, air-quality improvement, or acoustic dampening. These are then potential analytical extensions based on photo documentation from the years 2021-2025 not shown here..

4.1 Sensor Updates



Fig 7. Thermal sensor 'C' in context

In 2023, we hung eight low-cost sensors in different cells across the wall: one (sensor E) in an open cell with no planting, and the others within the plant and its foliage. These were intended to report real-time environmental data on moisture and daily temperatures to continue documenting microclimatic variation across the façade. Except for the one exposed baseline sensor (E), the plants shade the temperature sensors very well. The temperatures documented in the wall are significantly lower than those on the exposed sensor. Across multiple days in one-month (December 2023)

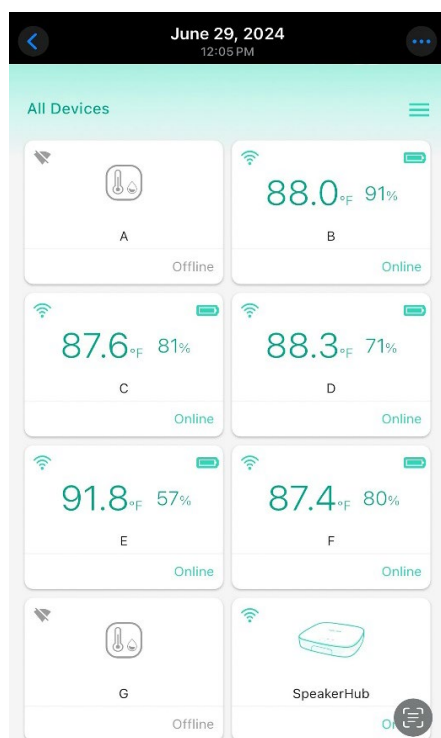


Fig. 8. Outdoor temperature and relative humidity display for one day reading. Two sensors are shown

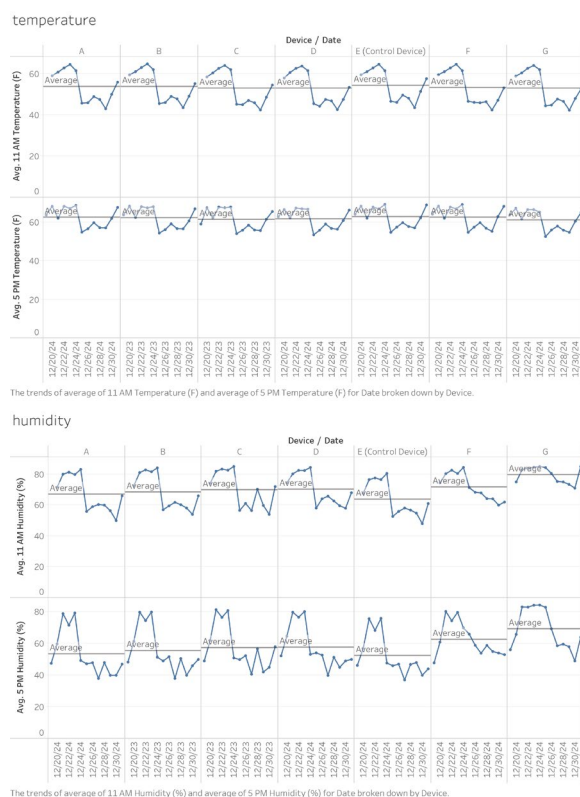


Fig 9. Data compilation over five days in December 2023

readings, we found surprising results, such as fewer temperature swings and greater humidity differences.

4.2 Qualitative Observation

The first drone data collection through photogrammetry, using a DJI Zenmuse XT 640X512 camera in conjunction with Radiometric Processing, was conducted over morning and afternoon of one day. The subsequent imaging used Autel Robotics EVO II Dual 640T Thermal Drone and Flir T400 Thermal Camera established a baseline temperature differential between the UTLW and the adjacent limestone wall on July 31, 2023. As a baseline start, we captured point differential temperatures on the same day and time and at the same station point location. The adjacent limestone wall shows a difference of 2.2 degrees lower than the UTLW pilot wall made of steel and planting (Fig 10).

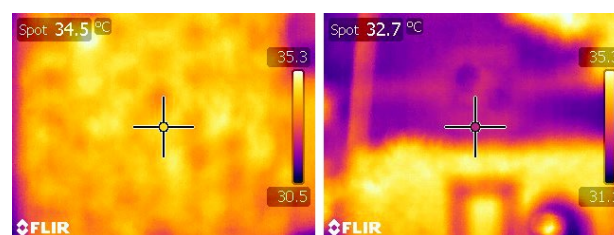


Fig 10. Illustrative temperature differential between UTLW and adjacent limestone wall

The project is located in Austin, Texas (30.28569° N, 97.74153° W; elevation 247 m; average annual precipitation 34.25 inches) on the west façade of the university architecture school. The three thermal images are labelled 10 AM, 12 PM, and 4 PM in the Central Time Zone. Because the camera does not register date-specific air temperature, relative humidity, cloud cover, wind speed, or recent rainfall, the images document the masonry wall, doorway, and adjacent façade under three observation periods. The supplied image lacks radiometric calibration and emissivity settings, a temperature scale, date-specific ambient weather conditions, and reference air-temperature and humidity measurements. These parameters therefore remain unverified. Quantitative surface-temperature comparisons are not reported because the displayed figure does not provide

numerical temperature data or a calibrated temperature scale. The images are beneficial as qualitative thermal documentation.

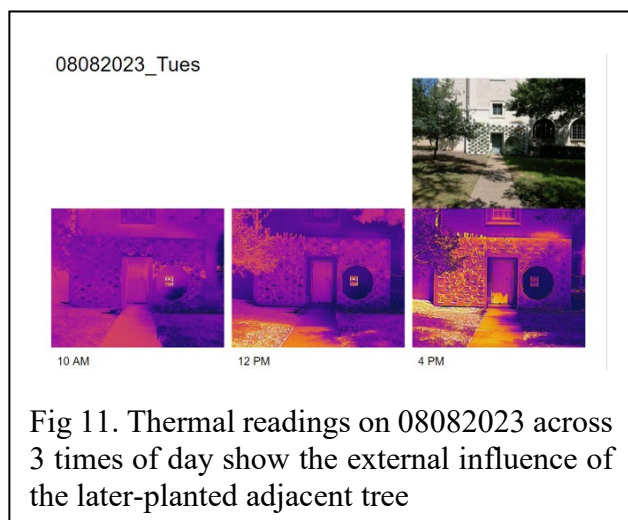


Fig 11. Thermal readings on 08082023 across 3 times of day show the external influence of the later-planted adjacent tree

6 Conclusion

The available project documentation supports the following observations and project-history statements. They should not be read as quantified performance findings where no underlying series or comparison is presented:

The original BIM workflow supported plant zoning, plant schedules, and quantity-based design exploration. The manuscript does not provide a before-and-after maintenance or irrigation dataset that would demonstrate a measured reduction in either. Automated watering should be described as a capability of smart irrigation systems generally, not as a function proven to have been controlled by the Living Wall's sensor data.

BIM can represent design information such as plant types, growing media, and irrigation layout, and environmental data could be linked to such a model. In this project, however, the ability to simulate heat absorption, water-use efficiency, air-quality improvement, or acoustic dampening is not equivalent to a measured result. These should be framed as potential analytical extensions unless project-specific simulation outputs and validation data are provided.

Project documentation describes the use of low-cost sensors and reports microclimatic variation across the façade, alongside subsequent species substitutions and irrigation adjustments. The sensor types and general workflow were described in prior work. The present manuscript does not include a complete dated temperature/humidity series or the metadata needed to assess seasonal patterns quantitatively. Statements that temperatures were

significantly lower than adjacent façade or ambient air, or that months were hottest, should remain provisional until supported by a plotted dataset with measurement locations, dates, units, sample counts, and a clear comparison method. It is also recommended to complete a monthly irrigation audit while the system is active and before reactivating it. The audit should include repairing leaks and calibrating the saturation time and schedule for the current plantings. Winterize the irrigation system during the last week of November. Winterizing includes draining the irrigation lines from the zone connection, mulching around the base of the risers, and confirming with the Irrigation & Water Conservation Department that no irrigation schedules are active.

The wall's participatory framework represents a redefinition of intelligent space as a social, as much as technological, construct. As both infrastructure and interface, the UTSOA Living Wall exemplifies a sustainable and equitable model of urban life. Its reliance on low-cost IoT sensors democratizes access to actionable environmental data, while its integration into architectural pedagogy ensures that diverse student communities participate in the stewardship of public space. By embedding ecological responsibility within a network of shared knowledge, the wall models how urban systems can be designed to serve both environmental goals and inclusive social engagement. Through the lens of environmental humanities, its presence asks us to reimagine architecture not as a static object, but as a living, evolving, and ethically charged site of interdependence—where maintenance is a form of care, and care is a practice of ongoing design embedded with nature and technology.

7 Disclosure

The UTSOA Living Wall has been documented in earlier publications, and the present paper builds on rather than reclaims that work. Briscoe's "Parametric Planting: Green Wall System Research + Design Using BIM" (ACADIA 2014, 333–338) established the project's BIM-based approach to encoding plant characteristics, generating modular planting arrangements, managing plant schedules and quantities, and considering interoperability and model complexity. "Living Wall: Information

Workflow and Collaboration” (eCAADe 2018, 207–212) subsequently described the built-wall pilot and its initial Arduino-based sensor workflow, including Grasshopper/Firefly integration and monitoring of environmental conditions such as temperature, light, sound, and proximity. Briscoe and Bright’s peer-reviewed article “Modular Living Wall: Collaborative, Regional Design on an Urban Campus in Texas” (Journal of Living Architecture, 2019) also describes the wall’s configuration and distinctive quantitative specifications, including its dimensions, planting and habitat units, substrate volume, approximate cell weight, and honeycomb arrangement. These publications form the technical and historical foundation for the current study.

This paper does not claim the original modular system, its published physical specifications, the BIM workflow, the initial sensor configuration, or the general interdisciplinary framework as novel. Its intended contribution is a post-occupancy account of later project developments and a more explicit interpretation of maintenance as ecological care. The paper identifies potentially relevant later records: plant observations, plant mortality and replacement, Opuntia flowering, thermal imagery, temperature and humidity readings, changes to planting-cell materials, multiple soil tests, and an updated maintenance review.

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