ABSTRACT

Urban infrastructure can provide opportunities for plant-scape, ecological balance and regeneration of natural resources through computational implementation. This work-in-progress paper describes a design process that stems from an extensive green wall pilot project along a 260’x70’ west facing parking garage façade in Austin, Texas. The parametric planning and planting methodologies challenge the capabilities of Building Information Modeling (BIM) as a design tool, experimenting with Comma Separated Value (CSV) files and Autodesk Revit Material Editor through visual programming plug-in dynamo. The design re-generates in association with external databases that originate from a multi-disciplinary academic research team from University of Texas at Austin School of Architecture— whereby architect, landscape architect, ecologist and civil engineer worked closely to meet the goals of Austin City Planning. The paper further discusses the benefits and limitations of a supplemental process using Rich Photographic Content (RPC). In effect, the pilot project redefines the “agency” of architectural design through a unique collaboration and the exchange of data to data metric to optimize design feasibility. By scheduling material take-offs of various pattern iterations and feeding that scheduled information back into the process, each pattern informs the collaborator’s tabular data and flags habitat relationships for team decision-making.
INTRODUCTION
Parking garages have become a common feature in the urban condition and are typically experienced as a separation from nature or even urban connectivity, rather than one of symbiosis. This paper summarizes a work-in-progress pilot project—a joint interest between the University of Texas at Austin and the City of Austin currently researching and designing a combination façade, living and habitat wall systems for the west façade of an existing University of Texas Parking Garage. This design collaboration is committed to measure and optimize aesthetic, water supply, temperature gradient, air quality, habitat and cost (capital and maintenance). The final project will demonstrate the environmental benefits and costs associated with a combination of green façade, living wall, and synthetic habitat technologies.

More specifically, this paper demonstrates the use of BIM as a means of achieving these commitments through the tracking and planning conditions of the selected plant and animal habitats within a wall system. An uncommon use of the software takes advantage of the platform’s ability to maintain complex sets of data. While also demonstrating the pattern generation that is typical among other parametric design software, the interface shows promise in handling issues of aesthetics and performance.

PRECEDENT
In recent years, green walls have become relatively prolific in architectural building development, but their realization has projected little to do with computational control or design. Herzog + de Meuron’s Caixa Museum, Snohetta’s SF MOMA Extension and ARUP’s Citi Data Center are just a few (building scale) examples of how a collaboration with landscape architecture is turning façade walls into a living patterns of planting—renewing the path designers pursue to achieve “a new approach that overcomes the false dichotomy between architecture and landscape.”

To understand advances and limitations of technology currently available in the market, the project team judiciously charted viable precedents and commercial products of both living and façade modular applications (Figure 1). The research also recognizes current parametric, modular plant and habitat research, such as Mark Miller’s ‘Crafting Technosols’ and CASE / Center for Architecture Science and Ecology’s ‘Active Modular Phytoremediation Systems (AMPS)’ that have identified, although not through BIM, the means by which topological modularity are created and calibrated using pedological and ecological performance metrics. In the same vein, this project explores factors at the scale of landscape and of material for formal pattern making and instantiation.

PROCESS: ANALYSIS
Although the initiating analysis is not the primary computation discussion of this paper, it is worth noting the multiple file types that assisted in the assessment and establishment of plant types for the ecologist and landscape architect. Multiple factors from geo-spatial capabilities, s, in association with daylight and thermal analysis, determined the team ecologist plant selection (Figure 2). The technical set up of GIS to CSV then categorized an initial plant species selection that was organized into three planting types: plants supported on a trellis structure (‘green façade’), plants rooted in growing media attached, and thirdly, in the wall itself (‘living wall’), along with habitat for beneficial fauna including pollinators (hummingbirds, butterflies), small reptiles, bats, songbirds and raptors. Knowing the surface area assisted in determining the scalability of the project for one particular plant or bio-habitat species.

These conditions were coordinated in a CSV file as resultant plant classifications, such as: ecological distribution, size, drought tolerance, habitat, soil drainage, and moisture, as well as Lepidoptera linkages and what species will serve as food for other species. (Figure 3) These unique parameters were transferred into the
Material Editor database of each plant file but have yet to fully play out their potential. A graphic color specification (RGB value), however, was assigned to each plant type, which would then serve, along with rendered image, as a way of testing pattern generation in BIM. Under each plant type, ten species were selected for diversity and a range of testing.  

**GEOMETRY**  
Versioning of modular size and shape for the 'living wall' components resulted in a consistent hexagonal geometry (as opposed to one of mass customization) at the scale of an 18” potted plant/habitat space. Although variation in geometry was tested through standard voronoi studies, the singularity of a component type allowed a reductive component-based system to accommodate stacking and nesting a hexagonal geometry approximately 18” x 18” in scale and proposed the plants themselves to be the variable or emergent 4D factor. One parameter of the component would foster root depth according to requirements of each plant type. Another parameter had to do with habitat size for migrating bird species. For both, the range would be 3”-12” differentials using curtain panel family types (Figure 4).  

The coinciding geometry of the component project addresses challenges such as root temperature tolerance and limited water availability for the City of Austin; drawing on large data from the granular physics of matter to develop the logistics of organizing plant systems and coinciding fauna species into a data in/data out process.  

**VISUALIZATION**  
Additionally, a workflow of files containing Rich Photographic Content (RPC) for each plant was tested in an effort to assist visualization pattern generation and renderings of each version. In effect, 2D and 3D views were able to display this planting entourage using simple line drawings as placeholders. Some placeholders were found to “misbehave” by inconsistently changing their orientation. When rendering a 3D view, the photo-realistic representation of the entourage displays in the rendered image, but proved to be limited in terms of expeditious output and the quality of the renderings, interpreting this part of the process unsatisfactory. A possible alternative would be to create more populous nested components to act as a single agent to the pattern generation in an effort to reduce data redundancy per component.  

**INFORMATION GENERATION:**  
**FAMILY TYPES**  
Each cell is assigned a certain plant species and complementary color. Plant parameters are embedded within each type properties menu, which can then be scheduled as a material take-off quantity, as if it were a sum of building material, from each generated pattern. By having the plant types read as a single abstraction of color (denoted on spreadsheet) allows for greater legibility of the patterns and reduces memory usage but yet retains all the information from the plant data sheet. The pairing of two hexagons begins to strategize a nested situation for developing a reduction in file size and generation time of pattern. Processing and rendering time becomes a critical factor for increasing interoperability solutions between the different components of a project.  

**VISUAL PROGRAMMING**  
The framework for creating pattern in abstract terms corresponds each hexagonal type component to the pixels’ gray value of a bitmap. The methodology stands apart from (what has become) a very common practice in visual programming as each pattern results in a material take-off schedule as feedback for ecological relationships or other aspects of feasibility. For instance in Scheme A, the gradient application is reversed, thereby changing the aesthetics of the pattern due to plant
color allocation. This simple shift of adherence to the bitmap dramatically changes the cost of each scheme and the ratio of Lepidoptera linkages due to plant combinations created (Figure 7) as the quantity of *sideoats grama* grass doubles from one version to the other.

The originating bitmap patterns, although initially arbitrary, were implemented as a way to parametrically control the design layout of the plants/habitats, to break down the horizontality of the garage spandrel panels, and lastly to serve as a means for irregular plant clustering. To this end, the ability to have an inconclusive design pattern with all necessary data enables those decisions to be made for flexibility in the design process among many stakeholders. More importantly, it allowed for inter-operability metric by which the plant selection could be evaluated by way of component and patterns. Playing upon the strengths of BIM/Revit, accompanying design data schedules assisted in the evaluation of ecological viability, cost and efficiency of planting schemes. The scheduled reports from these patterns then allowed for determinism and comparison of each pattern (for example, pattern with consequences and not simply aesthetic or technological novelty) and also fed resultant data back into the script to determine a secondary pattern.

On a basic level, the process generates pattern that is quantifiable and can be deterministic in selection or what is deemed as the optimized scheme through data metrics like cost or soil volume. Importantly, the scheduled feedback enabled quantifiable data of
ecological motives to be an enabler of design (the ability to get cost feedback of structure and plant distributions and other habitat relationships if possible) for the different iterations. Further development through prototyping begins to investigate material actualization and greater pattern definition.

OUTCOMES

Apart from the beneficial process noted earlier in this paper, the project has established several procedural BIM milestones:

- Exploration of the potential of Dynamo to handle visual programming for design iteration at the scale of landscape and building.
- A BIM data process, not merely a BIM software process. Shift away from treating BIM like merely a CAD documentation tool.
- Use of Revit/Dynamo as an ecological and landscape design tool with collaborative databases between multiple disciplines; more specifically, the deployment of BIM to support design, scheduling and future tracking of ecological behavior through a 4D and 5D platform like Navisworks.

The value of the paper lies in the lesson learned from the application and further insight in how BIM and analytical tools can be fine-tuned. Current methodology requires at least three to four software platforms, and this may be an area of innovation.

Further research will investigate the manner in which components correspond to visual patterns, where beneficial relationships are flagged (like is sometimes done for Revit clash detection). For instance if two plants have a high ecology rating, their proximity triggers a graphical indication of such, so the design pattern has a reading of optimization.
CONCLUSION

Taken as a whole, the paper offers neither a set of major findings at this point in time nor feigns conclusion. Instead, it goes to the objectives of the green wall pilot that have been set out by the multi-disciplinary team and explores the field it demarcates using BIM. The essay does, however, seek to qualify the claim that BIM is articulating a middle ground between the hyper complexity of advanced computational design and rote usage of BIM. This middle ground is crucial for future collaborations between disciplines as a viable and strategic workflow. It is the predictive role of computation to understand trends of migration and succession.

NOTES


2. Position held by Diana Balmori and Joel Sanders in their book, Groundwork: Between Landscape and Architecture.

3. Mark Miller’s ‘Crafting Technosols’ and CASE / Center for Architecture Science and Ecology’s ‘Active Modular Phytoremediation Systems (AMPS)’ are just two such examples using modular planting systems similarly to this paper research. Neither however use BIM as a design generator.

4. The multidisciplinary nature of the project contributes highly to its innovation. From the University of Texas at Austin School of Architecture the team is comprised of: Frederick Steiner (Dean and Landscape Architect), Barbara Brown Wilson (Director, Center for Sustainable Development), Danelle Briscoe (Assistant Professor in Architecture/Building Information Modeling Specialist), and Dr. Mark Simmons (Director, Research and Consulting, Ecosystem Design Group, Lady Bird Johnson Wildflower Center). Other participating disciplines, such as Dr. Atila Novoselac, (Associate Professor, University of Texas Department of Civil, Architectural and Environmental Engineering), Chris Riley (City of Austin Councilman), Daniel Woodroffe (RLA and urban planner from RLA), and Eleanor McKinney (RLA) are currently playing an active role as consultants in the development of the project.


7. The project is greatly indebted to Andreas Dieckman, RWTH Aachen University, for his assistance with Dynamo bitmap control and color to type output for ten plant species, as well as Zach Kron, Autodesk Specialist.

REFERENCES


IMAGE CREDITS

Figure 1. Briscoe, Danelle / Arosa, Francisca (2013) Precedent mapping

Figure 2. Simmons, Mark/Briscoe, Danelle/ Hadilou, Arman (2013) Initial analysis.

Figure 3. Briscoe, Danelle (2014) CSV to Material Editor Workflow.

Figure 4. Briscoe, Danelle (2014) component depth and type parameters.

Figure 5. Briscoe, Danelle (2013) workflow for Rich Photographic Content (RPC).

Figure 6. Briscoe, Danelle / Grenard, Laura (2013) Twelve component types.

Figure 7. Briscoe, Danelle / Grenard, Laura (2013) examples of pattern study.

Figure 8. Briscoe, Danelle (2014) state of current fabrication and pattern development.

DANELLE BRISCOE is an architectural designer who studied at Yale University and the University of Texas in Austin. Her ten years of work experience include designer at Gehry Partners, LLP and Marmol+Radziner LLP. She has exhibited work in Axis Gallery, Tokyo, 2004 ICFF in New York, the MAK Center in Los Angeles and more recently Objectspace in Auckland, New Zealand. She now lives in Austin, Texas, works as an independent practitioner and holds an Assistant Professor position at the University of Texas at Austin. She is primarily engaged in material fabrication research using Building Information Modelling (BIM).