MORPHOGENESIS IN THE LANDSCAPE: ALGAEIC INFRASTRUCTURE AND RECYCLED CARDBOARD

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1 ABSTRACT
Among the many emerging discourses and technologies potentially adhering to landscapes, morphogenesis, conceived as an architectural theory, derives materiality, functionality, and form from the biotic world. As part of a discussion of “data driven” or “bottom up” design, Leach’s morphogenesis recognizes that “nature itself can teach us about the efficiency of certain structural organizations.” (Leach, 2009) This case study experiments with morphogenesis in the landscape. The study method is to document a morphogenetically derived installation’s form in the landscape. The team developed a morphogenetic module, built 330 copies of it, and created an emergent intervention (Algaeic Infrastructure) for a specific site in an example of Clement’s Third Landscape.

Built from recycled cardboard, Algaeic Infrastructure proposes an emergent pattern derived from the module’s form, the landscape, and the process of building. The structure is created by interactive rules similar to the development of computer programs that “think” (Johnson, 2011) and thus physically models a version of “learning.” The interlocking system was deployed along an arroyo as an event space for High Desert Test Site (HDTS) in October 2013. The project site is Montessa Park, Albuquerque, NM, where the city’s edge intersects the military base and the airport. A past dairy, deep downcutting of the arroyo, a prison farm, and current “sacrifice” uses, such as ATVs, shooting ranges, and garbage collection layer this in-between (Third) landscape. The ecological implications of this study lie in the proposal of a flexible, modular, morphogenetic system allowing building/designing to accommodate ecological flows rather than impede them.

1.1 Keywords
morphogenesis, topological connections, emergence, third landscape, grasshopper, parametric landscape

2 THEORY
2.1 Morphogenesis in the Landscape:
On the one hand, the derivation of design form and function from biota as applied to landscape seems painfully obvious. Landscape architecture is posited, after all, as the design discipline of natural spaces and functions either within or outside of the urban form. Landscape architecture might be seen as the crucible in which the discredited divisions of nature and culture, man and animal, were melted down in the past twenty years. In 2011, Mirko Zardini opens Seemingly Seamless, an essay from Landform Building (Stan Allen, ed.), with a strawman opposition between landscape and architecture: “Landscape is irresistible. It is soft, neutral, and continuous, unanimously understood as good, reliable, and therefore not open to criticism” (Zardini, 2011), and architecture is the opposite. He suggests Landform Building (based on Landscape Urbanism) is a new theoretical direction for architecture and landscape in that “it seeks a path around distinctions between the natural and the artificial….the city is no longer understood as figure and ground, but as a complete environment.” (Zardini, 2011)

As a physical prototype for understanding a non-oppositional relationship of landscape and architecture, Algaeic Infrastructure uses the principle of modular organization with an open and flexible outcome to connect with a “third landscape” (Clement, 2006) site. The third landscape “interstitial space” (Clement, 2006) forms a matrix interlocking human intervention -- flood channels, aggressive grazing, erosive farming, and upstream development -- with untended plantings of
renegade, vestigial windbreaks and a persistent seedbank. The modules exhibit radial symmetry (reminiscent of algal forms) and topological interlocking connections. (Estrina et al., 2011) The functional equivalent can be found in the interconnections of colonial algae as they form interlocking matrices across water bodies. The structural requirements of the topological interconnections create a ninety degree orientation to the modules and thus a three dimensional connected fabric. As Leach, indicates, “nature itself can teach us important lessons about the efficiency of certain structural organizations.” (Leach, 2009)

“It (morphogenetic design) is not a question of what a cultural object might ‘symbolise’ – the dominant concern in the Postmodernist quest for interpretation and meaning – but rather what it ‘expresses’. The concern, then, is to understand culture in terms of material processes – in terms of the actual ‘architecture’ of culture itself.” (Leach, 2009)

Leach’s call to abandon a metaphoric understanding of design language and enter into a material and “actual” language, echoes De Landa’s Neo Materialism “… neo-materialism is based on the idea that matter has morphogenetic capacities of its own and does not need to be commanded into generating form.” (De Landa, 2012) In De Landa’s 2012 interview with New Materialism: Interviews & Cartographies, he defines a trajectory which seeks, as does Leach’s morphogenesis, to posit an engineering or mechanically based order to the world, allowing for a logic that emerges from material existence. The freedom from one-to-one correspondence of meaning and object opens a breath of fresh air into the discipline of landscape architecture. Not beholden to culturally mandated equations -- the signs, symbols, and signifiers of a semiotic era -- we are allowed to investigate material language. While morphogenesis may derive forms and borrow structural memes, a morphogenetic language is not then bound to the equation of algae, streambeds, and fertilizer blooms. A material language can obviate the opacity of a metaphor’s reliance on shared cultural texts and experiences, and thus, potentially disrupt a hegemonic order.

2.2 Theory: Scale

“Designers must take action and modify our stance at all scales and morphologies to have a positive effect on the global community. Our reflections on their possible role is first and foremost based on one succinct predicate: the end of scale.” (Mitchell, 2012)

One of the implications of the Algaeic Infrastructure prototype is scale. Using a modular building method allows a large structure to be derived from a small scale module. At first glance, there are two scales to be considered -- the scale of the module and the scale of the overall structure. In modular construction those scales continue to multiply, as the emergent structure is allowed to grow and intersect with the surrounding site. The module has an internal logic and formal structure based on its material nature and the topological interlocking requirements. Thus, the structure has an ever-variable and responsive form. Twenty modules create a self-supporting sphere, but forty modules interlocked do not form two self-supporting spheres, rather they create an emergent form dependent on the surrounding context. As Mitchell predicts the end of scale, Algaeic Infrastructure posits a scalar logic reaching both forward into a world of custom printed airplane parts, (Lipson et al., 2013) and back to the limitations of human scale technologies, such as hand laid masonry and post and beam wooden construction. Mitchell’s scale is perhaps the dominance of the Fordian globalization of manufacture and building. At this technological moment in Western culture, interventions replicate and iterate without interference or resistance from either land or material reality.

2.3 Theory: Ecological

Algaeic Infrastructure proposes design and construction interaction with a site as a process rather than an imposition of form. This offers a potential answer to Zardini’s observation that “…a deeper acknowledgement of multiplicity may provide such strategies with the full potential to negotiate between the soft and the hard, the neutral and the opinionated, the continuous and the fragmented -- offering a conscious distancing from previous spatial agreements based on “pure force.” (Zardini, 2011)

Algaeic Infrastructure prototypes a building process engaged with scale and site to model flexibility. Working with a module and allowing the site conditions to determine overall formal structure perhaps frees construction, not only from the cultural pitfalls of metaphor, but also from the blindness to ecological conditions which can accompany conventional grading and construction. This prototype offers a rearrangement of the priorities of design. Rather than privileging an
overall form and forcing the site to support that form, this process allows the site and the module’s capabilities to determine an overall intervention. Modular scalar building is not proved by this prototypical presentation, given that Algaeic Infrastructure is an art piece rather than a habitable space, but the proposition offers potentials to be explored in section 3.1 Implications.

3 PROCESS
3.1 Morphogenetic process -- limits and materials

"Morphogenesis... More recently it has been appropriated within architectural circles to designate an approach to design that seeks to challenge the hegemony of top-down processes of form-making, and replace it with a bottom-up logic of form-finding." (Leach, 2009)

Leach, in this articulation of morphogenesis, describes a process that could be applied to Algaeic Infrastructure’s growth. Is this an absence of design? It surely is an absence of the parti, the grand sketch, the overall gesture, that claims to synthesize a site and a program into an expression through the magic hand of the author. (Booth, 2011) It is perhaps a re-definition of the role of designer(s). We claim the result is emergent, as defined in Steven Johnson’s 2001 explorations. (Johnson, 2001) This does not mean it is undesigned, rather a form-finding process with simple rules has been enacted. Our criteria were replication, structural integrity, and a scalar flexibility.

We sought replication to create a flexible form which could be arranged in a variety of ways in the variable arroyo channel. In Albuquerque, an arroyo changes morphology with each year’s rain. A replicating form would allow for response to the variable conditions of the arroyo. It would also allow us to build in response to the site conditions of a particular day, both phenomenological and formal.

Structural integrity was required to allow the piece to build to the extent we were intending. The arroyo channel measured approximately 35’ at its base and about 130’ at the widest top of bank-to-bank measurements. The 35’ broken roadway/dam where we located the piece was fifteen feet above the floor of the arroyo. We needed to create a system which could span some of these distances yet create a dense intervention.

Scalar flexibility was necessary to allow a spatial element to come into play. We ended up with two scales of modules to allow a structure to emerge from the replication. The play with scaled modules could continue as we indicate in our potential outcomes of this experiment.

3.2 Process: Form-Finding Parameters

![Figure 1. Form Finding Sketches (2013). Diagrams by the Authors](image)
This sketch derived from early explorations of using inflatable modules to generate a thermodynamic structure. In the bottom right hand section, the formal antecedent to the final cardboard module emerges. The parameters for this form were to find a flat module which would generate a three dimensional fabric with an inherent geometry.

3.3 Process: Simulation

Once a basic formal intent is determined, formal responses to pressure and elasticity are determined through digital simulation. The platform for this investigation is Grasshopper, a visual scripting plugin for Rhinoceros 3D. The simulation itself is conducted through Kangaroo, a physics engine for Grasshopper. Kangaroo facilitates the simulation of material properties and form relative to dynamic forces such as pressure and gravity.

A basic footprint of the module is created within the Grasshopper environment, framing two mesh planes. Kangaroo simulates an increase of air pressure within the planes to enable inflation. The Grasshopper plugin Weaverbird optimizes the meshes, restructuring their internal organizations based off of the curvature necessary to represent the curvature of the surface.

Using the mesh framework optimized by Weaverbird, the surfaces can then be flattened into a two-dimensional plane that would inflate and approximate the dimensions of the digital model. This two-dimensional plane serves as the template for fabricating the modules.

Figure 2. Grasshopper Model (2013). Diagram by the Authors

Figure 3. Cardboard Collection (2013). Photo by the Authors
3.4 Process: Cardboard as Morphogenetic Material

Cardboard became the final material for the structure. We experimented with inflated modules which would have a photo-responsive function. Our team requirement to use a sustainable plastic required compostable bio-plastic, yet bioplastic's sealing limitations made it not feasible. We explored photo-degradable plastic but discovered that the modules did not retain air in the 1 mil plastic our computer models predicted would best inflate. Cardboard is not only a commonly recycled material, -- the EPA estimates in 2011 66% of the paper stream was recycled (EPA, 2011) -- but is also made from recycled content. The paper stream accounts for 70 million tons of waste. Recycled cardboard is valued at between $55 and $100 per ton (Metcalfe, 2012).

Our process transformed cardboard from heaps in a recycling yard into a structural and aesthetically viable product. We bought 900 pounds (just under half a ton) of cardboard from recycling services in Albuquerque. The usual waste stream for cardboard collected in Albuquerque is shipment to Mexico, where it is pulped and reconstituted as paper products. Our criteria was to look for boxes which would cover a substantial portion of a 4’x8’ sheet. We hand-picked refrigerator and large appliance boxes from mountains of material.

We then flattened, cut, and laminated five or six layers of recycled cardboard between two sheets of clean 4’x8’ double-ply cardboard. The lamination was a hand (and foot) process with gallons of wood glue and scrapers.

The final result was a board 1 5/8” thick and 4’x8’ in dimension. Boards were marked with a template and rough-cut with a hand jig saw to rough module dimensions. Final shaping was done with a band saw, and each piece took six minutes to cut. The team processed 900 pounds of recycled cardboard into thirty 4’x8’ laminated sheets and cut from them 330 individual modules in two sizes. Cardboard is not a permanent outdoor installation material. It requires quick assembly and disassembly based on precipitation and wind conditions.

We initially imagined cardboard as a sketch model material. We needed multiple modules to model the emergent patterning available with the form derived from our sketches and algal research. Cardboard is plentiful and cheap in our culture. As we worked with it, the cardboard’s durability, formal character and conversion from scrap to material replaced our earlier theories on photo-reactivity and inflatable architecture.

3.5 Process: Scale

The team began building with the module at a five-inch inscribed diameter scale in order to understand the formal implications of its replication. This exploration was a purely visual scalar model. Our next step was to build 240 one-foot inscribed modules made from the 1 ⅝” laminated cardboard sheets. This module created a piece which could be assembled into a 10’ x 10’ x 20’ installation. The scale was not habitable, but certainly more haptic than solely visual. The next version was 90 modules at a scale inscribed within a two and a half foot diameter. Those pieces shifted the perceptual scale to a habitable sphere. The two and a half foot scale responded to the 15 feet of rise between the arroyo floor and the top of the road. The final installation used both one foot and two and a half foot modules to respond to the site’s variations. The site scale in section has a ratio of 1:2, height to width of the arroyo floor, and 1:8 for the height of the roadway to the width of the arroyo’s widest bank-to-bank distance. The form seems steeper on site.
Figure 4. Cardboard Lamination (2013). Composite: Harris

Figure 5. Algaeic Infrastructure (2013). Photo by the Authors
3.6 Process: Site Installation

The process of installation became an exploration of the site conditions. The arroyo is a constantly changing field. Larger and later than usual fall rains filled one side of our chosen site at the old ford down into the fifteen foot head cut. The Tijeras arroyo, which runs through Montessa Park, was, according to aerial photos from the 1940’s, a surface intermittent stream. It has down-cut due to development and engineering, such that the surrounding lands, once farms, are now dewatered scrub. The site is in the Frisbee golf course at the eastern end of Montessa Park.

We installed the cardboard, testing and feeling out the modules’ movements beginning on Thursday afternoon. By Friday at 3pm we were done. We collected some camping gear and spent the night on the levee above the structure. The night was cold with a low of 26 F by the car thermometer. We slept, but woke with the booming of airplane engines, the sounds of late night target practice, and an anomalous weather radio driving by at high decibels. High winds rearranged our piece, so before dawn by the full moon’s light, we rebuilt the structure.

The sun rose with the piece in place and us roasting marshmallows. Our loved ones came and brought breakfast. People began to arrive around ten, slowly at first. The piece was hidden in the arroyo. People parked at the road side and walked into the site without our guidance.
SITE

4.1 Montessa Park - The Third Landscape/Sacrifice Zone -- or Why is a Modular and Temporary Intervention Appropriate for the Third Landscape?

The Third Landscape refers to Gilles Clement’s essay about interstitial landscapes that harbor biological diversity and ecological resilience. Third Landscapes are reservoirs for the possibilities of regeneration, and inherently revolutionary. Montessa Park, situated between the Albuquerque International Airport and a growing new urbanist vision to the south, could be seen as such a teeming and possible landscape. “The term Third Landscape does not allude to the Third World, but to the Third Estate. It is a referral to Abbé Siéyès’ question: « What is the Third Estate? Everything-What role has it played to date? -None-What does it aspire to? -Something » (Clement, 2006) In such a landscape, efforts at a temporally fixed architecture and landscape have largely deteriorated. The park is seen as a sacrifice zone to uses such as garbage collection, ATV use, and shooting ranges. Past tree plantations, farming, and prisons all exist in palimpsest demarcations on the ground surface. The space is public, yet access is virtually secret. The park entrance begins across the interstate, and while it appears to connect with the major artery from the University of New Mexico to the slowly growing new urbanist development, the road beds are actually separated by twenty feet of drop. Google Earth’s directions do not lead to the park.

Javier Mozas comments in his a+t “Strategy Series” introductory essay of 2008, “These spaces are ideal spaces to take in diversity without attributes, not just biological diversity, but also cultural diversity, the diversity which leads to dreams….the diversity which is expelled from other landscapes”(Mozas, 2008). There is an inherent flexibility in Montessa Park. Not only is it an ecologically shifting ground of erosion, flooding, and wind, but it is also a shifting ground of political allegiances and possibilities. Open Space administration rejected our first site proposal as too risky. The end of the park with heavy ATV presence is often home to random bullet holes, such as those perforating a sewer line the month before our installation.

IMPLICATIONS

Borrowing from Feyerabend’s anti-positivism, we refrain from conclusion and suggest implications. The strongest implications are for the scalar shifts from module to structure. The scalar shifts in Algaeic Infrastructure drive the interest we have in working with this module at different scales. The team imagines possibilities for this system to form an interlocking emergent module as erosion control or as a structural architectural intervention. If this formal language proceeds from landscape control to architectural form, then the Landform Building morphogenetic process could be fully articulated, fulfilling the promise of modular structures.

The morphogenetic implications of the structure may unfold with further material exploration. The cardboard has a temporary quality, depriving it of a determined function or structural demonstration. While morphogenesis and neo-materialism free us from the requirements of a metaphoric structure, further research into materials is required to articulate this module. From our original principles of replication, structural stability, and flexibility, we can derive a palette of materials to test further, perhaps largely cast, or printed.

Process implications link physical parametric computer modeling. Rather than a predictive computer model, we worked with a model analyzing an analog proposal. The gaps and resistances – ie: failure of the inflatable modeling and predicted gaps in the spherical form -- offer space for this process to be iterative and conversational, rather than a monolithic digital conclusion. The process of emergence comes from both ends of the project workflow.

During the installation we observed the expected deterioration of the cardboard and a less expected loosening of joints as the material shrank. This leads us to conclude that a relatively stable material would be required to maintain structural integrity. Likewise, were this structure to be applied to erosion control, the material would need to be inert to encourage siltation and allow for plant growth.

The emergent nature of the design, the unfolding neo-materialism, and the adaptation of scale offer implications for working with site design from a morphogenetic --“form finding”-- process.
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5 REFERENCES
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