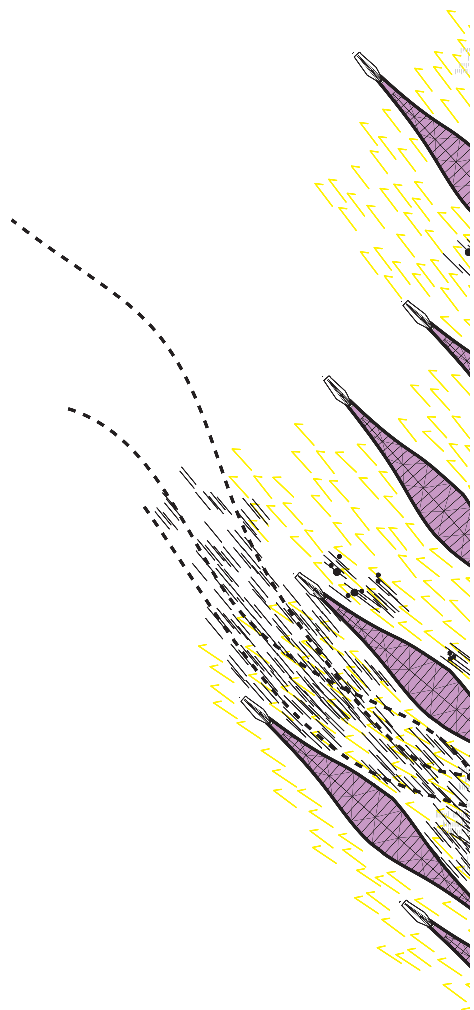
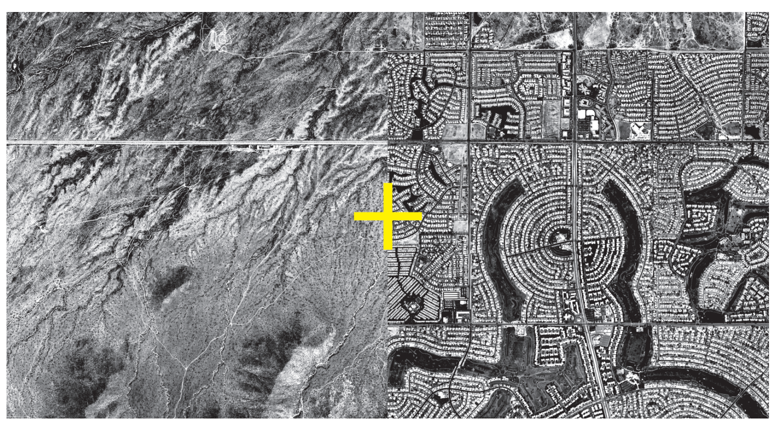
XEROHOUSE
FUTURE CITIES LAB
NATALY GATTEGNO + JASON KELLY JOHNSON



> "In a landscape where nothing officially exists, absolutely anything becomes thinkable, and may consequently happen..."
> —Reyner Banham, *Scenes in America Deserta*

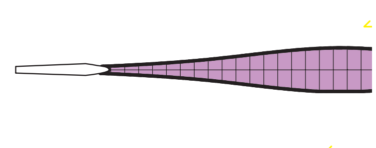
Architecture is in love with the desert. Banham called it, "an appropriate place for fantasies."[1] But if the American Dream is one such fantasy, few things stand in greater contrast to an ecological architecture than the image of bloated, refrigerated homes cul-de-sac-ing their way across the deserts of the American Southwest. Here, the environmentalists' call is seldom one of sustainability, but rather for extraction and total avoidance. Yet Banham's fantasies were not mass-produced in adobe-colored stucco; his were richly idiosyncratic, "dune buggy maniacs and lone hikers, the seekers after legendary gold mines, the exploders of the first atomic devices...and the diggers of gigantic earth sculptures."[2] Though anything may be thinkable in the desert, certainly no tabula rasa exists in the sand.

Xerohouse is a prototypical dwelling envisioned for the Sonoran Desert environs of Phoenix, Arizona. The name is taken from Xeromax, a term Future Cities Lab has used to describe a recurrent line of research in their work. Xero-, meaning dry or extremely arid, and max, to the furthest degree or totally, explicate the local environment's severity. Also culled from this desert context are the mythological narrative of the phoenix, precedents such as dugouts and tents, sand dune formations, the armor of armadillos and stomata from indigenous flora. These are not metaphors, but performative strategies in extreme climates. They catalog the forces to be engaged, not avoided or resisted, but inserted within, adapted to, and capitalized upon.



Aiding in the definition of specific formal, spatial, and temporal articulation are what Future Cities Lab terms live models. Not merely representational or indexical, they are composite analog and digital sensory devices that collect data and provide feedback to calibrate and optimize the configuration, orientation, and interrelationships of Xerohouse dwellings. These influences are not casual or approximate, but highly specific structuring thresholds and modulations of performative capacity.

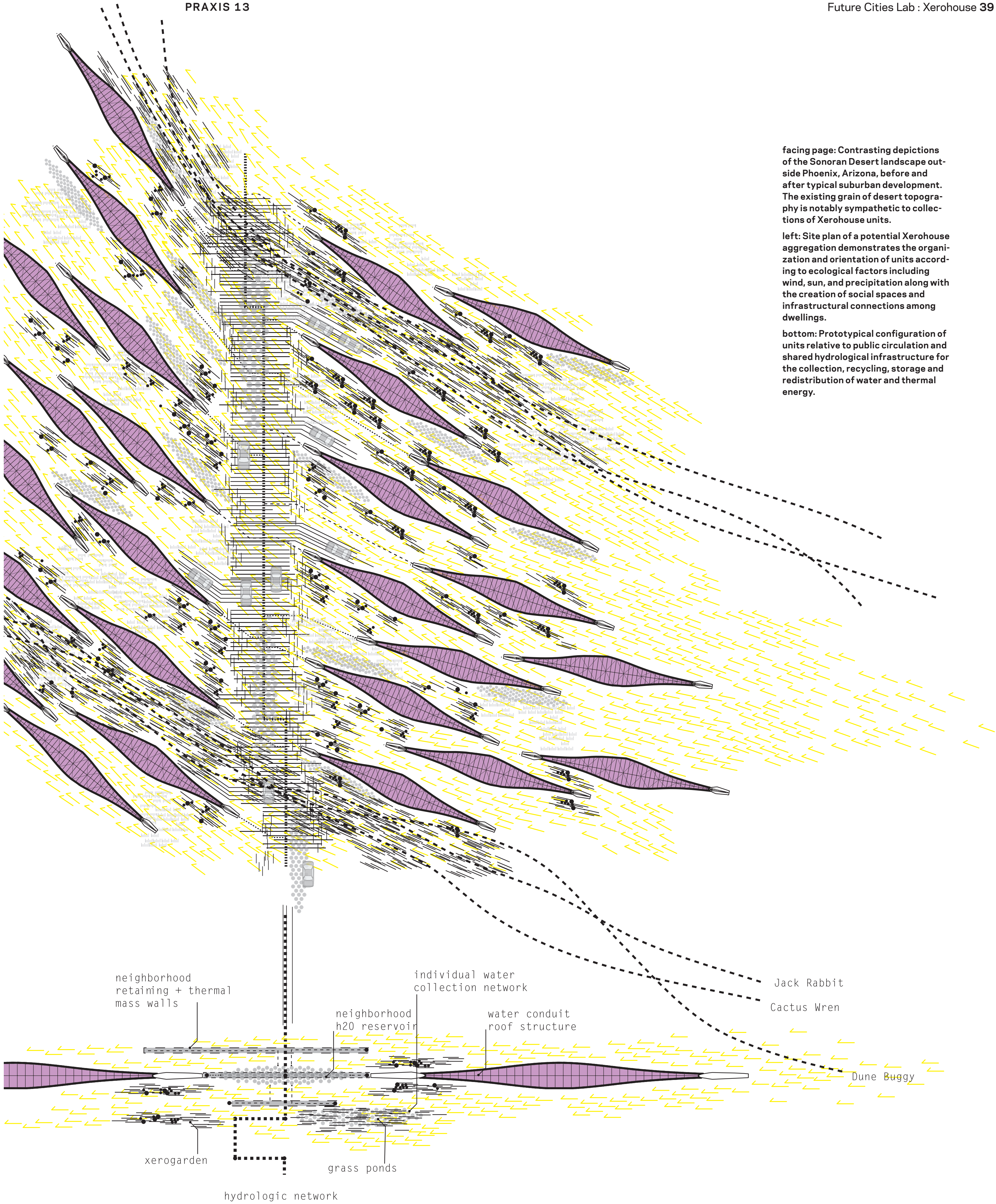
The resulting homes and their larger configuration bear little resemblance to the nearby suburbs of Phoenix. Their slender form is heavy, buried, and static while simultaneously light, open, and responsive. The circadian fluctuations of temperature, wind, and shade predominantly determine the program distribution. Units work together to perform various tasks such as the collection and distribution of energy and water resources, all while revealing an embedded logic of desert occupation.

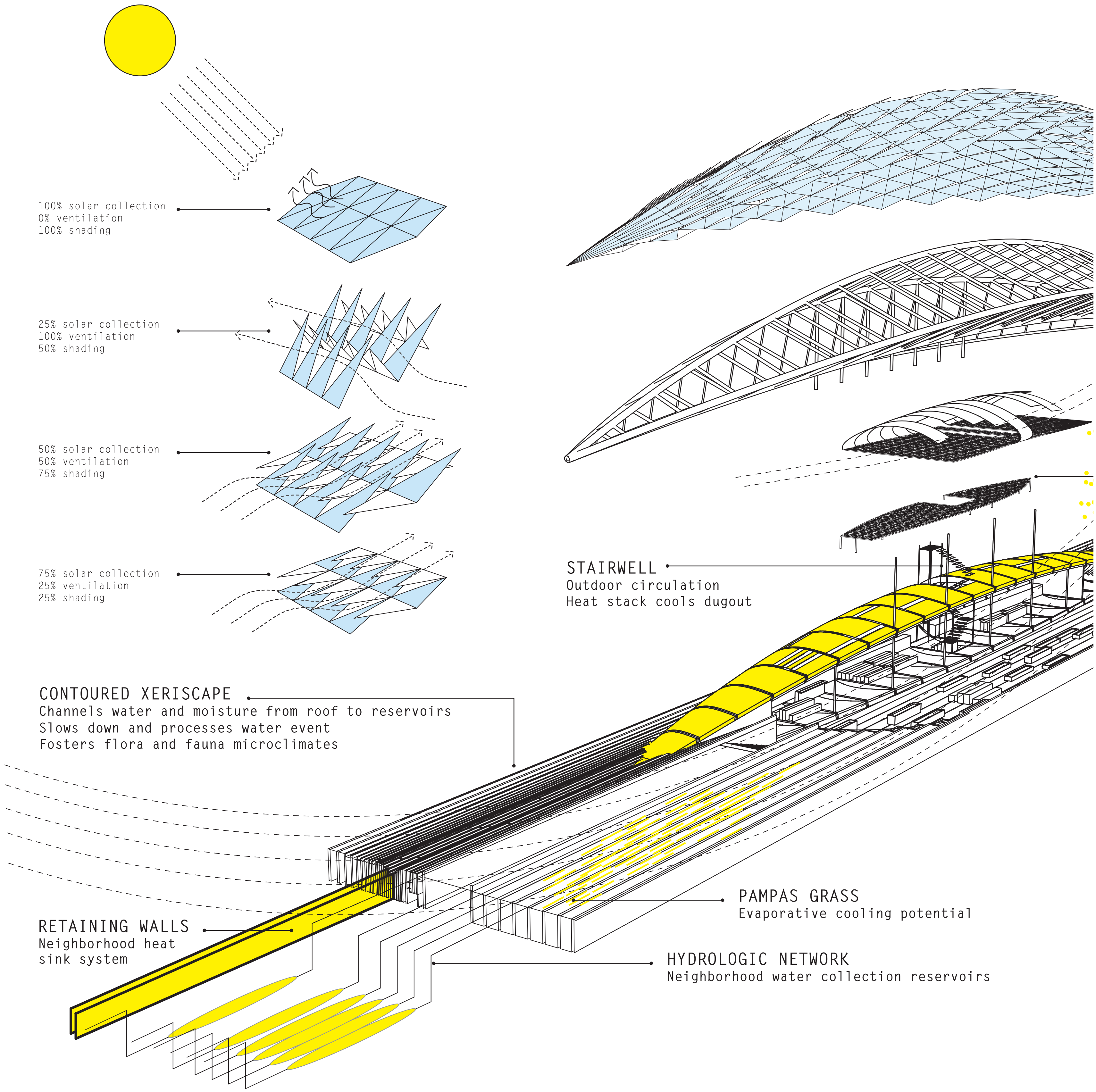


facing page: Contrasting depictions of the Sonoran Desert landscape outside Phoenix, Arizona, before and after typical suburban development. The existing grain of desert topography is notably sympathetic to collections of Xerohouse units.

left: Site plan of a potential Xerohouse aggregation demonstrates the organization and orientation of units according to ecological factors including wind, sun, and precipitation along with the creation of social spaces and infrastructural connections among dwellings.

bottom: Prototypical configuration of units relative to public circulation and shared hydrological infrastructure for the collection, recycling, storage and redistribution of water and thermal energy.

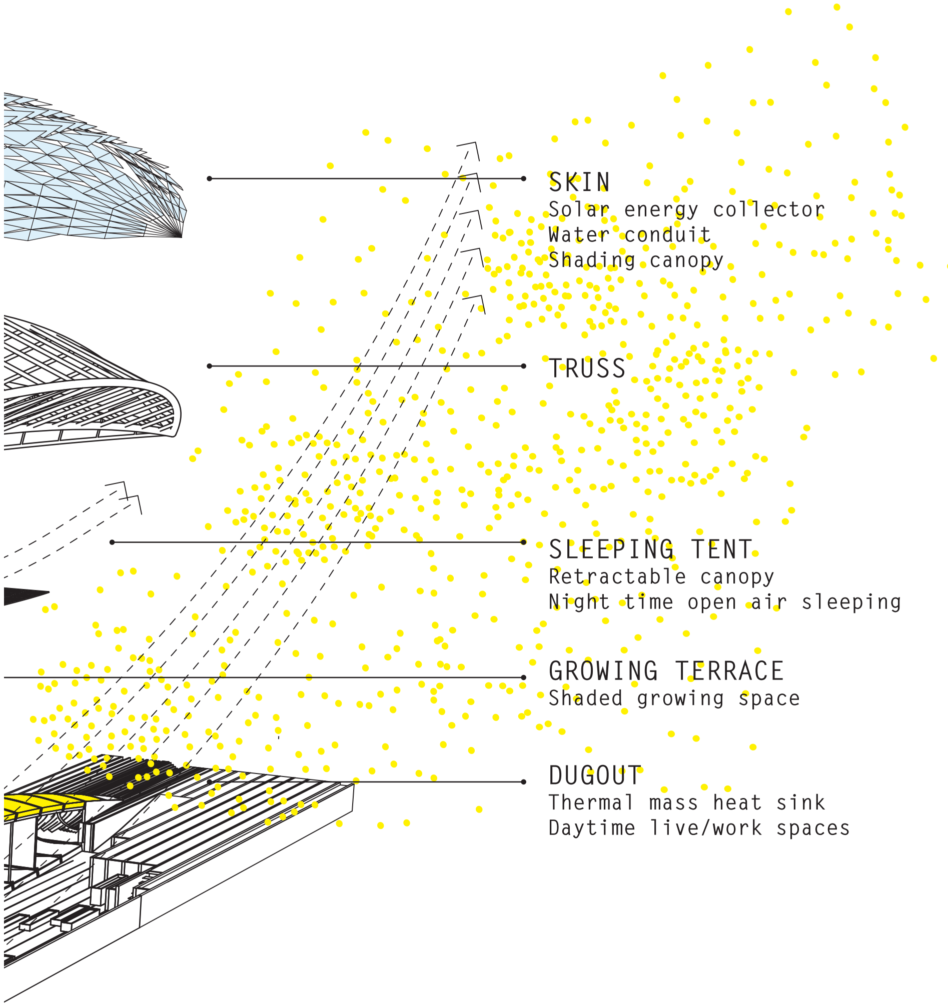




above: Exploded axonometric of a typical unit illustrating constituent systems, programmatic spaces and local context. The contoured xeriscape is a highly integrative landscape incorporating shared infrastructural elements. The diagram at left demonstrates the performance of the canopy skin that dynamically adjusts to maximize shade and solar energy and water collection.

right: Strategies of unit aggregation relative to prevailing seasonal wind directions and solar orientation. The resulting group configurations produce various housing typologies.

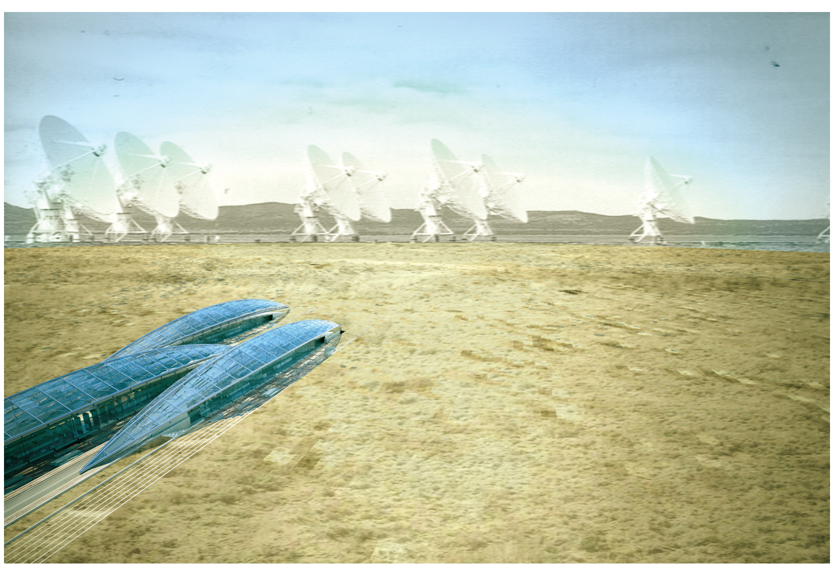
next spread: Plans at each of the unit's three levels: the dugout, where daytime activities such as food preparation and dune buggy repair can occur in a naturally cooler environment; the growing terrace, ideally suited for gardening and other leisure activities; and the sleeping tent, for most cool, night-time functions such as astrological observation.

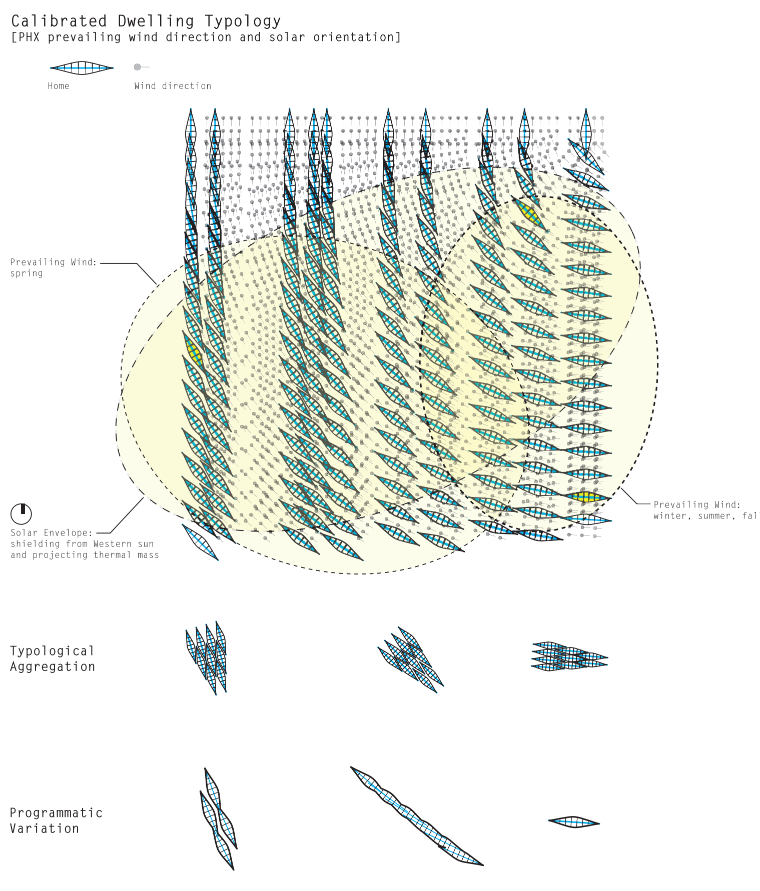


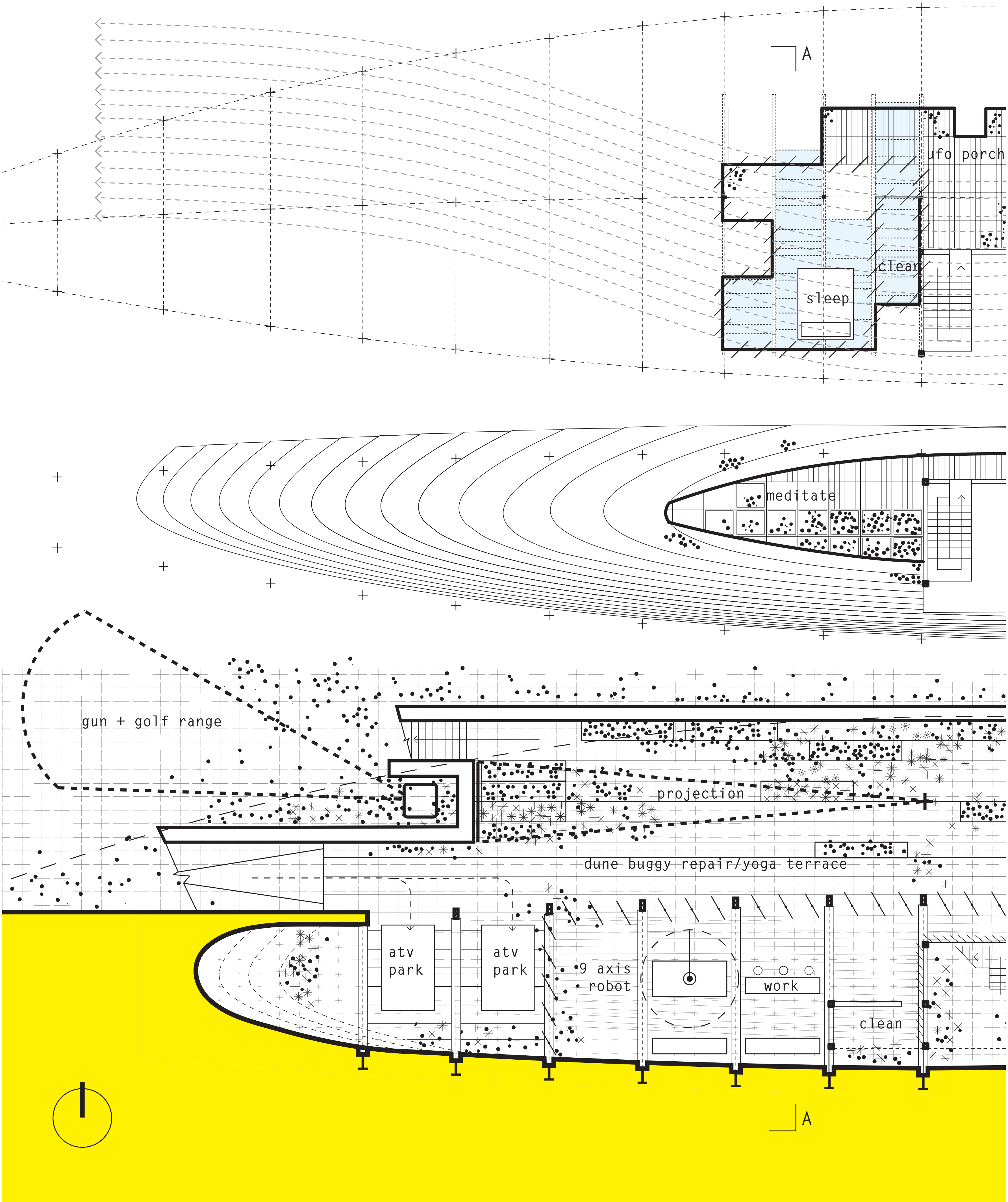
Counter to current trends in desert suburban development, Xerohouse is a porous, permeable, and evolving habitat in sync with its surroundings; hyper-situated, indigenous, and local, yet responsive to larger weather and climate patterns. It responds to the DNA of the desert: wind direction, solar orientation, temperature, and sand, while attempting to reconcile two antithetical and disparate conditions of modern desert living: extreme climate and extreme sprawl.

Xerohouse combines two archetypal desert typologies: the dugout and the tent. The dugout is stable; burrowed into the ground, taking advantage of passive thermal mass and encapsulating the daytime living programs that require cooling. The tent is flexible; suspended above, holding the sleeping quarters and a complex roof system that adjusts to cool or heat the house as needed. Between the two is an interstitial zone which allows for maximum air flow, accommodates the growing of food, and provides a shaded exterior space for leisure. The roof, designed to adjust to the prevailing seasonal solar orientation, opens to allow breezes to course through while closing down during the warmest parts of the day to protect the spaces within. Faceted roof channels distribute seasonal rains towards the communal underground storage tanks beneath the street. Arrays of small, spiky panels (similar to desert microphyllous leaves) prevent overheating while promoting self-shading through their size and overlap.

Xerohouse is a mutable residential unit that aggregates to form a colony of desert dwellings. The prevailing wind guides their primary orientation and provides passive cooling and protection from sand storms. Programmatic adjacency and solar






A
ufo porch
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gun + golf range
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dune buggy repair/yoga terrace
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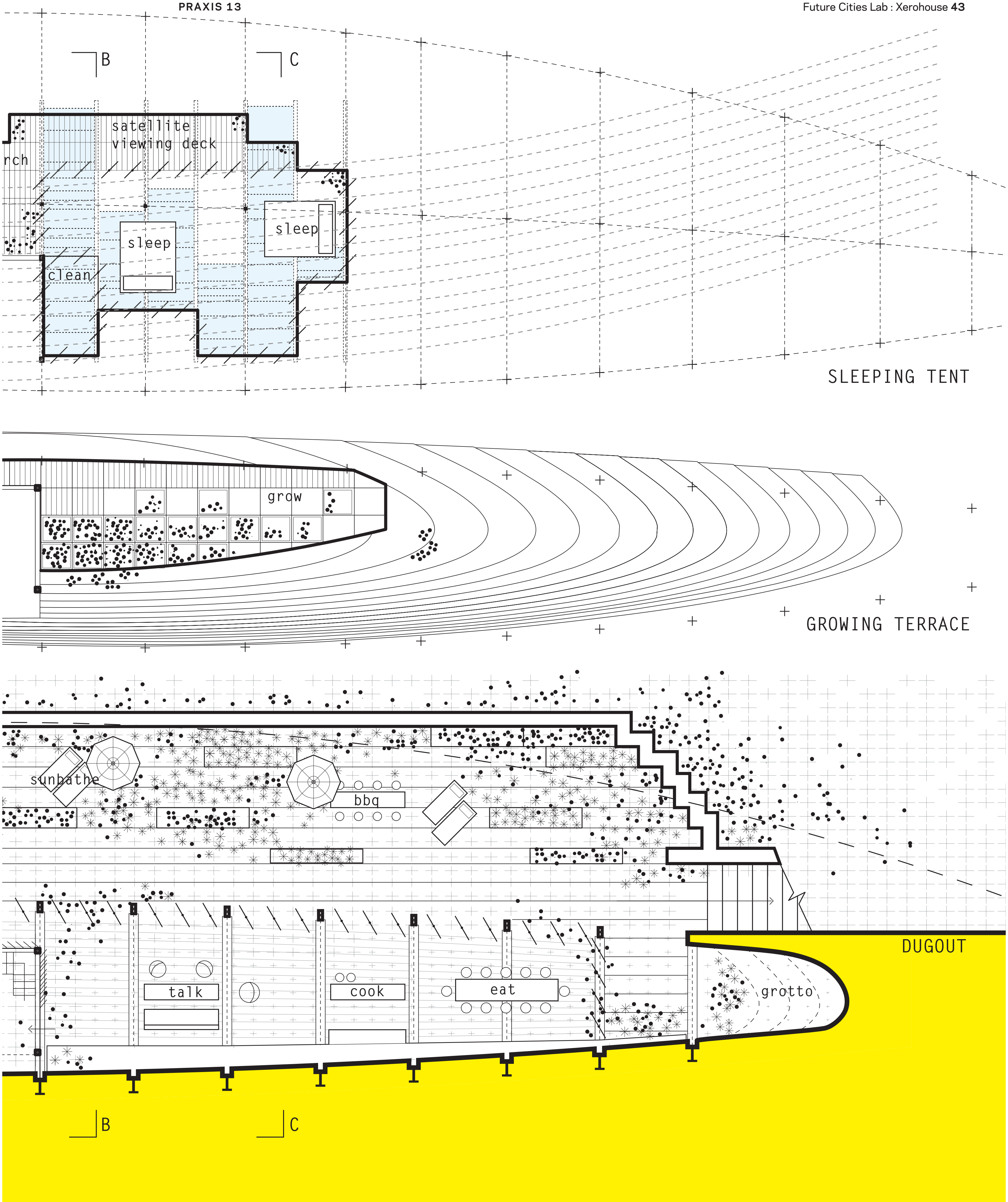
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left: Shaded side yard view with wind field beyond

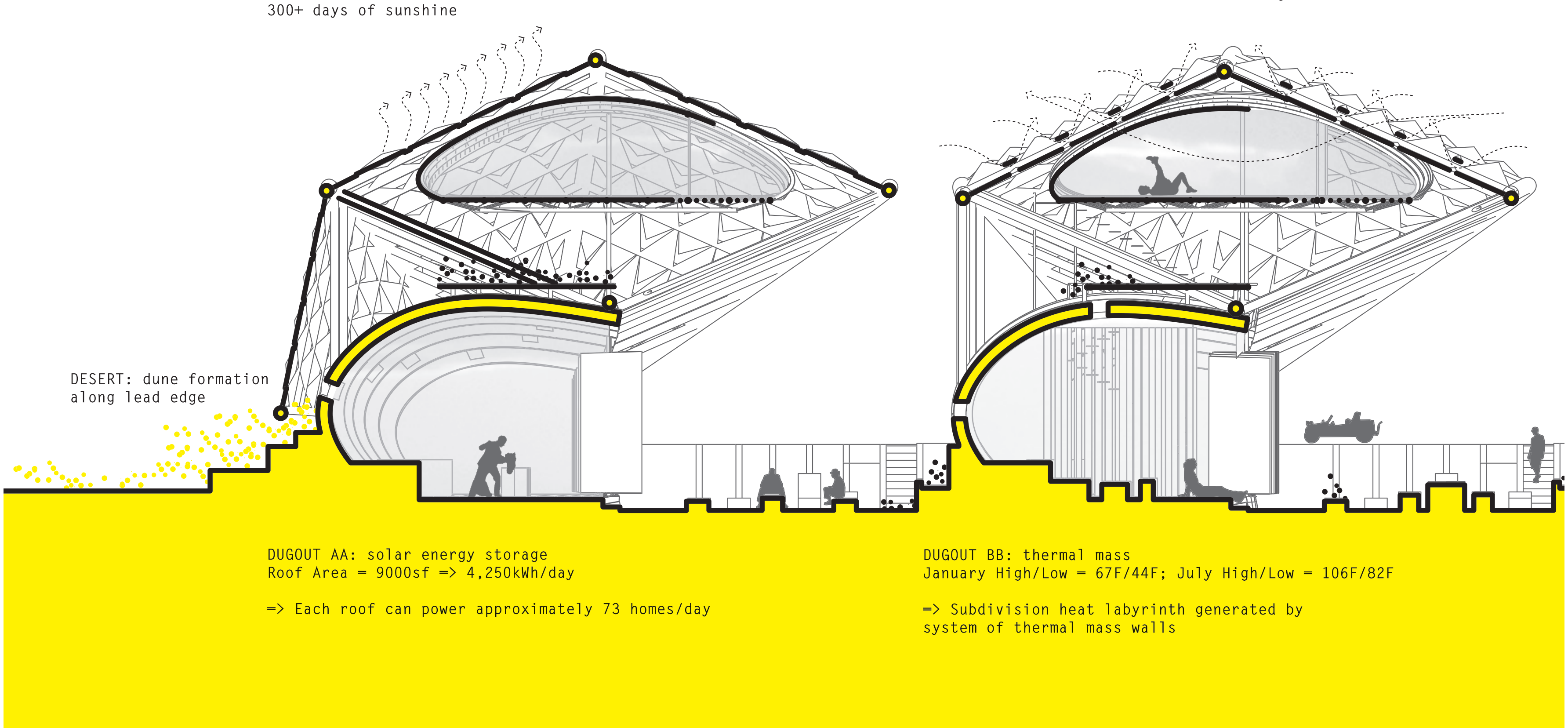
below: Transverse sections demonstrating various modes of occupation and aspects of temporal performance

Design Principals Future Cities Lab: Nataly Gattegno and Jason Kelly Johnson / **Design Assistant** Joy Wang / **Project Support** David Malda, Brad DeVries, Michael Hopkins, Jae Oh, Richard Tursky, Natalie Wiersma, the Taubman College of Architecture and Urban Planning and Tom Buresh / *for full project credits visit*: www.future-cities-lab.net

incidence provide further, more localized calibration. The built environment is embedded and subsumed; the desert landscape is intermeshed with hardscape, roads, and infrastructure while maintaining pathways for the movement of people, sand, and desert creatures. In a new suburban ecology, an otherwise gated, subdivided community is highly interconnected and infrastructural. Each roof collects solar radiation and water (both rain and dew), which is channeled through retaining walls to filtration systems and reservoirs laced beneath the streets to be used later for the courtyard gardens and food cultivation. Though each unit is programmatically independent, they collaborate to collect and share resources (water, solar energy) locally while protecting against the desert climate extremes.

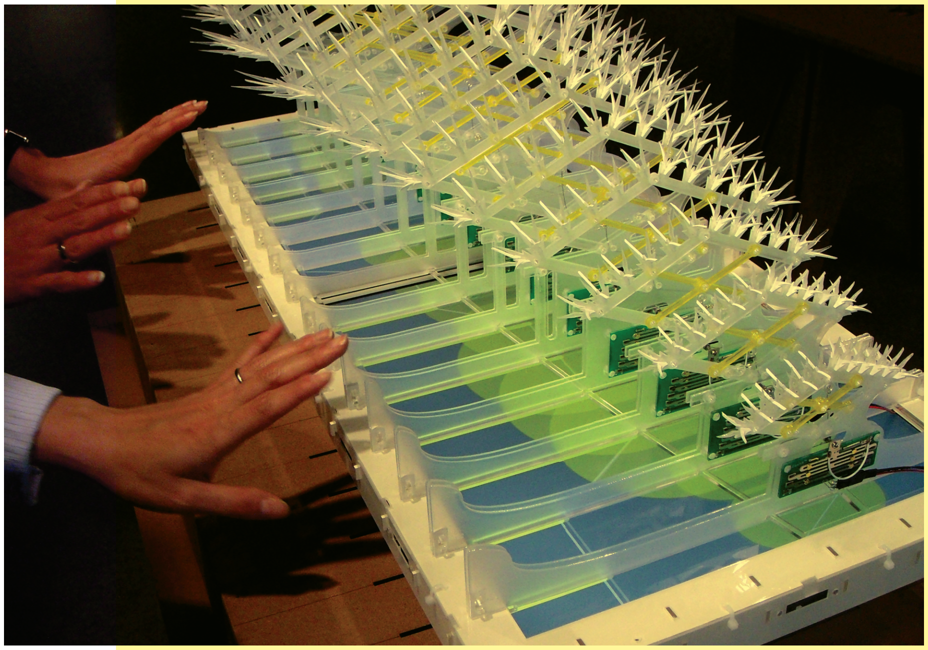
The scale of a suburban cluster as a whole is also calibrated and tuned; its infrastructure determined relative to local resource potentials. A temporal and ever-changing suburban landscape is checked by maximum and a minimum capacities, growing larger as resources allow and ceasing to sprawl thereafter. Growth is a strategically adaptive process of co-evolution; a mutable fabric with civic repercussions. No longer an isolated and independent entity, suburbia functions as a highly interdependent energy landscape where neighbors share more than a parti-wall or picket fence. The desert logics, the feedback loops between building and landscape, yield complex, ecosystemic frameworks for occupation.

—ANDREW COLOPY

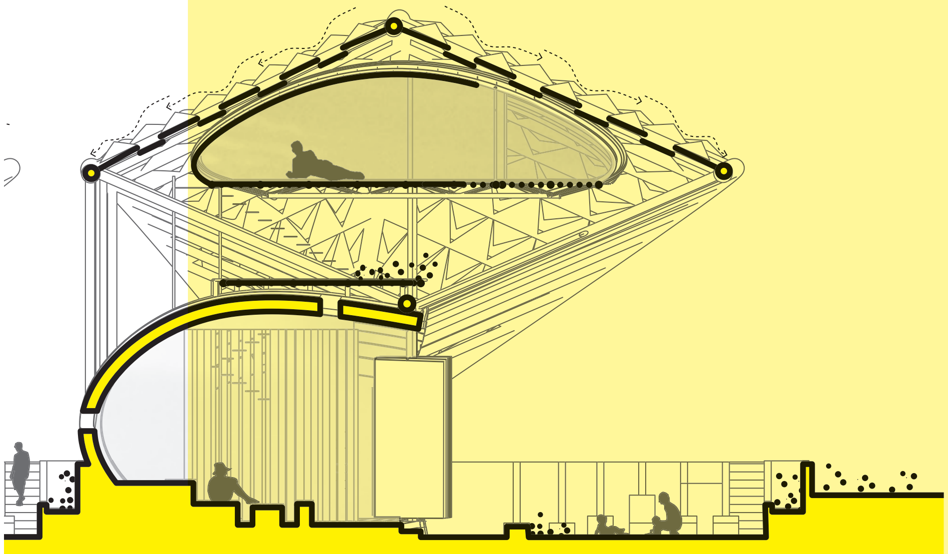


EXPERIMENTS IN LIVE MODELING

NATALY GATTEGNO + JASON KELLY JOHNSON



TENT CC: subdivision water collection system



DUGOUT CC: water reservoir
8"/year => Roof Area = 9000sf => 300 Gallons/year
Average annual household water consumption = 75,500 Gallons

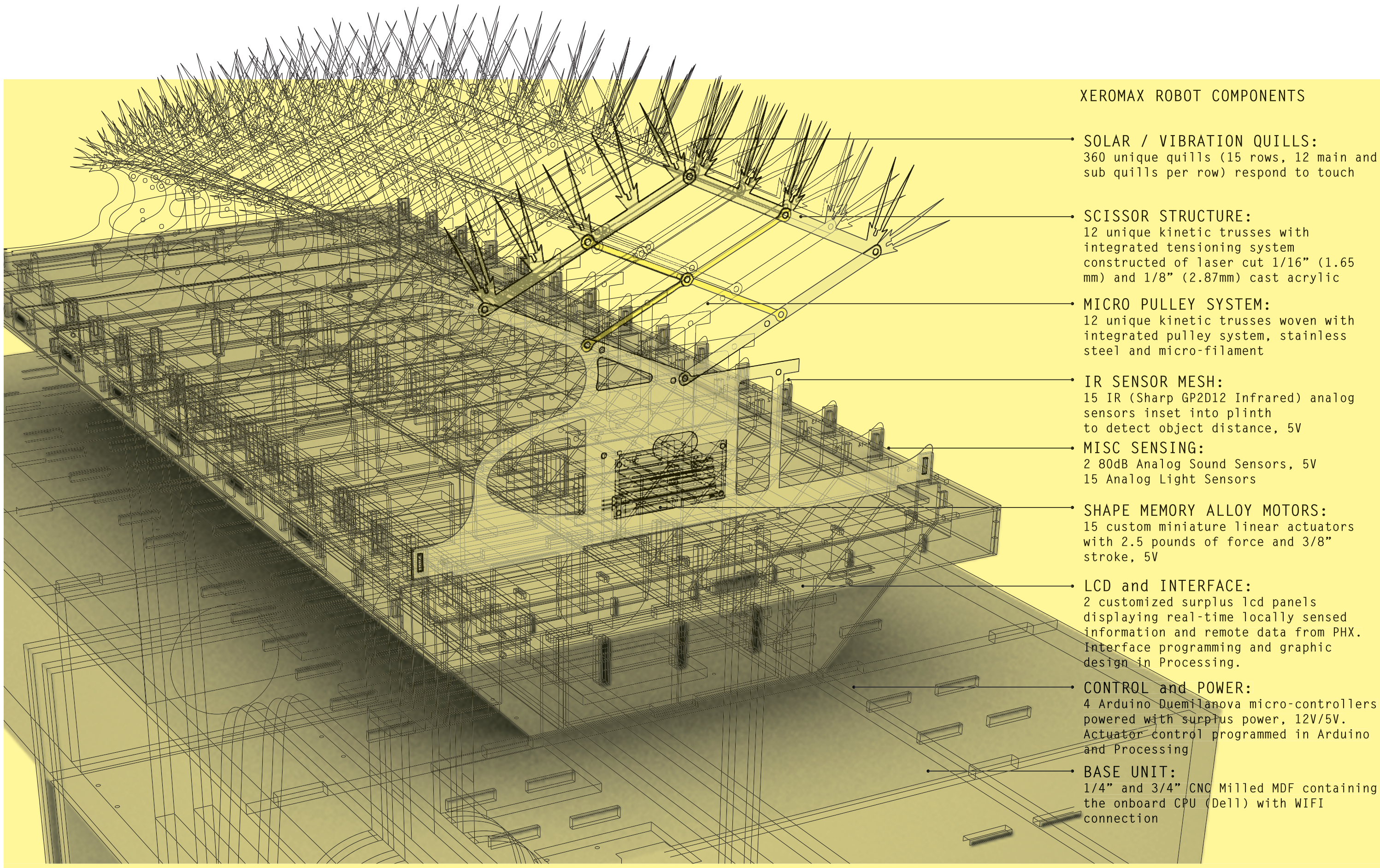
=> Subdivision reservoir system used for xeriscaping

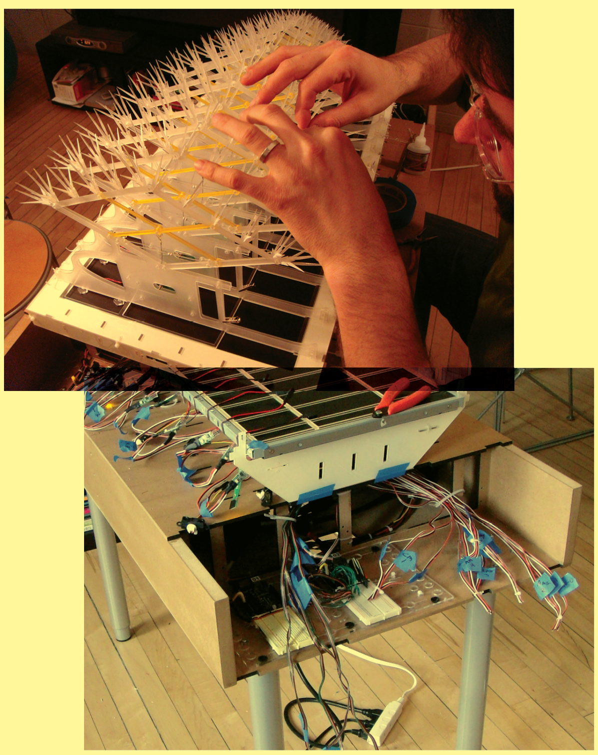
Live models are dynamic formations that sense, register, and continuously adapt to shifting atmospheric, microclimatic, and ecological conditions. They serve as analytical engines to understand the patterns and energies around us, and in some cases, as conceptual frameworks for experimentation and design. The most compelling do not merely depict the appearance of things, but reveal the irreducible nature and behavior of systems in transition. A fundamental shift is taking place as models are expected to perform as responsive, interactive, and intelligent participants of architecture and landscape ecologies. Activated by surrounding and intermingling energy fields and ecosystems, live models utilize sensors, actuators, and simple scripts to continuously adjust and regulate the complex and evolving variables of site, program, and microclimate.

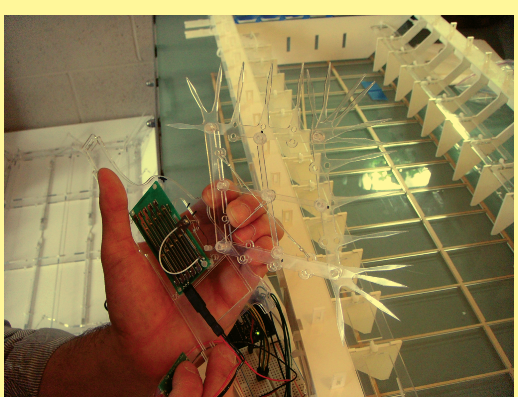
Etymologically, the word "model" is an auto-antonym, having two antithetical meanings. Models both represent a given condition and an exemplar or prototypical order. This duality is core to their operation, lending the ability to describe the nature of things while simultaneously revealing otherwise invisible conditions. This oscillation between analogical and ontological performance allows for the indexing and transformation of actual energies at play. Historian of science D. Graham Burnett suggests that, "... *what makes models so powerful is precisely the slipperiness of this distinction. The move from 'as' to 'is' can happen fast, can happen for only a moment, can subsequently be denied—it is in this instability, this indeterminacy, that models ultimately do their real work.*"[1] Live models thrive in such instability, reliant on existing forces and prevailing energies while flourishing in their unpredictable and blurred interpretations.

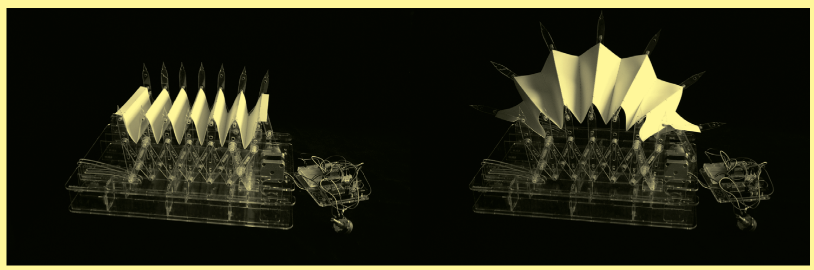
Orreries and astronomical clocks provide historical examples of this perceptual fluctuation. The gears and rotating orbs of orreries mechanically simulate the precise interactions of planets in the solar system while concurrently distorting and exaggerating spatial relationships such as position, volume, scale, and trajectory. They operate as dynamic models that allow users to see, experience, and juxtapose information from differing vantage points. Astronomical clocks powered by gravity further the slippage between the represented, i.e. simulated, and the ideal. Here, the applied forces are essentially 'live' and constant, and the system is limited only by the determinism of its motions and the mechanical friction of gears.

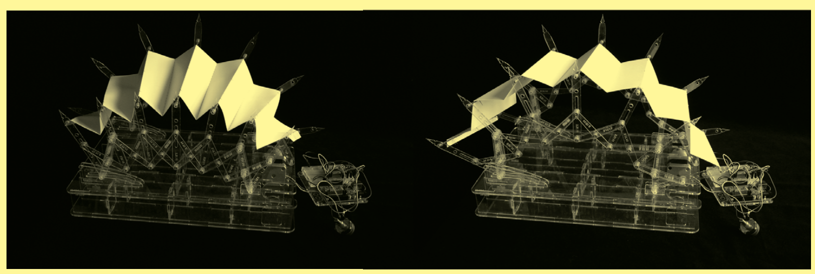
Contemporary examples, such as Sachiko Kodama and Minako Takeno's *Protrude, Flow*,[2] use a material's inherent properties to slip between analogical and ontological representations in a more fluid, immediate, and less prescribed manner. Protrude, Flow indexes the sonic energy surrounding an installation of ferrofluid, a liquid transformed in the presence of a magnetic field, with a











series of magnets that shape and pattern the material in relation to ambient sound levels. The ferrofluid does away with mechanics, instead representing energy exchange through the phenomenon of local magnetism while exposing the latent potentials within a material system.

As the examples illustrate, live models can be triggered by existing forces and energies that are both global—e.g., gravity or magnetism, and local—e.g., gears or magnets. Not only are they capable of calculating the underlying process logics, they represent phenomena and reveal emerging organizations of energy, form, and flow, in visually discernible patterns with occasionally unpredictable and surprising consequences. Such frameworks are highly integrated and constantly recalibrating relative to the ecosystems of which they are a part. They behave and evolve over time, are nimble and dynamic, temporal and multi-scalar. Regulated by processes of exchange that generate, consume, and distribute energy, they also delineate the direct relationship between energy and form; as such, live models constantly reconfigure themselves to manage energy through their formal structures.[3]

The ecosystemic logic of live models suggests a productive methodology for the design of buildings, landscapes, and cities. Rather than disconnected, impermeable, and fixed blocks of space, interconnected, porous, and elastic gradients are created and emerge. Environmental feedback loops learn, adapt, and evolve through time in response to surrounding energy fields and enable frameworks characterized not by figure-ground, but by the relationship between energy and form, and their co-evolution. Mark C. Taylor describes this co-evolutionary process as integral to the survival of complex systems: "For complex systems to maintain themselves they must remain open to their environment and change when conditions require it. Complex adaptive systems therefore inevitably evolve, or more accurately co-evolve."[4]

In general terms, ecosystems are defined by networks of agents that self-organize into complex hierarchies, patterns, and processes. The "-system" in ecosystem implies the importance of interaction among the parts.[5] The "eco-' in ecology connotes the structure and function of a collection of agents—whether microbes, particles, plants, animals, or emerging species of artificially intelligent beings—in relation to their environment.[6] Distinctly different from the evaluative term environmental, ecosystem ecology describes the behavioral logics of the system; the inputs and triggers versus the outputs and effects. Ecosystems are constantly confronted with a range of environmental fluctuations that vary transiently in magnitude and force.[7] Under these terms, conventional notions of scale are of negligible importance and are subservient to the interaction among constituent parts.

The aurora borealis demonstrates this multi-scalar interaction of components when flickering light is produced from the collision of highly-charged, solar particles with Earth's magnetosphere. In this process, a distant, vast, and otherwise invisible phenomenon is registered as a temporal cascade of light to those on the ground. The phenomenon describes a multi-scalar system, linking hyper-local and global territories through the behavioral logics of each component. Similarly, a live model uses sensors or remote feeds to register phenomena at multiple scales. The results are multi-scalar, dynamic cartographies that emerge latent with real-time data. Through immersive technologies, such cartographic models are rapidly becoming experiential worlds unto themselves. These dynamic, cartographic manifestations of energies and flows, parameters in flux, are in constant transformation and blur the distinction between models that merely depict, and those that create vital sensorial spaces, live and intelligent with fluctuating data.

The Xerohouse[8] robot (illustrated here) is a live model that blurs the boundaries between building and environment through the interplay of energy and form. Xerohouse is calibrated, tuned, and responsive to its desert habitat; reactive, mutable, and adaptable to the desert ecosystem. The model investigates how a responsive assembly might change shape and constantly negotiate the shifting energy cycles of its site for the harvesting of sun, wind, and water. It dynamically registers and adapts to the fluctuating energies and forces that surround it, and serves as a testing ground for understanding how its behavior might gain intelligence, complexity, and richness over time. The live model consists of a series of scissor-truss modules with integrated motors made of an ultra-thin, shape-memory alloy and embedded arrays of light. Infrared proximity sensors register local interactions and a customized, interactive, graphic display presents the fluctuating inputs. Xerohouse is part robotic structure, part experimental interface, and part analytical instrument.

The scale model responds in a material and an indexical manner. The roof trusses are designed to expand and contract depending on the values registered by the perimeter infrared sensors. The presence and proximity of an object to a sensor is representative of temperature and solar orientation. Once triggered, the roof structure contracts, reduces its exposure to the elements, and maximizes its self-shading capacity through the overlap of the roof thorns. Once the trigger is removed, the roof expands and allows for cooling breezes to permeate through the porous lattice. In correlation to this tectonic expression, a series of LCD screens display the varying inputs and generate a morphing energy datascape. As an indexical machine and an architectural framework, Xerohouse is a representation of the energy cycles and patterns surrounding the house. However, it is also a proposition for the possible material and sensorial performance of a desert habitat.

The Xerohouse live model offers an alternative vision of desert inhabitation. It explores issues of temporality, seasonality, change, and performance, through the experimentation of interconnected, complex, looped, and ecosystemic frameworks for design. Extreme environments, like the desert, are productive sites in which to test such models. They enable experimentation with minimum and maximum ranges of modulation so that the limits of such systems can be tested. Simultaneously, these extremes prompt us to critically rethink those environments and harness their inherent logics through the design of live models; models that recast the relationship between energy and form. Far from mere indexical devices, live models are dynamic architectural frameworks that are active, wild, and evolve over time.

NOTES

1–D. Graham Burnett, Masters of the Universe, in *Models: 306090 Books*, Vol.11, edited by Emily Abruzzo, Eric Ellingsen and Jonathan D. Solomon, New York: 306090, Inc., 2007, p.44. (emphasis added).

2–Troika: Conny Freyer + Sebastien Noel, Eva Rucki, *Digital by Design: Crafting Technology for Products and Environments*, Thames & Hudson, 2008, p.122.

3–For more on the concept of energy management see Cristina Diaz Moreno and Efrén Garcia Grinda, Energy Forms, in *Energies: New Material Boundaries: Architectural Design*, ed. Sean Lally, Wiley, London, 2009, p.78.

4–Mark C. Taylor, *The Moment of Complexity: Emerging Network Culture*, University Of Chicago Press, 2003, p.156.

5–Ferenc Jordán and István Scheuring, Network Ecology: Topological Constraints on Ecosystem Dynamics, *Physics of Life Reviews*, 1, 2004, pp.139–172.

6–Kevin Kelly, *Out of Control: The New Biology of Machines, Social Systems, & the Economic World*, Addison Wesley, 1994, pp.69–91.

7–S. A. Levin, The Problem of Pattern and Scale in Ecology: the Robert H. MacArthur Award Lecture, *Ecology*, 73 (6), pp.1943–67.