Pedagogical Experiments in Architecture for a Changing Climate

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ROUTLEDGE

7

LIFE SUPPORT

The Greenhouse as an Architecture of Survival

Daniel Jacobs and Brittany Utting

> *A pink glow washes the grid of numbered columns. Truss spans disappear against the blinding white surface of the roof, while a walkway network breaks the soft carpet of neon green seedlings below. In the distance, the only visible movement comes from the occasional flash of a worker's white lab coat. The volume of air is filled with the digital chirps of climatic sensors, punctuating the background hum of drones monitoring plant health.*

The contemporary industrial greenhouse is a sensing and sensorial machine: calibrating interior atmospheres, initiating thermal shifts, creating artificial suns, and adjusting fertilizer, water, and humidity. Through its climatic systems and chemical additives, the greenhouse and its sensing technologies abstract and simulate complex ecosystemic relationships to produce a perpetual growing season. Yet while these horticultural infrastructures are increasingly essential for global food supplies, their architecture reproduces many of the territorial conditions and extractive logics of global capitalism: colonizing landscapes, relying on fossil energy, and depending on waste-intensive processes.

Greenhouse infrastructures today are designed to operate as systems of production that can frictionlessly occupy any climate, deploying the scalar logics of expansion to engulf a landscape. Yet despite this tendency toward abstraction, the artificial environments of greenhouses remain characterized by profoundly haptic and sensorial conditions. These conditions are the by-products of the technical—yet intimate—labors of tending and nurturing: requiring the constant maintenance of heat, water, nutrients, air, light, and humus. Through this lens, such architectures offer alternatives to horticultural optimization, deploying new models of cultivation and care. Greenhouse technologies simulate living ecologies, producing aesthetic effects that directly tie a climatological condition to an experiential one, suggesting pedagogical formats that relate the human to the environment in new ways. This essay will explore how the greenhouse—as both

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an architectural type and technical form—can be reoriented toward projects of climate care and environmental pedagogy. To unpack this position, we will begin with an overview of the emergence of the long-span greenhouse and the reciprocal relationship between global horticultural markets and environmental technologies. We will then explore the large-scale interiors of the contemporary greenhouse and their effects on the organization of the city, its infrastructures, and its territorial expressions. Finally, we will shift to examine a series of case studies from both art and architecture that have retooled the greenhouse—its technologies, sensibilities, and ecologies—toward new forms of planetary care.

Captured Worlds

Mobilized by an emerging network of colonial extraction, the proliferation of greenhouse structures in the nineteenth century emerged from the reciprocal development of iron and glass building technologies and mechanized environmental systems. As European colonial empires accumulated land and dispossessed people for the extraction of wealth and natural resources, they built vitrines to house botanical spoils collected overseas. These collections developed alongside new architectural forms and environments for both cultivation and display. Long-span iron structures could accommodate large tropical trees imported from colonized lands and innovations in the production of curved glass sheets maximized the transparency of the enclosure, enabling captive plants to perform photosynthesis. With the rise of integrated hot water and steam-heating, central mechanical plants pumped water through extensive floor piping to simulate a constantly warm and humid tropical climate. This innovation made it possible to cultivate tropical plants in greenhouses, orangeries, hothouses, and winter gardens year-round despite the cold winter climates of northern Europe. Examples like the Palm House at Kew Gardens, designed by Decimus Burton and constructed by Richard Turner in 1848, were public vivariums that exhibited the living products of imperial accumulation, with the display of tropical plant specimens serving as a proxy for colonial power.[1]

Often situated in parks and gardens, these climate machines created an immersive nature, bringing the botanical spoils of empire to the public eye. Critically, the inclusion of "natural" environments such as greenhouses, parks, and gardens in the nineteenth century city also functioned as a release valve for the rising industrial working class: offering both a pacifying respite from the intense conditions of production as well as a space of social education.[2] Immersing visitors in a riot of palms, ferns, and orchids, this "theater of nature" fanned a type of collective fantasy and escapism, offering an alternative sensoria in the toxic and crowded spaces of the industrial city.[3] These captured worlds triggered intense public desires, leading to phenomena such as 'orchidelirium' and 'pteridomania' (or Fern Fever), when colonial plant hunting and importing was at its height.[4] These manias and deliriums combined with greenhouse technologies to also transform the space of

the home. Bay windows, sun porches, and hot-houses brought more sunlight into domestic space, permitting the indoor cultivation of imported tropical plants.[5] Enabled through empire, the profusion of tender "exoticks" in both the city and the domestic interior reflected an insatiable desire to produce a fragrant, sensual, and vital atmosphere.[6] These greenhouse systems and spaces directly tied the environmental conditions of a plant's survival to an emerging consumer culture, creating aesthetic and material sensibilities only possible through networks of colonial extraction and exchange.

The Planetary Greenhouse

Since the mid-twentieth century, these greenhouse technologies have evolved into a logistical landscape of horticultural production, emerging in concentrated enclaves around the world. Built on consumer desires for exotic plants as well as demands for off-season produce, contemporary greenhouse infrastructures form an unseen regional network that allows consumers to buy tomatoes in December and tropical flowers at any local grocery store. To supply a sharply increasing demand for stable food sources driven by both climate and population stressors, the large-scale greenhouse industry is projected to double before 2030.[7] However, the consolidation of horticultural production into regional distribution centers disrupts local food networks and increases reliance on food imports. Although such high-intensity production might be a necessary response to global food precarity, it serves to further abstract the relationship between consumer, producer, and environment. Indeed, these sprawling greenhouse infrastructures constitute a radical reorganization of both the countryside and the city.

For example, the province of Almería on the southern coast of Spain has become known as the Mar de Plástico—or "Sea of Plastic"—referring to the vast concentration of greenhouses blanketing the area. The vivid white landscape of plastic structures covers over 100,000 acres of land, reflecting so much light back into space that it actually cools the region.[8] It is among the largest aggregation of hothouse structures in the world: swallowing towns and the city of El Ejido, clinging to the Sierra Nevada mountains to the north, and stretching south to the Mediterranean coast. As Keller Easterling describes in her essay "El Ejido," these landscapes constitute a "plasticulture urbanism," a formless mat consuming all available surface area to capture solar energy for the plants housed within.[9] This "colonization of photosynthesis" is only possible owing to its position in an ideal climatic band of abundant sunshine with access to a rapidly depleting source of freshwater from subterranean aquifers.[10] In addition to cheap solar energy, this landscape relies on access to a heavily exploited labor force of North African immigrants who maintain the greenhouses, constituting another form of neocolonialism.

The traditional Almerían greenhouse type, known as the Parral, was first developed in the region in the 1960s by the Instituto Nacional de Colonización (National Institute of Colonization) for viniculture. These low-tech enclosures consist of a wood structure of columns and beams with plastic stretched over a flat

FIGURE 7.1 Aerial view of hothouses in Almería, Spain. Bernard Lang, *AV_MAR-PLASTICO_009*, 2014.
Source: www.bernhardlang.de. Courtesy of the artist

or low-sloped roof. Versions of this cheap and unconditioned Parral greenhouse still make up a large portion of the "sea of plastic," although more contemporary examples are being built, such as the multi-tunnel types which use simple steel structures with operable apertures and mesh ventilation.[11] These relatively cheap structures stand in stark opposition to the high-tech and ultra-calibrated hydroponic systems, chemical fertilizers, and nutrient-rich substrates within the

Almerían greenhouses, enabling the abundant production of year-round produce in what is effectively a desert. The scale of this landscape has drastic consequences on the ecosystemic health of the region such as increased soil salinity and desertification from overdrawing the aquifer for irrigation, pollution caused by the chemical fertilizer and pesticide runoff, and the immense waste of discarded plastic.[12] Even if this industrial landscape has reached peak productive capacity, it is still growing: a burgeoning copycat industry has emerged across the Mediterranean in Morocco, where land and labor is even cheaper than in Almería. The Moroccan production of hothouse agriculture (particularly in the Souss-Massa-Drâa region in southwestern Morocco) has outpaced that of Almería, indicating that the expansion of the desert hothouse is only just beginning.[13]

A New Sensoria

In The Netherlands, an industrial horticultural landscape even further abstracted from its climatic conditions has emerged. The Westland region of The Netherlands—within Randstad Megalopolis, south of The Hague—hosts one of the largest conurbations of high-tech, state-of-the-art greenhouses in the world. The urbanization patterns of the Dutch greenhouse landscape reflect a centuries-long process of land reclamation, or poldering, in which bodies of water are enclosed by networks of dikes and drained to create arable land. As researcher Leonoor Zuiderveen Borgesius observes, poldering effectively colonizes the sea to produce new land for settlement, increase food production, and create flood protections.[14] Originally, the small polder farms were created through a policy of land distribution for families of farmers. However, after years of neoliberal land governance, these farms have been consolidated into vast agricultural tracts owned and operated by large multinational companies. As architect and researcher Marten Kuijpers writes in *Automated Landscapes,* these policies produced a "kind of 'special economic zone'…with a separate energy grid, a segregated water structure, and a special zoning plan that is constantly adjusted to meet the wishes of the business within the zone."[15] In contrast to the loose and formless Almerían hothouses—whose semi-enclosed structures often conform to the non-orthogonal geometries of pre-existing settlement patterns—the Dutch greenhouses compose a rigid array of self-contained and tight-enveloped prisms gridded across the landscape. These vast greenhouses cover almost forty square miles of the Westland polders, feeding a global supply chain of vegetable produce, cut flowers, and ornamental plants. Critically, these policies of land reclamation come with social and environmental costs: poldering causes significant losses of biodiversity in the low-lying delta ecologies, and towns that were once dependent on fishing are now landlocked, devastating local economies.[16]

Unlike the "seas of plastic" in Almería and Souss-Massa-Draa, the climatic condition of the Netherlands is largely irrelevant to the growth of the plants housed within. The controlled atmospheres of the typical Venlo type Dutch greenhouse—steel structures featuring multi-pitched roofs with operable ventilation and horticultural float glass enclosures—can temper any local, seasonal,

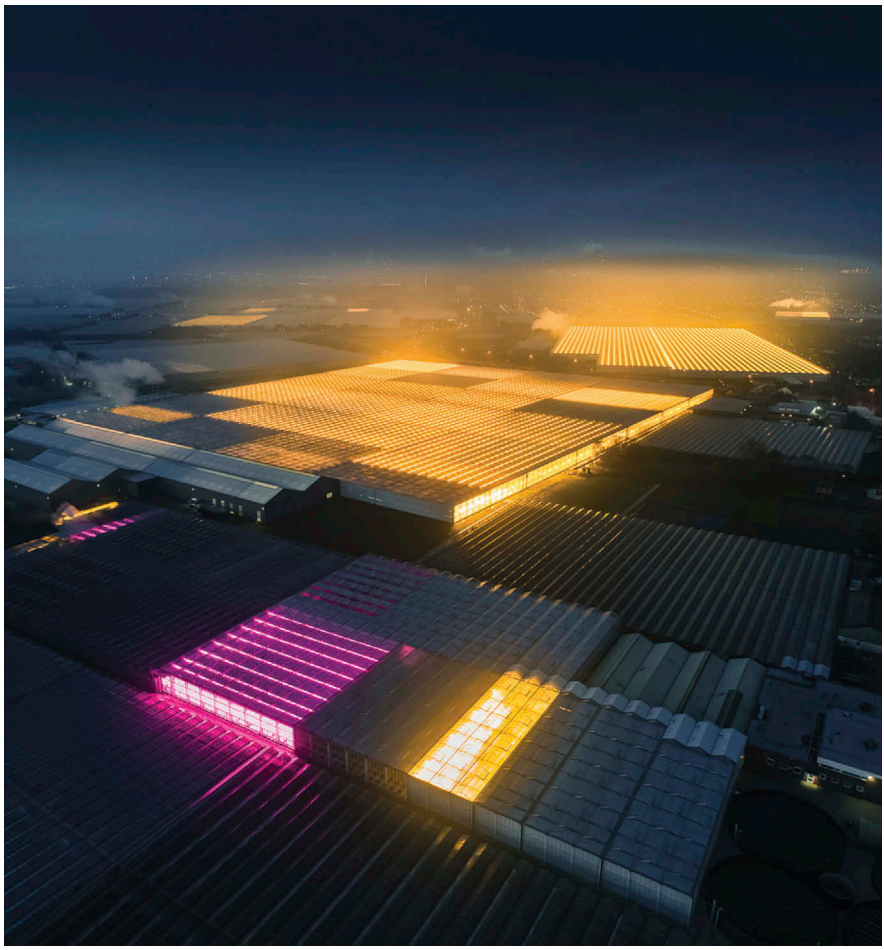

FIGURE 7.2 Aerial view of greenhouses in Westland, The Netherlands. Tom Hegen, *The Greenhouse Series*, 2019.
Source: Courtesy of the artist

or climatic shift. Manufacturers of these technologies advertise that the spaces are rapidly approaching full-automation in an effort to increase resource efficiency and decrease labor costs (though in fact these production lines still require human labor, often provided by migrant workers).[17] These systems deploy total systems integration within the greenhouse: pink grow lights produce a perpetual state of photosynthesis, hydroponics optimize water usage, and integrated sensors autonomously monitor the environment.

Unlike local forms of food production that are tied to seasonal variations, these horticultural infrastructures abstract climatological conditions. As architect Marina Otero Verzier argues, these spaces are "Cartesian Enclosures" in which

"data, technology, and energy fuel the maximization of the land for year-round crops."[18] The latest generation of greenhouses incorporates automated logistics platforms that provide full biological, computational, and climatic control: integrating drones, sensors, and mechanical systems to analyze plant health and calibrate growing conditions.[19] Although optimized for efficient usage of land, water, and fertilizer, these high-yield grow spaces are energy-intensive and rely on global distribution networks, contributing a significant carbon footprint and also disrupting regional food systems.[20] Operating as closed-loop, packaged, and marketable products, these architectural systems are ready for export to other global players keen on developing their own horticultural industry in regions lacking the consistent sunshine of Mediterranean climates.[21]

Not only do these greenhouse systems affect the ways that we measure, calibrate, and organize our environments, they also simplify the complex metabolisms of an ecology into a reductive and proprietary system of control. They create the illusion of abundance, hiding the environmental and social costs of such forms of production. Corporate controlled and privately produced, these proprietary systems contribute to the further loss of food autonomy: concentrating the means of food production into fewer and fewer hands while also rendering these conditions illegible to the consumer. Although environmental technologies have the potential to enable more nuanced and ecologically sensitive horticultural practices, their primary function is typically to optimize its interior ecology, creating a closed loop that serves hyperspecific markets. We argue that by instead framing the greenhouse as an active participant in the complex exchanges between the biosphere, atmosphere, and hydrosphere (rather than a space of environmental exception), this architecture has the capacity to cultivate new entanglements and sensibilities. How can we build on these sensibilities to reorient the colonial-capitalist tendencies of the greenhouse type toward more convivial environmental encounters and pedagogies?

Survival Tactics

Given that these increasingly closed, automated, and abstract worlds will continue to scale to fit the needs of the market, the following case studies sketch out alternative deployments of greenhouse architecture. As Anna Lowenhaupt Tsing writes in *The Mushroom at the End of the World*, "Scalability is not an ordinary feature of nature…It is time to turn attention to the non scalable.[22] Through this lens, these projects experiment with ways in which the sensorial conditions of the greenhouse—its temperaments and technologies—can challenge the scalar logics of industrial production. Take for example Mark Dion's art installation *Neukom Vivarium* (2006–) which deploys the greenhouse type to display the afterlife of a fallen Western Hemlock tree. Located on the southern corner of Seattle's Olympic Park, the greenhouse is an 80-foot by 30-foot tapered enclosure. Within the structure, the Hemlock nurse log completely fills the space, lying encrusted with a rich carpet of ferns, fungi, lichen,

liverworts, mosses, beetles, snails, and worms. The green glass of the enclosure mimics the light levels of the forest, creating an ideal habitat for plants and insects to participate in the decay process, creating soil and nutrients essential to the life of the forest floor.[23] The construction of the artwork allows visitors to understand the ecological exchanges of decay through framed views of the soil substrate, vitrinizing the process in glass. The architecture houses an infrastructure of environmental systems that replicate the natural processes of the ecosystem. Dion describes the project as follows: "We're putting [the fallen tree] in a sort of Sleeping Beauty coffin, a greenhouse we're building around it. And we're pumping it up with a life support system—an incredibly complex system of air, humidity, water, and soil enhancement—to keep it going."[24] Accompanying the project is also a field guide to the *Neukom Vivarium*, documenting the processes and socio-ecological relations of the project. Produced by the artist and curators, it describes the site's natural history and speculative climatic future, the flora and fauna active in the space, the nurse log's life history, as well as biographies of important naturalists. Critically, it shows that the project is not only about the end state of the log in its vivarium, but rather about the process that unfolded in laying the nurse log to rest.[25]

FIGURE 7.3 Mark Dion, *Neukom Vivarium*, 2006. Mixed media installation. Greenhouse structure length: 80 ft. (24.38 m). Gift of Sally and William Neukom, American Express Company, Seattle Garden Club, Mark Torrance Foundation and Committee of 33, in honor of the 75th Anniversary of the Seattle Art Museum, 2007.
Source: Paul Macapia. Courtesy the artist and Tanya Bonakdar Gallery, New York/Los Angeles

Part laboratory and part mausoleum, the *Neukom Vivarium* reorients the technologies of the greenhouse away from production toward the cultivation of decay: a living process essential to ecosystemic health. As curator Ruth Erickson writes about the project: "A vivarium encloses life—its very name comes from the Latin *vivere*, to live—to display its complexity and beauty, thereby cutting off the living contents from their networked community and dismantling the very ecosystem essential to survival."[26] The greenhouse is transformed into a pedagogical landscape—creating a climate awareness that is "full of mourning and melancholy."[27] The sharp smell of decay and the greenish gloom of the space transforms the greenhouse into a proxy for the forest ecosystem. The environmental technologies within the space are rendered legible as a life support system for a precarious planet. By playing host to this mourning process, the project introduces a new mood into the technical space of the greenhouse, reorienting its Victorian sensibilities and technical apparatuses to engage with environmental loss as a profound yet sensuous experience.

While the *Neukom Vivarium* deploys the greenhouse to cultivate a state of decay, artist Michael Wang's ongoing project *Extinct in the Wild* (2014–) uses greenhouse architecture and environmental technologies to display and care for plants and animals no longer found in the wild. Displayed at the Fondazione Prada in 2017, the project takes the form of a series of greenhouses, grow tables, and tanks that house a number of precarious species. Constructed using simple aluminum structures with a glass envelope, each greenhouse is equipped with a grow light infrastructure to maintain ideal living conditions for the transplanted organisms. The flora and fauna chosen by Wang—including the Vulcan Palm of Hawaii, the Axolotl of Mexico, the Red-tailed Black Shark of Thailand, the Parrot Beak Lotus of the Canary Islands, and Namibia's *Lithops werneri* succulent, among others—only exist in captivity, often bred as pets or houseplants. The gallerists were trained to care for the organisms, participating in the systems of human dependency and exchange required for each species' survival. As Wang writes, the project "became a kind of life support system—or ark—for these species, which survive only through human intervention. Curation was returned to its ancient root in *cura*, meaning care, extended here not to objects of art but to living matter."[28] More nuanced than a simple critique of anthropogenic climate change, the inclusion of the labors of tending and care within the gallery reflects the increasing entanglement of human and non-human forms of life. By using readily available materials and easy-to-acquire species, Wang points to the surreal banality of extinction: not a singular event but a slow and everyday violence. As Joanna Zylinska writes in *Nonhuman Photography*: "if we are to devise a truly cosmic political project—for the humans of here and now, but also for their human and nonhuman descendants—we need to force ourselves to combat our cognitive and sensory limitations in order to grasp extinction not just as a concept but also as a set of material conditions."[29] Wang's project does just that: transforming the experience of extinction—and the deteriorating forms of survival—into legible experiences that are both intimate and technical. While these greenhouse habitats

FIGURE 7.4 Michael Wang, *Extinct in the Wild*, 2017. Living organisms, lights, substrate, aluminum and glass enclosures at the Fondazione Prada, Milan.
Source: Photographs by Delfino Sisto Legnani and Marco Cappelletti

serve as critical life support systems for the organisms, they also represent the inadequacy of these environments for species preservation. While *Extinct in the Wild* makes visible the increasingly melancholic practices of care in the Anthropocene, the architecture also gestures toward a time of future replenishment.

FIGURE 7.5 HOME-OFFICE (Daniel Jacobs and Brittany Utting), *PALM-HOUSE*, 2020. Renderings of palm houses, printed on plastic and mounted in an aluminum structure.
Source: Courtesy of the artist

Finally, *PALM-HOUSE* (2020–21) by HOME-OFFICE, a research and design collaborative led by the authors, reimagines the greenhouse architecture of an ancient palm tree.[30] *PALM-HOUSE* explores what it means to preserve a single organism, redeploying greenhouse technologies to propose new life support systems in a changing climate. Displayed in the Citygroup Gallery in New York City, the project is a speculative design proposal for the Orto Botanico, a teaching garden and herbarium in Padua, Italy. Since its founding in 1545, the garden's plant and herb collection has been used to train students to identify species for medicinal and therapeutic remedies.[31] Also within the Orto Botanico survives the oldest of the garden's specimens: a 450-year-old Mediterranean Fan Palm indigenous to southern Europe. This particular palm is known more famously as "Goethe's Palm," serving as an inspiration and subject for Johann Wolfgang von Goethe's 1790 essay *The Metamorphosis of Plants*. In this proto-evolutionary text, Goethe argues that a plant's form is produced through the tension between its internal morphology and its external environment. Through direct observation of the palm, Goethe expanded theories of botany to include a plant's habitat such as climate, soil composition, and water availability, setting the groundwork for future theories of ecology.[32] Over the years, university gardeners have constructed a series of temporary (and ultimately permanent) greenhouses to both shelter and display the palm. These experimental structures serve as an index of the cultural importance of the palm: a unique historical artifact deemed important enough to protect.

Continuing these four centuries of preservation and pedagogy, *PALM-HOUSE* proposes three future prototypes to house this specimen. While greenhouse architectures often represent a problematic conflation of colonial extraction and ecological optimization, these prototypes instead make visible the environmental disruptions of climate change that threaten the future survival of the palm. Each of the three prototypes subtly mediates the palm's environment, deploying the tectonic and environmental systems used in greenhouses to bring into focus the conditions required for the palm's future survival. For instance, the structures allow caretakers to adjust air schedules, curate atmospheric compositions, filter pollutants, and balance ultraviolet radiation. They incorporate motorized filtration panels, mobile grow light walls, solar shields, and pneumatic tubes expelling gaseous mixtures, protecting the palm from the increasing frequency of heatwaves, cold spells, droughts, toxic clouds, and extreme rainfall events. Critically, these enclosures are not closed worlds creating ideal interior climates. They allow pollinators, atmospheres, and the increasingly hostile environment to continue to shape a living organism. *PALM-HOUSE* reimagines the historic preservation of a plant—not through the recreation of a past climate but instead through a demonstration of the life support systems necessary for its future survival. Fundamentally, the project asks: In the face of extinction, what are the costs, means, and methods of perpetual care?

Pedagogies for an Experimental Vivarium

By positioning these environmental systems and architectures within the space of the public gallery, each project performs as a pedagogical instrument to render visible the precarity of organisms and their habitats. Dion's *Neukom Vivarium* cultivates decay as a lively process; Wang's *Extinct in the Wild* reveals the precarious balance between extinction and human dependency; and *PALM-HOUSE* explores preservation tactics for future climates. As both the cheap hothouse structures of Almería and the automated systems of Westland reveal, the greenhouse and its technologies tend to empty a landscape of its complex urban and ecosystemic conditions, replacing it with an over-simplified interior world. These three case studies instead seek to détourn greenhouse technologies and their scaling logics, creating intimate and sensual environments characterized by empathy and encounter. By redeploying the aesthetics of the greenhouse—luminous, technical, and machinic—toward a new political condition, the projects center the reciprocity between technologies of cultivation and ecological loss.

How can design pedagogy reimagine environmental systems and their relationship to climate change beyond solutionism? While the call to design a vast greenhouse infrastructure to solve global food precarity poses a seductive architectural brief, it risks further dislocating humans from the spaces of production, creating abstract "seen-from-space" worlds that mystify the complex metabolism of nature. Questioning such techno-positive visions, architecture studios could instead design

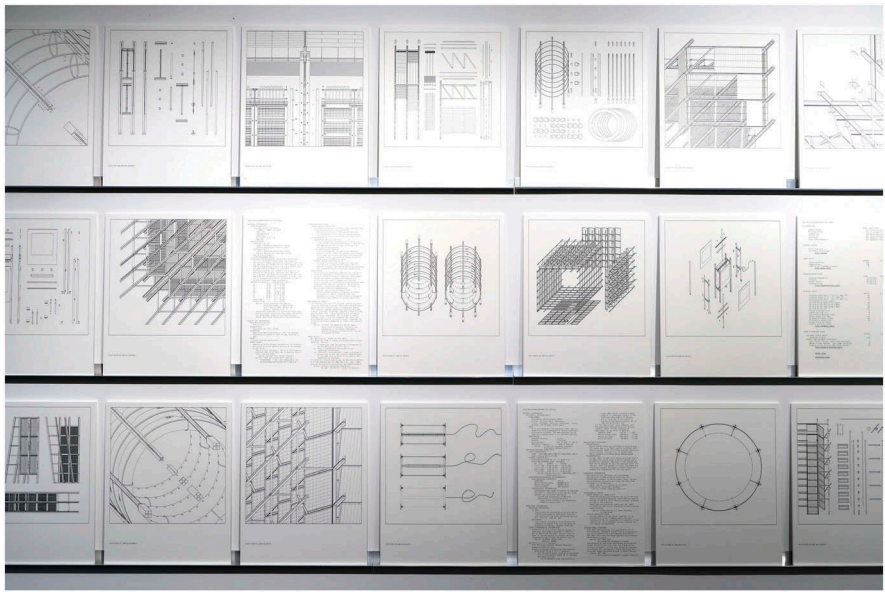

FIGURE 7.6 HOME-OFFICE (Daniel Jacobs and Brittany Utting), *PALM-HOUSE* (2020), Photo of Drawings, Courtesy of the Authors

experimental vivaria that more explicitly entangle humans with the machines, ecologies, species, and atmospheres that we rely on. Such constructs could complicate these spaces with programs that go beyond solving technical problems, creating open frameworks rather than closed worlds. The life support systems of a building could instead anticipate future climate and ecological conditions, rearticulating architectural enclosure and territorial scope to allow for environmental contingency, hybridity, and exchange. *Neukom Vivarium*, *Extinct in the Wild*, and *PALM-HOUSE* combine practices of multispecies coexistence with the technical systems of environmental care, reorienting the architectures of horticultural production toward a climate awareness. Likewise, an emerging generation of design pedagogies might ask: Can an infrastructure of environmental sensing and mediating machines more fundamentally reimagine the ways in which we live together? These new sensibilities could create a multitude of political, social, and ecological forms: from experimental design encounters to more collective modes of climate action and world-making.

Notes

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18 Marina Otero Verzier, "Cartesian Enclosures," *New Geographies* 12: Commons, ed. Mojdeh Mahdavi and Liang Wang (Cambridge, MA: New Geographies Lab, Harvard University Graduate School of Design, 2021), 44.
19 For example, Priva's PAR, or Photosynthetic Active Radiation sensor system constantly monitors the optimal light spectrum for photosynthesis and communicates with the mechanical systems of the architecture: automating shade curtains, CO2 diffusers, and lighting to reduce labor costs and optimize yields. Phenospex's PlantEye creates constant 3D scans of each plant, monitoring health through morphological and spectral analysis. These softwares allow growers to create data-rich models of the entire crop that integrate factors such as leaf area, projected biomass, and hue average into yield analysis software, calibrating the greenhouse's environmental systems, gantries, and sensor infrastructures.
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22 Anna Lowenhaupt Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (Princeton: Princeton University Press, 2015), p. 38.

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24 Mark Dion, "Neukom Vivarium," *Art21*, accessed September 14, 2022. https://art21.org/read/mark-dion-neukom-vivarium.
25 The field guide describes the Western Hemlock's origin in the Duwamish/Green River Watershed, the Muckleshoot tribe's rights over the land, the donation of the log by the municipally-owned utilities company Tacoma Water, the details of the process of lifting, transporting, and installing the log across the infrastructures of the city, and finally its tending by Dion and the cadre of scientists, environmental experts, scientific illustrators, and curators who made the project possible.
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30 The design and research team for this project included Daniel Jacobs (Co-Director, HOME-OFFICE), Brittany Utting (Co-Director, HOME-OFFICE), Jianing Cui, Leah Hong, Tiffany Xu, and Clara Núñez-Regueiro. The authors would like to acknowledge the support of the School of Architecture at Rice University and the Taubman College of Architecture and Planning at the University of Michigan in the realization of this project.
31 For more information on the design of the Orto Botanico, see Vittorio Dal Piaz and Maurizio Rippa Bonati, "The Design and Form of the Padua Horto Medicinale," The Botanical Garden of Padua 1545–1995 (Venice: Marsilio Editori, 1995).
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