The Convergent Workplace:
A Bamboo Factory in Aberdeen, Washington

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Abstract

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Since the Industrial Revolution, the relationship between human and work, landscape and production, has shifted immensely. The factory has reflected this shift in practice and in built form. The theorist Hannah Arendt posited that the experience of work in a factory has deteriorated due to division of labor, which replaces skilled, specialized workmanship with repetitive tasks performed by interchangeable people. Like the division of labor, factories have often been removed from the elements that shape production – design, research, landscape, and community – and which in turn are impacted by it. Yet, as the site of production, the factory is a prime opportunity for collaboration, innovation, and sharing of knowledge.

This thesis proposes a factory that reverses the physical division of labor, one in which activities, people, and landscape converge at the site of making. This convergent factory explores how architecture can reconfigure the relationship between people and the industrial workplace by promoting worker agency, interdisciplinary collaboration, and connection to landscape. The thesis investigates these possibilities through the design of a bamboo factory in Aberdeen, Washington. In a region seeking diverse, sustainable industry to regenerate its economy, the introduction of a new material challenges the existing paradigm of the industrial work setting while still offering elements congruent with local values.

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CONTENTS

1

INTRODUCTION

Since its appearance during the Industrial Revolution, the factory typology has reflected the relationships between people, work, nature, and technology that have been rapidly transformed by industrialization. Many modern architects saw the factory as a symbol of modernity, a place to experiment and innovate with the newest construction technology. Others sought to combat the notoriety of the factory as a place of environmental destruction and poor working conditions by designing buildings that merged with the landscape and offered amenities to workers. While these architects produced admirable works, this thesis suggests that factory design must also address the nature of work itself.

The theorist Hannah Arendt posited that industrialization caused a rift between two types of work, which she differentiated as "work" and "labor." Work is a fulfilling act with permanent impact on the real world, whereas labor is a repetitive activity done for self-sustenance. This difference was caused not by mechanization but rather by division of labor, which replaces skilled, specialized workmanship with repetitive tasks performed by interchangeable people.

Like the division of labor, factories are often physically divided from other stages of the production process - design, research, landscape, and community - which in turn are impacted by it. Yet, as the site of production, the factory is a prime opportunity for collaboration, innovation, and sharing of knowledge. Additionally, it is an opportunity to iterate the link between natural materials and the built world, as the factory is the place where one is transformed into the other.

This thesis proposes a factory that reverses the physical division of labor, and that brings together activities, people, and environments to converge at the site of making (Figure 1-1). This convergent factory will explore how architecture can promote collaboration and agency in work, and establish relationships between workers in various disciplines, local communities, and the landscapes they rely on.

The Pacific Northwest offers an ideal location for such a project. The long-established timber industry in this region has

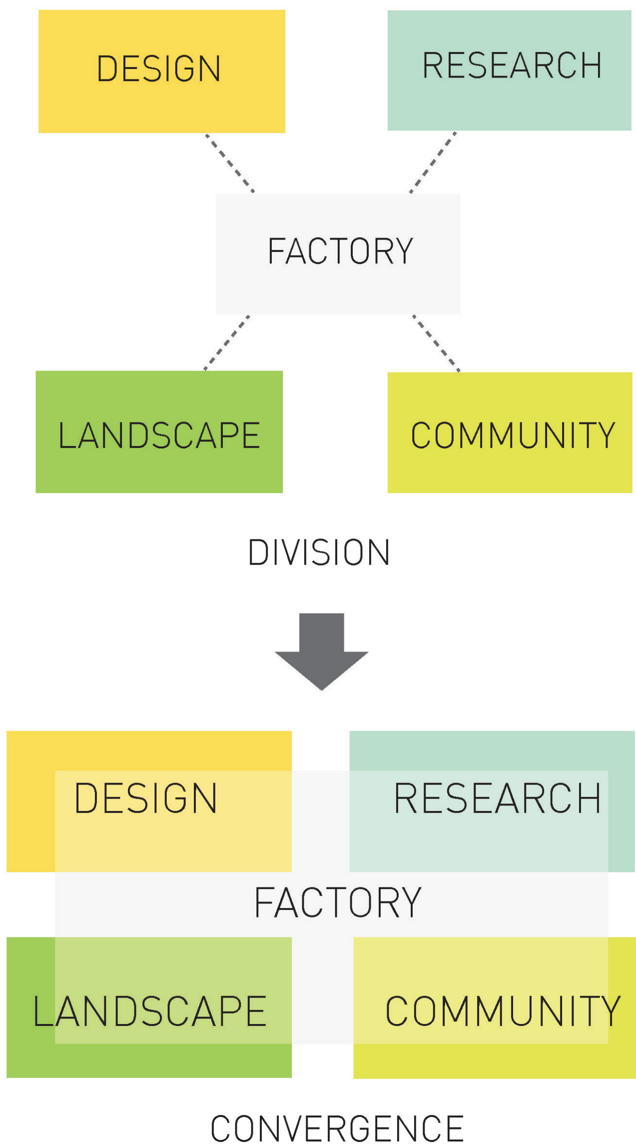

Figure 1-1. The proposed factory design is based on the concept of convergence of programs, activities, and knowledge as a means of fostering fulfilling work.

shaped a community skilled in woodworking and silviculture. This context in which the lives of workers was deeply connected to the landscape fostered a mindset Steven Beda terms "working-class environmentalism," referring to how timber laborers recognized the balance between resource extraction and respect for and conservation of natural landscapes.[1] However, the Pacific Northwest still faces the repercussions of the decline of the timber industry, and many rural timber towns are searching for new, diverse industries to boost their economies.

Bamboo offers a sustainable, versatile material with great potential as the basis for industry. Today, bamboo is drawing increasing interest across disciplines as a rapidly renewable, highly versatile material. Over 1,300 species of bamboo grow in temperate and tropical climates, and the plant can be used in myriad ways. Traditional uses across the globe include food, weaving, household goods, and building with whole poles. Today, new building technology and experimentation has pushed the possibilities of bamboo even further to include laminates, composite materials, new joinery techniques, and contemporary design (Figures 1-3 and 1-4). Once known as the "poor man's timber," the impressive strength and sustainability of bamboo has recently earned it the

Figure 1-2. Bamboo grove in Mishima, Japan.

Figure 1-3. "Bamboo Cell" stool by Fanson Meng

Figure 1-4. Markus Heinsdorff, German-Chinese House, Shanghai World Expo, 2010.

title of "the new green steel."[2]

The primary program of the bamboo factory will include a production floor for manufacturing bamboo panels and finishes, a workshop for the development of handcrafted pieces and prototypes, a research laboratory for the investigation of new material applications and capabilities, and a greenhouse for research on the growth of bamboo in the region. It will be located in a test grove that will evaluate bamboo growth on a large scale, provide material for the workshop, and form a natural setting for the enjoyment of employees and the local community.

A bamboo factory in the Pacific Northwest will at once challenge the existing paradigm of the factory while also offering a program consistent with regional values. Introducing a new material to the region requires an integrated program of research, design, and collaboration. It requires skills in woodworking and silviculture, which already exist in the region. Bamboo also offers a mutually beneficial relationship between work and the landscape, which speaks to the existing culture of working-class environmentalism.

The design proposal of this thesis will examine how architecture can bring these programs together and foster an environment of collaboration, innovation, and agency, all of which contribute to a connection to landscape and a fulfilling work experience.

2

FACTORY

The appearance of the factory type heralded a new age of industrialization. It was one of many new building types that came with the technological advancements of the Industrial Revolution. From the mid-1700s to the mid-1800s, steam power and new machine tools transformed industries throughout Europe. What had once been the work of skilled craftspeople using hand methods became the work of machine assembly lines, where the division of labor reduced worker activities to monotonous tasks requiring little skill. These new industries also instigated large-scale environmental pollution that continues to this day. As the center of production and utilization of new technologies, the factory was the building type most characteristic of the age. Moreover, the factory played a key role in the dramatically changing relationship between nature and humankind, work and worker. Industrialization distanced people from nature and appropriated workers into machine assembly lines.

Factory buildings themselves articulate an attitude towards industrial technology and labor. Factory buildings can convey authority and hierarchies of power and express the value - or lack thereof - of the employees in the building. They can be testing grounds for new building technology, pushing limits and exploring possibilities of new building materials. They can be experiments in architectural styles, which can conceal the building's utilitarian purpose behind ornamented facades or express and celebrate its functional program. They have alternatively been viewed as a sublime part of a landscape, a blight on the built and natural environment, a beacon of technological progress, a den of inhumane working conditions, and a model for modern aesthetics. (Figures 2-1 through 2-12).

Many prominent writers of the mid-19th century had an unfavorable reaction to the changes in production caused by the Industrial Revolution. Augustus Pugin, John Ruskin, and William Morris lamented the decline of hand-crafting and -building methods that led, in their view, to the degradation of societal values. They advocated a return to traditional ways and modes of building as a solution to societal ills.

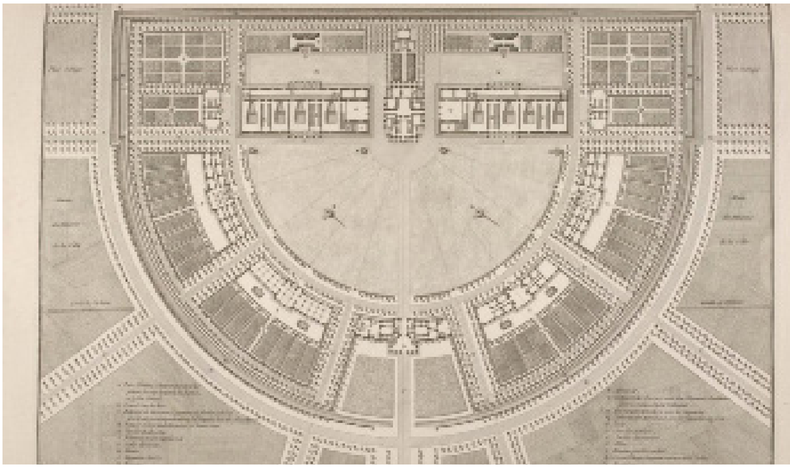

Figure 2-1. Plan of the Chaux Saltworks, Claude Ledoux, 1806. The plan reflects the hierarchy of the workplace and the authority of the French government. The Director's house sits at the center of the semi-circular complex, where it has watchful authority over the saltworks, which flank the house, and worker housing along the perimeter.

Figure 2-2. *The Ironworks at Coalbrookdale*, Philip James de Loutherbourg, 1805. This print was made as a souvenir for visitors to the plant. At the time, factories were seen as an awe-inspiring symbol of technological achievement and a sublime part of the scenery.

John Ruskin published his most well-known work *The Seven Lamps of Architecture* in 1849. In the chapter titled "The Lamp of Life," he bemoans the effect mechanized means of production had on the worker and the craft of building. Ruskin declares that the beauty of architecture depends upon "the vivid expression of the intellectual life which has been concerned in their production."[1] That is, the spontaneous ideas and emotions of the worker manifest themselves in subtleties and irregularities in work built by human hands, something that cannot be reproduced by mechanical means. The same materials, worked according to the same design, will be successful if shaped by thoughtful craftspeople who enjoy their work, but unsuccessful if manufactured by a machine or by a worker who is not invested in their work.

Ruskin later elaborates upon this comparison between the machine and the joyless worker. He argues that replacing human labor with mechanized processes deprives the worker of knowledge and personal joy. Ruskin differentiates between work necessary "for our bread" - what Hannah Arendt would later call "labor" - and work done for "our delight ... to be done heartily"[2] as part of a fulfilling life. In Ruskin's view, both the product of craft and its maker benefit from a manual fabrication process.

Figure 2-3. The Glasgow Carpet Factory, James Templeton, 1889. The lavish ornament was meant to evoke the similarly decorative carpets that the factory produced, and thus the factory building itself served as an advertisement for its product. Factories of this period often used historic styles of decoration on the new typology. Templeton based the facade design on Ruskin's drawings in *The Stones of Venice*.

Figure 2-4. Albert Kahn, Packard Plant #10, Detroit, 1903. In contrast to the Glasgow factory, Kahn believed that a factory should express its utilitarian function. Kahn's firm avoided hiring architecture graduates to maintain this non-decorative aesthetic.

William Morris, an English designer and writer, applied similar ideas to his work in the Arts and Crafts movement. Like Ruskin, Morris felt that the quality of craft was reliant on the contentment of craftspeople. For Morris, the betterment of society would be achieved through a socialist ideology which valued the worker and improved quality of life for the working classes.[3]

In his vision of the ideal factory, Morris describes a place where the building expresses the value of workers and its program and contributes to the happiness of the whole community. This factory would be a Utopian place in which workers would enjoy mastery of their craft and have ample opportunity for leisure and education. He describes the factory as situated in a vast garden where workers could relax and enjoy fresh air, greenery, and outdoor pastimes, including gardening. The industrial processes would not emit any pollution into this ideal landscape.

In order to make work enjoyable, Morris allows for machinery to replace the more tedious parts of labor. Still, these machines would not become a means of mass production for "profit grinding,"[4] nor would their maintenance become the primary activity of the factory workers. They would only be used to remove unpleasant tasks from the work flow. Workers would

Figure 2-5. Peter Behrens, AEG Turbine Factory, Berlin, 1907. This factory is sometimes called the first modern building, merging classical references with modern expression of steel, concrete, and glass. Behrens' work would have a profound influence on prominent modern architects such as Walter Gropius, Le Corbusier, and Mies van der Rohe.

Figure 2-6. Walter Gropius, Faguswerk, Alfeld, Germany, 1911. This building defined the modern "factory aesthetic." Gropius pushed the capabilities of new building materials, a feeling of weightlessness was achieved through expansive use of glass, and the corner showcases the cantilevered stair.

balance the less mentally demanding tasks of overseeing machinery with the more stimulating tasks of hand craft, each as a relief to the other.

Furthermore, this ideal factory would have ample amenities for its employees and for the public, including a dining hall, a library, a school, and study spaces, all decorated in celebratory ornament. These facilities would further the education of workers and the community, and provide spaces to be used for social gathering or cultural events. Morris stresses that the factory should be beautiful, but not in a way reminiscent of those which were heavily decorated by their owners to hide the miserable conditions within. Rather, the Utopian factory, as a center of fulfilling work, education, social gathering, and leisure, would be beautiful as an asset to a whole community.

Morris' ideas influenced many other prominent architects and artists, but his resistance to mechanized production did not survive in an increasingly industrialized world. Walter Gropius, German architect and founder of the Bauhaus school, at first adopted both Morris' ideas and his traditional methods but gradually adapted them to modern realities. Gropius maintained a foundation in craft but applied it to design for mass production: by

Figure 2-7. Giacomo Matte-Trucco, Fiat Factory, 1927. The Fiat Factory is a car assembly plant. The entire building is scaled to the size of a car, and they can be driven to any location in the 3.5 million square foot factory. The assembly line moves up in a continuous spiral, ending at a 1.5 mile long rooftop testing track.

Figure 2-8. Brinkman & Van der Vlugt, Van Nelle Factory, Netherlands, 1931. This factory celebrated new technology, using unbroken glass facades and hovering conveyor belts to move goods and people between buildings. It also included sports facilities, a garden, and a library for its employees.

studying the function of an object, the materials, and the industrial manufacturing processes as a craftsperson would, the designer could generate a useful and beautiful prototype capable of being mass-produced with no loss of quality.[5] In this way, the Bauhaus sought to bring affordable yet quality products to the masses. Skilled workmanship was still the highest priority, but the use of mechanized production became part of the production of craft.

While Le Corbusier and other modern architects idolized the factory and the machine as a model for architectural style, Alvar Aalto embraced modern technology as a means of improving human comfort. In his work, Aalto utilized technical innovations to generate curved, ergonomic forms receptive to the human body. For Aalto, a functional form was one which responded organically to human needs and adjacent landscape. Though he accepted machines as a useful tool, he stipulated that "Nature, not the machine, is the most important model for architecture."[6] Aalto cautioned that the ever-progressing development of manufacturing would become increasingly harmful as much as it was increasingly productive. His advice to designers in modern times was to implement "the step by step transition of industrialism into ... a harmonious factor of civilization."[7] Aalto designed several

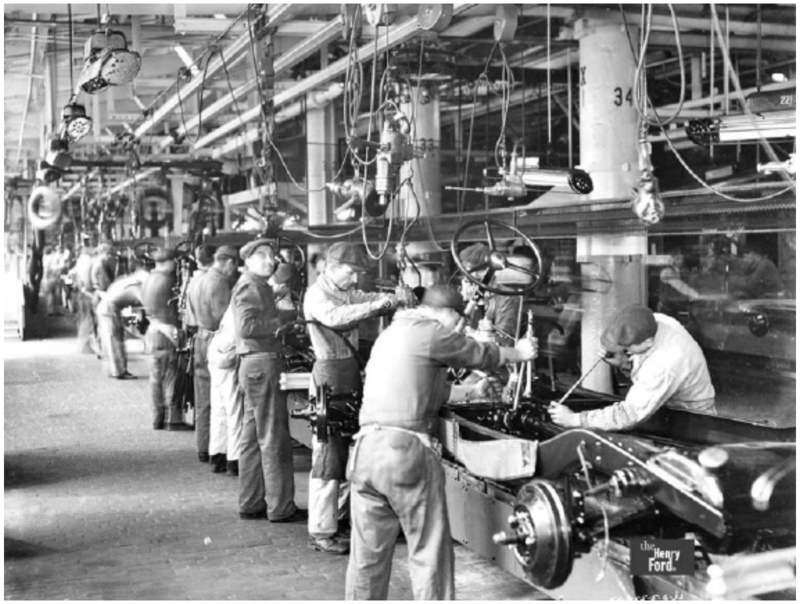

Figure 2-9. Assembly line at the Ford River Rouge Plant, 1933.

Figure 2-10. The Charlie Chaplin film *Modern Times* captured worker sentiment about human labor becoming part of machinery.

industrial works, and his balance of modern technology with humanist values is demonstrated in projects such as the Sunila Pulp Mill and Stromberg factory (see below).

At the same time, those involved in the business side of factories were developing strategies to streamline production and maximize profit, sometimes at the cost of human comfort. Implemented from the late 1800s, division of labor was one of the primary differences between traditional craftsmanship and factory work. These initial production lines were clunky in comparison with those of the 1920s, which were refined with interchangeable parts, increasing use of machinery, and conveyor belts. Frederick W. Taylor introduced a system he called Scientific Management, one of the most influential changes to the division of labor system. Taylor's innovations included the introduction of the stopwatch to measure worker speed, paying employees by the number of goods completed rather than by work hours, and heavily increasing the amount of management supervision over workers. These changes dramatically altered the agency of the laborer in the factory:

> A manager had to run every aspect of the production process with detailed breakdowns of each job, so that no one worker would possess knowledge that might put this worker in a position of power vis-à-vis management.[8]

By the end of the 1920s, Tayor's practices had been implemented in thousands of factories, most notably in those of Henry Ford. Ford had been instituting his own changes in the production line similar to those of Taylor. His unique contribution was the introduction of the conveyor belt, which moved the production process past stationary workers (Figure 2-9). This meant that workers now stood in a single place all day, completing the same repetitive, minute task. These kinds of changes took a tole on the bodies and minds of workers, and the membership of labor unions swelled during this time.[9]

In her 1958 book *The Human Condition*, political theorist Hannah Arendt discusses the state of industrialized society and analyzes three types of human activity that take place within it: labor, work, and action.[10] Labor and work both occur in the factory, and their definition illuminates how employment can be a fulfilling or a dissatisfying part of a person's life. Labor consists of activities that serve the biological needs of humankind, and which generate goods required to sustain life. According to Arendt, it is a repetitive, ceaseless cycle of production and consumption. Work, on the other hand, generates durable products, which in turn make up the built world that protects and separates humans from nature. This built environment is a point of stability and continuity in an ever-changing world and a record of historic events. Work is a distinctly human activity, and Arendt calls those who do work *homo faber*.[11] Arendt's description of *homo faber* places them and their work at the center of human activity: they make machines to replace labor, a built world for humankind to inhabit, and a permanent record of events in the political and historical realm.

Arendt identifies the source of problems of the industrial age as the division of labor, rather than mechanization itself.[12] Mechanization alleviates the difficulties of labor, much like the machines in Morris' workshop would relieve workers of the most tedious tasks. Division of labor, on the other hand, replaces skilled, specialized workmanship with repetitive tasks performed by interchangeable people. With only this limited, specialized skill, laborers lack knowledge of the production process and thus the ability to control the work environment. This in turn affects society overall: when labor, rather than work, is the primary activity in life, daily activities are performed only for the sake of producing and consuming, not for more meaningful goals which would have a permanent impact on the world. Furthermore, Arendt predicts that this change in values coupled with increasing rates of production will result in increasingly less durable goods, and thus a society that wastes more and produces less of substance.

Arendt's description of a society of consumption and waste foreshadows our contemporary concern with environmental crises resulting from industrial processes. In his 1988 article "Techné," Robert Meagher takes these implications and expands on them in the context of an increasing awareness of the impacts of environmental destruction. Meagher reflects on what the role of the architect - as the most influential of *homo faber* - should be. Meagher defines work, which he calls *technê*, as "making something into something it is not," a process that is "willful, materially violent, and materially productive."[13] Meagher expands on the connection between nature and the built environment only implicit in Arendt's book: *homo faber* conceptualizes the transformation of natural materials into built objects. The material we extract from nature for means of construction is "the missing link between the natural and the artificial."[14] This extraction, however, is necessarily destructive - "violent" - to nature.

In the conclusion of his article, Meagher expresses concern that *technê* is leading to humankind's own destruction, that the architects of our world have forgotten "compassion and goodwill" and are building in ways more destructive than creative. Meagher reminds architects that they have a responsibility to foster human well-being. This means conceptualizing humanity's relationship to nature not as a "plunderer" but as a steward, practicing architecture that will "at least ... leave the world as inhabitable as it found it."[15]

Some contemporary architects have responded to the increasing attention given to environmental and humanitarian concerns. While technical innovation remains a prominent theme in factory architecture, Nina Rappaport identifies three new themes in contemporary factory design: flexibility, sustainability, and "spectacle."[16] Flexible factories now seek to be expandable and accommodating to rapid changes in technology and markets. Many of these factories have lost their hierarchical arrangement and Ford-style assembly lines in favor of systems of non-linear, modular layouts that make the production process more humane. Some designs have even consolidated previously disparate departments, such as administration and R&D, into the same building as production to disrupt traditional hierarchies. Innovation in factory design now includes sustainable technologies. Sustainable building materials and passive design are introduced to reduce the impact of the industrial processes. MEP processes can also be

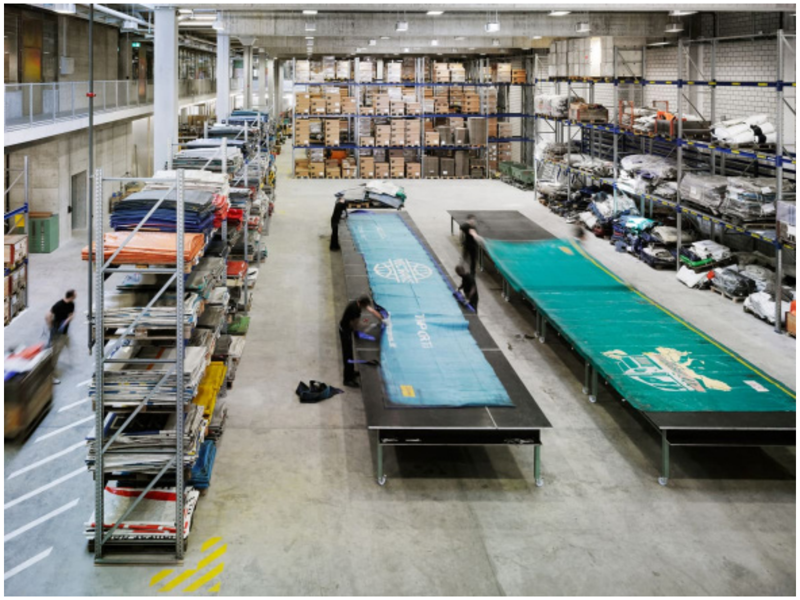

Figure 2-11. Rothen Architects, Noerd Building, 2011. This factory employs vertical integration of design, marketing, cutting, washing, and layout performed all in one building, which increases collaboration between designers and production workers.

Figure 2-12. The industrial zone in Kalundborg, Denmark, is designed to share and recycle energy and resources among disparate production types and complexes.

designed to use green energy and for reduction or reuse of waste materials and energy. Finally, Rappaport posits that factories have become part of the "spectacle" of modern life. They have moved back into the city, and in doing so, become a representation of the companies that own them. In order to be a flattering image of the company, the factory design becomes aesthetically impressive, environmentally responsible, and includes worker amenities.[17]

The factory has been the site of two of the more far-reaching and detrimental effects of the Industrial Revolution. First, the type of labor carried out in division of labor, as noted by Ruskin and Morris, is not fulfilling work. Tending machines and being part of an assembly line essentially makes workers part of the machine. In turn, the architecture of the factory is not built as a workplace for humans, but rather a means of generating capital. Yet, many Americans spend most of their waking lives working in an industrial setting.

Furthermore, the massive production speed of the factory has spurred a correspondingly massive consumption of natural resources. In return, the factory churns out waste, pollution, and products that are less durable and made of materials that cannot be reincorporated into cycles of nature. We have only recently become aware of the true extent of the effects on the environment that began with the Industrial Revolution.

The goals for this thesis are drawn from the thinkers whose ideas are gathered here. Aalto demonstrates how to take human-scale considerations into the design of the industrial workplace and integrate a utilitarian building into its landscape. Morris and Gropius illustrate approaches to balancing the joy of hand-craftwork with the necessity of using machine production, to differing degrees. Morris outlines how the factory can be a complete complex dedicated to employee and community well-being through leisure, education, and interaction with nature. One important concept, shared by Morris and Ruskin, is that fulfilling work is part of a happy life.

Arendt and Meagher demonstrate that, as the maker of the built world, *homo faber* plays a central role in society, and constitute a point of connection between nature and the built environment. This thesis argues that the factory can express this role, by providing its community and workers with fulfilling work and economic growth, by placing the factory activity in a mutually beneficial and intimate relationship to the natural setting that provides raw materials, and by making the facilities receptive to community education and leisure. In this way, the factory can foster a balanced relationship between work, nature, and people.

KINDRED PROJECTS

The following projects reflect the values this thesis seeks to achieve. They include both industrial and non-industrial works. Some are examples of workplaces which have been tailored to worker comfort and happiness, some are places that bring their users closer to nature, and some are both. All are encouraging, exceptional works of architecture.


Figure 2-13. Sunila Pulp Mill.

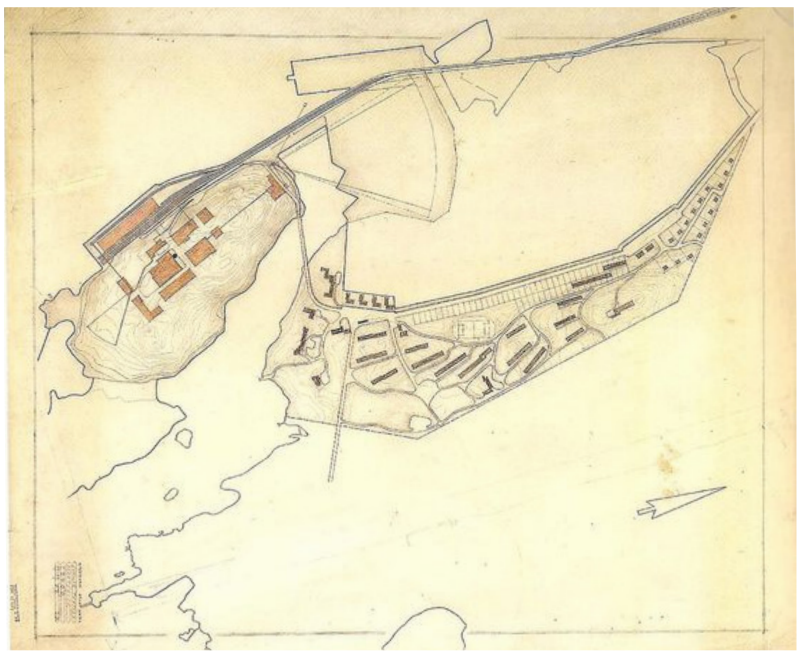
Figure 2-14. Sunila Pulp Mill site plan.

Alvar Aalto's humanist approach to architecture meant creating a better environment in the places where people spent their daily lives: at home and at work. His firm completed a number of industrial projects, including the Sunila Pulp Mill in Finland, completed in 1938. This project is notable for its attention to the natural landscape of the site and its relationship to the industrial buildings.

Though much of the form of the mill itself was determined by the manufacturing process, Aalto significantly impacted the master plan of the complex. The landscape is left unaltered as much as possible: despite the client's wishes to level out the site, Aalto insisted on maintaining the intense slope of the landscape. He did this not only to retain the natural features of the site, but also because he appreciated how the downhill zig-zag topography paralleled the production process itself.

The factory is organized in stepping terraces down this slope in accordance with the phases of the production process. The highest point of the complex contains the administrative offices and laboratories, and the whole complex can be seen from this terrace. Here, a quiet garden offers respite to employees. Buildings are separated only by untouched spans of wooded land that Aalto called "open-air corridors."

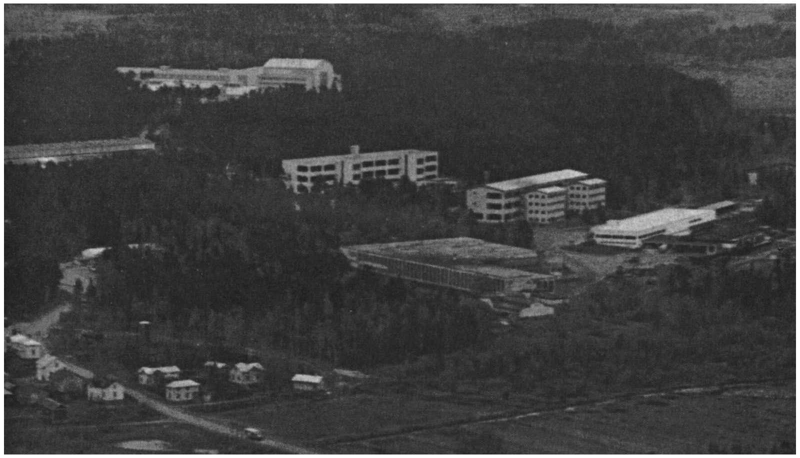

Figure 2-15. Oy Stromberg Ab factory complex.

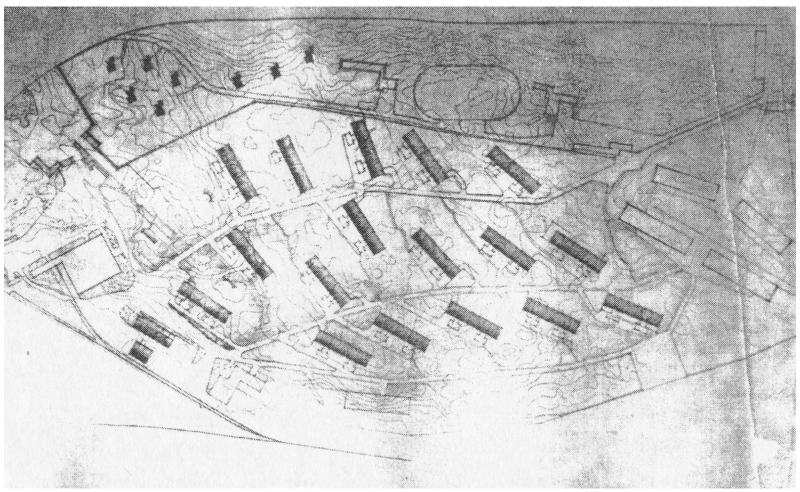

Figure 2-16. Site plan of the Oy Stromberg Ab factory.

Aalto had more freedom in his design for the Oy Stromberg Ab factory in Vaasa, completed in 1948. Aalto was brought in for the first stage of the process, in which he designed a master plan for the factory and a town as well as residential and production buildings.

In this case, the factory process did not require a continuous line of production, but rather consisted of separate units with unique production types. Taking advantage of this, Aalto arranged the factory buildings as a series of small, intimate spaces arrayed in curved rows that followed the topography. The flora of the site - forest and meadows - were the backdrop of these scattered buildings: Aalto's goal was to cultivate "mankind and nature living in collaboration."[18] Factory management appreciated the smaller workplace as well; they found that it created a stronger sense of cohort and solidarity among employees.

Although the project saw several more phases of development under different lead architects, Aalto's original master plan and project intention remained a guiding concept for the development of the factory.

Figure 2-17. Exterior of the Passivhaus Factory.

Figure 2-18. Interior of the Passivhaus Factory.

The Passivhaus Factory in Pemberton, BC was built by Hemsworth Architecture in 2014 for the manufacturing of prefabricated panels that meet the rigorous sustainable Passivhaus standards.

The factory building typifies the values that define its product. The building is a simple wooden box constructed from Passivhaus panels and glue-laminated timber columns and beams manufactured in British Columbia. Conditioned spaces meet the Passivhaus standard as well, utilizing energy-efficient methods such as solar shading, heat-recovery ventilation, and natural lighting.

The result is not only a more sustainable building, but also a more pleasant place to work. The architect states: "The main inspiration for the design came from the belief that the industrial, everyday buildings that make up a vast amount of our built environment can be just as important, and well-considered, as our 'public' buildings."[19]

The factory is an admirable demonstration of ideals: the highest sustainable design standards and the importance of industrial architecture to the people who inhabit it.

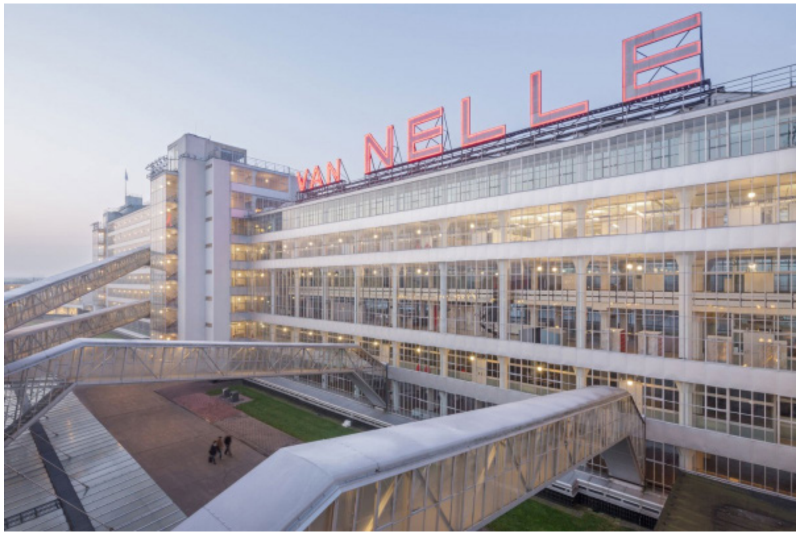

Figure 2-19. View of the conveyor belts between buildings.

Figure 2-20. Van Nelle Factory at night.

The Van Nelle Factory by Brinkman & Van der Vlugt, completed in 1931, was lauded as a masterpiece of the International Style and a celebration of new technology. Factory processes determined the layout of the building: different production lines are each given their own building, as were storage warehouses and administrative offices. Within each, the production process moves as if a force of gravity, with raw materials starting at the top and moving downwards, the completed product emerging at the ground floor.

The materials celebrate modern building technologies. A concrete frame with a curtain wall allows for ample expanses of windows. By day, the building shines glossy and transparent; at night, it glows like a beacon. Extravagant conveyor belts hover between production and storage buildings, and bridges extend circulation between buildings.

Another admirable feature of the Van Nelle Factory is the consideration shown for the work environment. The transparency of the building is not only for style, but also for the maximum light and air for the comfort of the workers. The program includes amenities such as sports facilities, a garden, and a library.

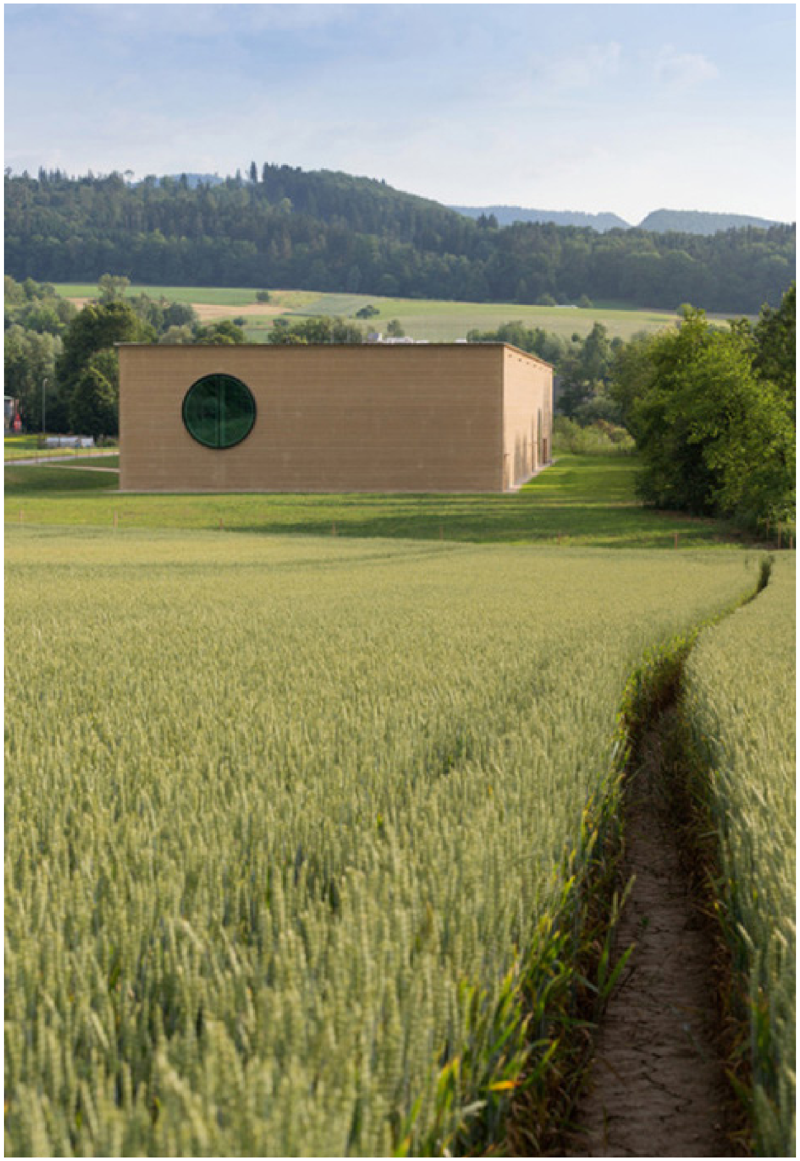

Figure 2-21. Rammed earth facade and viewing portal into the Ricola Herb Factory.

Herzog & de Meuron have completed a number of industrial buildings for Ricola, a manufacturer of herb-based cough drops. This Herb Processing Plant, which grows and processes herbs, was completed in 2014 in Laufen, Switzerland.

The facility is built primarily of rammed earth bricks. This earth was acquired locally and manufactured at a nearby facility. The long form of the building stretches across the landscape, mimicking the hedges typical of the region, and showing the length of the linear production line.

Sustainable features include the natural temperature regulation of the rammed earth walls, PVC panels on the roof, and use of waste heat from nearby industrial facilities. The building's responsiveness to its site is well summarized by Herzog's statement that it "literally grows out of the ground."[20]

Figure 2-22. Students studying among the rice fields.

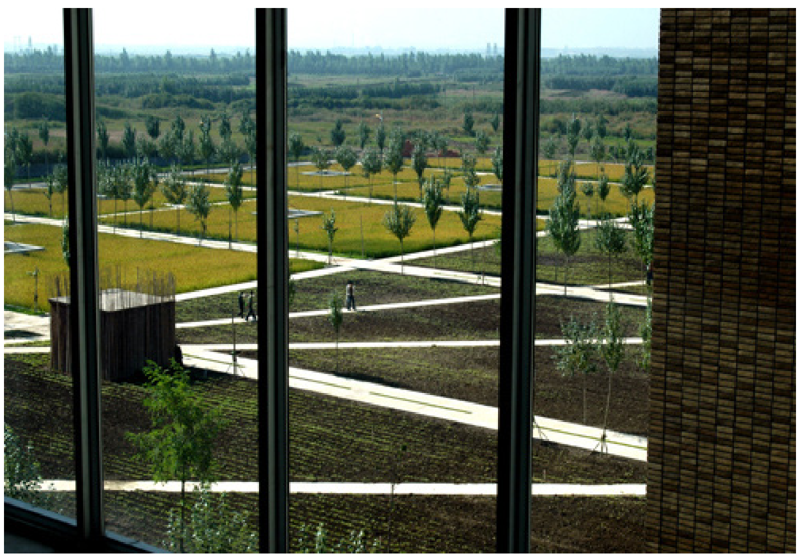

Figure 2-23. View of the campus from a classroom.

This landscape project for Shenyang Architectural University by the firm Turenscape creates a site of engagement between students and the agricultural landscape. Under the pressure of budget and time constraints, Turenscape produced a simple design concept that managed to address contemporary issues in Chinese landscape while creating an educational campus with immersive natural features.

The new campus was to be built on a rice field already fitted with irrigation systems and with plentiful quality soil. Turenscape was faced with the destruction of good agricultural land to make way for urbanization, a frequent occurrence in China in recent decades. The decision to keep the land's original purpose was both a comment on this problematic trend and a way to engage students with their culture and the natural environment. Students maintain and harvest the rice; the pattern of growth and harvest have become part of the school year. The rice, known as "Golden Rice," has become a university icon and part of student community identity.


Figure 2-24. Ponds on the public side of the wall.


Figure 2-25. Picnic area on the river.

In the Willamette River Water Treatment Plant in Wilsonville, Oregon, Miller Hull takes a utilitarian building and makes it into a leisure and educational site open to the community. The initial design by an engineering firm generated a typical box for the treatment equipment, one that was meant to be hidden from view. The city decided to hire Miller Hull, with the goal of making the facilities an asset to the community.

The architectural intervention transformed the site by inserting a "garden wall" running parallel to the river and the industrial process. This 800-foot-long concrete wall separates the site into a treatment side and a public side. Windows in the wall allow visitors to view the treatment equipment in action; informational displays on the wall explain the processes.

On the public side of the wall, a verdant park features picnic areas, a public meeting room, river access, and a series of ponds. Trails link the park to other parts of the city.

The Treatment Plant is exemplary of the role architects can play in industrial buildings, beyond putting a pretty face on an otherwise banal building. By bringing public space to the utility building, it connects citizens with the processes that sustain daily life, and connects them back to nature.

TIMBER

Before discussing the program and design of the convergent factory, it is important to understand its economic and cultural context. In the Pacific Northwest, both are deeply entwined with timber. For millennia, the region west of the Cascade Mountains from northern California to British Columbia was covered by millions of acres of old-growth temperate rain forest. Ample precipitation, mild climate, and rich soil fostered the growth of Douglas Fir, Western Hemlock, Western Redcedar, and other species, some of which grew as large as several yards in diameter and hundreds of feet tall. The lives and culture of Native communities in the region have relied on these trees for everything from monumental architecture and canoes to clothing and tools.

During the nineteenth century, the American timber industry moved westward as intensive logging depleted forests first in New England and then in the Great Lakes area. The timber industry in the Pacific Northwest was established in the 1850s, when logging companies purchased expanses of forested land and set up logging camps, mills, and company towns. Myriads of towns in western Washington and Oregon began as a logging or mill community. Lumber exports were first sent to California, but soon expanded across the Pacific Rim, including Hawaii, Australia, South America, and Asia. By 1905, Washington was the largest producer of lumber in the United States, with Oregon close behind.

The history of the logging industry in the Pacific Northwest is a complex relationship between workers, mechanization, and nature that is still evident in the politics of logging today. Richard A. Rajala's *Clear Cutting the Pacific Rainforest* examines how policy decisions and technological development controlled by lumber companies affected workers and the environment. Rajala argues that owners used advancements in technology and division of labor to gradually wrest control of design, work pace, and knowledge of production from workers. By expanding technology into the forest, owners brought the factory to the outdoors. By maximizing the exploitation of laborers and nature, owners accelerated rates of logging and manufacturing.[21]

Rajala notes that workers occupied an "intermediary position" between capitalist practices and nature, but does not examine this relationship further. In his 2014 dissertation, Steven C. Beda examines the role of place in the lives of early timber workers and the "working-class environmentalism" that developed

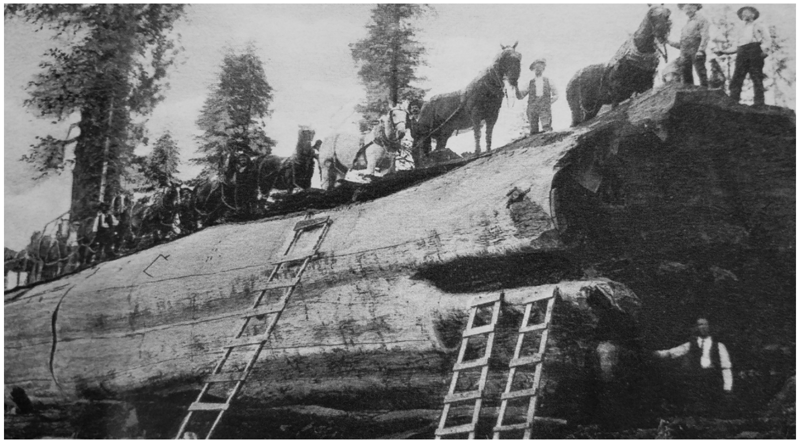

Figure 2-26. An old-growth tree felled by loggers, Washington, 1910.

Figure 2-27. Hills owned and clear-cut by the Walville Lumber Company, Washington, 1920s.

from their close relationship with the landscape. Beda describes how the people who came to the Pacific Northwest to work laid the foundation for cultural values of respect for nature and labor rights:

> Workers coming from farms brought land-use traditions and subsistence practices that would help workers see the forests as more than just sites of work. Midwestern loggers brought experience in industrial labor and a distrust of their employers. Scandinavians and Eastern Europeans brought labor radicalisms that would shape latter-day industrial union movements. Employer policies that incentivized married workers also shaped timber workers' understanding of place. They saw the forests not just as worksites but also places that entwined their homes and communities.[22]

Often living in unsettled or undersupplied areas, workers and their families relied on the forest for all aspects of their life: as a supplementary food and income source via hunting, fishing, and foraging and for recreational activities such as hiking and skiing. The brand of environmentalism that grew from this intimate relationship with the forest acknowledged the necessity of taking from nature in order to meet human needs but simultaneously recognized that nature must be preserved in order for it to continue meeting those needs. Furthermore, this mode of thinking recognized the value of leaving some parts of nature untouched and preserved.

The earliest loggers ventured out into the forest with simple hand tools, but in the 1930s and '40s new inventions such as chainsaws, diesel yarders, logging trucks, and caterpillars ushered in what Rajala calls the "factory regime." Using these tools, owners began the practice of clearcutting. The increased rate of production not only denuded land at a greater pace but also created a more dangerous work environment. One employee of a mill in Cosmopolis, Washington, in 1917 recalled working in the midst of the new machinery, and described the terrifying speed and size of the huge bandsaw at the head of the mill that made the whole building roar and shake. Steam power, in his words, had made the mills into "places of darkness, noise, [and] peril of whirring saws, clattering conveyors, and treacherous cogs and wheels and constantly moving parts."[23]

From its introduction, the practice of clearcutting was controversial. Owners, managers, workers, silviculturists, and Forest Service employees debated its merits and risks as an economic and environmental practice. Timber workers were especially unreceptive to this method, and reacted with criticism of their employers. Notably, they felt protective of the forests in the face of their destruction; one union member voiced a popular sentiment when he stated, "as far as I'm concerned, the forests are the heritage of our people and should be used for our people, and capitalism has no place in our forests."[24] In general, however, logging companies alternated between clearcutting, selective logging, and small patch cutting practices throughout the early 20th century more in accordance with market demands than any research-based claims or community concerns about forest depletion.[25]

In this environment, various timber unions joined together in 1937 to establish the International Woodworkers of America (IWA), which voiced worker concerns over wages, working conditions, and control over the work environment and company towns. Significantly, the IWA frequently used its political power to voice worker concerns about forest destruction. Throughout the '50s and '60s, the union worked alongside urban, middle-class environmentalists to demand harvesting controls in order to ensure future jobs and preservation of untouched expanses of wilderness. Their efforts resulted in the establishment of several forestry laws, national park expansions, and finally the Wilderness Act of 1964.[26]

Unfortunately, this partnership did not last. Beda

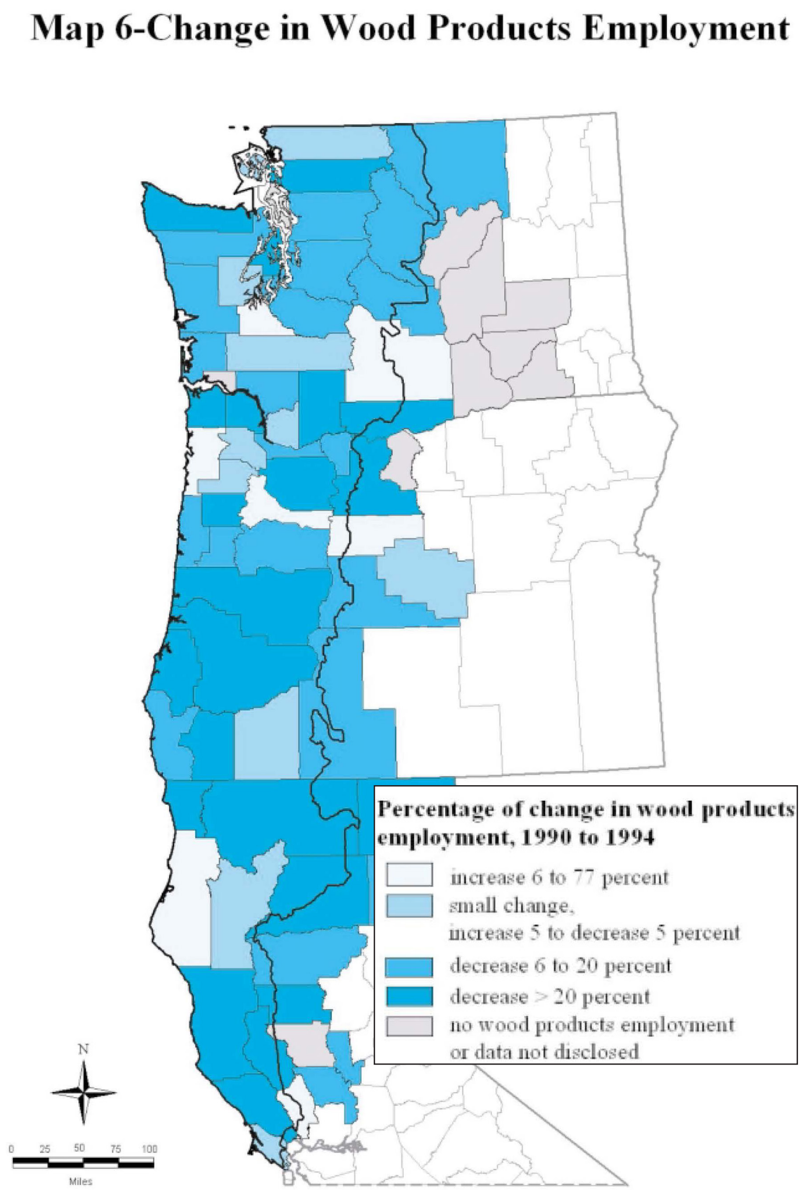

Figure 2-28. United States Department of Agriculture, changes in timber industry employment in the Pacific Northwest between 1990-1994.

identifies 1964 as the point at which "both the [environmentalist] movement and the definition of who was counted in the movement fractured along class lines."[27] Urban communities began to define environmentalism as leaving all nature completely untouched for the sake of preserving a pristine landscape. This in turn meant that the elimination of logging became part of the urban environmentalist agenda, which distanced their activities from those of working-class environmentalists. In the 1970s, the northern spotted owl entered the scene. When research revealed that the owl, which requires old-growth forest for habitat, was close to extinction, environmental groups used it as leverage to fight for old-growth preservation. Between the 1970s and the 1990s, these groups issued a series of lawsuits and injunctions to protect old-growth from logging by allotting a certain acreage per owl. Eventually, logging on federal lands was completely shut down throughout the region. The legal battles culminated in 1993, when President Clinton implemented the Northwest Forest Plan (NWFP). This act reopened some federal land to logging and provided subsidies for workers and communities which relied on the timber industry. Ultimately, the amount of Federal land available for logging was reduced to less than half.

While these legal actions led by urban environmentalists were a significant contribution to the decline of the timber industry, other factors had already begun to impact its success. Timber harvests had reached an all-time peak in 1989 at 15.6 billion board feet in a year. This production level was impossible to maintain. Nationwide, job markets were shifting away from manufacturing, and manual labor in the timber industry was increasingly replaced with mechanized processes. Globally, timber exports faced more competition, especially from Canada. Demand from Asia, which had been boosting the market, fell. By 1994, production had fallen to 8.4 billion board feet.[28]

Though the proponents of the new regulations often painted a picture of the "timber baron" as their target, the large, private logging companies were in fact relatively unaffected by the preservation of old-growth forests. They operated on private, not federal, land that generally had younger trees that had been replanted after earlier logging. In fact, because it did not affect them, big logging companies largely stayed out of the legal battles over the old-growth. Smaller, independent logging companies and mills were disproportionately impacted because they relied on purchasing timber from federal lands. It was these small-town businesses that went bankrupt and whose employees lost their jobs.

For urban environmentalists, the NWFP was a victory in continuing efforts to save old-growth forests from logging. For rural workers, the downfall of the industry threatened their livelihood and way of life. For both sides, the Spotted Owl became a proxy and potent symbol of the clash between rural and urban. Timber towns found it ironic and frustrating that people who lived in cities where nature had been all but eradicated would tell them how to preserve their forests. Worse, they found themselves being characterized in condescending and sometimes hateful rhetoric as ignorant, destructive country bumpkins who had no respect for nature. Yet this was far from how the rural residents felt, even in the midst of their economic crisis. In a 1989 article, an editor for Grays Harbor County newspaper *The Daily World* articulated a sentiment very different than what urban environmentalists commonly ascribed to them:

> Mankind cannot take lightly its responsibility to the environment ... Should we care about other creatures with feathers, fins, and fur? They don't have mortgages to meet and groceries to buy. Indeed we should, for with every species we eliminate from the face of the earth, the closer we come to making ourselves extinct.

The editorial ended with a plea to those who imposed the regulations seemingly without consideration for the communities it would effect:

> With this much potential for economic havoc, then in a kindlier and gentler America we can surely find ways to assist the communities that will absorb the blow.[29]

Though the timber industry still exists in the Pacific Northwest, this large, long-term loss of jobs has permanently affected communities throughout the region. Like all industries, it suffered during the Great Recession but has shown moderate growth since its end. The timber towns themselves have responded by seeking out new industries, especially tourism. Seeing the success of Bend, Oregon in becoming a vacation destination for wealthy urbanites, other towns have followed suit.[30] Oakridge, once known as "The Heart of the Timberland Empire," has now rebranded itself as "The Mountain Biking Capital of the Northwest." By turning to tourism, Oakridge uses preservation measures to its favor: one Oakridge city administrator touted the permanence of the natural landscape by saying "Look at that view! That is never going away! ... There are spotted owls over there!"[31]

Many rural towns in Washington and Oregon are still looking to revitalize their economies since the decline of the timber industry. Indeed, these places have great resources to offer new industries. The workforce has manufacturing skills and experience in both factory and outdoor settings. The communities understand the balance between nature and human needs. The region has a history of fighting for worker's rights and protection of the environment. In the wake of economic decline, much could be made with the opportunities present in historic Pacific Northwest timber towns. A solution offered to these towns must consider the existing still set of workers and the culture of working-class environmentalism.

3

BAMBOO

This thesis proposes a bamboo products factory in Aberdeen, Washington, as an exploration of the factory as a fulfilling work environment and place of connection between work and the landscape. The factory will include a manufacturing facility, workshop, greenhouse, and research center. It will produce bamboo panels and finishes, as well as investigate how bamboo can be adapted as an agricultural, silvicultural, and manufacturing industry in the Pacific Northwest. Bamboo was selected for this purpose because it is exceptionally sustainable, shows great promise as a versatile fabrication material, offers a variety of enjoyable workplace activities such as gardening and fabrication, and its forests are pleasant year-round as a natural setting for the factory.

Lightweight and flexible, yet strong, bamboo is a large grass consisting of almost 1,300 species native to all continents except Antarctica and Europe, and which cover an estimated 61 million acres worldwide.[1] It is a versatile material that has been utilized for centuries for purposes as varied as baskets woven from paper-thin fibers to buildings constructed using whole poles, or "culms," as structural members. In many cultures, it has traditionally been used to make home goods, furniture, paper, and textiles. The sprouts can be harvested as a food source. Due to its versatility and wide availability, bamboo has long been an essential resource for developing countries. It is estimated that as many as 1 billion people live in houses constructed of bamboo materials.[2]

Over the last several decades, bamboo has been rediscovered as a contemporary manufacturing product. In addition to its traditional uses, recent innovations include bamboo laminated panels and laminated structural beams, corrugated roofing made from woven and pressed bamboo strips, 3D printing filament, and a composite material that could replace steel in reinforced concrete.[2] Recently, it has increasingly been used as a substitute for wood products. Because the length of its fibers are longer than those of wood, bamboo sometimes makes a superior product. In 2012, international trade of bamboo products was valued at 1.1 billion USD (Figure 3-1). [3]

Bamboo has proven to be a highly sustainable and rapidly

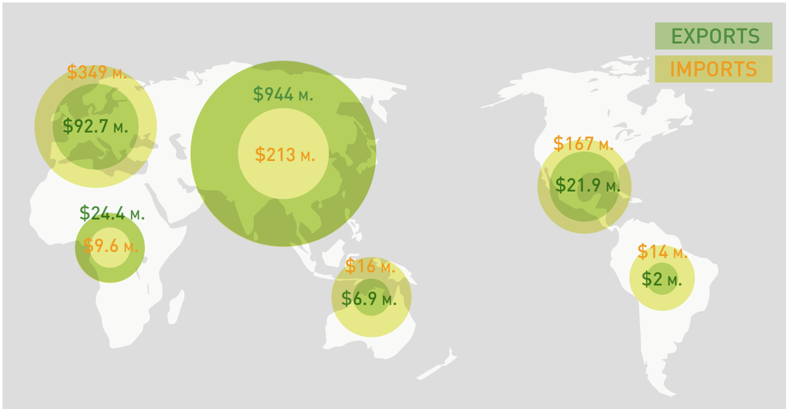

Figure 3-1. In 2012, international trade of bamboo was valued at 1.1 billion USD.

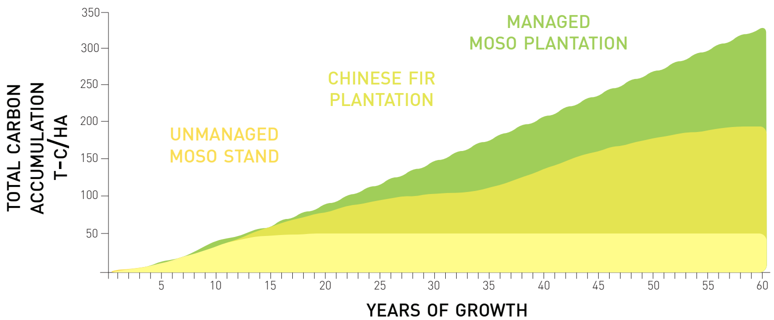

Figure 3-2. Carbon sequestration of bamboo.

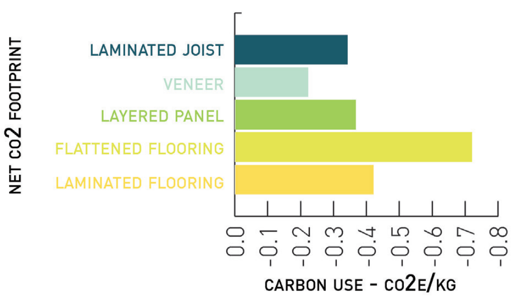

Figure 3-3. Carbon footprint of bamboo products.

renewable resource. It is known for its rapid growth: after an initial growing period of as little as five years, bamboo produces poles for annual selective harvest. Current research is looking into replacing timber with bamboo in manufacturing to reduce pressure on forests. Furthermore, managed stands of moso bamboo can aggregate more carbon than similar tree plantations, and sequestering of carbon can be maximized with durable products (Figure 3-2).[4] In the United States, bamboo products are carbon-negative, even accounting for harvesting, processing, and shipping from Asia (Figure 3-3).[5] As a material that has a beneficial impact on the environment and myriads of uses, bamboo offers great potential as a manufacturing material generating meaningful jobs.

Furthermore, a bamboo factory and grove offers a variety of activities for employees, including outdoor work such as planting, harvesting, and maintenance, as well as fabrication that utilizes craftsmanship and manufacturing expertise. Anyone with woodworking or agricultural experience could easily adapt to the processes of caring for and manufacturing with bamboo.

Bamboo not only has a beneficial impact on the environment, but it also benefits from human care: bamboo groves that are cared for by skilled farmers are healthier than untended

Figure 3-4. These bamboo boards manufactured by Conbou utilize the natural shape of the material. Oblique sections of bamboo are laid between cross-laminated bamboo sheets.

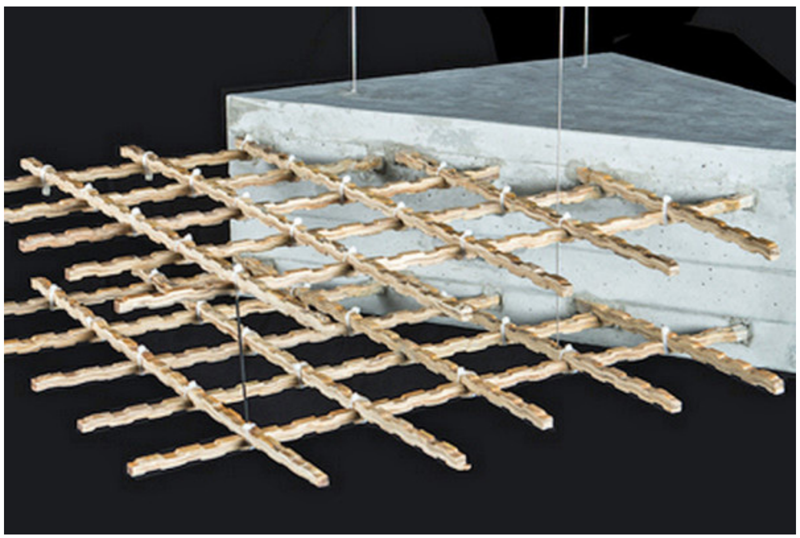

Figure 3-5. Dirk Hebel at the Swiss Federal Institution of Technology, Zurich, is developing a bamboo composite material that could replace steel as reinforcement in cement.

groves. In untended groves, older and dead culms inhibit the growth of new shoots. Crowding in unthinned groves causes lower branches to die from lack of sunlight, damages culms as they rub against each other in the wind, and fosters growth of garden pests.[7] Thus, the relationship between bamboo and humans can be a mutually beneficial one.

As a landscape element, bamboo offers a meaningful year-round connection between humans and the natural environment. Bamboo is selectively harvested - never clear-cut - as culms of different ages and sizes grow in rings from a single clump. Thus, a forest of bamboo is a constant presence in the landscape. A bamboo grove is a truly immersive experience, where the culms reach as high as twenty meters, pale leaves carpet the ground, and wind sways and rustles the branches. As a useful product and beautiful landscape element, bamboo shows potential as a means of connecting the human built world to a meaningful natural environment, becoming a great asset to its community.

In the last few decades, bamboo silviculture has spread throughout the Pacific Northwest. The American Bamboo Society has a regional chapter that holds an annual bamboo festival in Portland, Oregon. They compile information on purchasing and


Figure 3-6. Bamboo grove in Kyoto, Japan.

growing bamboo as a garden plant or as a crop. Many individual nurseries throughout the Pacific Northwest are still learning particularities of how various types of bamboo adapt to the region's climate. These projects show promise, but would benefit from a centralized, open-source library and research effort focused on manufacturing.

The proposed convergent factory will grow primarily moso bamboo (*Phyllostachys edulis* or *Phyllostachys pubescens*). Currently, the two most commonly used species as building material are Moso and Guadua, due to their size and superior mechanical properties. Guadua, a tropical species native to South America, would not thrive in the Pacific Northwest. Moso, on the other hand, is a

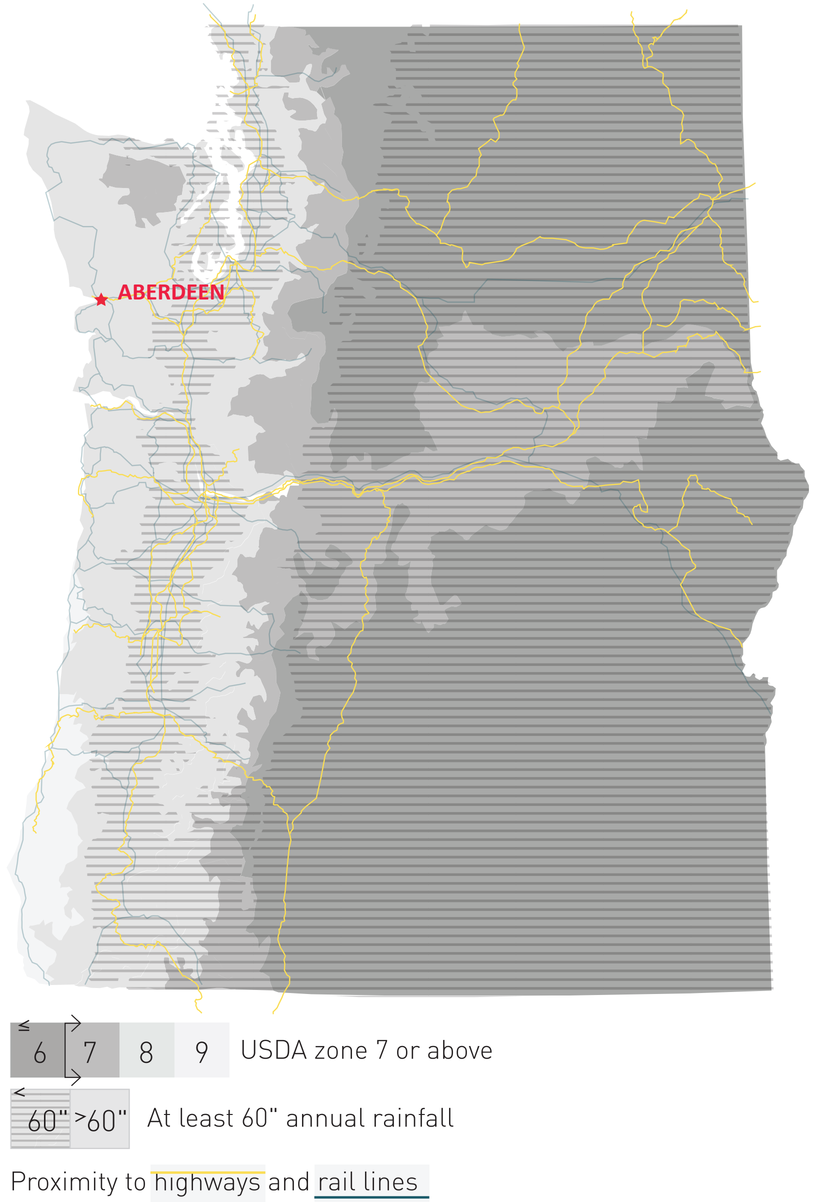

Figure 3-7. Criteria for site selection.

temperate species native to areas of Japan and China that have similar climatic conditions to western Washington and Oregon. Moso can survive temperatures down to 5°F, and flourishes in areas with plentiful rainfall throughout the year.

In addition to these requirements, the bamboo factory would benefit from an area with workers experienced in agriculture and woodworking, who could quickly learn tending and fabrication processes for bamboo. Rail and river access would also be ideal for transportation of supplies and goods. After considering these factors as well as cultural and historic context, Aberdeen, Washington, was selected as the site for the bamboo factory (Figure 3-7).

ABERDEEN

Aberdeen is situated on Grays Harbor, a vast bay seventeen miles long and twelve miles wide carved out of the west coast of Washington at the south end of the Olympic Peninsula. From here, huge quantities of timber and other goods have been exported across the Pacific Rim. Grays Harbor was once known as the most prolific exporter of timber, which was felled in the dense forests that surround the harbor to the north and south.

It was these ample forests, along with fishing, that attracted Euro-American settlers to the area in the century after Captain Robert Gray entered the bay in 1792. This region is the ancestral homelands of the Quinault tribe, who lived on the bounty offered by the sea and the forest. In 1855, they, along with the Hoh, Queets, and Quileute tribes, signed the Quinault River Treaty with Washington, which ceded title to lands in their historic territory while setting aside 1.2 million acres in tribal reservation lands and ensuring fishing rights. Eventually, most of the reservation land ended up as the property of Euro-American settlers as individual tribal members sold - by choice or under pressure - their allotments.

Chehalis County, which would later be called Grays Harbor County, was established in 1860. Settlers began to trickle into the region, and the first major economic establishment was the Cosmopolis Sawmill, built in 1880. In 1881, the mill shipped the first of many loads of lumber from the harbor. In 1884 and 1885, sawmills opened in Aberdeen and Hoquiam, respectively. Aberdeen would become the cultural and commercial center of Grays Harbor. Indeed, this was the future its founder Samuel Benn had pictured in 1868 when he bought the 740 acres of land that would become the town. After purchasing the land, Benn offered plots to anyone who would set up saw mills and canneries. Later, he offered land as payment to those who would donate labor and supplies to construct a rail line to connect the harbor to the rest of the state. Its completion in 1895 ensured the economic prosperity of the lumber and fishing town, and between 1890 and 1900 the population of Aberdeen doubled.[8]

The rails brought lumbermen, mill hands, and many other laborers, both American-born and immigrant, from all over the United States. It also attracted less savory industry: brothels, gambling houses, and saloons sprouted up in Aberdeen to serve the working men of the region. While they, too, contributed in no small way to the economic success of the town, they also earned

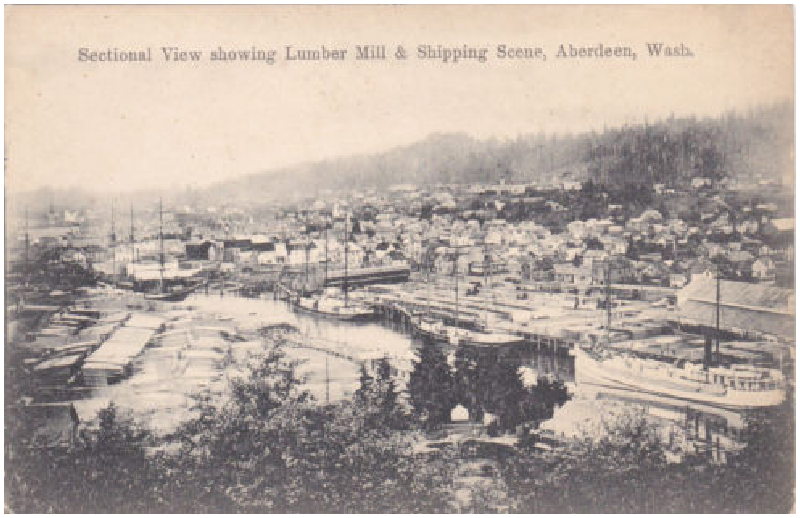

Figure 3-8. Postcard showing the shipping waterfront in Aberdeen. Estimated date 1907-1915.

Figure 3-9. Aberdeen Founder's Day Parade, 1940.

Grays Harbor the unofficial title of "Hellhole of the Pacific." But it was the working conditions of lumbermen and mill hands that merited its other, arguably worse, nickname, "The Penitentiary of the West." Timber industry employees worked under notoriously dangerous working conditions. It is estimated that, on average, a logger died every other day between 1870 and 1910 in Grays Harbor.[9] Those who survived crippling accidents were out of work. On top of this, men worked long hours for very little pay. Workers were exploited first by job sharks, who demanded pay in return for finding them employment, and then by their bosses.

In response to these conditions, union activity grew in the area, fueled in no small part by the socialist values prominent in the primarily Finnish settlement of Hoquiam. In 1910, the International Workers of the World (IWW) charted a section of their union in Aberdeen, uniting several union groups in the region. They set the foundation for union activities in Grays Harbor and elsewhere, fighting against public speech restrictions set by city government in an attempt to suppress union activity. As the protests continued, they simultaneously gained increasing support from statewide unions, and increasing ire from business owners and city officials. Eventually, the situation turned violent. In 1912 the city gave in and signed a treaty with the IWW restoring free speech rights. Thanks to these efforts, unions would later successfully negotiate for better working conditions during the high demand for shipbuilding in WWI.

Most notably, Aberdeen hosted a strike led by the Sawmill and Timber Workers Union in 1935. They demanded a number of workplace improvements, including shorter hours and a better minimum wage. At its peak, the movement involved 15,000 workers on strike, which at the time comprised almost half of the region's workforce. The strike lasted three months, ending due to lack of solidarity among various unions. Employers gave them a small raise and slightly shorter hours, but mostly, demands were unmet. However, the union did see a huge swell in their numbers, from 15,000 to 70,000, which would serve them well for further efforts in the 1930s and 1940s.

Despite this turmoil, the Aberdeen timber industry was booming. In 1924, the harbor shipped its billionth board foot of lumber in one year, and Aberdeen dubbed itself "The Lumber Capital of the World." In 1926, the harbor mills manufactured 1.5 billion board feet in one year, a world record that has not since been broken. These numbers are still a source of pride in Grays Harbor residents today.

However, this production peak was the beginning of a gradual but persistent decline. Timber clear-cut from private lands were not replanted; rather, depleted lands were abandoned after the old-growth was cut. In the 1960s, a tsunami in Japan caused widespread destruction, and the country sought out timber from the Pacific Northwest in order to rebuild. Counter to expectations, this actually led to a decrease in work for local mills, as they were outbid by Japanese mills for unprocessed timber, causing local mills to lose a lot of work. Between 1965 and 1975, it is estimated that Washington lost up to 40 percent of its wood processing capacity.[10] Fishing, too, was seeing the effects of over-harvesting. From 1967 to 1993, razor clam harvests fell from 749,000 to 32,000. Even more stunning, the Coho salmon catch plummeted from 1.38 million in 1976 to 74,000 in 1993.[11] The Coho salmon would be listed as an endangered species in 1996.

Ultimately, like many timber towns in the Pacific Northwest, Aberdeen was economically devastated by the events of 1980s and 1990s, including the environmental regulations established to protect northern spotted owl habitat. After discovering in 1989 that the Quinault district would cut the timber

Figure 3-10. Downtown Aberdeen.

Figure 3-11. Sign over the Wishkah River, which runs through the town of Aberdeen, displaying the town slogan.

supply to local mills from 90 million board feet to 42 million, local owners were dismayed. In response, employers and employees joined to form HALT, Harbor Against Land Takeover, with the objective of preventing the government from closing up federal forest. They promptly sued the government, hoping that the 1949 Grays Harbor Federal Sustained Yield Act, which guaranteed that any timber logged in Grays Harbor federal lands would be milled within the county to ensure jobs, also guaranteed the supply of that timber. The suit was a failure. In April 1990, after injunctions led to a complete freeze of federal timber and legal battles were going nowhere, Hoquiam hosted a rally of about 1,500 workers and their families. The demonstration culminated with the blockage of Highway 101. But again, these efforts made little impact.

After three years of struggling with the effects of the injunctions, Hoquiam mayor Phyllis Shrauger spoke at the 1993 Forest Summit held by President Clinton. She spoke about the dire economic impacts the environmental regulations had had on her town. Unemployment was at 19.5 percent, and the resulting economic down-spiral had impacted the city's budget for everything from federal workers to school lunches. She requested that the president set aside federal funds to bring industry back to Grays

Harbor.

Federal assistance never came to Grays Harbor, but the region has continued to search for new industries. Aberdeen offers a skilled worker base, a receptive cultural context, and ideal physical location to the bamboo factory. Its mild climate has an average low of 34.5°F and it rains 181 days of the year, totaling 83" of precipitation. The warm temperature would foster growth of bamboo, and excess rainfall could be stored for irrigation during summer months. The port and rail lines are still functional for shipping products and materials. Moreover, the history of working-class environmentalism suggests compatibility with the approach to the factory. These were the reasons Aberdeen was selected as the site for the thesis project.

PROJECT PROGRAM

Bringing the bamboo industry to the Pacific Northwest requires introducing the crop and material via an integrated program of production, research, and design (Figure 3-12). Research on material applications and bamboo growth can take place in the laboratory and greenhouse, respectively. Development of prototypes and handcrafted design pieces occurs in the workshop. Meeting spaces, a library, and display cases function to share knowledge among employees as well as host community members and regional bamboo enthusiasts. The factory is sited directly on a bamboo test grove in order to connect the factory activities to the natural landscape and foster a pleasant work environment. This grove serves as a research endeavor, source of material for the workshop, and as a park for community members. All of these elements center around the factory, which produces bamboo panels and finishes.

Manufacturing Facility

On the factory floor, bamboo laminated panels are manufactured in a process resembling that used for similar wood products. An on-site port provides a means of shipping in raw material from Asia for use in the factory. Fresh bamboo culms must be treated to remove starch and sugar content, which attracts insects and fosters fungi. First, culms to be used in lamination are split into strips and rough milled to remove irregularities at the nodes. There are a variety of treatment options, including simple immersion in water - which takes several months - dry heating, and chemical baths. The most feasible option for a manufacturing-scale facility is chemical baths. In this process, water is mixed with a caustic soda or sodium carbonate, which leeches out the starch and sugars. Poles must be immersed for about ten minutes, then wiped clean, and re-immersed until the process is completed. After this, they must be kiln-dried, which takes approximately two weeks.

Dried strips are then milled to square profiles and laminated. After lamination, the panels are sanded and finished. Finished materials are shipped out, and some can be set aside for use in the workshop.

Workshop

In the workshop, employees fabricate furniture and home goods, developing their own ideas for products that could be manufactured on a small or large scale. Here, workers can explore design ideas utilizing various forms of bamboo, including the

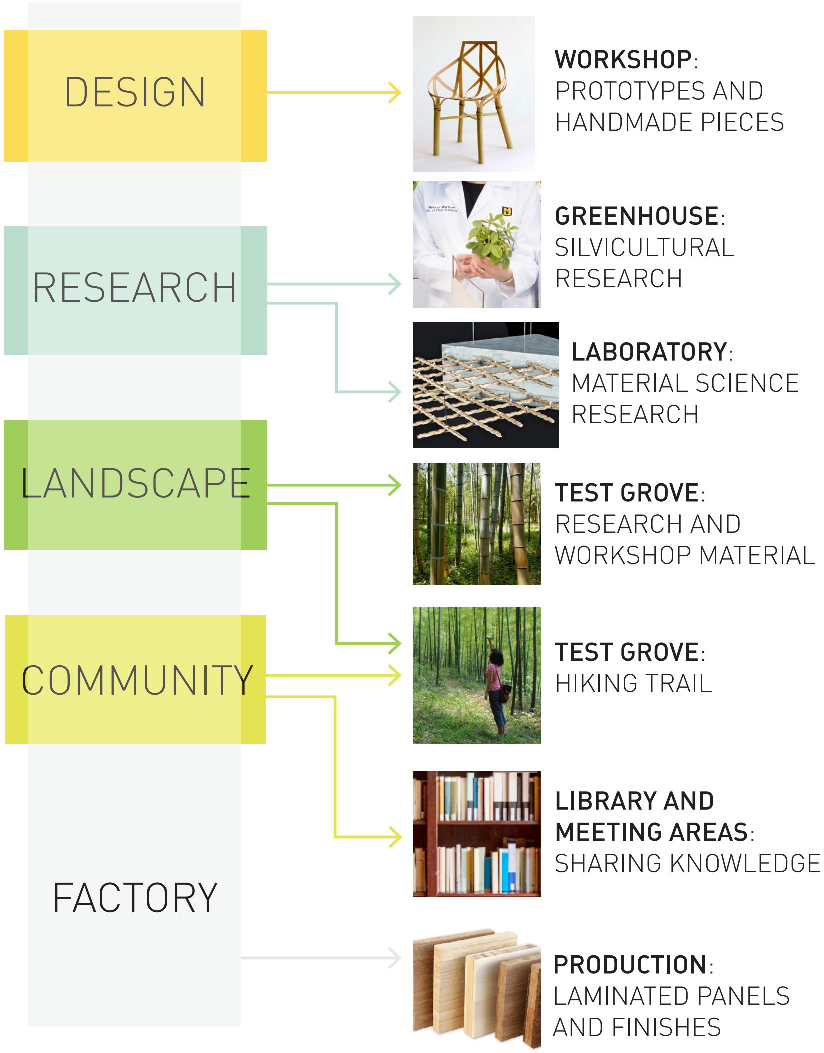

Figure 3-12. Various disciplines and aspects of the production process make up the program of the convergent factory.

boards manufactured on site, whole poles, or any other form or part of the bamboo plant. The workshop offers hand woodworking tools as well as basic wood shop tools, including bandsaws, chopsaws, planars, a CNC router, a vacuum press, and table saws. Metalworking tools are also available in the workshop to develop any joinery or complementary parts.

Research Center

In the research center, employees examine the potential for expanding bamboo as a manufacturing industry in the Pacific Northwest and developing and keeping up to date with new developments in bamboo technology. They can develop ideas for new products and applications by working in collaboration with other factory employees who can offer insights from their daily work with the material.

Greenhouse

In the greenhouse, researchers study various bamboo species as silvicultural products in the Pacific Northwest. This work is supplemented by research and upkeep in the grove. Greenhouse employees propagate new bamboo plants and evaluate the health and success of the plants in the grove.

Propagation of new plants is essential to maintaining the

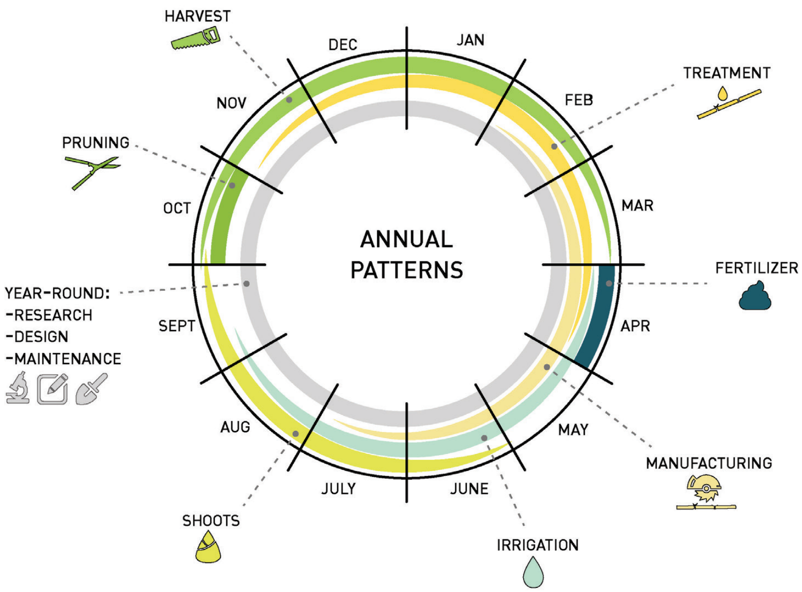

Figure 3-13. By placing a test grove on site, workers can engage in various indoor and outdoor activities that vary with the season.

genetic diversity of the plants. Moso bamboo flowers once every 60-120 years, after which all the flowering plants die. The cause of flowering is not well understood, but there are warning signs in the year leading up to its occurrence. To avoid the death of the entire grove at once, it is essential to avoid planting only seeds or shoots from a single ancestor and to gradually replace older plants with new ones.[12]

Silvicultural Program

The bamboo grove consists of approximately 128 acres of forested land. This grove will test the introduction of bamboo to the region. Workers oversee plant propagation, containment, maintenance, and harvesting.

Because bamboo spreads via the root system, it is relatively easy to contain using a barrier system around the perimeter of the growing area. This should be a thick concrete wall extending several feet below ground level. After new buds begin to emerge in the spring, the barrier and its vicinity must be examined for roots that might have broken through or underneath the barrier. Natural features such as bodies of water or steep inclines can also be effective as barriers.

As a species from a climate with a rainy summer, moso

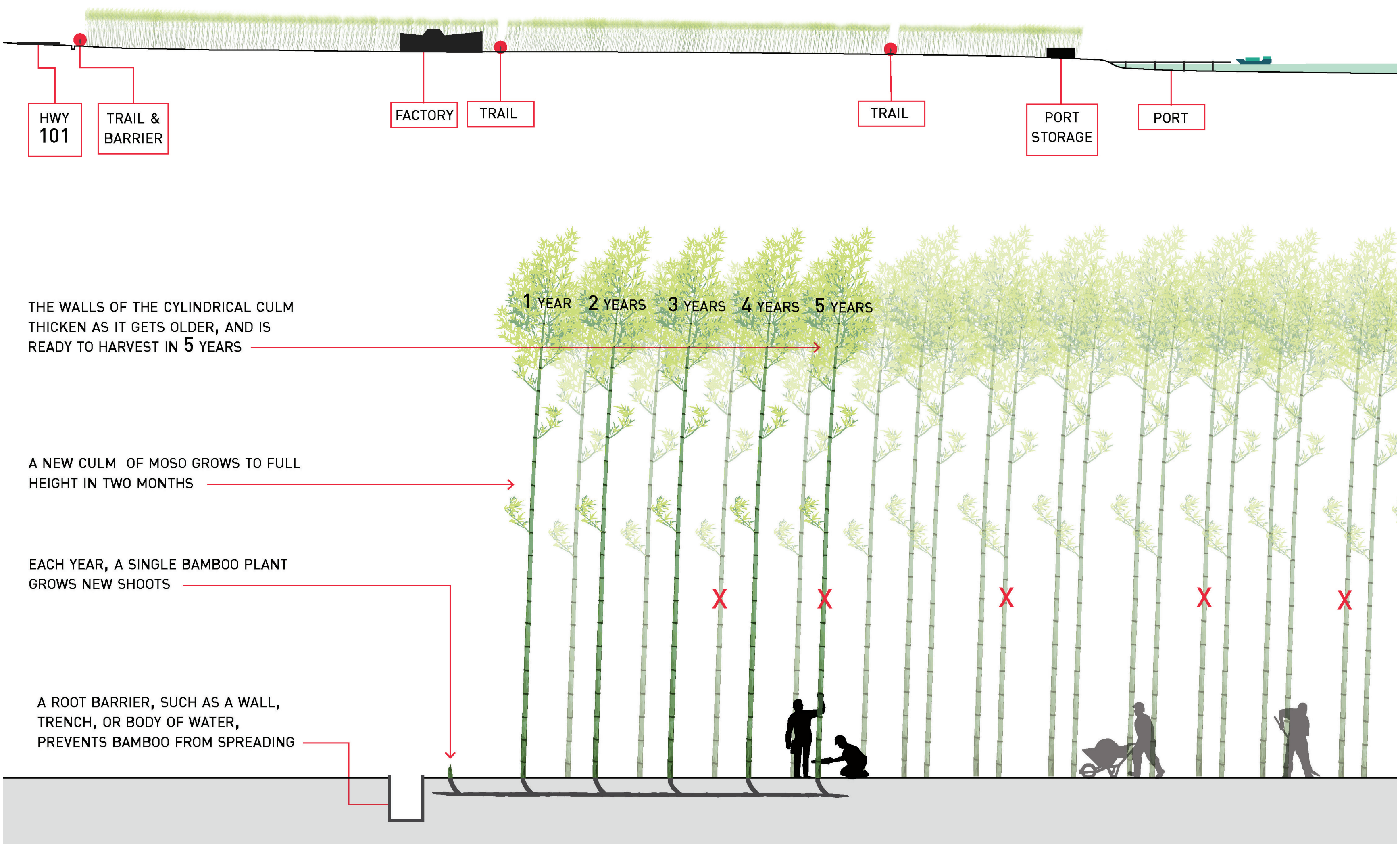

Figure 3-14. The introduction of bamboo to the site will have various implications for site interventions and worker activities.

bamboo usually receives as much as 30" of rain in a summer. Poles will only grow to their full potential if they receive water at least once a week.[13] Thus, the grove requires an irrigation system, including a lake to collect excess water during the winter months and store it for use in the summertime.

Maintenance activities include watering and drainage, weeding, filling vacant patches of land, mounding around plants two years after planting, and applying fertilizer and mulch. Harvesting takes place primarily in November through January, although it can begin as early as September and last until new shoots emerge in April. The procedure requires selecting the culms from each plant that are of sufficient age to be cut; in this case, five to six years of age. Low branches are trimmed for access to the base, where the stem is cut at a 45 degree angle just above the lowest node. This prevents water from pooling inside the chamber and causing rot.[15] The best tools for this precise job are hand tools such as axes or saws.

Auxiliary Program

For educational purposes, the factory hosts a library that compiles information on bamboo and any subject related to the factory program or which is requested by its users. Meeting areas of various sizes can be used to share knowledge among workers about new innovations or work methods. A shared lunch room and kitchen creates a social space where all employees can gather and relax. Either the lunch room or the library can be used for breaks, depending on whether a worker prefers a quiet or a social one. The library and grove are open to locals and visitors interested in learning about bamboo and seeing the manufacturing process.

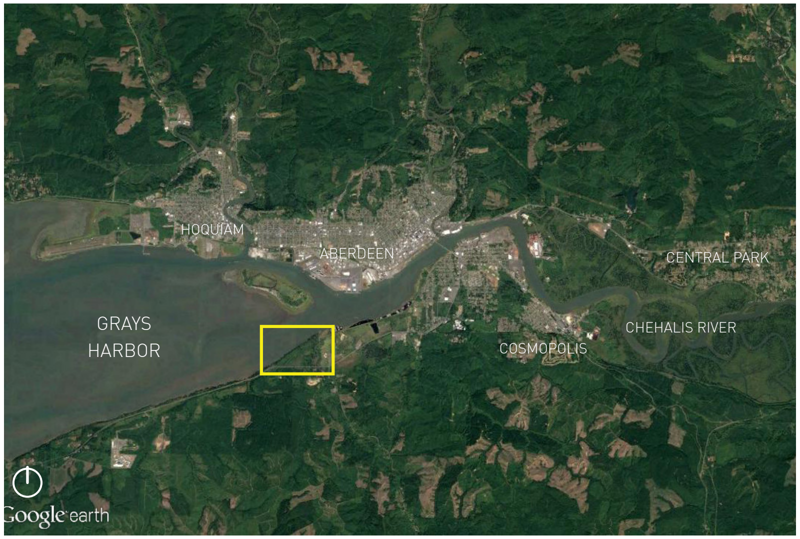

Figure 3-15. Site location on Grays Harbor

Figure 3-16. Overview of existing site conditions.

PROJECT SITE

The factory site is located on a triangular patch of land outlined by the harbor and a small creek (Figure 3-15 and 3-16). To the south, the site is bordered by Highway 105. Approximately 120 acres of undeveloped, unforested land lies within this perimeter. These natural boundaries, supplemented by a trench, will prevent the spread of bamboo beyond the site.

In addition to the adjacent highway, the site is close to rail lines and directly on the harbor. Gray's Harbor is an international port with connections to states and countries throughout the Pacific Rim. With this connection, it will be possible to import raw material from Asia for factory production. The port and rail lines, as well as the highway, can then be utilized for shipping out products.

The site is accessible only from Highway 105. A bus route runs along the highway from Westport to Central Aberdeen, where it connects to a larger network that extends to Cosmopolis and Hoquiam. Since it is impossible to pull off to the side on this road, a parking lot and bus stop with ample room for approaching vehicles must be constructed.

Figure 3-17. Site plan with 10' topogrphy lines. Data courtesy of Grays Harbor County.

Figure 3-18. View just east of the site, looking up Newskah Creek towards the opposite shore of the harbor.

The topography of the site is relatively flat (Figure 3-17), and slopes most at the water. A defunct hiking trail, which once connected Aberdeen to the city of Westport, parallels the shoreline. It can be accessed from the Bishop Athletic Facility, a currently active sports field just east of the site. This hiking trail currently ends at Newskah Creek, and the bridge crossing the water is unusable. However the stretch of trail extending east is still used, and presents an opportunity to connect the site to an existing park service.

Grays Harbor County has designated these parcels as Industrial District I-2, allowing industrial activities such as processing, fabrication, and other uses that support industrial buildings. This also includes research and design laboratories. It is one of the largest portions of industrial land in Grays Harbor. The size, zoning, and proximity to the harbor were the reasons for its selection as the site for the Convergent Factory.

4

THE CONVERGENT WORKPLACE

The proposed design for a bamboo factory in Aberdeen, Washington, seeks to cultivate collaboration, innovation, and agency in the industrial work environment. The factory building brings together several stages of the production process to a space in which employees from these various disciplines can interact and share knowledge. By cultivating this convergence of program and people, employees have the agency to choose and rotate among a variety of workplace activities; to respond to changes in the marketplace, landscape, or technology; and to alter the functions of the factory itself.

The factory is located on a 128-acre site (Figure 4-1), a large part of which serves as a test grove for growing bamboo in the Pacific Northwest. The grove tests how various species respond to the climate and provide material for use in the workshop. Raw material for the factory is shipped in from Asia via the harbor. A road runs from the port, to the west side of the factory, to the highway bordering the south of the site. Raw material and finished products move along this road. Workers and visitors to the factory arrive at the site from the highway, either by car or by bus. A footpath through the grove leads from the parking lot to the factory, creating a transition from the commute to the workplace. A grid of paths throughout the site allow for pedestrians or small maintenance trucks to move throughout the grove. All areas of the grove can be accessed within a three-minute walk from these paths. The pathway paralleling the waterline connects to a hiking trail that once crossed the site. By restoring this connection, which extends through a nearby sports park and back to the city of Aberdeen, the bamboo grove could be used as a trailhead for or a destination along the hiking path.

The layout of the building follows a simple diagram (Figure 4-2). The factory and modular work spaces are arranged in parallel bars, and an atrium space forms a seam between the two, all using a 30’ bay system. The bars are porous along the walls of the atrium, allowing activity from the separate spaces to spill out. The atrium is also the central means of circulation. Thus, the atrium is a mixing space that fosters free-form work activities, events, large-

Figure 4-1. Site plan, 1:7500, 10’ contour lines.

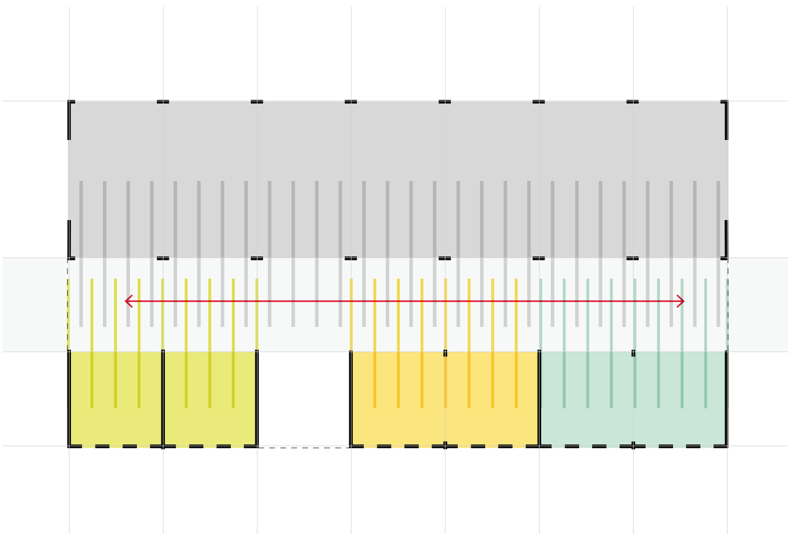

Figure 4-2. The factory floor is placed to the north, while the auxiliary program fills the modular spaces at the south. The activities from these spaces converge at the atrium between the two bars, which is also the main means of circulation.

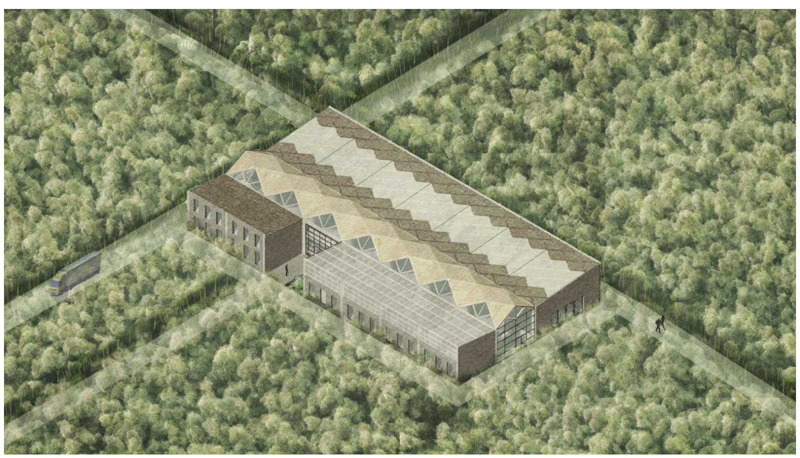

Figure 4-3. Aerial view of the factory building

scale building experiments, and random encounters. It is a place of convergence between the disciplines, activities, and people.

Raw material enters the factory at the west, where a set of large sliding doors open directly to a loading zone on the shipping road. From there, the production process moves in a U-shape. The process includes rough milling, treatment to remove starch, drying, refined milling, laminating into panels, planing, cutting, and sanding of laminated pieces, and packaging. Storage areas for material are distributed between these stages. Views to the landscape filter through the exterior walls of the factory all the way to the atrium, reinforcing the connection between landscape and the production process.

A gap in the bay system forms the main entry, where water from the rooftops gathers in a pond. The communal spaces - kitchen, lockers, restrooms, and office - lie to the west of the entry. The office is able to watch the main entry, and dining tables can extend from the kitchen into the atrium. Lockers, showers, and bathrooms are all unisex. The placement of these communal spaces also requires people using the other work spaces to cross the length of the atrium and gather at specific times throughout the day: arrival, departure, and mealtimes. This gathering point

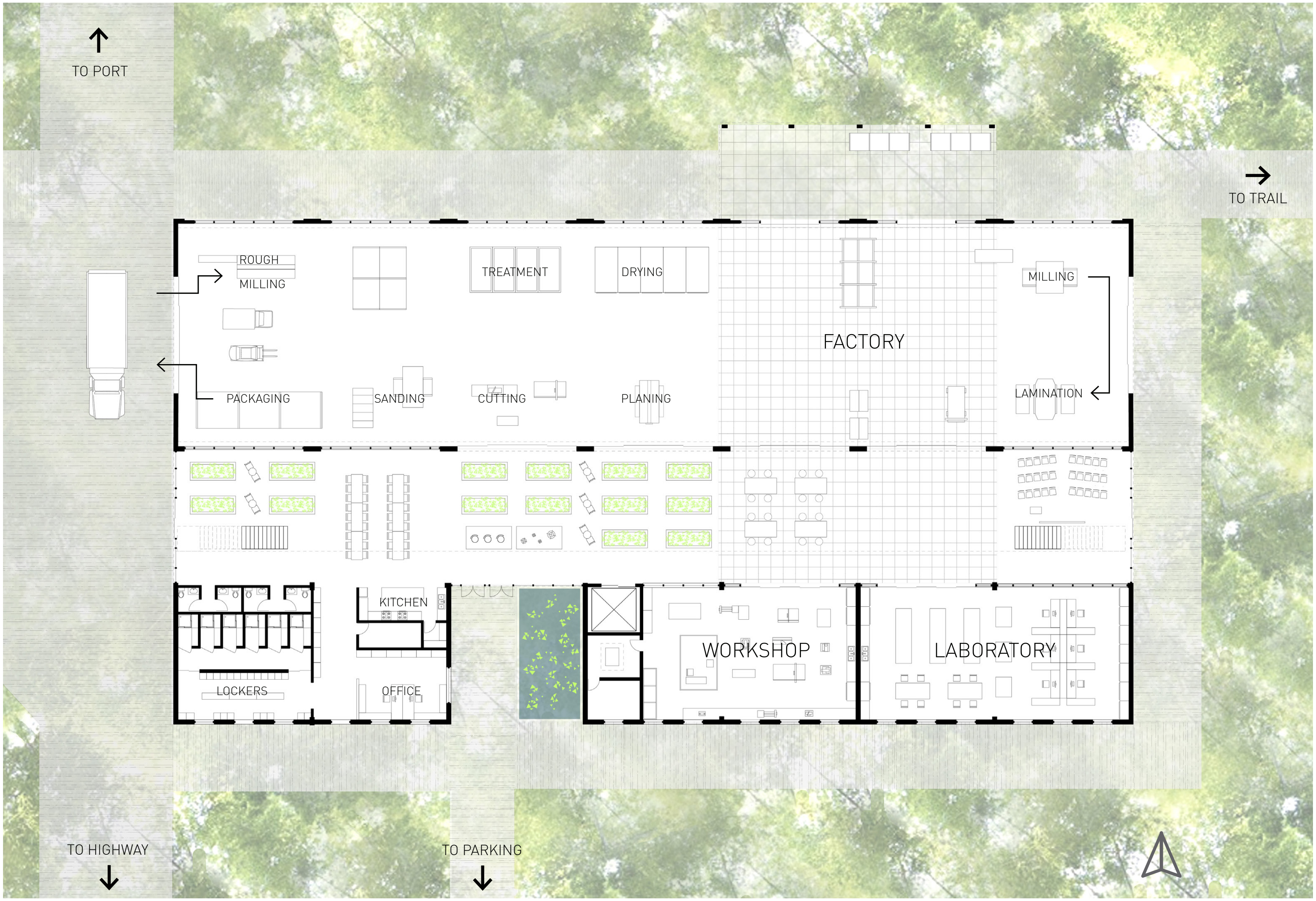

Figure 4-4. First floor plan, 1/32" = 1' - 0"

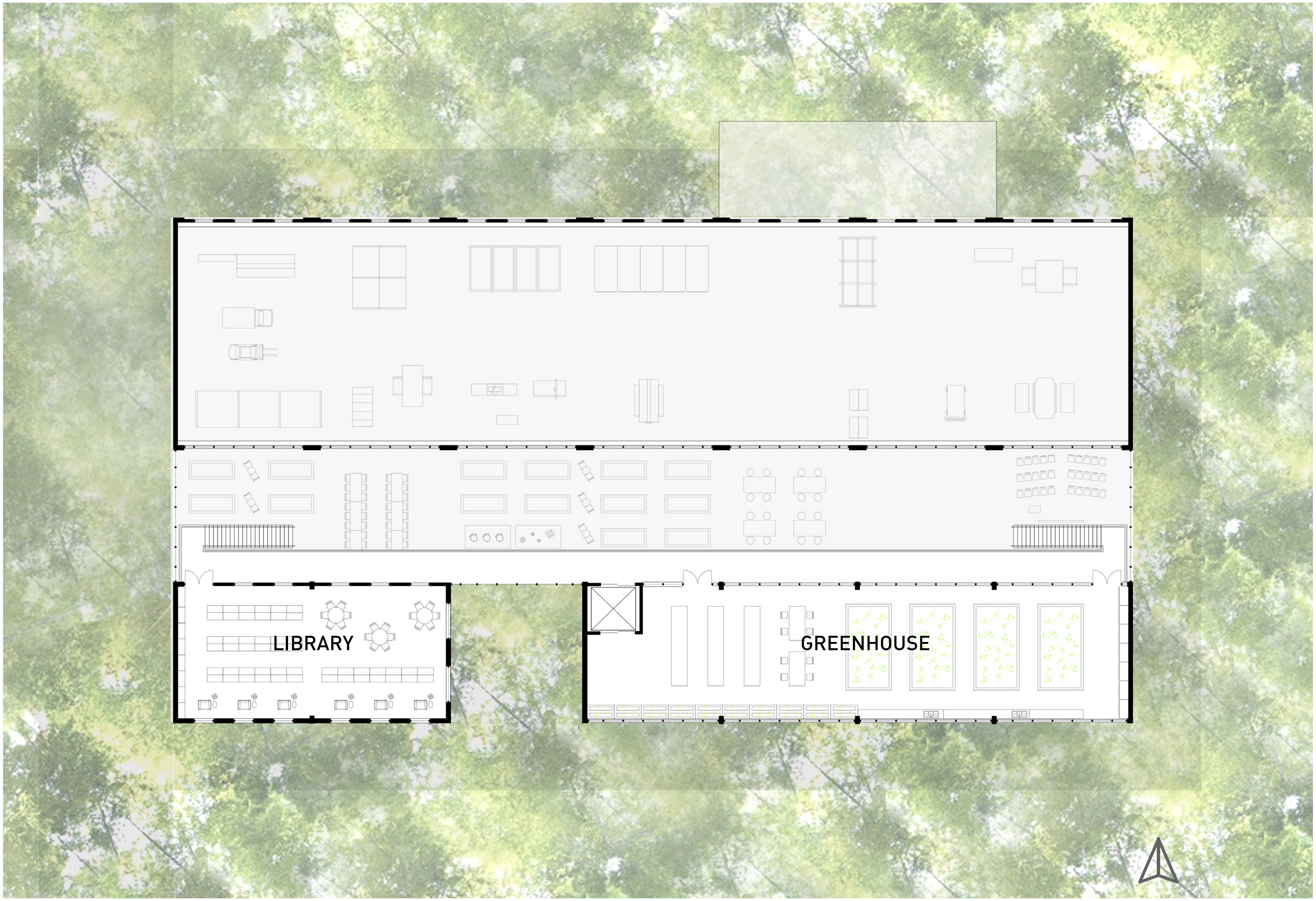

Figure 4-5. Second floor plan, 1/32" = 1' - 0"

increases the chances that people from different disciplines will have spontaneous interactions, both work-related and social. A library available to employees and community members is located on the second floor of this zone, and offers a quieter work space and a place to compile information on bamboo. From this space, users can enjoy a view into the upper level of the grove.

To the east of the entrance is the workshop and laboratory. The workshop houses various wood- and metalworking tools, while the laboratory accommodates research on material applications and technology. Above these spaces is the greenhouse, which receives ample sunlight on the second floor. The greenhouse grows starter plants for the grove and executes research on the silvicultural success of bamboo in the region.

The atrium in between these two bars can act as an extension of the spaces on either side, allowing the various activities to overlap, or host separate activities of its own. The workshop and laboratory spaces have adjacent bays of sliding doors, as do the factory bars opposite. This allows for easy movement of material and equipment into the atrium at this juncture, accommodating collaboration and interaction between users of the workshop and laboratory. Work tables occupy this space for daily use, but it could be cleared out for larger-scale experiments. This zone stretches through the factory and extends outside for activities too messy to be done indoors. The kitchen also opens directly to the atrium. Dining tables occupy this atrium bay to host gatherings of all employees. The atrium is also activated by displays for employee design, mobile planters of various bamboo species, and tables for individual work or smaller meetings. All of the furniture and program are movable, and the whole atrium could be rearranged to accommodate large gatherings, the movement of small vehicles, or the rearrangement of program as seen fit by the workers.

In section (Figure 4-6), the two stories of work spaces and the double height factory bend towards the interior atrium, where a domed structure of bamboo stitches together the two sides. The atrium is day-lit and porous, allowing the adjacent bars to access light and air from both sides.

The material system (Figure 4-7) consists of a concrete frame holding brick infill at the exterior walls and panels of glass and sliding doors at the interior. The mass of the concrete and brick walls contrasts with the lightweight frame of bamboo at the ceiling, and the grey color complements both the vibrant green

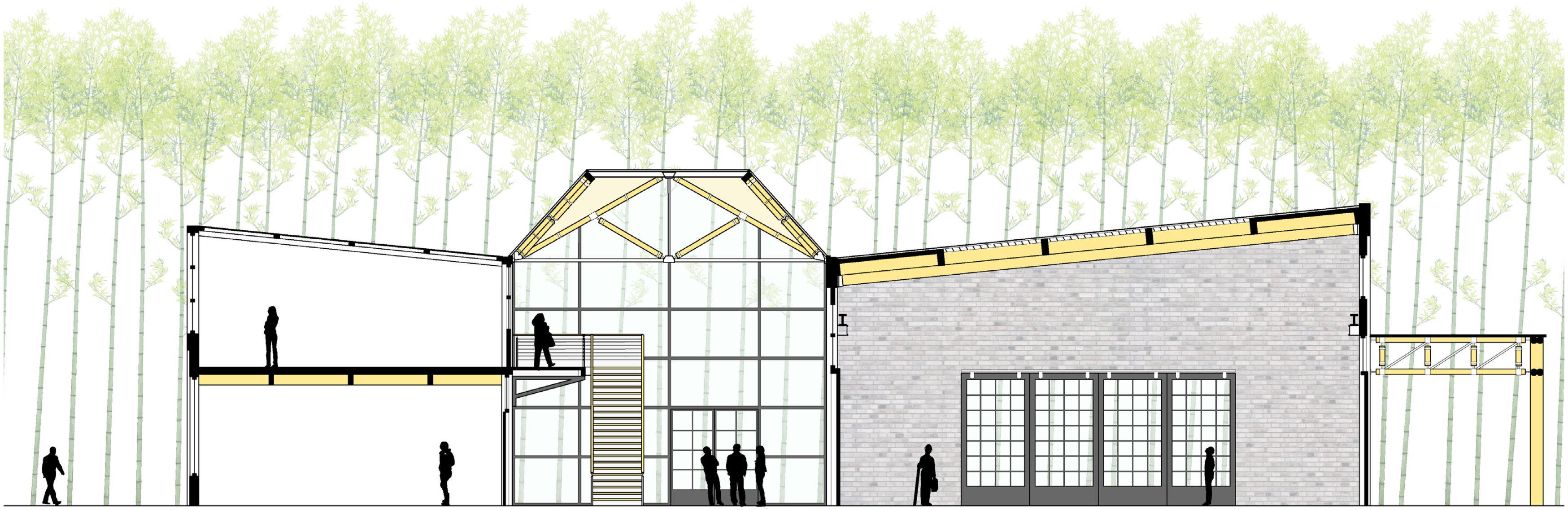

Figure 4-6. Section looking west, 1/16" = 1' - 0"

of bamboo in the landscape and the warm browns of the treated bamboo materials. At the factory, crushed bamboo beams span the 50' width. In between, a latticework of beams holds solid bamboo panels and louvers which bring soft daylight into the middle of the space. Crushed bamboo beams act similarly to laminated timber beams, but rather than milling down the material to a square profile, the bamboo pole is split lengthwise, unrolled, and laminated firmly with other unrolled pieces. This is a much more efficient use of material, and creates beams that, in this early age of testing, appear to be at least as strong as their laminated timber counterparts.

At the atrium, the roof demonstrates a structural use of unmilled bamboo poles. In recent years, a new system of joinery devised by Simón Vélez has greatly increased the structural capabilities of bamboo poles.[1] By filling the end chamber with concrete, the poles can be connected to any kind of steel joint. These trusses use steel connectors and tension members to create a domed system which highlights the modular bays and captures indirect light in the ceiling.

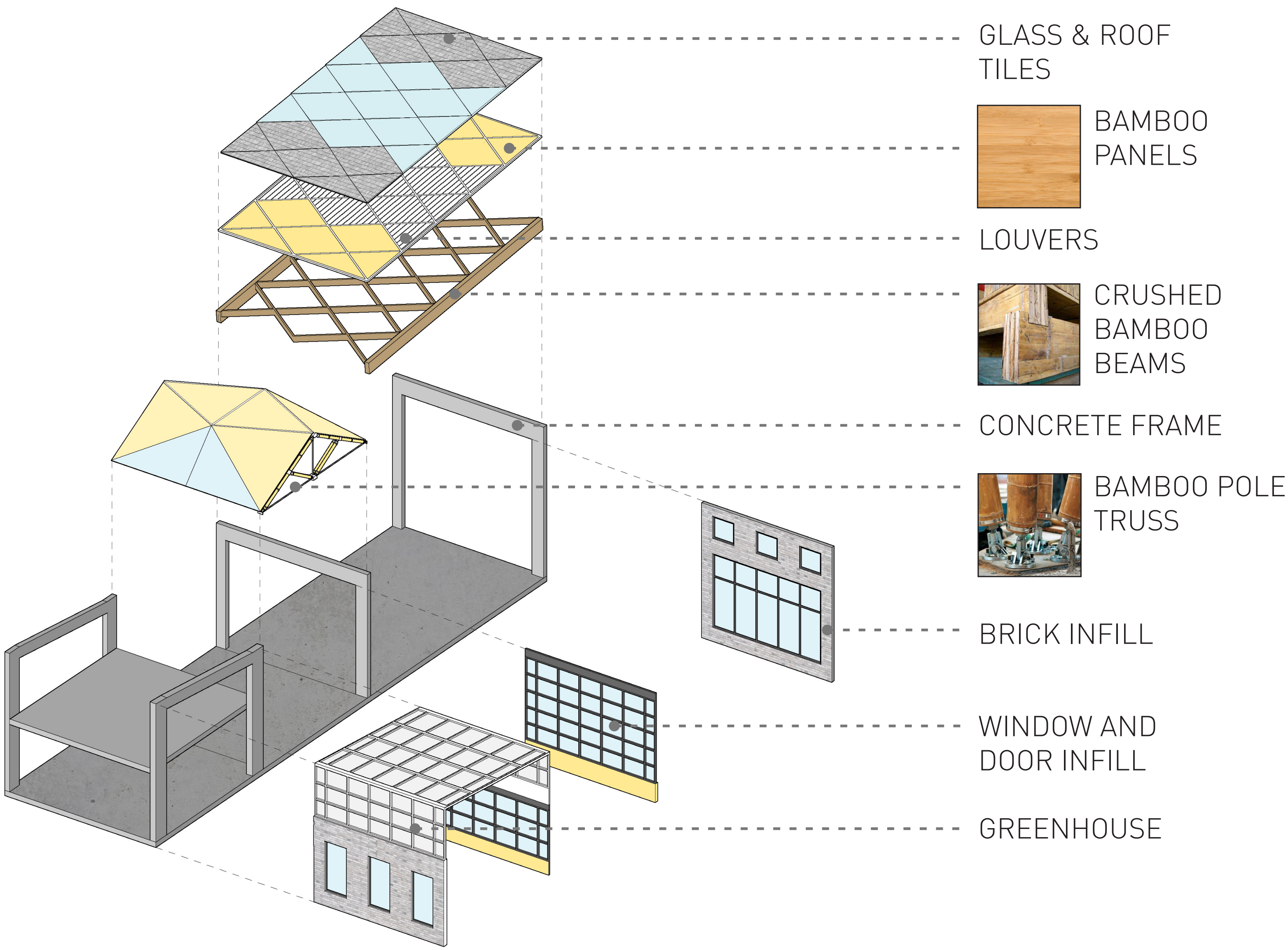

Figure 4-7. The tectonic system consists of a concrete frame with brick infill at the exterior and porous windows and sliding doors lining the interior. Bamboo spans the ceiling and bamboo finishes act as a warm highlight at various places through the building.

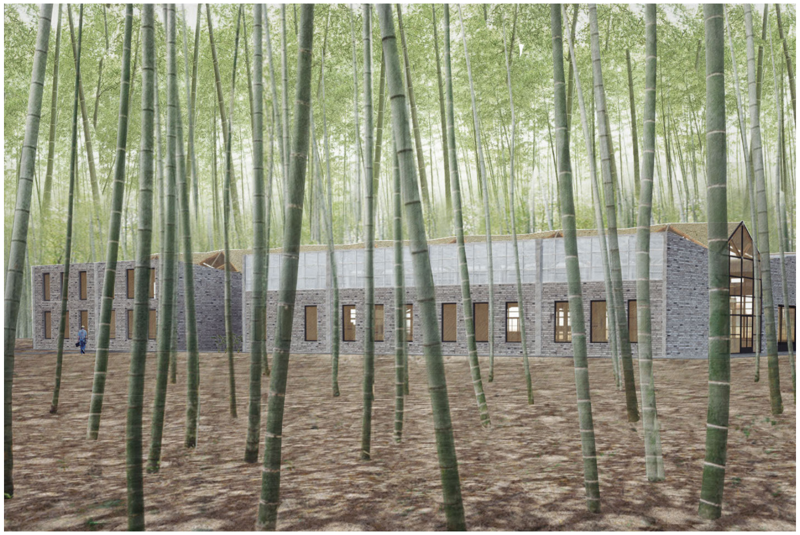

Figure 4-8. Approach from the parking lot

Figure 4-9. View of the atrium looking east

A DAY IN THE LIFE

In order to illustrate the intention and potential of the proposed design, this narrative and accompanying series of renderings imagines what a day in the life of a factory worker might be like.

Upon arriving at the site, the factory worker approaches through the grove via the footpath, transitioning from the commute to the workplace (Figure 4-8). They first go to the lockers to pick up their gear, then stop by the kitchen to have a cup of coffee with coworkers (Figure 4-9). Here, they chat with a researcher from the greenhouse about their experiments with madake, the new species they are growing on site, and how it responds to steam-bending as compared to moso. The researcher heads out to the grove to survey the growth of new shoots, while our worker moves to the factory floor (Figure 4-10). They spend the morning removing strips of bamboo from the drying shelves and milling them for lamination. By lunchtime, the group working in the factory prepares a cart full of milled sticks ready for the next shift to laminate.

At lunch, employees gather at the kitchen again to eat. The worker chats with other employees about their favorite nearby

Figure 4-10. View of the factory floor looking west.

hiking spots. A researcher from the greenhouse announces that they are arranging a class for local farmers on growing bamboo as an agricultural crop, and asks people to spread the word to anyone they think might be interested. After lunch, the worker moves to the workshop tables to spend the afternoon developing the design of a chair (Figure 4-11). If successful, they might produce several handmade pieces to sell online or to boutiques in Seattle. The greenhouse researcher stops by to follow up on their morning conversation and see the madake experiments. Later, a laboratory researcher walking by notices the chair in progress and stops to talk about a 4D CNC lathe they are developing for milling bamboo poles. The two share ideas about what capabilities the machine

Figure 4-11. View of the atrium looking southeast towards the workshop (right), laboratory (center), and greenhouse (above).

would need and how it might be used to make the chair and other furniture. At the end of the day, the worker stores their things in their locker, saying their goodbyes to other employees on the way out, and departs through the bamboo grove.

5

CONCLUSION

This thesis explores a new approach to factory architecture, one which centers on the human relationship with work and landscape. The project is an architectural design proposal, not a business plan, and issues of economic or agricultural feasibility are suspended for the sake of exploring the design idea to its fullest extent. The production material and program of the factory was selected as a response to regional context and their ability to accommodate the concept of convergence in the factory setting. The project seeks to illustrate this concept in the hope that the core values and strategies of the design could be adapted to factories of other types.

In a region seeking diverse, sustainable industry to regenerate its economy, the introduction of a new material challenges the existing paradigm of the industrial work setting while still offering elements congruent with local values. The sustainability and silvicultural elements of bamboo offer a mutually beneficial relationship between worker and landscape. The introduction of bamboo requires an integrated system of production, design, and research to further innovation and adaptation to the region. And this integration of program spaces, activities, and landscape fosters a workplace that offers agency, collaboration, and fulfilling work.

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