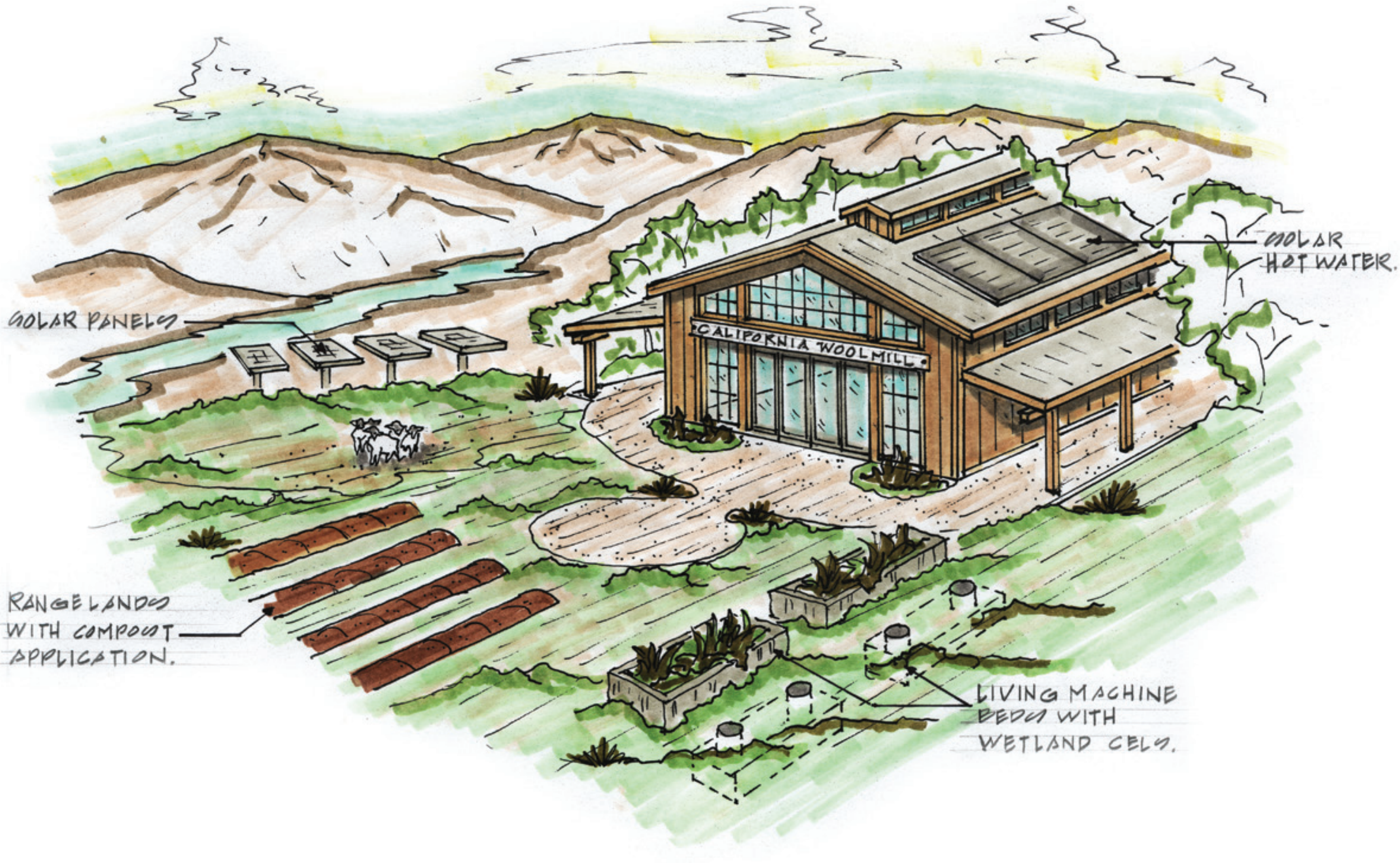
fibershed

local fibers · local dyes · local labor



Fibershed Feasibility Study for a California Wool Mill

FEBRUARY 2014

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for a California Wool Mill

by Amber Bieg, Rebecca Burgess, Dustin Kahn,
Erin Axlerod, Jenny Kassan, Marcia DeLonge, and Lydia Wendt

Abstract
The California Wool Mill Feasibility Study was conducted to assess the production of cloth in a vertically integrated supply chain using 100% California grown wool fiber. The Study Team began with a supply analysis to assess the quality and quantity of California wool, and created an ideal technical road map for an ecologically sensitive closed-loop mill design utilizing renewable energy, full water recycling, and composting systems—the products from the Mill were analyzed and shown to have a high potential for net carbon benefit. The suggested model outlines the potential for a multi-stakeholder coop that would close the financial loop between profits and the producer community, furthering the positive economic impact for our ranching and farming communities.

Acknowledgements
The Mill Feasibility Study Team would like to acknowledge and thank Lorene Arey and Don Shaffer for working with us to establish the framework for this study, and for having the vision and understanding for how to create the fertile grounds for socially and environmentally responsible business. We'd like to acknowledge and thank John Wick and Peggy Rathmann for their commitment to facilitating vitally important research on rangeland management and climate change—and their tireless efforts to see human material culture transformed into that which is climate beneficial and socially equitable. We are grateful for the work of Heather Blackie and the Blackie Foundation for providing instrumental support of this project from day one. We would like to thank Mike Corn of Roswell Wool for providing guidance, advice and support. Also for taking so much time to prepare the 2012 California auction dataset. We are grateful to Lynda Grose for all of her research on the demand for wool textiles and interviews with key brands. We acknowledge and are very grateful for the volunteer and skillful efforts of Dan Rhodes from Gaston College who provided us with use of his research facility, and time; he was graciously able to connect us with reputable manufacturers of milling equipment—and on that vein of acknowledgement we are thankful for the tireless efforts of Amaury DeLaforcade from Schlumberger, who worked with us through many iterations to produce a workflow plan and machinery options that both optimize efficiency while supporting our needs for an ecologically sensitive system.

Cover: Conceptual sketch of a California Wool Mill, by Bill O'Callaghan

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EXECUTIVE SUMMARY

The California Wool Mill could potentially process up to 5 million pounds of raw fiber, turning greasy wool into fabric and garments in the most technologically advanced and ecologically sensitive facility designed to date in the world. The California Wool Mill feasibility study was inspired by the need to address the existing issue that only .03% of California's wool is currently being processed within the state, and yet California remains a net importer of wool goods. The Mill design was created to address a need to support our local farms and ranches through placing a higher value on wool fiber, while providing livelihoods, and ecologically sensitive and 'homegrown' goods for the local population.

The conclusion from this analysis is that The California Wool Mill is an optimistic and ideal design for textile processing. The environmental and cultural impacts of the mill are numerous. The capital costs for the Mill design are estimated at $26 million. It has been determined that milling at this scale, at this time, is not yet feasible for California, given these high start-up costs. After more than a century since California's wool processing heyday—there is little to no skilled or experienced labor to build the necessary team to manage a facility of this size. Furthermore, there is more work required to build the 'local cloth' movement to determine a clear demand for higher priced textiles coming from such a high cost facility.

Prior to investing in the full-scale design outlined in this study, the team recommends building the demand for ecologically high-priced cloth through the construction of smaller and less financially risky supply chains. Through prototyping textiles with East Coast mills, and supporting the creation of small California yarn milling operations—the work to create high-end and ecologically sensitive textile economies in California will emerge over time. Textile engineering skills and business acumen will develop organically as smaller mills arise on the California landscape and begin to train a qualified labor pool through on-the-ground experience.

In the meantime, as California builds a qualified labor pool, establishes a clear demand and proves the concept through smaller facilities, we invite Fibershed communities across the nation and globe to utilize aspects of this study for their own milling designs. The feasibility study should be viewed as a composite of building blocks—the wool supply analysis, the water recycling system, the green house gas life cycle analysis, and the list of equipment engineers and suppliers can all be transfigured into useful shapes and scales for each community. Our bioregions are rich arenas for textile creation, and to further develop these natural and cultural landscapes we must continue to share our successes and set-backs in what is a collective process to re-vitalize local production of a basic human need—our clothing.

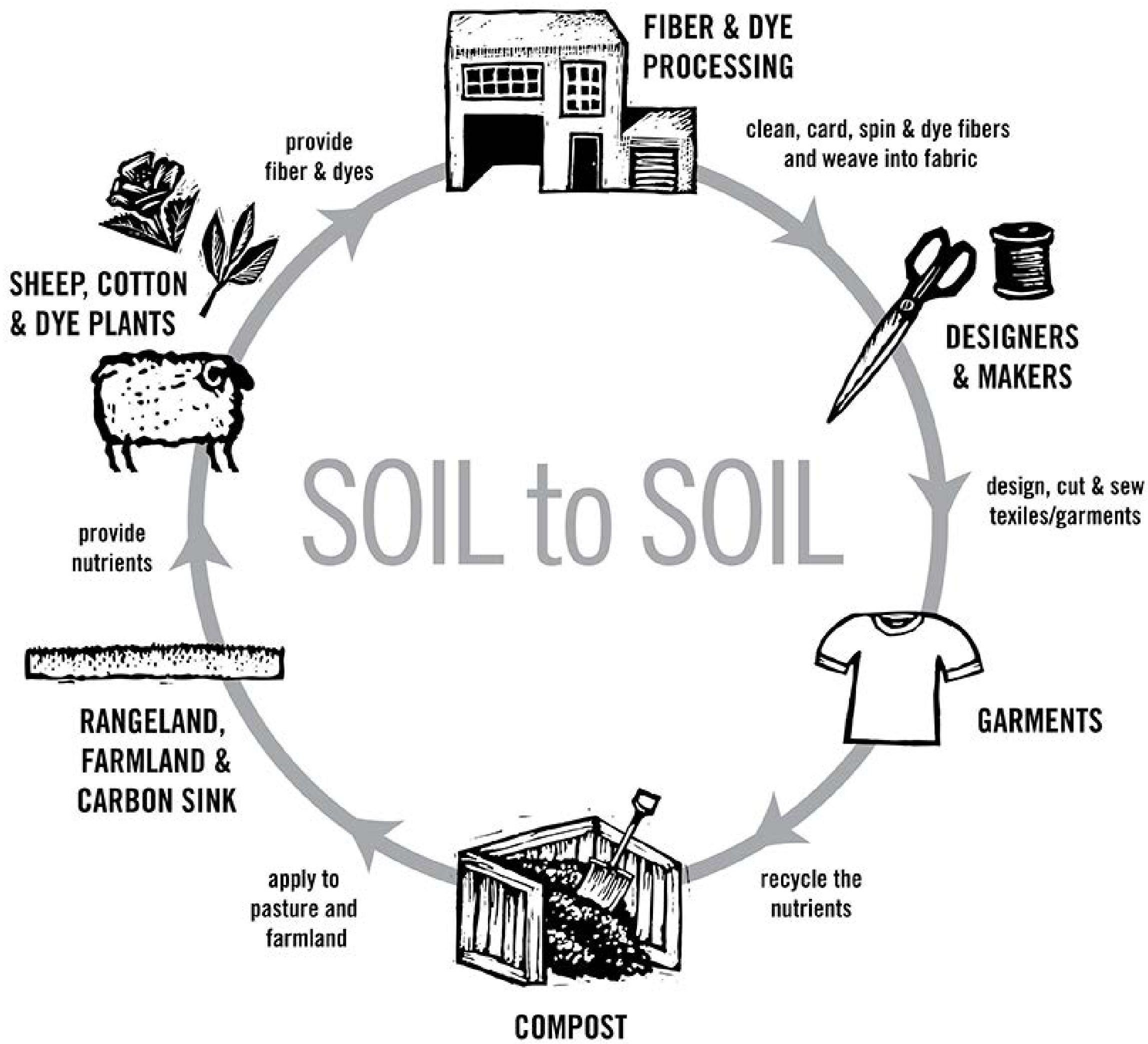

Figure 1: The Fibershed Soil-to-Soil Milling Relationship. © Fibershed, 2013.
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INTRODUCTION

The price of textiles today does not account for the costs accrued from the negative impacts of the current industry. While garment manufacturing has recently received the spotlight for atrocities in human rights violations in Bangladeshi garment factories, the upstream textile supply chain has been mostly ignored. Textile production still perpetuates slavery with major incidences of forced and child labor especially in the regions with the largest textile exports such as China and India (Anti-Slavery International, 2011). These human rights abuses are compounded by the environmental destruction.

Textile manufacturing is the second largest source of fresh water pollution (from dyeing and treatment), accounting for 20% of global water contamination (The World Bank, 2013). The use of synthetic fibers in everything is destroying our ecosystem. The New York Times published an article citing a report from Environment Science and Technology saying that synthetic garment fibers, released through laundry-based sewage run-off, account for the greatest share of plastic pollutants on the world's beaches (Browne, 2011). These negative impacts cost current and future generations the right to fair employment and a healthy environment. John Anderson, past president and chief executive officer of Levi Strauss & Co., succinctly states: "For the fashion industry to be sustainable economically, it must be sustainable socially and environmentally too." Essentially, the textile industry needs to change.

Feasibility Study Background

The impetus for the California Wool Mill began with a humble attempt at producing a 100% locally constructed wardrobe made entirely of regional fibers, dyes and labor (all within a 150-mile radius from project headquarters). This project was given the name "Fibershed," to coin a term meaning "a geographical region that provides the basic resources required for a human's first form of shelter (aka clothing)." The initial wardrobe produced zero toxic wastewater, omitted the use of all endocrine disrupting compounds, and (via carbon accounting on the wardrobe's single most important pair of pants), the footprint proved to be one sixth of conventional equivalents (Dr. Srinivasan, 2011). The biggest challenge for constructing this wardrobe was not due to any lack of quality materials, but instead, a severe lack of processing infrastructure to make fine gauge yarns and cloth.

California produces over 3 million pounds of wool annually (United States Department of Agriculture, 2007), the milling capacity is around 10,000 pounds per year or three-tenths of one percent of total production.

Local ranchers and artisans have long discussed the lack of value-added processing in California, and yet none of those involved in artisan scale farming or clothing production were interested in developing the more industrial systems required to make fine quality cloth. Many local designers and larger brands have begun to investigate the potential use of regional fiber, but the processing capacity deems this quest for localizing their supply chains impossible.

History of California Wool Milling

Prior to the turn of the 20th century, twelve vertically integrated woolen mills across California, including the Pioneer Mill of San Francisco, once employed 700 men and women, producing blankets, shawls and carriage robes. In the south, the Los Angeles woolen mill produced a small line of flannels and blankets and kept nine looms and 260 spindles at full capacity until 1891. California once provided durable goods for local populations through the woolen textile trade prior to the construction of the Pacific Railway lines (Vivian, 1890). Wool mills existed in Merced, Petaluma, Santa Rosa, San Jose, Woodland, Oakland, Marysville, Napa, San Francisco and Los Angeles.

California's brief stint in woolen textile production hit its pinnacle in the last quarter of the 19th century. Once established trade routes and railway lines were solidified with the East, the mills on the West could not compete with production in the Carolinas, whose facilities benefited from lower coal costs, cheaper wages, and lower loan rates (Vivian, 1890).

The current state of textile production in California has evolved little since the debasing of the industry 'post-railroad' in the 19th century. Spawned by free trade agreements and a thirst for cheaper labor and energy costs, the search to lower the price of production for the maximization of profit has continued. All the while California remains the lead producer of wool in the nation, and currently only processes three-tenths of one percent of this raw material within the state.

Farmers and ranchers today in California have three options for the sale of their wool: 1) The international commodity market which sells to value-added processing centers primarily overseas, 2) The hand-spinning and knitting market, and 3) compost and landfill.

In the last few decades farmers and ranchers have had little incentive to continue to raise wool producing animals (Redden, 2013), and the sheep rearing community has been shifting their breeding to what are known as hair sheep, or self-shearing sloughing animals, whose wool is unusable for durable goods (Redden, 2013). The California milling project seeks to shift these economic and agricultural trends by supporting ranchers and farmers through the creation of local outlets for their wool that are not dependent on international commodity market pricing. The project's assumed scale of production will serve a larger market segment than the hand-spinning and hand-knit community, as well as offer a consistent market to deter landfilling and composting of this precious resource.

The California milling project has been assessed for its role as an economic and environmental solution for California ranchers, farmers, designers, apparel brands and wearers. Given the historical richness of California's wool milling tradition this feasibility study builds on the context that began 'pre-railway' lines, with a focused assessment on the possibility for a new era of regionalism, and vertically integrated business.

Study Goals

The purpose of the study is to assess the technical, environmental, and economic feasibility of a vertically integrated wool textile mill in Northern California that could process up to five million pounds of California raw wool annually.

The feasibility study is broken into five main sections with goals specific to each section:

1. Wool Inventory and Supply Analysis
2. Demand Analysis
3. Operations and Site Feasibility
4. Financial and Environmental Performance
5. Economic and Social Impact

1. Wool Inventory and Supply Analysis goal was to inventory and analyze the quantity and quality of California wool for fabric production. The target objective was to complete the first ever supply analysis of California wool and inventory at least five percent of the California wool supply. The Study Team directly inventoried 1.408 million pounds of raw fiber (44.8 percent of the California wool supply) for its quality (micron count) and quantity (pounds of wool per year). Then the Study Team worked with industry experts to determine the optimal uses of California fiber, dividing end use by quality (micron count).

2. Demand Analysis goal was to calculate the demand for California wool mill products and determine the optimal pricing. The target objective was to conduct interviews with at least ten California brands that would be interested in using California produced fabric as part of their supply chain. The Study Team conducted interviews with 12 brands that collectively purchase 85 million yards annually, with a total value of $409 million. Other information to support the demand analysis is macro market research and consumer trends data.

3. Operations and Site Feasibility goal was to build a techno-economic model to determine the potential scale and scope of a 'soil to soil' fabric processing system based upon the California wool supply. The target objective was to create a systems-based design for the California mill; where one part supports the next in a closed loop system and the end of life for Fibershed fabric becomes the compost, fertilizing the rangelands, producing better grass and thus better wool. Like an ecosystem, every part is mutually supportive. Sourcing data and technical specifications from consultants and engineers, the Study Team has built an economic model that integrates engineering specifications and various scenarios for a closed-loop fabric manufacturing process.

4. Financial and Environmental Performance goal was to analyze various scenarios based on the integrated economic model and propose a scenario that optimizes both financial and environmental performance of the mill. The Study Team analyzed four scenarios comparing location of the mill as the only variable. All other variables were set as conservative assumptions, based on research for what the most probable scenario would be.

5. Economic and Community Impact goal was to quantify the macro Economic and Social Impact of the mill on the community where the mill will be situated. This impact analysis used existing research on economic multipliers and metrics for quantifying social impacts as well. This impact analysis is predictive and only gives an estimate based on the optimal scenario specified by the environmental and financial performance.

Study Team

Rebecca Burgess Rebecca Burgess is the Executive Director of Fibershed. She is the author of the best-selling book *Harvesting Color*, a bioregional look into the natural dye traditions of North America. She owns and operates the first North American temperate climate indigo project, which currently provides the raw material for our nation's first 90-mile radius denim supply chain. She has built an extensive network of farmers and artisans within our region's fibershed to spearhead prototype development of bioregional textiles.

Amber Bieg is an entrepreneur with over a decade of project development and management experience. She started three successful ventures: Open Tree Map (www.opentreemap.org), Fabripod (www.fabripod.com), and Green-Ideas (www.green-ideas.com). As principal of Green-Ideas sustainability consulting firm, Amber has worked with clients such as the City of San Francisco, Autodesk, ChicoBag and Food Commons, where she most recently worked on a feasibility study for a regional food system. She has an MBA in Sustainable Management from Presidio Graduate School and a BA in International Studies with a focus on Economic Development from the University of Oregon.

Dustin Kahn is the graphic designer and administrator for Fibershed, and has been working with the organization since June 2011. Her 35 years of graphic design and marketing experience include work with diverse organizations, including California Academy of Sciences, The Presidio Trust, Yosemite National Park and Spirit Rock Meditation Center. Dustin holds a Permaculture Design Certificate, and is currently part of a volunteer group that is developing an educational permaculture garden on public land in San Anselmo.

CONSULTANTS

Amaury De Laforcade has 15 years of international experiences in business management, development, sales, project management and service, with a focus on customers. Amaury is the president of NSC USA Inc., part of the 200-year-old NSC Group, which designs and manufactures machinery for the textile and the packaging industries. He provided consultation on the types of equipment needed for a sustainable textile mill in California for this report.

Dr. Marcia DeLonge is an Ecosystem Science Scientist and post-doctoral scholar at Silver Lab, University of California, Berkeley, Dept. of Environmental Science, Policy, and Management. Her research interests focus on surface-atmosphere interactions and the influence of surface cover and land-use on atmospheric and biogeochemical processes. She is particularly interested in interdisciplinary approaches to complex environmental problems, using both field observations and numerical modeling techniques.

Lynda Grose has been working on sustainability in fashion for 20+ years. She co-founded ESPRIT's ecollection line, launched in 1992 which was the first ecologically responsible clothing line marketed internationally by a major corporation. As a practicing designer, consultant and educator, Grose now works in a range of capacities across many sectors of the economy from farmers and artisans, to private companies and NGOs. Grose's client list includes UNDP, The Sustainable Cotton Project, Aid to Artisans, G.Hensler, Gap Inc, Turkish Government, US Department of Agriculture, Market Place India, Patagonia, Greenpeace, 13-mile Farm, and Shayan Craft Center. She runs workshops on sustainability for design teams, and is a frequent speaker at corporate offices, trade conferences, and universities.

Jenny Kassan has over eighteen years of experience as an attorney for and creator of social enterprises. She has raised funds for and launched a public space cleaning and maintenance business, a landscapers' cooperative, and a public market. She has extensive experience with direct public offerings, nonprofit-for-profit joint ventures, cooperatives, and creative financing tools. She has a law degree from Yale and a masters in city planning from UC Berkeley.

Dave McNulty works for Kent Wool, a state-of-the-art, wool-based yarn spinning operation serving a diversified international customer base—producing the highest quality yarns in the industry.

Dan Rhodes is the Product Development Specialist at Gaston College Textile Technology Center in North Carolina. He consulted with the Study Team on the design and implementation of wool scouring and milling for this report.

Dave Trumbull is the Principal of Agathon Associates and has 20 years experience in textiles and international trade. He has represented U.S. textile interests in trade and development policies at negotiations and conferences throughout North America, Western Europe, East Asia, and sub-Saharan Africa. He was appointed, in 2007, to the Industry Trade Advisory Committee on Textile and Clothing (ITAC 13) by Ambassador Susan C. Schwab and Secretary Carlos M. Gutierrez. Re-appointed, in 2010, to ITAC 13 by Ambassador Ronald Kirk and Secretary Gary Locke.

Lydia Wendt is a textiles specialist with more than 20 years of design and production in the garment industry. She has worked with Tom Ford for Perry Ellis America, Calvin Klein, Armani, Jones New York, SC Johnson and Sons, Clary Sage Organics, Lucy yoga, and The North Face to name a few. While at Made in America, a private label manufacturer, Lydia's accounts covered a broad spectrum of markets such as PVH, GH Bass, The Limited brands and Bloomingdales. Her expertise in fabric and fashion development include trend forecasting, market research, line planning, design team as well as supply chain management, and prototyping for commercial production. She is currently Sustainable Cotton Project's fabric development and fiber conversion expert. Lydia has in-depth knowledge of life cycle assessment and fiber-to-apparel supply chain systems for greener sourcing, manufacturing and the shift towards sustainable practices.

INTERNS

Erin Axelrod is a problem-solver, systems-designer, entrepreneur and community organizer. Erin is passionate about building Local Living Economies based on bioregional-scale zero-waste design, deep-rooted connection to place, and reverence for nature and ecology. After earning her BA in Urban Studies from Barnard College, Columbia University, Erin worked for four years as the City Programs Coordinator for Daily Acts Organization producing water conservation programs for cities, transforming lawns into food, and helping design and manage a successful greywater reuse education & installation program. A frequent public speaker, she has given presentations at conferences including the Sustainable Enterprise Conference and the CA Greywater Conference.

Key Definitions

Carding: a mechanical process that disentangles, cleans and intermixes fibers to produce a continuous web or sliver suitable for subsequent processing. This is achieved by passing the fibers between differentially moving surfaces covered with card clothing. It breaks up locks and unorganized clumps of fiber and then aligns the individual fibers to be parallel with each other.

Felt: a non-woven textile that is produced by agitating and pressing fibers together. There are many different types of felts for industrial, technical, designer and craft applications.

Fiber: a hair portion of, or filament from a vegetable, mineral or animal tissue substance, which is traditionally formed or manufactured into textiles.

Fibershed: a geographical landscape that defines and gives boundaries to a natural textile resource base. Awareness of this bioregional designation engenders appreciation, connectivity, and sensitivity for the life-giving resources within our homelands.

Knitting: a method by which thread or yarn is used to create a cloth. Knitted fabric consists of a number of consecutive rows of loops, called stitches. As each row progresses, a new loop is pulled through an existing loop. The active stitches are held on a needle until another loop can be passed through them. This process eventually results in a fabric, often used for garments. Knitting may be done by hand or by machine.

Micron: a measurement for the diameter of wool fiber. Micron ranges from 17-22.9 are recommended for garments worn close to the skin. Larger micron counts up to 24.9 can be used easily for garments. Micron numbers exceeding 25 are generally used for household fabrics and felt. The California wool inventory documented that 79% of our wool in the state is 24.9 microns or less.

The Milling Process, from Sheep to Skin: Wool fibers (called fleece at this stage) are removed from sheep annually and sometimes biannually through the shearing process. Experienced handlers called sheep shearers are hired by herd owners to do this work. The wool is often baled and sent to a mill directly or to a third party to be sold on the international market. Once at the mill, the bales are opened, the wool is picked apart mechanically, washed, and then combed. In some mills the wool is pin-drafted by a machine to ensure the wool fibers are running parallel to one another. Once combed and possibly pin-drafted the wool is spun into yarn. Depending on the type of yarn produced, it will then be knit or woven into finished cloth for cut & sew production of clothing or household goods.

Pin Drafting: a system of drafting in which the fibers are oriented relative to one another in the sliver and are controlled by rolls of pins between the drafting rolls. It is primarily used for long fibers in the semi-worsted and worsted spinning systems.

Raw Wool: After wool is sheared from the sheep, it is graded and sorted with regard to wool type, length, fineness, and shade of fibers. This unprocessed raw wool is called “grease wool” and requires further processing prior to yarn formation. Grease wool contains the sheep’s natural oils, dirt, vegetable matter, dried perspiration (suint), and other extraneous debris. The fleece of the sheep may contain as much as 60% by weight of this matter.

Scouring: Greasy wool, contains a high level of valuable lanolin as well as dirt, dead skin, sweat residue, pesticide, and vegetable matter. Before the wool can be used for commercial purposes, it must be scoured, a process of cleaning the greasy wool. Scouring may be as simple as a bath in warm water, or as complicated as an industrial process using detergent and specialized equipment.

Shearing: Sheep shearing is the process by which the woolen fleece of a sheep is cut off. The person who removes the sheep's wool is called a shearer. Typically each adult sheep is shorn once each year (a sheep may be said to have been "shorn" or "sheared," depending upon dialect).

The Soil-to-Soil Concept: The California Wool Project starts with an understanding of the soils from which the forage grows that feed the sheep. There is now a protocol under development with the state of California to support rangeland managers, including shepherds and shepherdesses in the act of building soil through a composting application that sequesters carbon dioxide, and increases the water holding capacity of pasture and grasslands. This protocol has been generated from five years of science on California rangelands. The California Wool Mill Project seeks to work with wool producers who are engaged with the composting protocol. California's wool would ideally be processed through a renewable energy powered mill, with a Living Machine® system to recycle 100% of the water on site, creating a potentially carbon neutral—or carbon sequestering—wool fiber supply chain. To complete the cycle, worn and depleted garments could be composted and returned to soils to facilitate the renewal of the soil-to-soil cycle.

Weaving: a method of fabric production in which two distinct sets of yarns or threads are interlaced at right angles to form a fabric or cloth.

Woolen: Woolen yarn processing combs the wool in a manner that the fibers do not lay parallel to one another. The fibers are combed and then spun into yarn creating a less processed and less strong finished yarn.

Worsted: Worsted yarn [often written as Ne(w)] processing gently pulls the wool through pins and combing devices to ensure the fibers lay the same direction and are parallel to each other before they are spun into yarn. To align the fibers the wool may pass through many such combing and pin drafting machines several times over before it is ready to be spun into yarn.

Yarn Count: Yarn count numbers describe the diameter of the yarns. In the worsted system that we reference in this study, the larger the number referred to, the finer the yarn's diameter.

CALIFORNIA WOOL INVENTORY AND SUPPLY ANALYSIS

Research goals and methodology

The Fibershed California Wool Inventory was the first broad scale qualitative inventory that has been undertaken on California wool resources. The USDA Agricultural Census provides data on quantity of wool produced in California, but does not have data on quality. The primary goal of the California Wool Inventory was to measure the quality of California wool in order to assess its viability for garment production. The secondary goal was to collect data on land management practices (irrigation, strategic grazing, and stocking rates) to build the foundation for an environmental life cycle analysis (LCA). The Study Team completed the supply analysis, utilizing primary source data and other data through the development of some key public and private partnerships.

DATA COLLECTION STRATEGIES:

1. United States Department of Agriculture (USDA) agricultural census, National Agricultural Statistics Services (NASS) database and statisticians.
2. Shearer surveys and fiber sample collection: The Study Team worked with four California shearers who collected wool samples and information on breed and wool quantity. The wool samples were sent to a consultant for the American Sheep Industry Association for micron testing. Micron testing calculates the diameter of each fiber.
3. Roswell Wool (the largest wool auction warehouse in the U.S.) provided micron data and quantity information from their 2012 California shearing and baling process.
4. Online survey: Dissemination and collection of our online survey and in-person visits to ranches and farms for wool sample collection verified the wool quality and built relationships with the individual producers.

California Wool Production

California produces 3.1 million pounds of wool annually, making it the largest wool producing state in the U.S. (National Agricultural Statistics Board, NASS, 2013). Like the rest of the country, California has seen a steep decline in sheep populations since 1945, however, interestingly this decline California has slowed since 2000 (National Research Council, 2008). This slowing of the decline can be attributed to an increase in demand for lamb from the fast-growing Asian immigrant population, moving here for the tech boom (Fagan, 2013), as well as resurgence in textile manufacturing in the US, with the increased popularity of 'American Made.'

While the concentration of wool production is in large-scale sheep ranches (see Figure 2, at right), there are significantly more small-herd farmers (see Figure 3, next page). 71 percent of sheep farmers manage 24 sheep or less (United States Department of Agriculture, 2007). At 24 sheep or less, most of these producers are losing money, suggesting that they are raising sheep for grazing small acreage, personal consumption or as a hobby. This indicates that most wool producers are not optimizing their production for the sale of wool on a commercial scale.

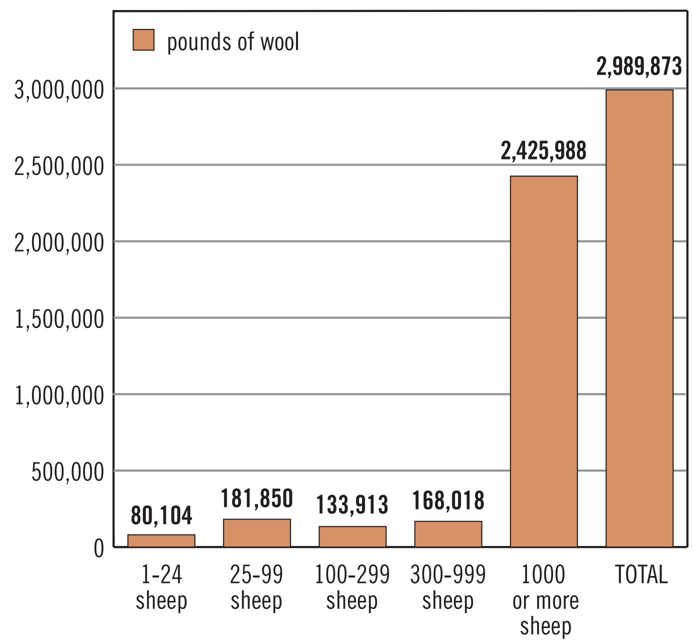

Figure 2: California Wool Production by Flock Size. Source: USDA Census 2007.

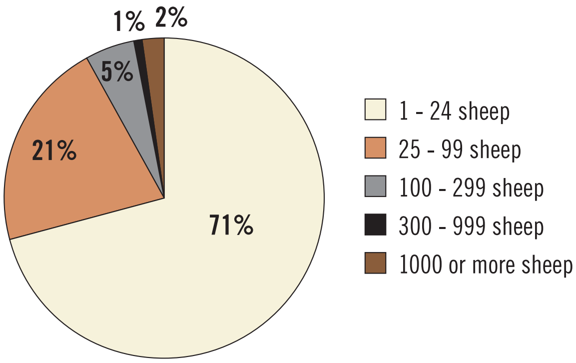

Figure 3: Distribution of California Sheep Farmers by Flock Size. Source: USDA Census 2007.

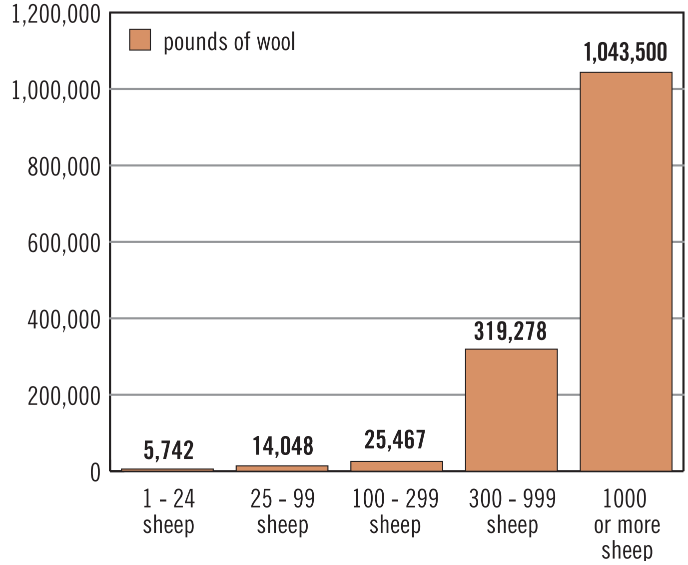

Figure 4: Roswell/Fibershed Wool Production by Flock Size. Source: Fibershed Wool Inventory

QUANTITY

The Study Team directly inventoried 1.408 million pounds (44.8% of the total wool in California) of raw fiber for its quality (micron count) and quantity. The farmers that produce this particular supply either responded to the Fibershed survey or they sell wool through Roswell Wool auctions. This wool supply is immediately available for milling and can be purchased in the April and May annual wool auctions.

QUALITY

To the surprise of the Study Team, 1,098,715 pounds (79%) of wool in the Fibershed inventory is fine enough to wear next to the skin, allowing for the production of functional and commonly worn garments. This strongly suggests that local milling could have sufficient scale to justify the investment in industrial-scale equipment and building.

Based on conversations with Kent Wool and Clover Knits, wool in the range of 19-20.5 micron with an average 19.8 micron count can produce 42 Ne(w) worsted yarns that will knit a 4.5 oz. jersey. Wool in the range of 20.6-21.9 micron with an average of 21.4 micron count can produce 36 Ne(w) worsted yarns that will knit a 8 oz. Ponte di Roma (McCarter, 2013). Table 1, on the following page, explains the breakdown of micron to yarn to fabric relationship.

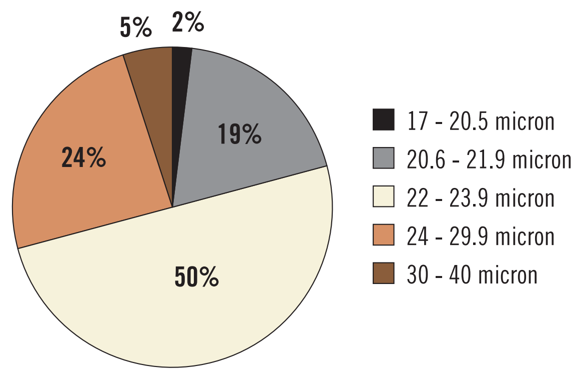

Figure 5: Fibershed Inventory by Micron Count. Source: Fibershed Wool Inventory

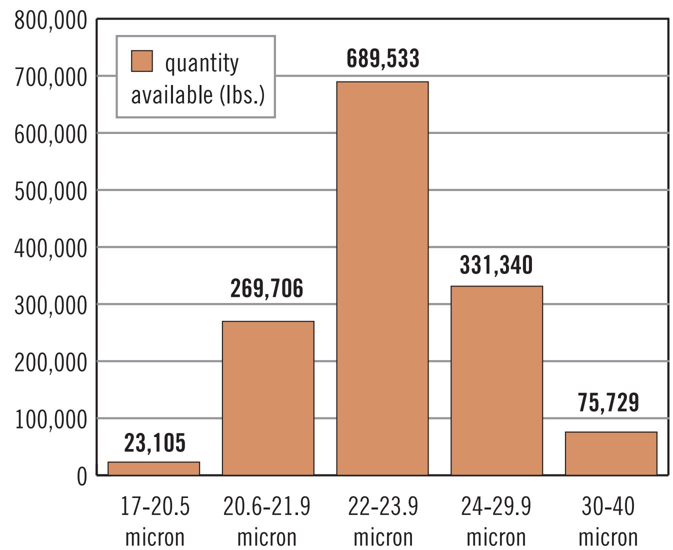

Figure 6: Fibershed Inventory by Micron Count. Source: Fibershed Wool Inventory

Table 1: *Micron Count to Yarn Count Conversion*

Micron count	Ne(w) yarn count	Average fabric weight	Fabric use
17-20.5 micron	42	4.5 oz.	Base layer/underwear
20.6-21.9 micron	36	8 oz.	Lightweight shirt/sweater
22-23.9 micron	28	12 oz.	Midweight outer layer
24-29.9 micron	24	20 oz.	Heavyweight outer layer
30-40 micron	12	24 oz.	Upholstery/carpet

Table 2: *Relative Batch Sizes in Fibershed Inventory*

Ne(w) yarn count	Average Fabric weight	Fabric Use	Micron Count ranges	Average micron count	Quantity Available (lbs)	% of wool supply
42	4.5 oz.	Base layer/underwear	17-20.5 micron	19.8	23,105	2%
36	8 oz.	Lightweight shirt/sweater	20.6-21.9 micron	21.4	269,706	19%
28	12 oz.	Midweight outer layer	22-23.9 micron	22.8	689,533	50%
24	20 oz.	Heavyweight outer layer	24-29.9 micron	25.5	331,340	24%
12	24 oz.	Upholstery/carpet	30-40 micron	31.7	75,729	5%

Note. Fibershed California Wool Inventory.

Key Study Team members Rebecca Burgess and Amber Bieg, with consultant Lydia Wendt, spent two days working with textile engineers at Gaston College to reverse engineer five sample fabrics that the team deemed good examples of what the garment industry and consumers would buy. The purpose of this was to determine if the California wool supply could replicate textiles that have wide commercial distribution. Of the five samples reverse engineered, four matched volumes appropriate for the wool supply inventoried. See Table 3, below.

Table 3: *Fibershed Reverse Engineering Results*

Weight	Fabric	Color	Sample source	Ne(w)	Wool micron count	Available quantity (lbs.)	% of CA supply
Midweight	Woven	Heather grey	Pendelton waistcoat	16.37	25 or coarser	296,819	21%
Heavyweight	Woven	Natural tan/grey	Bespoke Tailor knickers	9.8	25 or coarser	296,819	21%
Lightweight	Woven	Natural white	Light button-down shirt	37.8	19-21.9	291,746	21%
Midweight	10 oz. Knit	Brown	Tunic/dress	26.12	22-24.9	805,903	58%
Lightweight	4 oz. Knit	Purple	Ibex base layer	39.55	17-18.9	1,066	0.1%

Note. Fibershed California Wool Inventory.

VALUE

According to sheep rancher survey responses and an interview with Mike Corn of Roswell wool, the finer quality wool (25 micron or finer) from larger flocks is sold at prices typically below $2 per pound for greasy wool (not washed or combed). There are a handful of small producers who sell at much higher prices and they are included in the “wool sold” category. While approximately 5% of the wool is landfilled or goes to waste, the majority is, for the most part, sold to large-scale buyers and shipped abroad for textile manufacturing (Corn, 2013).

GEOGRAPHY

Wool quality is highest in the hotter and drier inland regions of California. These areas also show the greatest flock sizes. The map below correlates the USDA climate zones with micron count.

California Sheep Flock and Wool Quality Map

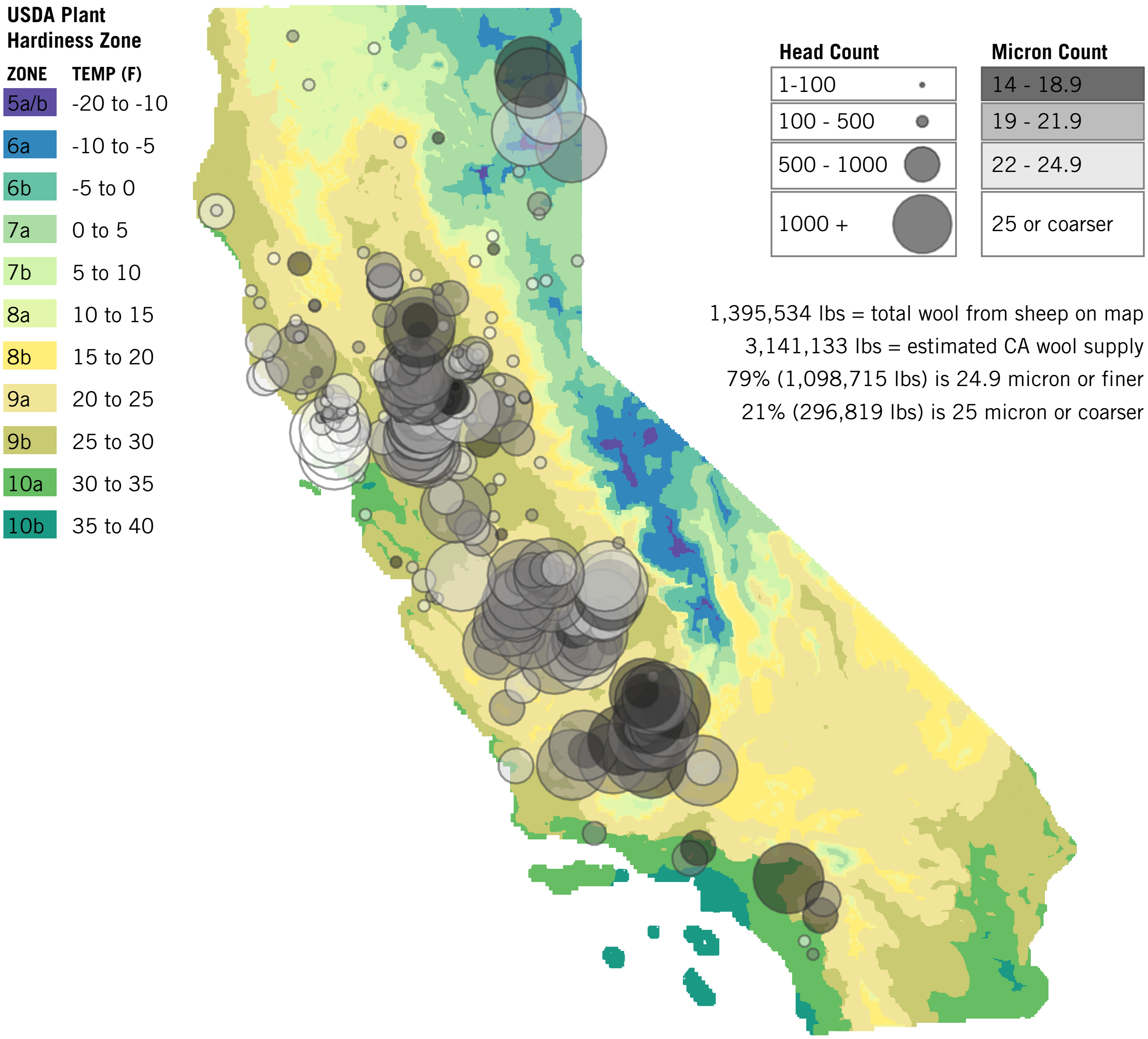

Figure 7: California Sheep Flock and Wool Quality Map. Data Sources: USDA Agricultural Census 2007, Roswell Wool Auction Data 2012, Fibershed Wool Survey 2013 (2012 sales numbers). Climate Zone Map. PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, created 2 June 2013.

GROWING THE COLORED WOOL SUPPLY

Based on the figures from our supply analysis, attaining a reasonable scale of production for fine fiber colored wool—such as gray, black, and brown wools, California producers would need to institutionalize new breeding programs within their herds. The genetic stock for fine colored fleece already exists in California and with support from Fibershed's non-profit producer program, strategies for breeding and building flock size throughout the state could potentially be done.

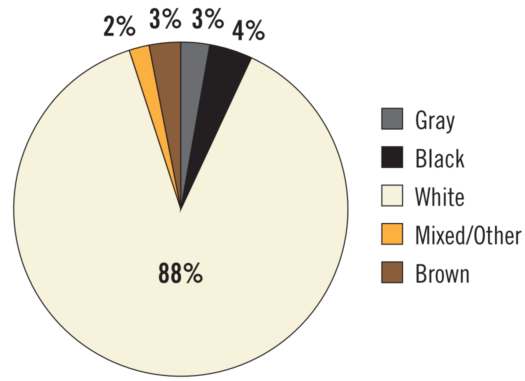

Figure 8: California Wool Distribution by Color. Source: Fibershed Wool Inventory.

From our qualitative wool analysis we identified a fine fiber colored Merino flock in Yolo County's Capay Valley. These genetic lines could be bred into other hot weather central valley flocks through ram selection and transport. Coastal climate breeding programs have begun with efforts from large-scale rancher Robert Irwin. Irwin's genetic program is currently focused on importing embryos from Australia. The goals of the program are to breed for a sheep that maximizes its ability to live on grass-fed systems, resists parasites and hoof rot, and produces a fine fiber. After speaking with Irwin about the inclusion of colored sheep, he agreed that increasing color variety could be created as long as the market for colored wool was established. Irwin is raising 250 of his own sheep and imported 3,000 sheep from out of state to graze for several months under his management. In four years time Irwin plans to increase his flock size to 1,000 sheep and import up to 5,000 sheep from out of state to graze. Irwin's contribution to genetics, and a shift towards colored wools would be a significant contribution to the fiber supply.

Trends in Wool Production

DECLINING US WOOL PRODUCTION

Despite the high performance and versatility of wool, production has declined 90% over the past 70 years (see Figure 9, below). In 1945, the total US sheep population was 56 million head with approximately 390 million pounds of wool production (National Research Council, 2008). As of January 1, 2013, the total US sheep population was 5.34 million head with a total shorn production at 28.5 million pounds of wool (National Agricultural Statistics Board, NASS, 2013). This steep decline in sheep and wool production is related to a number of economic, environmental, policy and cultural trends.

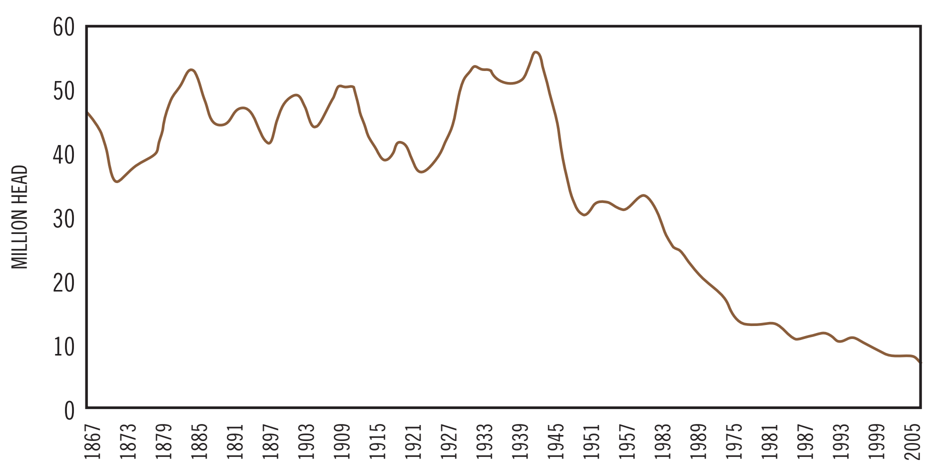

Figure 9: U.S. Sheep and Lamb Inventories (January 1), 1867-2007. Source: USDA (2007b).

Figure 10: Global Wool Supply at 50+ Year Lows. Source: The Woolmark Company, Poimena Analysis.

Wool production has declined not just in the US, but global supply of wool is at the lowest levels in 50 years (see Figure 10, above). However, this low supply started to drive up wool prices in 2011, leveling in 2012 and 2013. Even though these low prices boosted global production by approximately 1.7%, many wool experts believe that without a significant change in demand for wool, a fast recovery in world wool production is unlikely because of competition from synthetic fibers (American Sheep Industry Association, 2011).

DROP IN GLOBAL WOOL PRICES

"The sagging demand for wool can be attributed to widespread consumer acceptance of non-cellulose man made fibers such as nylon, polyester, and acrylic in formerly all-wool products (Jones, 2004)." The decline in wool use was accompanied by a subsequent decline in lamb and mutton consumption. U.S. per capita consumption dropped from 4.5 pounds per capita in the early 1960s to around 1.1 pounds in the 1990s (Jones, 2004). The American cattle industry ramped up efforts to market beef during the 60s, replacing lamb and mutton on American tables. This trend continues: Income from lamb has dropped 30 percent in 2012 due to price fixing by the meat-packing (National Research Council, 2008). At one point in time, wool was the primary product with lamb being the secondary product, now this relationship is reversed; wool production depends on lamb sales. This skewed relationship is due to the extremely low price of wool, at less than $2 per pound for greasy wool. Wool currently only accounts for 10-30 percent of revenue from rangeland sheep production, the rest is from meat (National Research Council, 2008).

In 1989 and 1990 the Australian wool market collapsed when reserve prices were removed from Australian wool. Stockpiles built up in excess of 5 million bales, which lead to worldwide price collapse. While, this could have been a means for wool to edge back into the textile industry, synthetic fiber prices also dropped, weakening wool demand further, leading farmers to liquidate their herds and leave the industry. This was compounded by the perceived lack of quality of U.S. wool (Jones, 2004).

RECENT INCREASE IN US WOOL PRICES

Real prices for US wool continued to trend down after 1990 declining at a much faster rate during the mid-1990s, and then plateauing in the 2000s. The price for raw, greasy wool averaged around $0.88 per pound in 2007 and was the highest it had been since 1995. The average price for wool top (washed and combed wool) was $2.26 in 2007 and rose to $4.68/lb, in 2011, up 71 percent from the prior year, and has leveled off in 2012 (American Sheep Industry Association, 2011). These are strong indicators of resurgence in the demand for wool, particularly American wool.

With the economic recovery in 2010, the prices of wool started to significantly split by quality. The demand for fine-grade wool rose much more steeply than the lower grades. This is an indication of the increase in demand for wool as a performance fiber. Companies like Smartwool and Ibex are increasing production, thus driving up prices.

Global pricing for wool isn't evenly distributed. Due to effective Australian marketing campaigns; "Prices for U.S. wool range from 60 to 75 percent of imported Australian wool prices (National Research Council, 2008)." The Australian WoolMark Company has been marketing Australian wool (50 percent of global supply) as the highest quality. However, two studies conducted by Texas A&M University prove that "American wool is well-suited to produce the finest of fabrics (American Sheep Industry Association, 2011)."

Due to the limited demand and processing infrastructure in the United States, 80 percent of U.S. raw wool exports go to China and India, totaling approximately 17.1 million pounds of clean wool in 2007. 'Clean wool' is wool that has been washed or scoured. The yield of clean wool is typically 55% of greasy wool. However, the US exports to both countries have fallen in the years since 2007 and most significantly in 2010. This in part was due to a shift in demand within the United States as a result of the economic recovery, a cultural shift in purchasing "American made" and increased clothing production and sales in the United States (United States Department of Agriculture, Economic Research Services, 2013). Global price and even more importantly, a domestic price increase could drastically change the supply of wool, as wool producers will increase breeding to meet demand.

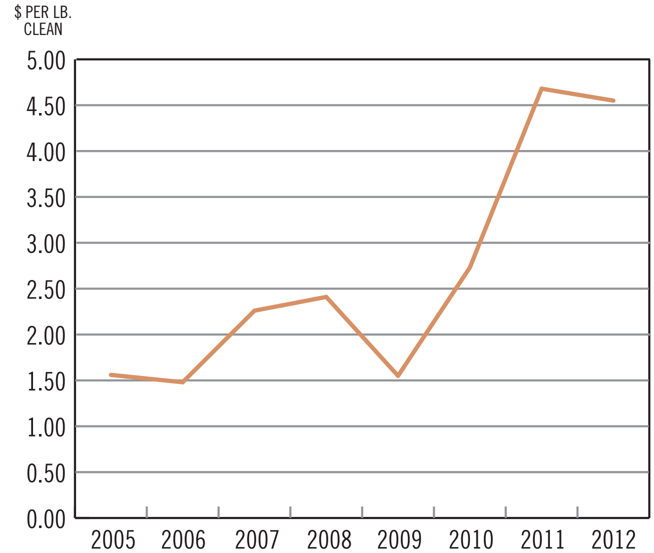

Figure 11: U.S. Average Clean Wool Prices. Source: USDA/AMS, ASI.

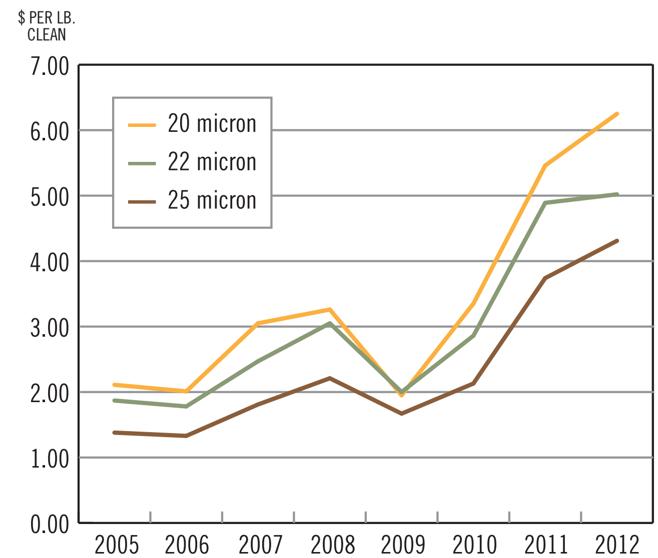

Figure 12: U.S. Average Clean Wool Prices. Source: USDA/AMS, ASI.

ENVIRONMENTAL

Loss of rangeland, predation and cost of feed have made sheep ranching a challenge in the US. With historically low wool and lamb prices, costs have risen disproportionately to rancher and farmer income. The past few years of unprecedented drought in the mid-west significantly reduced feed crop yields, thus increasing alfalfa prices by 97 percent and corn prices by 60 percent in 2012 (Agricultural Marketing Resource Center), driving up the cost of feed, requiring more reliance on rangeland. Moreover, many sheep ranching states such as New Mexico, Colorado, Wyoming and Texas have seen unprecedented drought (Corn, 2013). The desertification of these regions has destroyed rangeland, forcing sheep ranchers to buy feed or offload their flocks. The price of agricultural land in California, the largest wool producing state in the US, reached a record high of $7,200/acre, up by 13 percent from last year (Hearden, 2012), reducing the viability of range-land herds even further.

Continued regional droughts in Australia and the worst drought in New Zealand in 30 years have challenged lamb inventory expansion plans in both countries (J.S. Shiflitt, 2013). The implication is that the US may see an increase in demand for domestic lamb. However, lamb prices still haven't recovered enough to make it profitable enough to increase meat sheep numbers.

More than two-thirds of U.S. sheep production comes from the Southern Plains, Mountain, and Pacific regions. In 1974, coyote predation alone may have reduced gross U.S. sales by $27 million, or 9 percent. In 1999, the direct loss from predation on sheep and lambs was estimated at $16.5 million, just over 3 percent of gross sales (Jones, 2004).

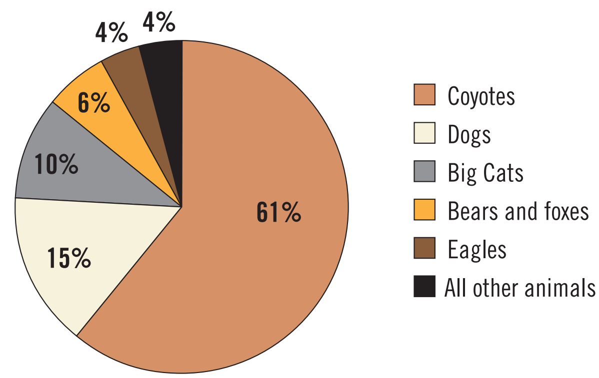

Figure 13: Sheep and lamb losses from predators, 1999. Source: U.S. Department of Agriculture, National Agricultureal Statistics Service (NASS), Sheep and Goats Predator Loss. Compiled by Economic Research Service, ISDA.

POLICY

From 1938 – 1953 the US government offered pricing subsidies for wool through the Agricultural Adjustment Act. Then in 1954 the National Wool Act was signed, providing subsidies for wool production up to, at times, 20% of the income for the entire sheep industry until the National Wool Act was terminated in 1995. In the years preceding the termination of the National Wool Act, the subsidies paid to sheep farmers for wool averaged 2.3 times the actual market value of the wool (United States Department of Agriculture, Economic Research Service, 2004). While a 2002 subsidy program was approved by congress, this program was a loan-based program rather than direct payment, and so far has been non-effective (Jones, 2004).

Since the end of the National Wool Act in 1995, U.S. wool producers have struggled to make wool profitable, while competing with global markets demanding such low prices on wool. This is even worsened by Chinese agricultural policies, subsidizing production. China spends a total of $73 billion annually on agricultural subsidies, equal to 9% of production. This artificially lowers the price of commodities. However since 2012, this trend is changing with the increased cost of labor and value of the Chinese currency (United States Department of Agriculture, Economic Research Services, 2013). This may be the first time that U.S. farmers can compete on price with Chinese imported wool and, if the social changes in China continue this trend, they could drive up the price of wool worldwide.

CULTURAL

Sheep ranching in California is based on an aging workforce, reflective of a general trend towards aging agrarians within the United States, (United States Department of Agriculture, 2007). Reasons for this include a culturally accepted norm in the ranching community that avoids or puts off retirement, (Eidelman, 2013). These aging ranchers are often supported by adult children who help their parents stay active by stepping into the family business—often to provide continuity to the family culture, and in preparation to sustain the ranching legacy within their own lives. For herd sizes of 1,000 head and larger this scenario is common. This herd size is used as a general marker for denoting if a rancher is involved in the industry as their full time job (Eidelman, 2013). Second generation heirs often bring another career and skill base into the family business, and do not rely on ranching as the sole means of support. However, they value the way of life and are often committed to sustaining it beyond the life span of their parents, (Eidelman, 2013).

California land inheritance for sheep ranchers is not the norm. More often than not sheep ranching is sustained by grazing contracts, and unlike the cattle industry, wool producers often do not own their own land (Eidelman, 2013). Innovative approaches to grazing have evolved. For example, the Colusa plains solar array was designed to be grazed by sheep and is maintained through grazing contracts. Another common grazing contract scenario includes crop residues, whereby row crop and alfalfa farmers will contract with grazers to remove vestiges of last seasons crop from the fields. Vineyards are also contracting for biomass management with sheep grazing contracts. These contracts have successfully allowed herd managers and owners to run their businesses without the expense of land ownership. The only major risk posed to these contracts is the sale of farmland in California for housing developments. Suburban sprawl has been the greatest threat to mobile grazing operations (Eidelman, 2013)

Young ranchers entering the sheep business, who do not inherit land, seek grazing contracts and diverse income streams. Brittany Cole-Bush of West Marin has sustained places for her animals to graze with contracts from public land agencies, on terrain where fuel load reduction is essential, (Cole-Bush, 2013). Robert Irwin of Lake County has sustained his shepherding work by establishing relationships and contracts with large vineyards in three elevation zones, allowing him to move the animals in a targeted manner based on the seasonal pulses of biomass growth, (Irwin, 2013). Aaron Gilliam of Sonoma County has a grazing contract on a private ranch to maintain the health of the California grassland ecosystem for the landowner (Gilliam, 2013).

Sheep ranching in California has evolved since the days of very large herds and a handful of shepherds. Second-generation sheep ranching heirs, young emerging ranchers and the work by many full time producers to establish innovative new grazing contracts with row crop farmers has slowly transformed the industry. This has moved shepherding into a place where its survival does not rely on the sole ownership of rangeland by its producers, finding mechanisms for maintaining continuity through generational transitions.

Summary of the Future of the California Wool Supply

Sheep are an important part of a healthy well-managed landscape in California. Sheep are natural grazers, offering vineyards weed control and rangeland managers affordable fire-prevention measures. When sheep are grazed properly, they disturb, fertilize and compact the soil for holistic land management. When combined with compost protocols, sheep grazing can provide a carbon sink, offsetting greenhouse gas emissions for California. More importantly, sheep wool is an important agricultural product that has a high value add when processed. It is an important part of California's history that needs to survive.

The future of California Wool depends on an increase in price. A California wool mill could significantly drive up prices and change breeding practices for California sheep ranchers. There is a precedent for rapid sheep population growth based on demand. The post-Depression recovery of the 1930s and the start of World War II caused a surge in demands for wool in the US. From 1935-1945, sheep populations for wool production grew from approximately 35 million head to 55 million head (National Research Council, 2008). This 20 million head increase over 20 years is not impossible to replicate. What is needed is the economic incentive for farmers to increase production.

DEMAND ANALYSIS

In assessing the feasibility of the California Wool Mill, the Study Team analyzed the demand for California grown and produced fabric. This study is a compilation of broad market research as well as specific product research. The Study Team collected data from various reports, online surveys of apparel companies and interviews with key potential customers. (See Appendix C for questions asked in the survey.) Based on this data, the team concluded that there is indeed a strong demand for California knit fabric, but at the right quality and price. The Study Team identified three key indicators of demand for California Fabric: 1) A shift towards domestic textile and apparel production, 2) Change in consumer behavior towards local and sustainable purchasing, and 3) California apparel brands stating that they would purchase California wool knit fabric if it were available. This analysis concludes that there is a demand for California grown and produced textiles given the appropriate price conditions.

Global Textile Markets are Changing

The global textile and clothing industry generates $602 billion USD in world exports and accounts for a 4.6 percent share in global merchandise exports. While the US is the sixth largest textile exporter in the world with over $16.8 billion in exports (including $500 million sold to China). China, at over $200 billion, is by far the largest player in the global textile industry (World Trade Organization, 2010).

In the 1970s when apparel manufacturing started to move overseas, developed countries initiated the Multi Fibre Arrangement (MFA), which imposed quotas on the annual amount of textiles that developing countries could export to developed markets from 1974 through 2004. This was designed to ease the transition from domestic production to overseas production in the textile industry. The MFA expired in 2005, lifting any remaining quotas and textile exports from China to Western countries grew 100% in one year (500% for some items) (China Textile Network Company, 2010).

China's strong-hold on the textile industry is driven by low cost (primarily labor), government investments and subsidies, currency manipulation and industry internal organization in China (Forbes, 2013). Aggregate personal income in China is only 42 percent of the GDP, compared to 86 percent in the USA. But this dynamic is quickly changing: Real wages in Asia between 2000 and 2008 rose by 7.1-7.8% a year (The Economist, 2013). According to economist, Stephen Roach, former chairman of Morgan Stanley Asia: "The biggest problem in China is not inflation, but shifting its economic structure to maintain sustainable growth (China Textile Network Company, 2010)." As China shifts its economic structure, wages, and thus cost of production are rising, opening up opportunities for competition in the textile and apparel industry.

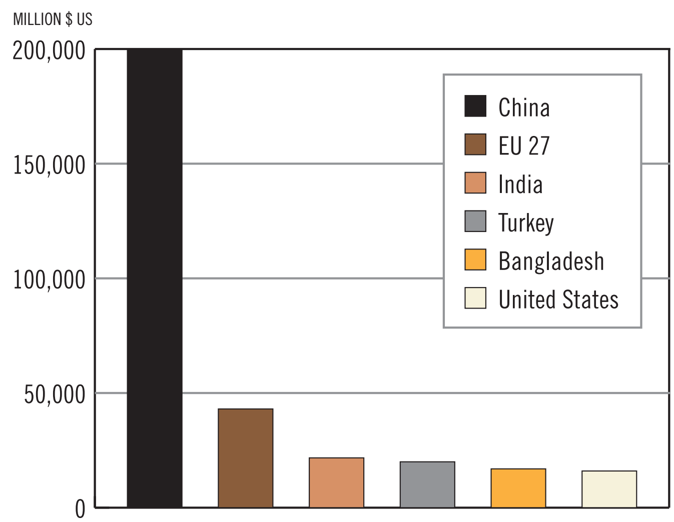

Figure 14: 2010 Textile Exports by Country ($ millions USD). Source: World Trade Organization (WTO)

India has been investing heavily in its textile industry to raise its share in the global textile and clothing market, with a view to replace China. Other countries, such as Pakistan and Bangladesh are also "waiting in the wings" to capture this lost market. However, a more than $20 billion investment in supply chain for both of these countries is required to compete with China. (Jamal, 2013).

And perhaps low-wage countries aren't the only ones poised for competition. With rising consumer awareness of wage-inequality in the textile industry, rising costs of transportation and efficiency gains in new technology, high-wage countries are starting to look competitive on the global textile market for certain niche segments. According to a 2013 study by MIT, 14% of the largest US manufacturing firms with multi-national operations have firm plans to bring production back to the US (The Economist, 2013).

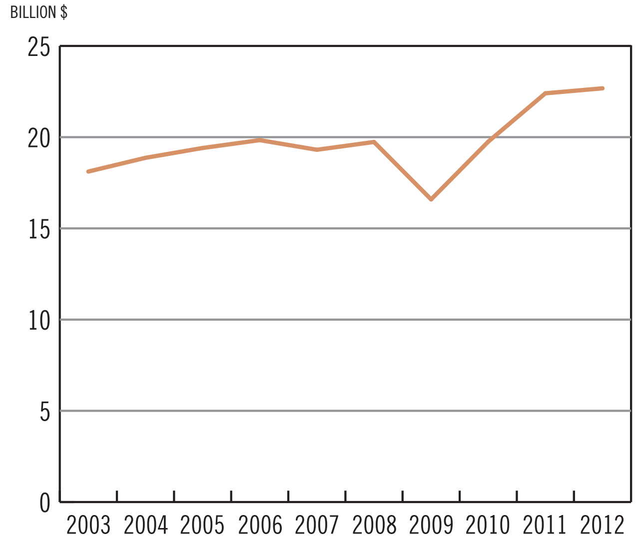

Figure 15: U.S. Exports for Textiles and Apparel. Source: U.S. Department of Commerce, Office of Textiles and Apparel

U.S. AND CALIFORNIA TEXTILE MARKET IS GROWING

U.S. apparel consumption is the largest in the world, comprising about 28 percent of global consumption and has a total value of $331 billion, yet the United States only produces a fraction of the apparel and textiles consumed. While the U.S. only exports $16 billion in textiles, the domestic market is growing. At one tenth of the U.S. apparel consumption, California's textile market is estimated at $36 billion, employing more than 120,000 in the sector rising from only 100,000 two years ago (California Fashion Manufacturing, 2011). This has much to do with a growing demand for 'American Made' products. In 2012, textile and apparel exports were $22.7 billion, up 37 percent from just three years earlier (U.S. Department of Commerce).

Made in America' is a fast growing trend. "In the last few years, brands such as L.L. Bean, Pendleton, Frye, Stetson and Woolrich have played up their made-in-America heritage, creating a fashion trend for Americana (Los Angeles Times, 2011)." American consumers care about supporting the domestic economy more than they care about brand identity. 'Made in America' has become a significant brand advantage. "In a survey of 1,300 affluent shoppers conducted by Unity Marketing, the U.S. ranked highest on the scale measuring quality in luxury goods manufacturing. It topped both Italy and France, home to such brands as Louis Vuitton, Prada and Hermes (Los Angeles Times, 2011)." Perhaps the most compelling evidence of this trend is a 2013 New York Times survey, showing that 68 percent of respondents preferred products made in the United States, even if they cost more, and 63 percent believed they were of higher quality (New York Times , 2013).

CALIFORNIA LEADING THE WAY

The idea of 'Going Local' is growing ever more popular in the US fashion industry with consumers demanding to know where their clothes are manufactured (Morgan, 2013)." At the 2011 Textile show at the California Market Center, there were over 800 textile lines (most were overseas lines), with more than 11,000 designers and private label sourcing agents, demonstrating a strong California-based garment industry (California Fashion Manufacturing, 2011). Manufacturing in California is becoming very attractive to apparel brands because of speed, quality control and more recently cost-effectiveness. Because of this, some large apparel companies (large = $30 million plus) are finding that they can produce in California with only a minimal price difference passed on to shoppers. "LA's Single brand can turn around 800 silk print dresses for Neiman Marcus and Lord & Taylor in as little as two weeks, now that 90% of its production is done at home with only a $1/dress price difference, with quality control and timing much better (Los Angeles Times, 2011)." Large apparel companies used to have to move production offshore to stay competitive on price, but now because of price and quality competitiveness coming from domestic apparel production, they are able to offer consumers a competitive product.

Brands Demand Speed – the age of fast fashion

Unfortunately the 'Quick to Market' concept also brings along the idea of fashion consumption being fast, low-price and disposable. Luckily, consumers are starting to wake up to the idea that fashion has an impact on the planet. The New York Times published an article citing a report from Environmental Science and Technology saying that synthetic garment fibers, released through laundry-based sewage run-off, account for the greatest share of plastic pollutants on the world's beaches (Browne, 2011). Moreover, 13.9 million tons of textiles are sent to landfill every year in the USA (United States Environmental Protection Agency, 2011).

However, Quick to Market doesn't necessarily mean cheap or disposable. There are many advantages to being Quick to Market, such as only making what sells and thereby not over-producing, reducing the need for liquidation and waste. Many companies save money with Quick to Market production strategies. The key to success is having the entire supply chain either vertically integrated or close in proximity to the customer. This allows for the designers to produce only what is in demand and on-demand.

If consumers get what they want, when they want, they are more likely to be satisfied with their purchase. If it is also high quality and slightly more expensive, they are also more likely to wear it longer, increasing the amount of time before disposal. Companies such as H & M and Zara are known for employing Fast Fashion practices, manufacturing in Europe to meet their European demand. However, they have yet to achieve the perception of quality or durability.

Consumers Demand Sustainability

Today's savvy consumers don't just care about supporting the domestic economy; they want complete transparency on the product supply chain and are demanding this from apparel brands. These concerns reached peak awareness as international news sources reported that two factory disasters in Bangladesh together killed more than 1,200 garment workers who were making clothes for Western companies. Major brands are starting to recognize the need for change in taking responsibility for their supply chains. John Anderson, past president and chief executive officer of Levi Strauss & Co., succinctly states: "For the fashion industry to be sustainable economically, it must be sustainable socially and environmentally too."

LOHAS (Lifestyles of Health and Sustainability) is a new significant US consumer demographic that is driving brands to take responsibility for their supply chains. According to a 2002 study conducted by Natural Business Communications and the Natural Marketing Institute (NMI), LOHAS consumers make up 30% of all U.S. households and this ratio is growing (Rosen, 2002). Also according to NMI (2011), subsequent research indicates that the LOHAS market is "a high-growth marketplace with rapidly increasing mainstream interest and consumer engagement." Nationwide, this demographic of consumers is roughly 41 million U.S. adults that annually spend $290 billion on food, products and services that benefit the environment, social justice, health and sustainable living (LOHAS, 2010). LOHAS consumers value and appreciate the interconnectedness of the environment, one's health and community.

"How do you convince someone to spend $300 dollars on a designer they might not have heard of, on a product they've never touched? If you can tell them that story and give them that emotional attachment and something to believe in," said Maxine Bedat and Soraya Darabi of Zady, the new online retailer that lets shoppers know if something is locally sourced, handmade, made in the US, made from natural materials or environmentally good. Last year, Zady's revenues were up 300% from the previous year (Nielson, 2013).

Carbon Regulation Creates Demand for Sustainable Textiles

Many global businesses are struggling to cope with strict carbon regulation in the EU, and soon this trend will expand to the U.S., where greenhouse gas legislation is being proposed. CA AB 32 and California's cap and trade program are early examples of a fast growing trend. As companies reach to comply with governmental regulation on greenhouse gas emissions, more companies will push the cost of carbon down through to suppliers and customers. "This leads to high resource prices and greater regionalization and vertical integration as business seeks to find and secure low-carbon, local sources of materials as an alternative to vast global supply chains (Forum For the Future, 2013)."

Domestic Purchasing Policies

The Berry Amendment (U.S.C. Title 10, Section 2533a), which goes back to 1941 and was first enacted as part of America's preparation for World War Two, requires the Department of Defense to give preference in procurement to domestically produced, manufactured, or home-grown products. In the case of clothing or textiles of wool the Department is prohibited from foreign acquisitions above the simplified acquisition threshold of $150,000. Furthermore, in the case of wool, the requirement is "fiber forward," meaning that, for example wool socks purchased with Department of Defense funds must be knit in America, of yarn spun in America, of wool fiber raised in America.

Wool is Hot

Over the past decade there has been resurgence in demand for wool garments. This is evident in the growth of U.S. brands such as Smartwool, which has maintained an annual growth rate of 20-30% per year over the past ten years reaching approximately $150 million in revenue (RAF Industries), and Ibex, which grew from $1.5 million to $10-$20 million in annual sales, also in the past ten years (Standford Graduate School of Business, 2013). While the demand for wool garments has been very strong in the outdoor apparel segment, this trend has finally returned to the designer fashion world.

British wool manufacturers are seeing a large resurgence in the demand for wool. The week of October 14th, 2013 was Wool Week for London's Fashion world. "Globally, there is such demand for wool that farmers are now being paid three times more for their fleece: it's a massive improvement, considering it once cost more to shear a sheep than you'd make for its pelt (Perri Lewis, 2013)." Old mill towns such as Hawick in Scotland and Saltaire in West Yorkshire have been "regenerated" with new mills recently built and in full-swing.

WHY WOOL IS NOT JUST A PASSING TREND

Wool is nature's performance fiber. No other material, natural or man-made, can match its qualities. Humans have a very long relationship with wool. With the dawn of human agriculture, the domestication of sheep became a key part of providing the key ingredients to three basic human needs: food (meat, milk and fertilizer), clothes (wool), and shelter (wool). Humans have refined wool over the past 10,000 years through selective breeding of sheep for qualities such as durability, water repellency and stain resistance, absorbency and resistance to flame (International Wool Textile Organization). These performance qualities make wool one of the most versatile and useful fibers on Earth.

WOOL'S NATURALLY OCCURRING QUALITIES INCLUDE:

Durability: The flexibility of wool fiber makes it durable. "A wool fiber can be bent back on itself more than 20,000 times without breaking, compared to about 3,000 times for cotton and 2,000 times for silk." The natural elasticity of wool also makes woolen fabrics resistant to tearing. In addition, the outer skin of the wool fiber acts as a protective film, giving wool cloth improved resistance to abrasion (American Sheep Industry Association).

Water Repellency and Stain Resistance: A thin sheath of overlapping scales covers wool fiber (see Figure 16, left). The scales cause liquid water to form beads and roll off, enabling wool fabric to repel rain, spills and dirt (Tantech Pty Ltd).

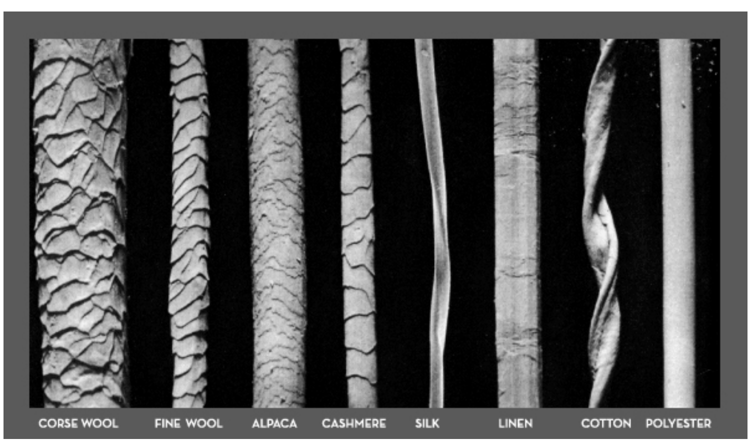

Figure 16: Microscopic photographs of fibers.

Moisture Absorbency: Wool absorbs water vapor (from the air or from perspiration), through the porous coating over the scales (see Figure 17, right). Through this porous structure, wool allows vapor to pass through to the heart of the fiber. Wool can easily absorb up to 30% of its weight in moisture without feeling damp or clammy (American Sheep Industry Association).

Temperature Regulation: When water vapor enters the fiber, energy is released. Every kilogram of wool generates about as much energy as the human body metabolism produces in one hour. On the other hand, when wool is exposed to a warm dry environment moisture is released, resulting in a cooling effect (Tantech Pty Ltd).

Resistance to Flame: Wool fiber has the highest ignition threshold for any natural fibers, is flame retardant up to 600º C and is self-extinguishing. When exposed to flame, wool chars, but then stops burning when it is removed from the source of fire (American Sheep Industry Association).

Renewable and Ecologically Beneficial: Wool is grown not made; every year sheep grow a new fleece. The sun, rain and soil grow the grass. Sheep eat the grass and grow the wool. Unlike other fibers, wool is obtained from rangelands, and with appropriate rangeland management, is climate-beneficial fiber. Based on initial research by the Marin Carbon Project, it is estimated that one wool garment from wool grown with good rangeland practices can sequester at least 37 Kg in CO2 (DeLonge, 2013).

Biodegradable: Wool is biodegradable and when disposed of, natural wool fiber takes only a few years to decompose, and with a high nitrogen content, wool can even act as a fertilizer (The Campaign for Wool, NZ, 2013).

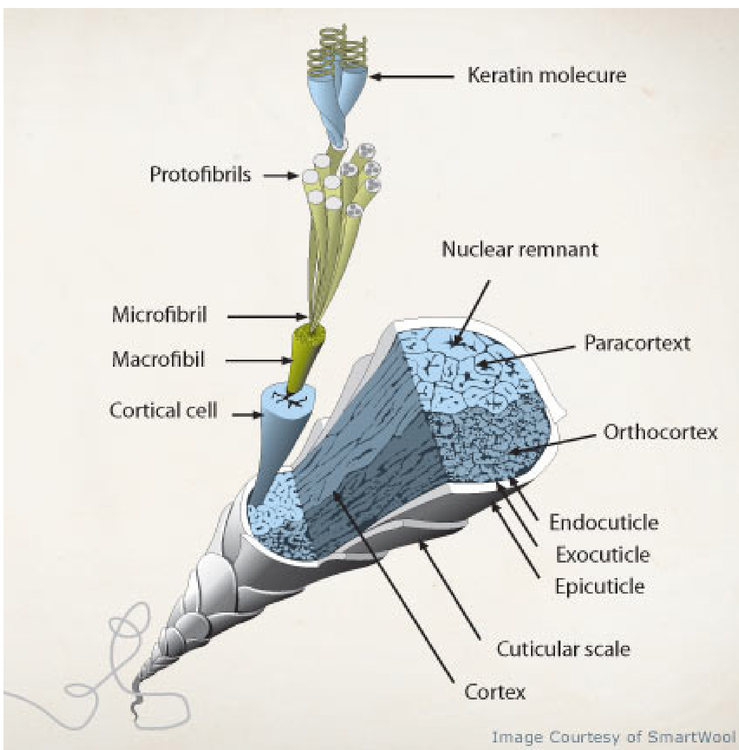

Figure 17: Diagram of a wool fiber. Source: Smartwool.

California Wool Mill Products

As a vertically integrated mill, the California Wool Mill will be able to produce and sell products at any point in the textile supply chain, including: Raw wool, scoured wool, lanolin, super washed wool, carded bats, felt, combed top, yarn, knit fabric, and seamless knit garments. The more finished or processed products, such as knit fabrics or seamless knit garments, have the highest value add, and therefore the highest revenue potential.

For this study, the Study Team analyzed the market potential two product categories: Wool knit fabric and lanolin.

WOOL KNITS

Based on the current available California wool supply, the Mill could initially produce four different wool knit fabric products. The potential wholesale prices shown here are one possible scenario, and will change based on wool supply and actual start-up costs when a business plan is developed.

- 4 oz. knit fabric, 60" wide on bolt – $11/yard
- 8 oz. knit fabric, 60" wide on bolt – $16.50/yard
- 12 oz. knit fabric, 60" wide on bolt – $19/yard
- 20 oz. knit fabric, 60" wide on bolt – $30/yard

PRODUCTION

Year one California Wool Mill production is expected to be approximately 640,000 yards of fabric, reaching 4 million yards of fabric by year ten.

DEMAND BASED ON PRICE

At the above listed prices, large brands did not affirm interest for integration into their annual purchasing. Small brands affirmed interest and commitment at these prices. Based on the Mill's output there is not yet an established demand for wool knits at this scale and at these prices.

RESEARCHED CUSTOMERS

The California Wool Mill assessed three target customer groups:

1) Large Apparel Brands
2) Small Apparel Brands and Individual Designers
3) California Consumers

A preliminary list of 33 early potential customers includes:

Addidas	Econscious	Ibex	Ocelot Clothing	Taylor Stitch
B. Spoke Tailor	Edgevale	Indigenous Designs	Pact	Tea Collection
Beta Brand	Eileen Fisher	Isa Ora	Patagonia	Timberland
Blue Canoe	ExOfficio	JackKnife	Pop Outerwear	Turk and Taylor
Carve Design	Filson	Lucy	Puma	Under Armour
Christina Kim	Gap / Athleta	Nike	Red Ants Pants	
Chrome bike gear	horny toad	The North Face	Smartwool	

ADDRESSABLE MARKET

Of these apparel brands, the Study Team interviewed twelve brands to assess the market viability of fabric produced at the California Wool Mill. These twelve brands represent $3.4 billion in annual apparel sales, with an average company size of $10,000,000. The combined total yardage of fabric purchased by all companies the team interviewed is 85 million yards annually, with a total value of $409 million. In looking at our early target customer list of 36 companies, the estimated fabric purchase is 3 billion yards, at a value of $14.7 billion. This is a potential total addressable market for the California Wool Mill if prices could be lowed.

Total Potential Market = $14.7 billion

KEY PRODUCT ATTRIBUTES

Through interviews and feedback from the brands the Study Team interviewed, a few key product attributes were identified. The Kano model, a theory of product development and customer satisfaction developed in the 1980s by Professor Noriaki Kano, was used to map the relationship of the Mill product offering performance against these key product attributes. The Mill should aim to meet all of these product attributes.

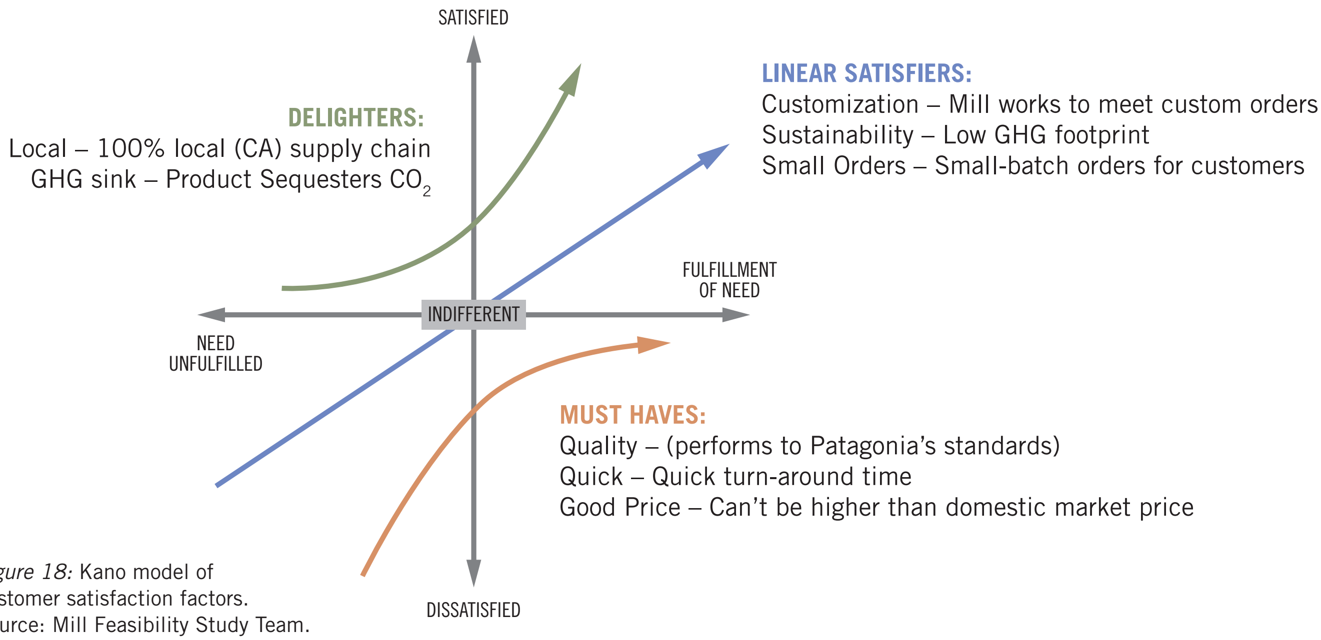

Figure 18: Kano model of customer satisfaction factors. Source: Mill Feasibility Study Team.

Competition

Like most industries, in the textile industry, two main factors drive competition: quality and price. The California Wool Mill will have to outperform not in just this category but in others as well, offering sustainability, customization and quick turn-around and delivery. The two primary sources of competition are from overseas imports and domestic mills.

COMPETING WITH OVERSEAS PRODUCTION

While not thought possible five years ago and still small in scale, American-made fabrics are already competing on price. Many American-made fabrics, especially wool, are price competitive with fabrics produced in Asia, and are often touted as higher quality. A recent article in the *New York Times* states:

> "American [textile] manufacturing has several advantages over outsourcing. Transportation costs are a fraction of what they are overseas. Turnaround time is quicker. Most striking, labor costs — the reason all these companies fled in the first place — aren't that much higher than overseas because the factories that survived the outsourcing wave have largely turned to automation and are employing far fewer workers. (Clifford, 2013)."

This advantage is particularly true in the production of wool knits. The cost of raw material is the same, the labor is minimal and the cost of transportation is less, making a more cost efficient product. Bayard Winthrop, the founder of the sweatshirt and clothing company American Giant said: "Now it is cheaper to shop in the United States," (Clifford, 2013).

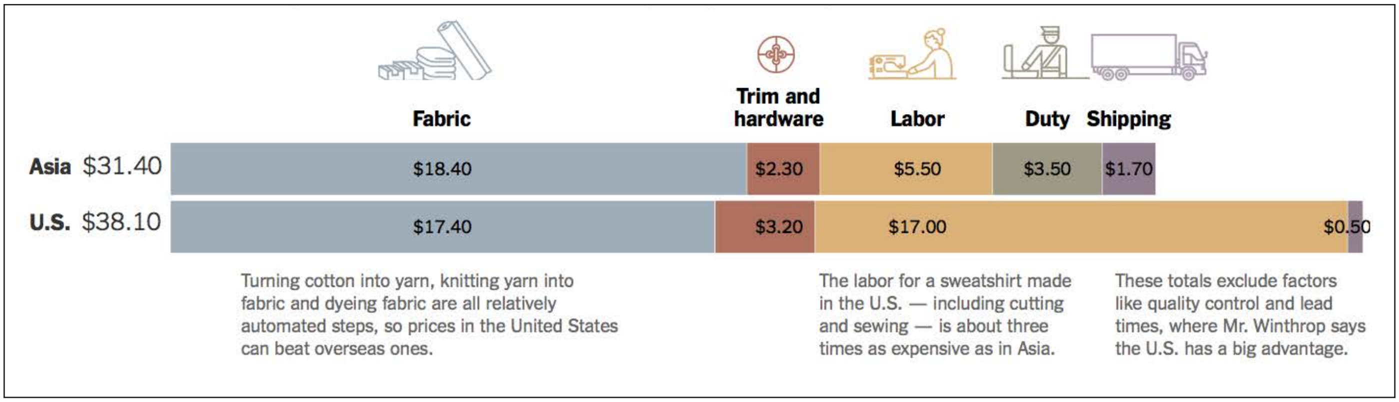

Figure 19: How much it costs to make a hoodie. Representative wholesale costs, according to Bayard Winthrop, the founder of American Giant. Source: New York Times, September 19, 2013.

Domestic Mills

Within the United States today there are currently no large scale vertically integrated worsted wool mills working from raw fiber to finished cloth. Each aspect of the manufacturing process has been divided into specialty mills. The sole large-scale wool scouring facility in the United States is Chargeurs, located in Jamestown South Carolina and in operation since 1954. Today the company scours 22 million pounds of wool annually from international sources into wool top, which is sent to a variety of on and off shore sites for further value-addition. Smaller scale wool top and scouring production occurs in micro-scale yarn milling facilities, which can be found closer to home in our own state. Businesses such as the Yolo Wool Mill (Yolo County), Oakhurst (Madera County), and Morro Fleece Works (San Louis Obispo), scour and draft wool top for the hand spinning and knitting markets. These mills process between 8,000 and 10,000 pounds of wool per year. Two of the smaller aforementioned yarn mills, (Yolo and Oakhurst), are producing woolen yarns—their main market is the hand knitting community.

Once wool is washed, carded, pin-drafted and turned into what is known as 'top' it travels to another facility for yarn spinning. Within the U.S. there are several independent worsted wool spinners that are capable of creating comparable fine yarn counts, similar to the yarns proposed for manufacture by the California Wool Mill. These spinning businesses include Kent Wools in South Carolina, Jagger Brothers in Maine, Hanora in Rhode Island, and Burlington in North Carolina. Of the four, Kent Wools, Jagger, and Hanora sell their yarn directly to independent knitting and weaving companies for cloth production; Kent Wool also serves an in-house knitting operation for sock production. All of these mills serve global yarn markets, and consume raw material from a range of international sources.

Since the debasing of the textile economy in the months and years following the adoption and implementation of NAFTA in 1994, more than 60% of the fine count yarn mills closed (McNulty, 2013). Those that survived had to modify their business strategies to serve smaller customers, create custom yarns and commit to shorter runs. These adjustments have been the major reason for their survival (McNulty, 2013). Now with the resurgence in domestic textile production, new mills are reopening such as the Parkdale Mills in Virginia.

Of the three non-captive worsted wool spinners—most yarns produced for domestic manufacture end up in one of several knitting facilities that have the technical skill for wool jersey production. Some of the more prominent knitters include Almanac, in North Carolina, Clover in South Carolina, and Texollini in Long Beach, California. These knitting facilities serve domestic and international cut and sew operations for small and medium clothing manufacturers. These businesses have remained operational and at capacity using similar strategies as the above mentioned yarn mills—including small runs, strategic partnerships with spinners and finishers/dyers and custom yardage.

Table 5, on the following page, lists all the existing mills of scale that work with wool and some that currently work with synthetics (at least 1 million pounds).

Table 5: *Comparison of U.S. Wool Mills*

Name of facility	Location	Input	Product	Annual scale (approx.)	Number of employees	Company size
Kentwool (worsted spinning)	Greenville, SC	Wool top	Worsted yarn	3 million pounds	N/A	N/A
Hanora Spinning (worsted spinning)	Woonsocket, RI	Wool top	Worsted yarn	1 million pounds	25 to 50	N/A
Burlington (vertically integrated)	Burlington, NC	Wool top	Worsted yarn	10 million pounds	N/A	N/A
Jagger Brothers (worsted spinning)	Springfield, ME	Wool top	Worsted yarn	1 million pounds	25 to 50	N/A
Chargeurs (wool scouring)	Jamestown, SC	Raw wool	Wool top	22 million pounds	55	$54 million
Clover Knits (knit fabrics)	Clover, SC	Worsted yarns	Knits	5 million pounds	50 to 75	$7-8 million
Alamac Knits (knitting, dyeing,design)	Lumberton, NC	Worsted yarns	Knits and full package design, dye, finishing	N/A	100 to 200	$50-80 million
Texollini Knits (knitting, dyeing, printing, design)	Long Beach, CA	Worsted yarns	Knits and full package design, print,dye, finishing	N/A	100 to 250, some consultants and part time	$33 - $40 million
Aetna Felt	Allen Town, PA	Cleaned wool	Felt	N/A	N/A	N/A
Crescent Woolen Mills	Two Rivers, WI	Wool top	Woolen yarn	N/A	25 to 50	N/A
National Spinning Co.	Raleigh, NC	Wool top	Worsted yarn	N/A	N/A	N/A
Tuscarora Yarns, Inc.	Mount Pleasant, NC	Wool top	Wool blend yarn	N/A	N/A	N/A
Pharr Yarns	McAdenville, NC	Wool top	Wool blend yarn	N/A	N/A	N/A

Note: Mill Feasibility Study Team.

Value of Byproducts: Lanolin

Wool grease or lanolin is a byproduct of the scouring process. As a secondary product, wool grease or lanolin is not the primary focus of the demand analysis. Nonetheless, it is valuable to assess its market viability because it can provide an additional revenue stream for the Mill. And while lanolin has a diversity of applications, from industrial lubricants to medical and cosmetics, the primary question for Lanolin market viability is: What are the trends in the natural personal care products that are likely to use lanolin?

With a healthy US market sales growth of 12% from 2009-2010, the total US Market sales of natural personal care products in 2010 was $3,981M, the largest segment of which (42%) was skin care (Kline & Company, 2011). With growth in the LOHAS market and increasing consumer concern for health and environment, these numbers are expected to grow.

In an interview with the Sheep Industry News, Ronald Devlin says: "Lanolin is actually getting a little hard to get a hold of, but I have been able to secure a steady supply, and I do see price increases, although not to a horrible degree. Lanolin has gone up but not as much as the petroleum-based stuff (Talley, 2011)." This same article outlines nearly a dozen other valuable uses for lanolin, and concludes by saying "There are literally endless uses for the product" (Talley, 2011).

The natural properties in lanolin have good characteristics for a lot of skin types, particularly dry skin and sensitive skin. Lanolin is known to be hypoallergenic and safe for use with babies. Many notable baby-care companies, such as Lanisoh, Medela and Ameda, specialize in lanolin-based products that support lactating mothers.

PRODUCT

Unrefined lanolin by 5 gallon container

PRODUCT DIFFERENTIATION

The primary product differentiator for lanolin from the California Wool Mill is that it is extracted through a sustainable manufacturing process.

TARGET CUSTOMERS

At first the lanolin will most likely be sold through a broker, however, the California Wool Mill can develop relationships with companies that have the capacity to refine lanolin further into a higher grade product. Some initial customers include:

Jedwards International, Inc.	Medela, Inc.
iherb.com	Marcha Labs
Bulk Apothecary	The Hain Celestial Group
Lansinoh	REdex Industries (Udderly Smooth Udder Cream)

ADDRESSABLE MARKET

Marcha Labs, the manufacturer of Wool Wax Creme, uses the "cosmetic grade" product, which is refined to high degree. According to Ronald Devlin, the company's owner, Marcha Labs uses about a barrel a year, which yields approximately 425 pounds of lanolin (Talley, 2011). Marcha Labs is relatively small compared to companies like Lanisoh. The total addressable market for lanolin is still unknown. However, sheep industry interviews say that there is a shortage of lanolin and demand is very high, suggesting that if the Mill sells lanolin at market price, it won't saturate the market. Chargeurs scouring facility in South Carolina produces over one million lbs of lanolin per year, selling at $3.67 with revenue of $3,670,000.

Addressable Market = Unknown

PRICE

In just two years the price of unrefined lanolin has grown from $2.20 per pound to $3.67 per pound (Paullier, 2013). It is recommended that the Mill sell lanolin at market price.

Price = $3.67/lb.

MARKET CAPTURE

Since the total addressable market for lanolin is unknown, the true market capture is unavailable. The total volume of lanolin that the Mill can produce ranges from 69,000 lbs per year to 240,000 lbs per year. This is a relatively small volume compared to the production of scouring facilities such as Chargeurs at approximately 1 million lbs per year. The California Wool Mill will only produce 7% of the lanolin that Chargeurs produces.

While the exact number of companies that use Lanolin is unknown, because of Lanolin's diverse applications, in everything from industrial lubricants to natural body care products, and the growing recognition about the harmful chemicals in body care products, the demand for Lanolin likely to continue growing. The important product attributes that meet customer need are only speculative at this point. There is opportunity for further product refinement and development of the lanolin business. However this can be further explored when the Mill is operational. At this point in time, the focus of the Mill is on the production of fabric, with lanolin offered only as a valuable by-product.

MILL OPERATIONS AND SITE FEASIBILITY

Wool Aggregation and Sourcing

Sheep are shorn at various 'large-scale' ranching operations and a 'wool grader' is sent to the site during the shearing process. The wool grader is an individual who classifies the wool for its quality. The commodity market, as operated through a New Mexico based company called Roswell Wool currently sends a grader into the fields in California to segregate and label the wool supply for large flocks. Once graded and baled, wool is sent to distribution hubs throughout the state. Ranchers and farmers who produce at smaller scales can directly engage with the wool market by delivering their baled wool to Roswell hubs—which are often feed stores that double in function as receiving stations. Once the shearing season ends, the wool is transported by Roswell Wool to a central hub in Central California where it is stored prior to being sold. The California Wool Mill project has developed a relationship with Roswell Wool, and it is clear that a partnership would ease the wool purchasing process through increasing the efficiency, scale, and by retaining a clear understanding of the quality of the fiber and pricing. Fibershed contract truck drivers will pick up the raw wool during shearing season.

Milling

The California Wool Mill will process 1.39 million pounds of greasy wool in year one. This raw material quantity is based upon the 2013 Wool Inventory. Conservative growth projections (15% average annual growth rate) predict that this will grow to approximately 2.4 million pounds of wool by year five and 4.8 million pounds of wool by year ten.

The production is broken down into batches grouped by micron count. The range of wool microns that can produce particular yarn counts determines this division of batches. For example a micron count range of 17-20.5 micron can produce a 42 worsted yarn, which can produce a 4 oz. Jersey knit. This is an ideal weight for a base layer fabric that can be used for garments worn next to the skin, like wool underwear. Table 1, below (also in the supply analysis), shows the yarn and fabric appropriate for each micron count group.

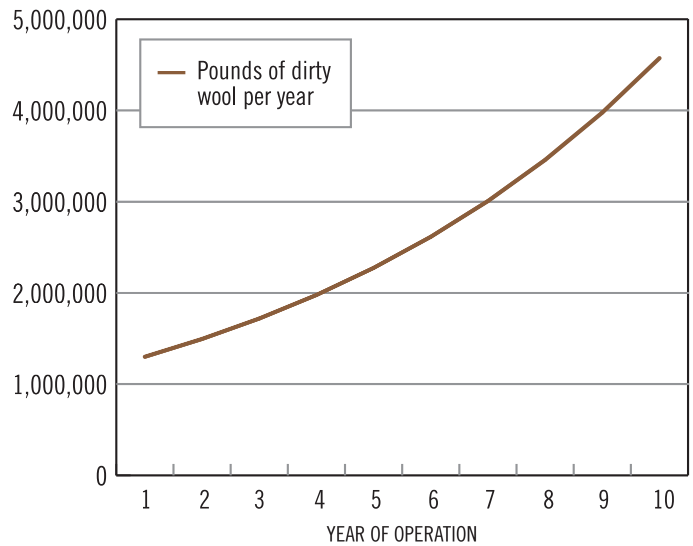

Figure 20: Mill throughput. Source: Mill Feasibility Study Team.

Table 1 (repeated): *Micron Count to Yarn Count Conversion*

Micron count	Ne(w) yarn count	Average fabric weight	Fabric use
17-20.5 micron	42	4.5 oz.	Base layer/underwear
20.6-21.9 micron	36	8 oz.	Lightweight shirt/sweater
22-23.9 micron	28	12 oz.	Midweight outer layer
24-29.9 micron	24	20 oz.	Heavyweight outer layer
30-40 micron	12	24 oz.	Upholstery/carpet

Note: Mill Feasibility Study Team.

These groupings were applied to the current wool supply and used to determine the first year batches. Table 6, below, shows the batch sizes per micron count group.

Table 6: *First Year Batches*

Micron Count	Average micron count	Quantity Available (lbs)	% of wool supply
17-20.5 micron	19.8	23,105	2%
20.6-21.9 micron	21.4	269,706	19%
22.1-23.9 micron	22.8	689,533	50%
24-29.9 micron	25.5	331,340	24%
30-40 micron	31.7	75,729	5%

Note: Mill Feasibility Study Team.

While initially the superfine batch is small, the batch sizes will change as California sheep farmers optimize breeding for wool fineness. As the Mill production increases and breeding is optimized, the batch sizes become more evenly distributed see Figure 21, below.

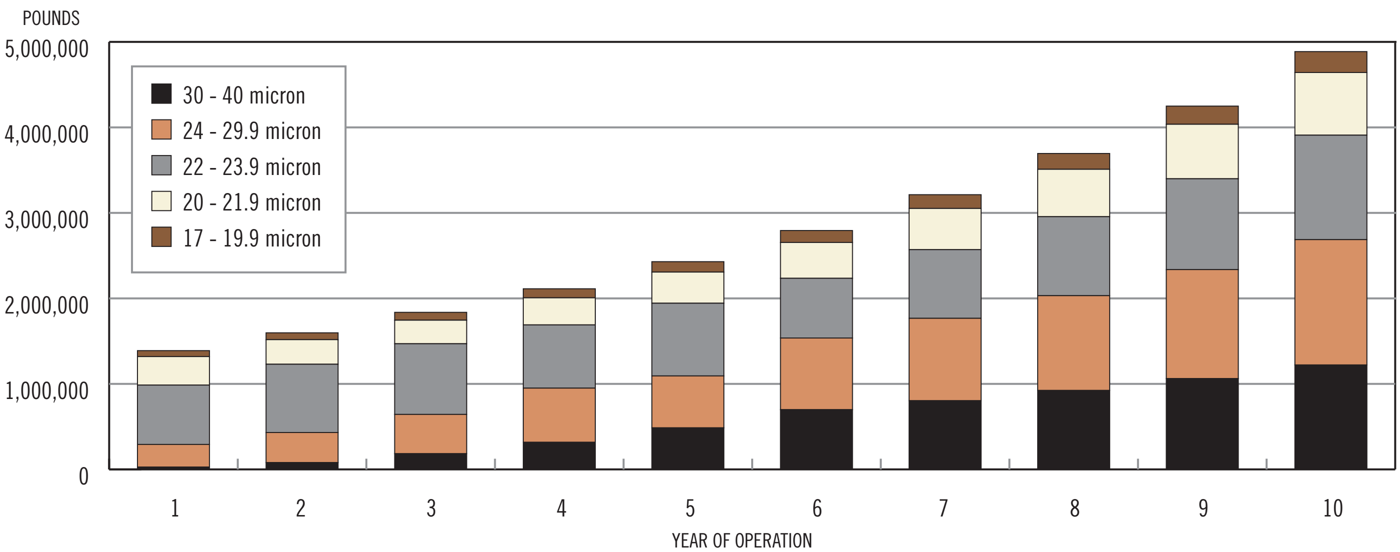

Figure 21: California Wool Mill batch sizes over 10-year timeframe. Mill Feasibility Study Team.

Vertically Integrated Wool Processing

Each of these batches listed above flow through a series of stages that comprise the vertically integrated milling operations. The raw materials for the California Wool Mill are: wool, detergent, enzymes, and water. Energy is used to convert these materials into a commercially viable product: fabric.

Figure 22: Steps in the milling process. Mill Feasibility Study Team.

Stage 1 – Scouring: Greasy wool is delivered to the mill in compressed bales (bale compression is done post sheep shearing at the farm or ranch). Once the bales arrive at the mill they are stored until they are ready for scouring (washing). The wool is fed through a feed-in conveyor and heated to 140 degrees Fahrenheit in steam-heated bowls, then passed through squeeze presses that provide 15 tons of pressure.

Greasy wool is comprised of wool fiber, lanolin and solids. The weight breakdown varies depending on the type of sheep as well as the ecosystem in which they live. Certain climates have more vegetable matter that gets caught in wool than other climates. Some sheep produce more grease than others. Based on core sampling of hundreds of California flocks, the average wool yield is 55% wool and 45% other. While grease often comprises more than 15% of the weight of a fleece, the amount of lanolin available for extraction is only about 5%. Figure 24, at right, shows the yield of wool fiber, lanolin and solids from the scouring process.

Figure 23: Wool scouring line. Source: Andar Holdings.

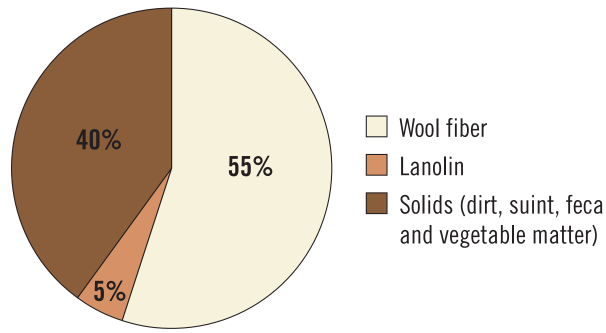

Figure 24: Typical Greasy Wool Yield. Source: Mill Feasibility Study Team.

After the extraction of wool fiber, which is sent to stage two of the processing line, there are two recoverable by-products from the scouring process: Lanolin from the wool grease recovery (WGR) plant, and bio-solids that are collected from the heavy solids loops. As the dirty water and wool grease (lanolin) are taken out of the scouring line, it goes into a centrifuge that separates the lanolin from the dirty water. The lanolin is packaged in 5-gallon containers and sold via a broker.

The dirty water, or effluent, goes into a primary recovery tank where the heavier solids are settled and then composted on site at the mill facility and later deposited onto rangelands for added fertility and carbon sequestration. The remaining effluent from the recovery tank passes through a Living Machine® system (described on page 45) to be cleaned and purified, and is then piped back to the scouring line to be used in again, or for other non-potable uses in the building and on the landscape.

Stage 2 – Opening: Once wool is fully scoured and cleaned it then is moved through what is known as an opening line. This series of machines includes fans, cleaners, and conveyor belts, blending bins, filters and fans. The wool is then automatically fed to the carding machines.

Stage 3 – Carding: The carding machine is a 3.3-meter width large-scale animal fiber comb, like that used to comb the coats of many domestic animals. The Carding machines are designed with fine metal teeth that comb through the wool and pull apart thick areas creating an even layer of fibers.

Figure 25: Combing Machine. Source: NSC

Stage 4 – Drafting: Once the fiber is carded it is fed into a system of machines that align the fibers to bring them into a directional order—this is called drafting. The worsted system relies on repeated combing of the wool to ensure all fibers are aligned and separated properly, this process must be repeated over and over again to ensure a high quality outcome. Machines such as chain gills, defelting equipment, and vertical rubbing frames are all used to create what is known as wool top. The entire carding and combing process entails a 5% fiber loss to lint – which is recoverable and can be either composted or stored for later felting processes.

Figure 26: Gill Chain Machine. Source: NSC

Stage 5 – Spinning: Once in the form of wool top, the wool is then ready to be ring spun and turned into worsted yarn. Canisters of wool top are manually placed at the back-end of a spinning frame and the top is drawn through the frame and spun. This spinning is modular with 48 spindles per section. It consists of a steel frame holding the draft system, the fiber waste collecting system, the spindle base holders, the ring rail and the feeding creel. Spinning requires a particular ambient temperature humidity which is maintained by sensors and a ventilation system tied into the Mill's geothermal climate control system.

Figure 27: Worsted Ring Spinning Frame. Source: NSC

Stage 6 – Winding & Twisting: The yarns come from the spinning frame on plastic cones that are manually placed into a machine utilized traditionally for dye equipment. Once the yarns are spun they are ready to be wound on an automatic winder onto larger cones that will satisfy the quantity and mass requirements of the knitting frames. The yarn cones then go through a twisting machine, which is designed to enhance the strength of the yarn, and to ensure it holds the correct spin to create well structured cloth.

Figure 28: Twisting Machine. Source: Savio Macchine Tessili S.P.A.

Stage 7 – Knitting: The final stage of the process is knitting. After yarns are ready they will be manually arranged in one of several knitting machine options. It has been recommended from industry experts that we utilize three different types of circular knitting machines, smaller more specific/specialized additional machines may be add-ons at a future date. The knitting output in yards for the first year is estimated at 640,985 yards, reaching 3,962,423 yards by year ten (47,998 bolts of fabric), assuming a 15% growth rate.

Variations in quantity of wool processed, numbers of operating shifts, and days the mill is open are all variables that define the numbers of machines required.

Table 7, on the following page, shows the list of machinery needed, but does not list the quantities. The total initial investment in machinery for the first year of operations is estimated to be $13.3 million.

Figure 29: Double-knit eight-lock Machine. Source: Monarch Knitting Machinery UK Ltd.

Table 7: *Wool Mill Machinery List*

Scouring		
Scouring line		TBD
Wool grease recovery plant		TBD
Fiber Opening & Blending Unit		
Worsted Card for Wool		TBD
Combing		
Gill chain	GC30 type 1656	N. Schlumberger
Gill chain	GC30 type 1656	N. Schlumberger
Gill chain	GC30 type 1613 RE	N. Schlumberger
Combing machine	Era LM	N. Schlumberger
Gill chain	GC30 type 1656	N. Schlumberger
Gill chain	GC30 type 1263 RE	N. Schlumberger
Preparation		
Defelter	D3GC30 type 1627	N. Schlumberger
Gill chain	GC30 type 1627 RE	N. Schlumberger
Gill chain	GC30 type 1683	N. Schlumberger
Gill chain	GC30 type 1698	N. Schlumberger
Vertical rubbing frame with 24 heads	FMV41-A	N. Schlumberger
Ring spinning frame	IDEA 73R	Finlane
Additional		
Automatic winder	POLAR E Premium, 64 spindles	Savio Macchine
Two-for-One Twister	SIRIUS 250C, 240 spindles	Savio Macchine
Knitting Machine		
Interlock, Double Knit Eightlock	M-9ME22	Monarch
30-inch basic single knit jersey	MXC-E3.2RE	Monarch
Rib, Double Knit (Reconditioned)	V-ER11	Monarch
Monarch add-ons for year 5:		
30-inch single knit jersey	VX-RSFY6	Monarch
Interlock, Double Knit Eightlock	M-9ME22	Monarch
Seamless Knitting Machines	Whole Garment Mach 2S	ShimaSeiki

Note: Mill Feasibility Study Team.

Superwash system vs. enzyme use for wool top manufacturing

Contemporary performance standards for wool include the ability for the wearer to be able to wash and dry their clothing in modern washing and drying equipment. For wool to function under these conditions and not shrink or felt (the matting and hardening of the fibers), the wool fibers must have a percentage of their microscopic scales removed, and are commonly sprayed with poly-acrylic resins to smooth and coat the fibers.

Currently 75% of machine-washable wool is treated by the Chlorine-Hercosett shrink-proofing process, (Textilchemie Dr. Petry GMBH, 2012) This method guarantees the felt-free superwash standard, and works on the basis of chlorination and subsequent coating of the fiber material with a polyaminoamide. The process uses large amounts of water as well as dangerous substances and leads to significant pollution of wastewater with organic halogen compounds (AOX) (Comyns, 1999).

To avert the use of the Chlorine-Hercosett process, the California wool mill has investigated the use enzyme treatments to de-scale our wool. The most common enzymatic treatment includes Protease, which can be used to degrade the cuticle of the wool fiber, and will impart a degree of shrink-resistance. The attributes of enzyme use includes the omission of water pollutants—the Living Machine® system engineers have stated that these materials can be broken down by their system (Lohan E., 2013). The known drawbacks of enzyme use is that they are relatively new to wool processors and there are unknowns in relation to how they function and perform compared to chlorine based systems. If the application process is not carefully administered the enzymes can weaken the fiber, and often take more time in processing.

The Study Team has been in communication with two enzyme companies, Textilchemie Dr Petry GMBH in Germany and Devan Chemicals in the UK, that are interested in working with the Mill. These companies also have a willingness to create enzymatically treated cloth samples with our California wool. Mark Johnson from Dylan Laboratories and Ulrike Beurer from Dr. Petry are familiar with the California Wool Mill Project goals for creating a closed-loop water system that simultaneously provides the Mill a high performance wool for the creation of fine wool cloth.

Engineers from Schlumberger (the company providing the combing and de-felting line) have expressed interest in working with the above mentioned enzyme laboratories to assist the California Wool Mill project in the research and design of new application equipment that could enzymatically treat California wool in the form of wool top, and their newly designed system would also include machinery to naturally dye the enzymatically treated wool with natural dye extracts.

If the mill were to have a system for the symbiotic use of enzymes and natural dye applications—The California Wool Mill would be the first facility in the world to utilize these two non-polluting, and bio-sphere based applications within a closed-loop water system. Based on the current status-quo reliance on chlorine and poly-acrylic resins for wool treatment, the mill will need to hone and perfect an alternative solution for high performance wool. It is the Study Team's recommendation that further investigation occur for the potential of an enzyme and natural dye system utilizing the support of Schlumberger engineers and the European enzyme laboratories.

Natural Dye Potential

The California Wool Mill will function to provide a biosphere-based cloth for garment production, forgoing all use of synthetic and fossil fuel based color agents. The business will focus on processing all of California's useful wool—including naturally colored and white fibers. To enhance the range of hues offered, natural dye extracts have been investigated as a means to increase the color palate.

For the design of this feasibility study the Study Team assessed the potential costs for the inclusion of natural dye application processes—and have included these details below. During our research with dye equipment makers and natural dye experts we discovered that there were areas of unknown that warrant further research beyond this feasibility study.

Areas of unknown that require follow-up and further research:

1. **Machine Compatibility:** Can equipment used for synthetic dyed wool top creation be modified, or potentially used 'as-is' for use with natural dye extracts?
2. **The use of natural dye extracts on enzyme treated wool:** Wool washed with chlorine and sprayed with poly-acrylic resins a.k.a. superwashed wool is known to work well with extracts, however, enzyme treated wool and its compatibility with natural dyes is unknown—this issue warrants further research
3. **Building a consistent supply of sustainably harvested and processed natural dye extracts:** Currently the market provides a quantity smaller than what would be required for full scale production, there are currently no domestic natural dye farm and extract makers working to support industrial use at the scale required for the California Wool Mill.

For these reasons the Study Team recommends that the California Wool Mill be designed to house natural dye equipment in future, in preparation for a time when the above questions have been solidly answered. Also useful to the process of creating naturally dyed wool cloth—would be in the research and production of a more in depth natural dye feasibility study with the inclusion of agro-ecological research to assess the potential viability of natural dye crops and extraction processes for California.

Below are cost estimates from Botanical Colors, an existing natural dye extract company based in Seattle, Washington:

Table 8: *California Wool Mill Feasibility Study Budgetary Dye Pricing, 10/9/2013*

Annual Processing of Wool Fiber	Average Dyestuff on WOF	RED	BLUE*	YELLOW	GRAY
2,000,000 lbs.	5%	500,000 lbs.	500,000 lbs.	500,000 lbs.	500,000 lbs.
Amount of dye required		25,000 lbs.	25,000 lbs.	25,000 lbs.	25,000 lbs.
Current annual availability at 2013 production levels		40,000 lbs.	40,000 lbs.	40,000 lbs.	25,000 lbs.
Price per pound of dye		$26.00	$20.00	$14.00	$23.00
Totals		$650,000.00	$500,000.00	$350,000.00	$575,000.00

Note: All prices are budgetary and final pricing is dependent upon volume and colors chosen. Pricing does not include shipping, duties or other taxes. *Blue listed is Saxon Blue, not vatted indigo.

Submitted by:
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Packing and Shipping

PACKING

Fabric will be rolled onto long cardboard tubes, and then wrapped in canvas (in lieu of plastic). The canvas will be treated with natural pest repellent oil and the bolts will be stored in airtight containers with cedar wood cubes or balls (also for pest control). The private label seamless garments will be placed in cardboard boxes lined with the pest repelling canvas and with cedar balls. Since these will be produced on-demand, the storage time is minimal, with a quick delivery to the customer, further reducing risk of damage by pests.

The packing of Lanolin will be done in five-gallon plastic containers. These can be easily transported to the customer and empty containers can be easily returned for reuse. Customers will be incentivized to return the empty containers by receiving a discount on shipping.

SHIPPING

If the delivery is within a short distance to the mill, like one of the major design hubs (San Francisco or Los Angeles), the Mill will be able to deliver using the Mill's truck and driver. However if the product is sent further than the nearest design hub, the mill will use a major shipping company to deliver products and shipping will be added onto the price.

Staffing

The Mill will require a mix of management and labor. As the mill production increases, the labor requirements and sales requirements increase. The Mill pay distribution is fair—management never earns more than three times the lowest paid employee (based on an hourly rate). With employee ownership, total compensation becomes even more equalized. For a comparison of total payroll expenses, see Figure 30, at right.

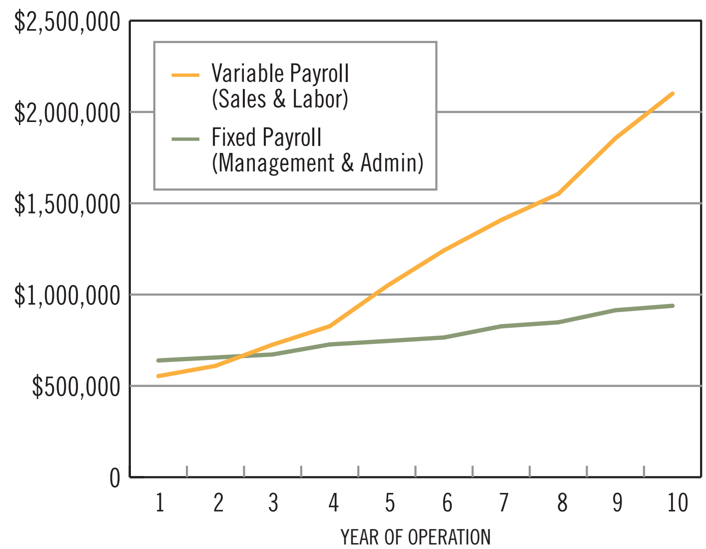


Figure 30: Payroll Expenses. Source: Mill Feasibility Study Team

VARIABLE STAFF – LABOR

Machine Operator: Each machine operator is responsible for up to two machines. Each stage has distinct machinery and thus requires specific training to operate. These are broken down into: Carding/Combing/Spinning line operators, Knitting Machine Operators, Scouring Line Operators, and Superwash Operators. Part of the machine operator's job is to move the fiber from one stage of the process to the other.

Floor Manager/Shift Manager: Assists the Plant Operations Manager by supervising machine operators, troubleshooting, and resolving technical issues in daily operation.

Machinist: Maintains functionality of equipment and supplies. Maintains accurate records and logs.

Shipping and Receiving: Receives and warehouses incoming supplies of wool and other materials needed for operations; packages and ships finished products to customers.

Truck driver: Transports wool and finished products in a safe and timely manner. Maintains accurate records and logs.

Janitor/Groundskeeper: Keeps the building in a clean and orderly condition, performs routine maintenance, maintains the grounds of the property.

STAFF TRAINING

Training staff to operate equipment is a process whereby selected individuals will be sent to the machine supplier headquarters, and in some cases engineers are brought on to the mill site to train. The training is all-inclusive and provides a means for employees to fully operate equipment with trained engineers prior to running the mill. Engineers from Schlumberger and Andar Holdings have provided these figures based on average estimates for training time and travel costs.

Table 9: *Staff Training*

Training	Cost
Scouring: 15 days of work	$21,000
Wool grease recovery plant	$5,936
O/B + carding: additional 15 days of work	$21,000
Combing + spinning: additional 15 days of work	$21,000
Rewinding and twisting: included	0
Knitting - included	0
Total training (Included in Operating Costs)	**$68,936**

Note: Mill Feasibility Study Team.

MANAGEMENT AND ADMINISTRATIVE STAFF

CEO: Provides strategic leadership for the company by working with the Board and other management to establish long-range goals, strategies, plans, budgets and policies. Oversees the operation of the mill in accordance with the direction established, while demonstrating the leadership necessary to make the organization a success and maintaining awareness of the competitive landscape, opportunities for expansion, customers, markets, new industry developments and standards.

Director of Design and Product Development: Provide design direction to develop textile and garment prototypes, by working with sales and marketing as well as technical team and CEO. Oversee production quality control/testing, dye/finishing and lab dips.

Production Manager: Responsible for planning and execution of all fabric production, overseeing quality and ensuring customer satisfaction.

Director of Marketing/Sales: Accomplishes business development activities by researching and developing marketing opportunities and plans; implementing sales plans; managing sales reps.

Sales reps (commission only): Serve customers by selling products; meeting customer needs.

Customer Service/Receptionist/Office Manager: Serves customers by providing product and service information; resolving product and service problems. Serves visitors by greeting, welcoming, and directing them appropriately. Supports company operations by maintaining office systems, supervising staff.

Bookkeeper: Maintains records of financial transactions by establishing accounts; posting transactions. Manages payroll.

Plant Operations Manager: Oversee management of all areas of manufacturing to produce products and direct activities so that products are manufactured on-schedule and within quality standards and cost objectives. Responsible for general supervision of all phases of plant operations including: production, quality control, maintenance, receiving, and shipping.

Feasibility of Proposed Site

LOCATION

For the purpose of the study, we researched four possible locations for the wool mill: Santa Rosa, Woodland, Marysville-Yuba City, and Firebaugh. Some of the criteria used for selecting these potential locations were proximity to the design community in metropolitan areas such as San Francisco and Los Angeles, freeway access, and proximity to the California wool supply. All four areas are similar distances to farms, though Firebaugh has a slightly better weighted average distance by wool quantity. Other criteria such as weather and access to water are discussed further, starting on page 44.

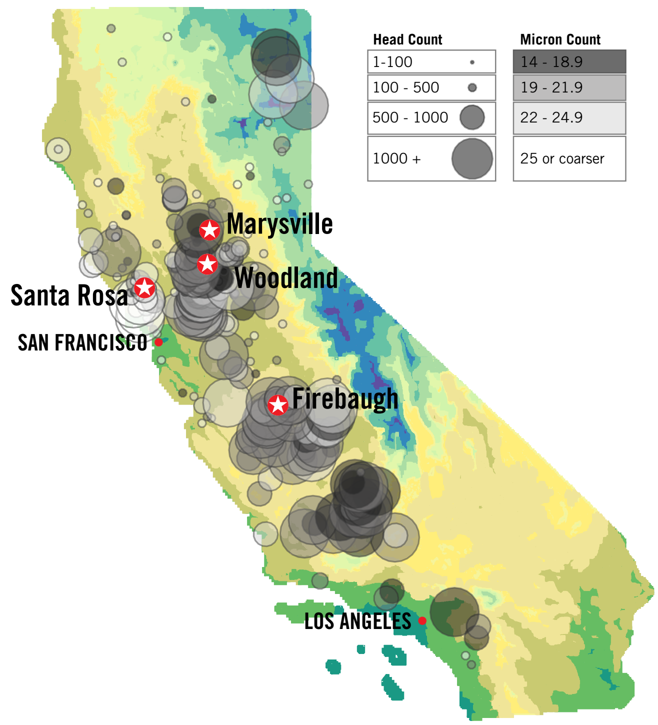


Figure 31: Potential locations of the California Wool Mill, and their proximity to the wool supply. Source: Mill Feasibility Study Team

Santa Rosa

Santa Rosa is the seat of Sonoma County. Situated 55 miles north of San Francisco, it is the largest metropolitan area between San Francisco and Portland, Oregon. State Highway 101 provides easy access to the major north/south commerce corridor. Rail access for freight is available, and the north/south running SMART train will begin service in 2014 (City of Santa Rosa). With a population of approximately 165,000 (approx. 19% of whom are college educated), the current labor force in Santa Rosa is over 82,000. Roughly 11% of the working population is employed in the manufacturing industry (PolicyMap). In addition to the Santa Rosa Junior College, there are two nearby universities – Sonoma State University and the North Bay campus of University of San Francisco.

According to Santa Rosa's General Plan, the city welcomes new businesses that reinforce the community identity, exhibit sustainable business practices and which have a long term, vested interest in Santa Rosa (City of Santa Rosa). Raissa De La Rosa, of the City of Santa Rosa's department of Economic Development, expressed that the City has been interested in making Santa Rosa a fashion and textile hub and would welcome a wool mill there, particularly one that operates with environmental sensitivity, such as the one being proposed (De La Rosa, 2013).

Possible drawbacks to locating in Santa Rosa include higher land costs or leasing costs than the other areas researched (LoopNet), as well as high fees for initial water and sewer hook-ups if the mill were to be located within an area providing municipal water and sewer (Murray, 2013). In the Land Use and Livability section of the General Plan, one of the stated goals is to "Allow expansion of buildings with light industrial uses up to 50 percent of existing floor area and re-occupancy of existing buildings with light industrial uses consistent with Light Industrial zoning standards, but do not allow construction of new light industrial buildings" (City of Santa Rosa). This could limit possible location of the wool mill to an existing building that can potentially be retrofitted to the needs of the mill.

Woodland

Woodland is the county seat of Yolo County, and located approximately 15 miles northwest of Sacramento. Ease of access to the city is provided by the close proximity of I-5 and I-80 as well as the Sierra Northern Railway and the California Northern Railroad (Wikipedia). With a population of approximately 55,000 (approx. 16% of whom are college educated), the current labor force in Woodland is over 28,000. Roughly 6% of the working population is employed in the manufacturing industry (PolicyMap). In addition to Woodland Community College, there are two nearby universities – UC Davis and Cal State Sacramento.

According to Woodland's General Plan, Woodland has a healthy industrial sector, most of which is located in the northeastern part of the city, generally well separated from residential areas. The General Plan designates land for and seeks to expand the city's industrial base to provide for greater economic development and employment opportunities for Woodland residents (City of Woodland). Woodland's Economic Development Manager, Wendy Ross, has expressed that Woodland would be an ideal location for the wool mill, and is very interested in meeting to discuss that possibility (Ross, 2013).

Marysville

Marysville is the county seat of Yuba County and one of California's historic cities. The city is located 40 miles north of Sacramento, where Highways 70 and 20 intersect, and is served by two railroad lines. While Marysville has a population of approximately 12,000 (approx. 8% of whom are college educated), nearby Yuba City has a larger population of 65,000, so the labor force in the Yuba City-Marysville area is 70,000. Roughly 5% of the working population in Marysville is employed in the manufacturing industry (PolicyMap). According to Marysville's General Plan, however, there is very little land left for industrial development within the city (City of Marysville).

Although Yuba City's roots are agriculturally based, its location near the state capitol and Beale Air Force base have made it a regional hub attracting entrepreneurs, manufacturers and green technology companies. The primary transportation corridors are Routes 99 and 20, which connect to I-5. In addition to Yuba Community College, three universities are within an hour's drive – UC Davis, Cal State Sacramento and Cal State Chico (City of Yuba City).

According to Yuba City's General Plan, the city wishes to attract and maintain quality business and industry, and to increase the industrial base (City of Yuba City, 2013).

Firebaugh

Firebaugh is located in Fresno County, approximately 43 miles west of the Fresno and 18 miles east of Interstate 5, the main north-south link between San Francisco and Los Angeles. While Firebaugh has a population of approximately 7,500 (approx. 5% of whom are college educated), nearby Fresno has a larger population of 505,000, so the labor force in Firebaugh-Fresno area is over 440,000. Roughly 9% of the working population in Firebaugh is employed in the manufacturing industry (PolicyMap). In addition to West Hills Community College in Firebaugh, there are numerous colleges and universities in Fresno.

According to Firebaugh's General Plan, the city wishes to "promote economic development and enhanced employment opportunities in Firebaugh by designating sufficient land for industrial uses" (City of Firebaugh). Ken McDonald, the City Manager of Firebaugh, said "I would like to see a wool mill in Firebaugh because we have a good workforce that is used to seasonal work. I think a mill would offer more stable employment and be a valuable community asset" (McDonald, City Manager, City of Firebaugh, 2013).

As stated in the Firebaugh General Plan, flooding is a possible drawback to locating the mill in Firebaugh, depending in the actual site. Portions of Firebaugh are subject to flooding according to Flood Insurance Rate Maps prepared by the Federal Emergency Management Agency (FEMA). Dam failure is also a concern in Firebaugh. There are a number of dams on both San Joaquin and Kings Rivers that could cause flooding in the event of dam failure (City of Firebaugh, 2013).

SITE COMPARISON

Of all the cities the Study Team considered, Firebaugh has the lowest median income and the highest rate of poverty (27.8%), lowest percentage of college-educated citizens and the second highest unemployment rate at 12.3%. With 1.7 times the population, Marysville has similar income levels, the second highest rate of poverty, the second lowest percentage of college educated citizens, and the highest unemployment rate at 14.2%, which is double the US unemployment rate. (United States Department of Labor) Marysville and Firebaugh would stand to benefit from having the influx of jobs and the multiplier effect that these jobs would bring.

Santa Rosa, on the other hand, which is the largest city the Study Team considered, has the highest income levels, the second lowest rate of poverty, the highest rate of college educated, and the lowest unemployment rate. It also has the advantage of being located closest than any of the other sites to a major metropolitan area. Advantages of Santa Rosa include exposure to the largest number of people in both the city's size and being that Sonoma County is a major tourist destination. Drawbacks include the high cost of utilities hook-ups and property taxes.

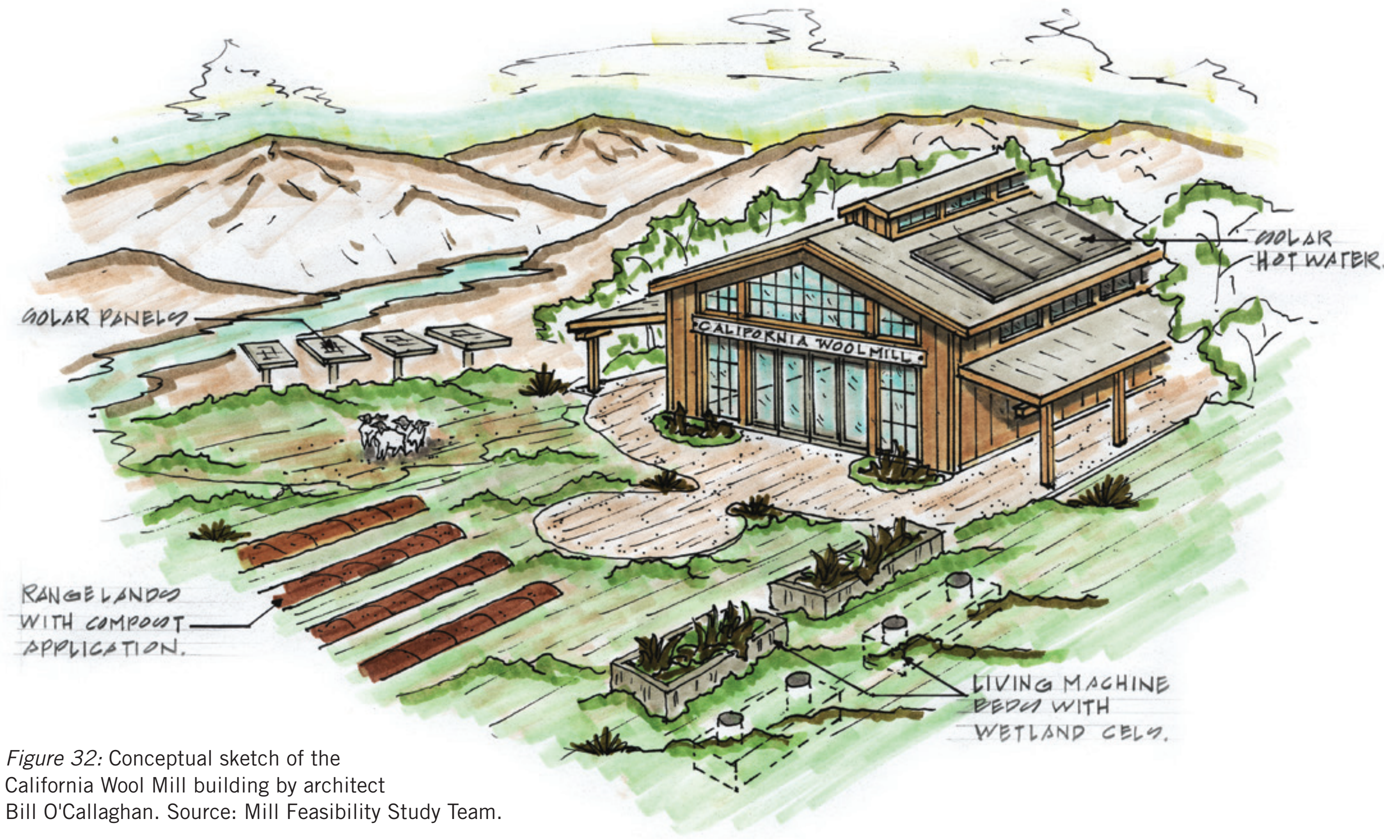


Figure 32: Conceptual sketch of the California Wool Mill building by architect Bill O'Callaghan. Source: Mill Feasibility Study Team.

The Building

The California Wool Mill facility will be designed as a state-of-the-art facility optimized for environmental performance and longevity. The building systems specified in this document are designed for milling, but every system has a closed loop. The building design should aim to meet the The Living Building Challenge™ certification criteria, demonstrating this facility as one of the greenest manufacturing plants in the world. The wastewater coming off the scouring line feeds into a centrifuge where the lanolin is extracted, and then the dirty water goes to the water recycling system, where 100% of the water is recycled and sent back through the building. The toilets and drains feed into the same system. The energy system is looped into this as well. The water is pre-heated with solar hot water heaters on the roof of the building, and then sent to the scouring line. The heat from the machines is re-captured and used as part of this system. The humidity from the scouring line will be pumped into the spinning room where it will be controlled to maintain the perfect conditions for worsted yarn. These systems are built into the pro forma, so that they can be analyzed for environmental and financial performance.

The idea is to build an example of what modern manufacturing system can be. This building should also serve as a classroom and education facility to teach other leaders how a sustainable manufacturing system works. This building will aim to meet the requirements for the Living Building Challenge and exceed LEED platinum requirements. For a drawing of the suggested floor plan see Appendix E. The next sections describe in detail how these systems operate.

California Wool Mill Systems Workflow — Soil to Soil

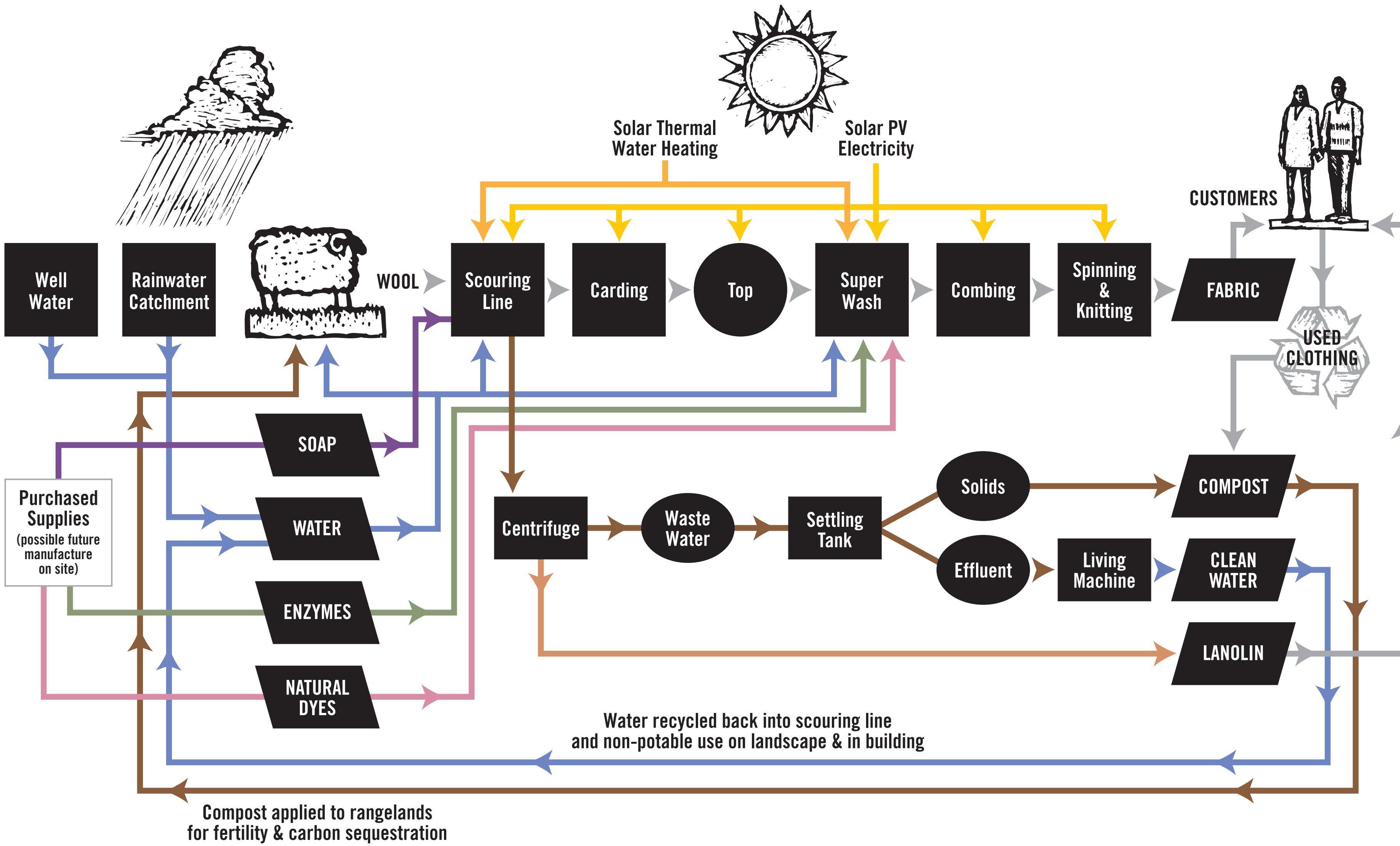


Figure 33: Conceptual diagram of the California Wool Mill systems workflow. Source: Mill Feasibility Study Team. Illustrations © Ron and Joe/Shutterstock.

Water

LOCATION OPPORTUNITIES AND CONSTRAINTS

The four locations considered for this study all have a Mediterranean climate distinguished by warm, wet winters and dry, hot summers. Firebaugh receives an average of only 11 inches of rain per year. Marysville and Woodland both receive an average of 21 inches of rain per year. Santa Rosa receives the most rain of the four locations, with an average of 30 inches per year. (Western Regional Climate Center)

California's water supply comes from two sources: surface water, or water that travels or gathers on the ground, like rivers, streams, and lakes; and groundwater, which is water that is pumped out from the ground.

Firebaugh obtains all of its domestic water supply from the groundwater underneath the city. This supply has experienced elevated levels of iron and manganese and, as of January 2007, also exceeded the State levels for arsenic. The City operates seven groundwater wells and a water treatment plant. The City is currently re-designing the treatment facility to begin utilizing hypochloride to treat the water as a replacement for the historic practice of using gas chloride. (City of Firebaugh, 2013)

Santa Rosa obtains the bulk of its water supply from groundwater wells near the Russian River belonging to the Sonoma County Water Agency. This water is treated with chlorine gas for bacterial disinfection, and sodium hydroxide to adjust the pH. The City also has two very deep wells that provide 2.5 million gallons per day to meet summertime requirements. Sodium hypochlorite is added for disinfection. Water recycling takes place at the tertiary-level Laguna Treatment Plant, the Oakmont Treatment Plant, a compost facility and a reclamation system that provides irrigation water. (City of Santa Rosa)

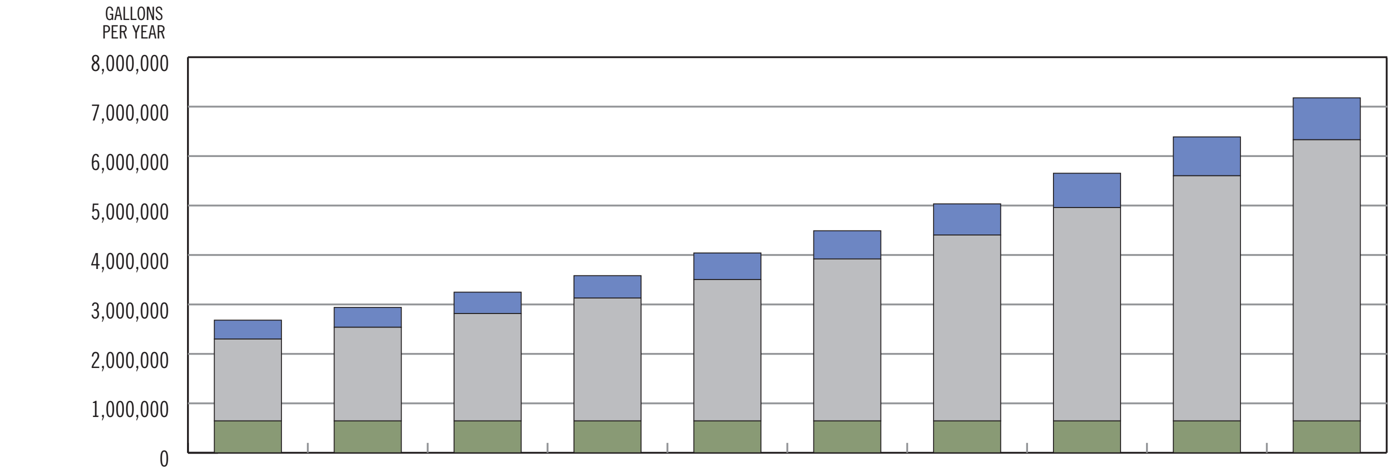
Woodland uses groundwater for all water supplies, but the quality is declining so the City is participating in a regional project to pump and treat Sacramento River water, which is of higher quality than Woodland's groundwater. Surface water will become the primary water source when the project is complete in 2016, although some groundwater will be used as needed. (City of Woodland)

Marysville obtains its groundwater water supply from Cal Water, a company that utilizes seven wells to pump groundwater. Cal Water uses a variety of techniques to treat the water, including microfiltration, advanced oxidation, and ultraviolet units, or granular-activated carbon filtration. Chlorine is commonly used to disinfect the water. (California Water Service Company)

MILL WATER USE

According to the California Department of Water Resources, "Climate change is having a profound impact on California water resources, as evidenced by changes in snowpack, sea level, and river flows. These changes are expected to continue in the future and more of our precipitation will likely fall as rain instead of snow. This potential change in weather patterns will exacerbate flood risks and add additional challenges for water supply reliability." (California Dept. of Water Resources)

As wool scouring is a very water-intensive operation, requiring approximately 1.2 gallons of water for every pound of greasy wool, the Mill will have to be very conservative in water use. The mill not only has scouring water requirements, but human and irrigation water needs as well. The chart below illustrates the water needs by use. Only a small portion of the water needs are potable needs. Most of the water required for scouring, toilets and irrigation could be greywater. This allows for the possibility of water recycling and rainwater catchment to meet a significant portion of the total Mill water demand.



Year of Operation:	1	2	3	4	5	6	7	8	9	10
Potable Demand:	382,000	402,000	432,000	452,000	538,000	570,000	630,000	694,000	786,000	848,000
Greywater Demand:	1,654,500	1,893,000	2,171,100	2,485,065	2,858,050	3,274,517	3,785,675	4,314,311	4,957,476	5,684,978
Irrigation Demand:	645,190	645,190	645,190	645,190	645,190	645,190	645,190	645,190	645,190	645,190
TOTAL WATER DEMAND:	**2,681,690**	**2940190**	**3,248,290**	**3,582,255**	**4,041,240**	**4,489,707**	**5,060,865**	**5,653,501**	**6,388,666**	**7,178,168**

Figure 34: Water Use. Source: Mill Feasibility Study Team.

WATER RECYCLING

Rather than take an averaged 3 million gallons of water per year for wool scouring and other facility needs from either municipal sources or well water at the mill location, the Study Team proposes to use a technology called the Living Machine® that will constantly clean the water from scouring, toilets and faucets in the building, and recycle 100% of it back into the plumbing for non-potable reuse in the scouring line, toilets, and irrigation.

The following description of the Living Machine system is taken from their brochure (see Appendix F):

> To treat wastewater, the Living Machine® system uses the latest technologies and engineering to recreate the ecology of natural coastal wetlands. After an initial settling stage, wastewater is pumped into 'tidal-flow' wetland cells – gravel-filled planters – which are alternately flooded and drained to oxygenate the wastewater. The specially engineered gravel within the cells promotes the development of micro-ecosystems, which efficiently remove nutrients and solids from the wastewater, resulting in high quality effluent. Although a typical Living Machine system recycles thousands of gallons of water a day, everything occurs below the wetland surface. All the casual observer sees are lush, vibrant plantings. The final polishing stage, which involves filtration and disinfection, leaves water crystal clear and ready for reuse or safe environmental disposal. Online sensors continuously monitor water quality to ensure that reclaimed water is completely safe.

Another advantage of the Living Machine system is that it provides a way to clean a strong effluent from the scouring line that would otherwise need to be sent to a municipal wastewater treatment system. In most cases this is not feasible. In the case of Santa Rosa, there would be high fees imposed by the municipality (Murray, 2013). In the case of Firebaugh, our waste stream appears to be more than their treatment plant can handle (McDonald, 2013).

The Study Team interviewed John Scarpulla, the project manager for the Living Machine installation in 2012 at the PUC headquarters in San Francisco, to hear how the system is performing. John said that the system has been trouble free, and requires only and hour or two per week of staff time to maintain, mostly for daily water sampling to ensure water purity. He highly recommends Living Machine as an excellent system for water purification and recycling (Scarpulla, 2013).

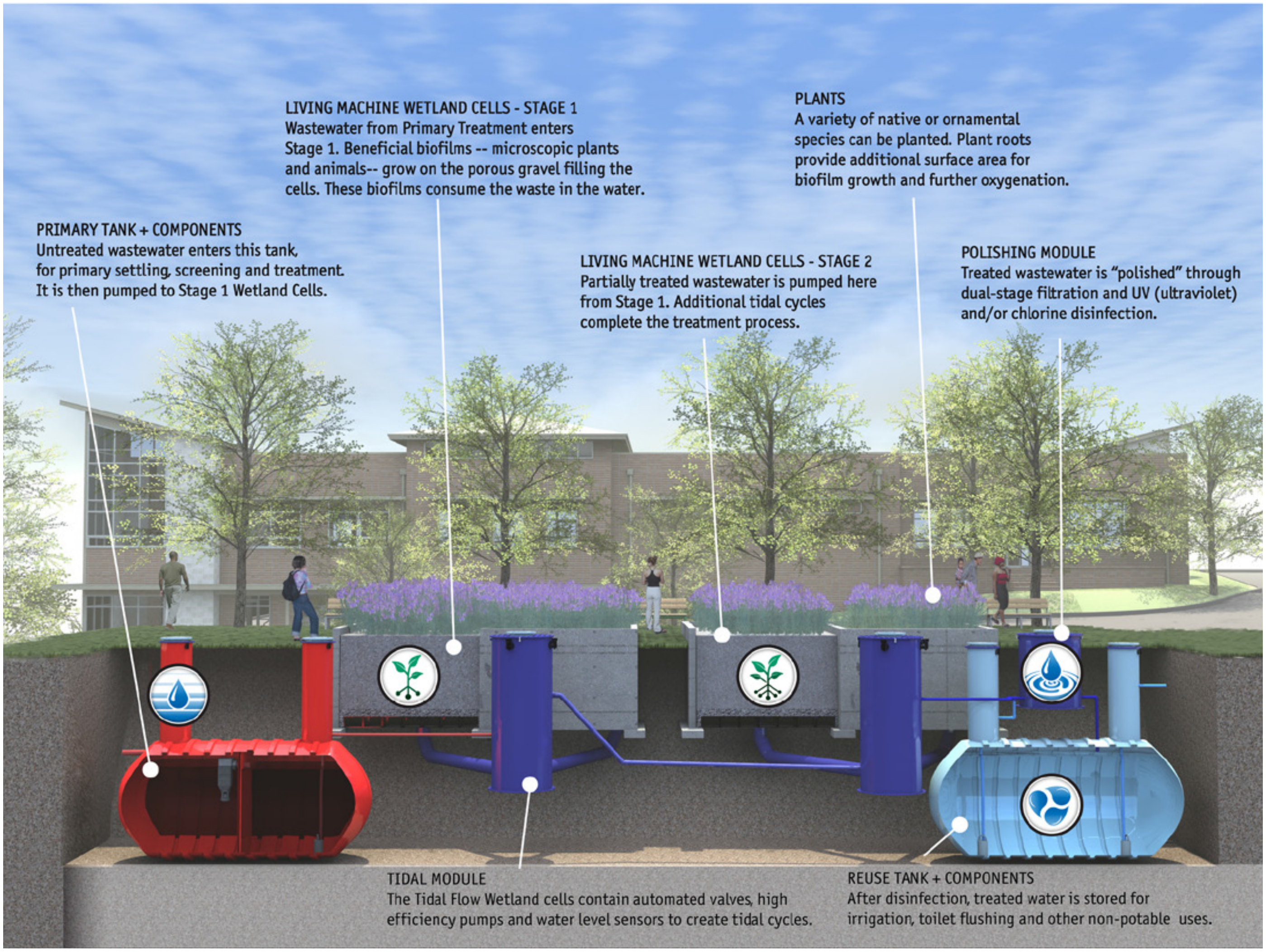


Figure 35: Living Machine® System. Source: Living Machine®

RAINWATER HARVESTING

According to the California State Water Code, Section 10571(c), "Rainwater and stormwater, captured and properly managed, can contribute significantly to local water supplies by infiltrating and recharging groundwater aquifers, thereby increasing available supplies of drinking water. In addition, the onsite capture, storage, and use of rainwater for non-potable uses significantly reduces demand for potable water, contributing to the statutory objective of a 20-percent reduction in urban per capita water use in California by December 31, 2020." (State of California)

With an estimated 85,000 square foot building for the wool mill, it makes sense to consider a water catchment system on the building. In order to capture rainwater from the roof, a network of gutters and pipes moves water from the roof surface, sends it through a filter to remove leaves and other matter, and then into storage tanks.

Given that the annual rainfall on our four potential locations varies from 11 inches to 30 inches per year, the potential amount of rainwater that can be harvested from the 85,000 square foot roof is anywhere from 580,000 to 1,588,650 gallons. The limiting factor is the size of the storage tank or tanks on the site. It is recommended that the mill store up to three months of excess water supply (517,692 gal or 69,303 cubic feet). The water stored in the tanks could be used for irrigation in the dry months, or for flushing toilets during the winter when there is a more constant supply of rainwater.

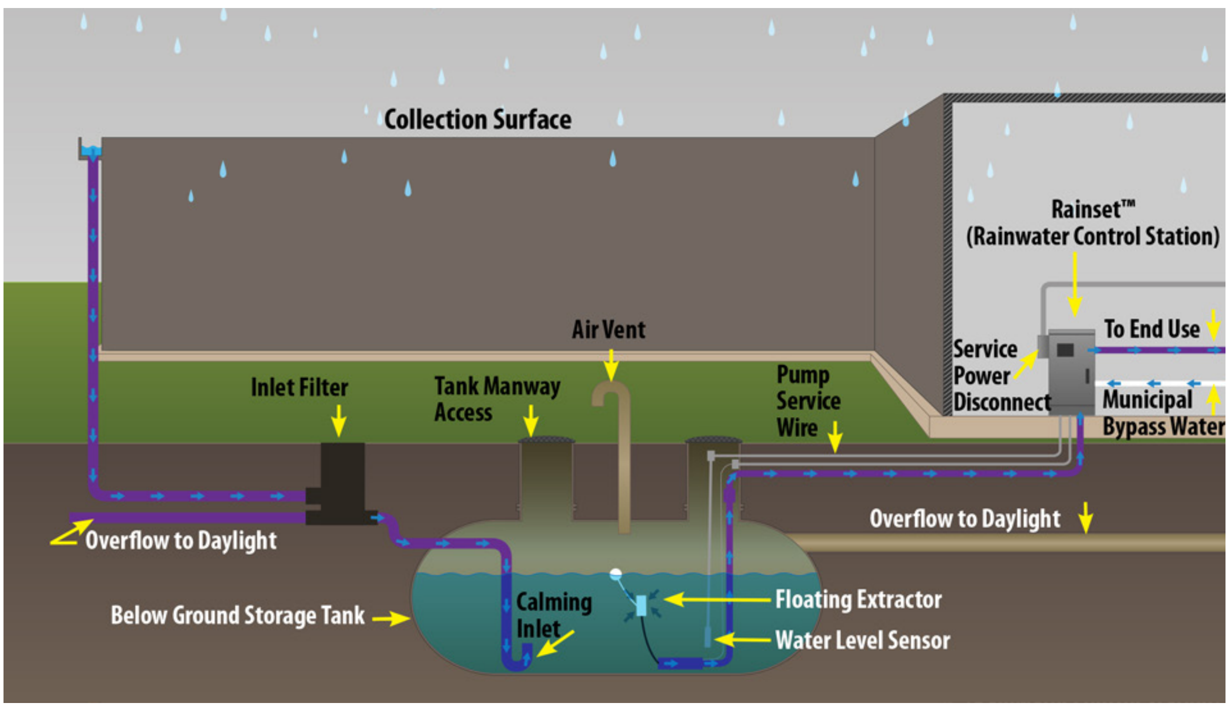


Figure 36: Typical belowground rainwater catchment system. Source: Watts Water Technologies, Inc.

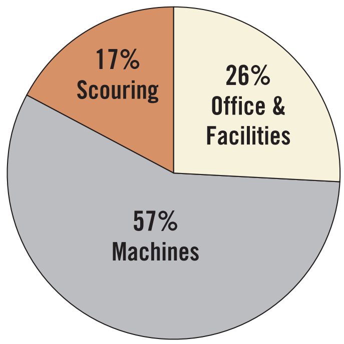


Figure 37: Average Annual Energy Requirements by Use. Source: Mill Feasibility Study Team.

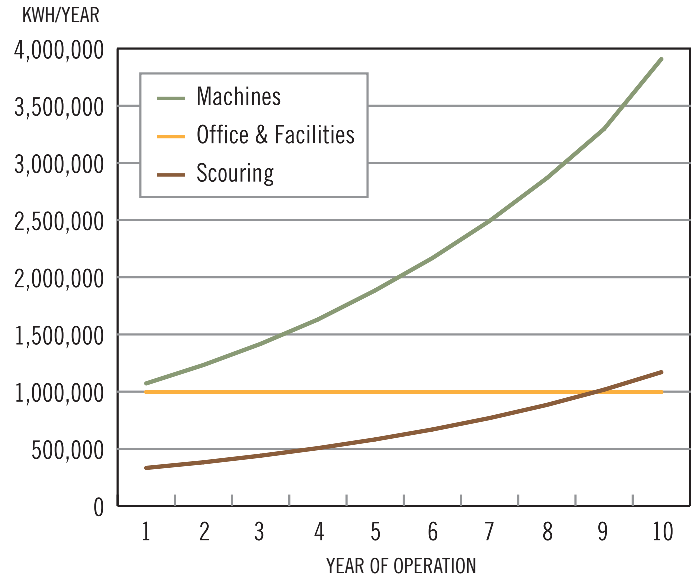


Figure 38: Annual Energy Requirements. Source: Mill Feasibility Study Team.

Energy

The energy requirements for the Mill steadily increase as Mill production increases. Machine use is the primary energy consumer for the Mill, with scouring as the secondary energy consumer. Most of the energy required for scouring is for heating water, rather than generating electricity. 70% of the scouring energy needed can be provided by solar hot water, the rest must come from a boiler heated by natural gas.

SOLAR POWER

A photovoltaic (PV) system needs unobstructed access to the sun's rays for most or all of the day to be effective. Shading on the system can significantly reduce energy output. Abundant year-round sunshine makes solar energy systems useful and effective nearly everywhere in California (California Energy Commission).

On average, there are 247 sunny days per year in Marysville, 256 sunny days per year in Santa Rosa, 269 sunny days per year in Woodland, and 271 sunny days per year in Firebaugh. (Sperling's Best Places). Because there are a number of non-sunny days, the Mill will need to be tied into the grid or have an energy storage system, such as compressed air storage.

While costly, the PV system can provide 100% of the Mill's electricity needs. The total cost of Solar PV in the first year is $1.5 million, assuming 100% of the Mill's electricity needs are met by solar. Additional panels can be added as demand for energy increases with Mill production.

In comparing the cost of solar versus grid, the variable is set at 50% solar and 50% grid. Over a ten-year time frame and using the current price

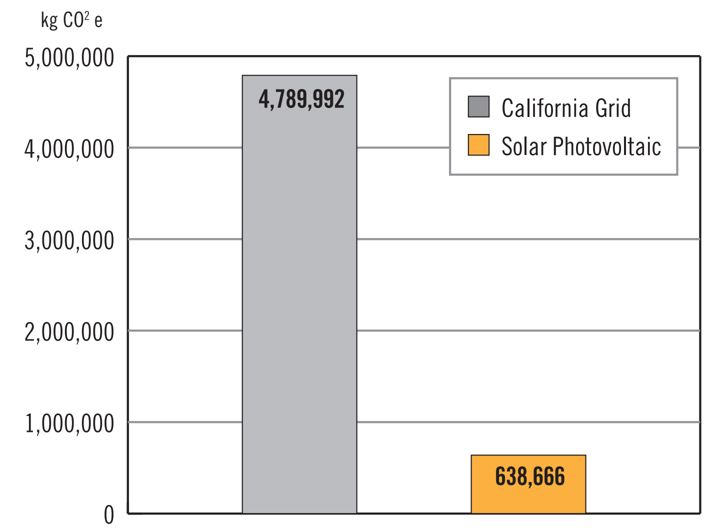


Figure 39: Greenhouse Gas Footprint (kg CO_2e) of California Grid vs. Solar Photovoltaic. Source: Mill Feasibility Study Team.

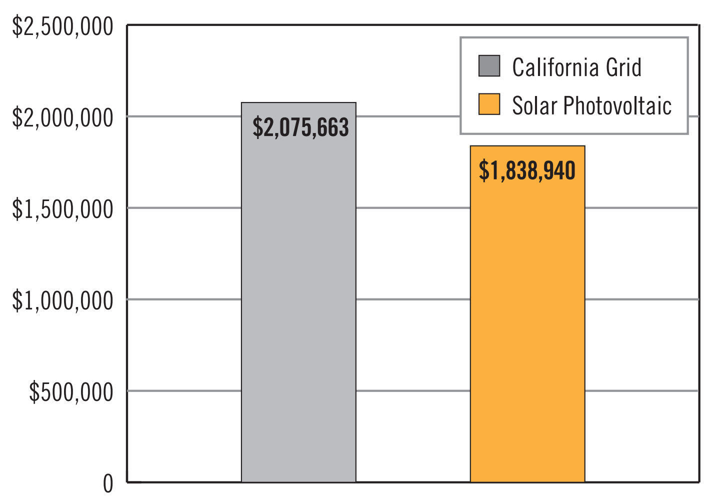


Figure 40: Total Cost of Grid vs. Solar (10 year). Source: Mill Feasibility Study Team.

of solar photovoltaic panels, solar pv outperforms on cost and on greenhouse gas emissions, making a clear choice for the use of 100% solar. The performance is detailed in the charts at right.

SOLAR THERMAL WATER HEATING

Most solar water-heating systems for buildings have two main parts: a solar collector and a storage tank. The most common collector used in solar hot water systems is the flat-plate collector. Solar water heaters use the sun to heat water, which is then held in the storage tank ready for use, with a conventional system providing additional heating as necessary. (Meline Engineering)

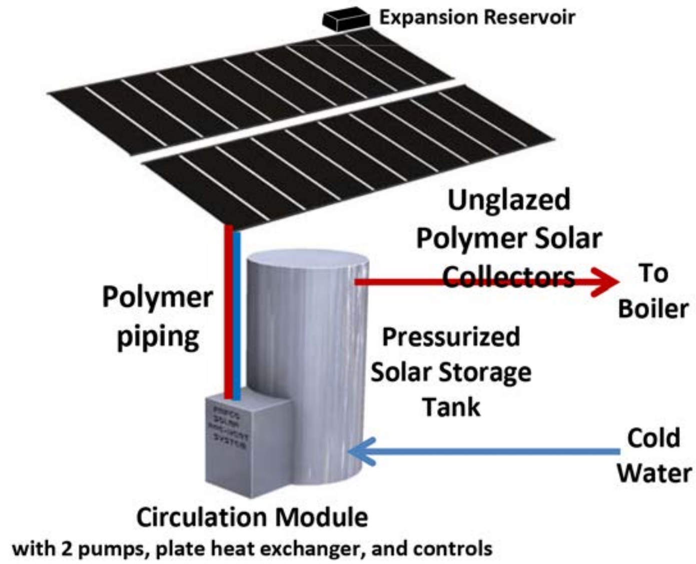


Figure 41: Solar Thermal System with Economical Polymer Array. Source: Meline Engineering.

The Study Team consulted with Meline Engineering of Sacramento to determine if solar thermal would be a good choice for some of the water heating needs of the scouring line. Meline determined that a solar thermal system would be an excellent investment, and would supplement a standard boiler/chiller/tower system. An economical solar polymer array and storage system by Fafco (see Figure 41, above) would cost $48,500 and provide $11,000 dollars in operating savings per year. (See Appendix G.)

In order to heat the water up to 70% of its needed temperature would require a larger system using flat-plate glazed collectors. The square footage of such a system would need to be roughly 6,000 square feet, and cost approximately $100,000.00 after rebates and credits.

GEOTHERMAL HEAT PUMP

A geothermal heat pump, also known as a ground source heat pump or Geoexchange, taps the energy stored in the earth to provide energy-efficient heating, cooling and hot water for buildings. The technology uses the constant temperature of the earth as the medium of heat exchange instead of outside air temperature.

Less than 10 feet beneath the surface of the earth, the ground remains at a relatively constant temperature. In winter, this ground temperature is warmer than the air above it. In summer, the ground temperature is cooler than the air above it. A geothermal heat pump takes advantage of this temperature difference by exchanging heat with the earth through a ground heat exchanger (Meline Engineering). See Figure 42, right.

The Study Team consulted with Meline Engineering to determine if a Geothermal Heat Pump would be a good choice for heating and cooling. Meline determined that a ground-source system does not appear economical; cooling loads are so high [due to the substantial motor loads from the equipment] that the system would almost always dump heat to the ground are rarely draw heat from the ground. A large ground loop would be required resulting in high first costs. Further, even a large loop could result in high returning water temperatures from the ground, resulting in very little increase in cooling efficiency versus standard systems. (See Appendix G.)

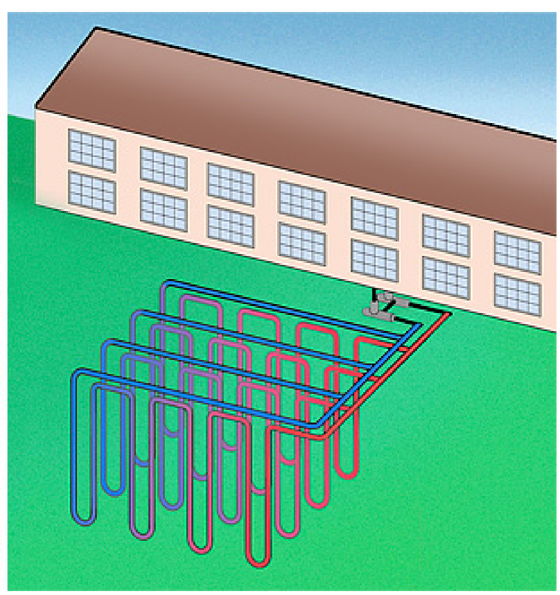


Figure 42: Geothermal Heat Pump. Source: Meline Engineering.

However, another type of geothermal heat pump, called a "Pump and Dump" system, looks more promising, according to Meline Engineering . In this scenario, water would be pumped from the ground, and heat from the building would be dumped to this water. This heat dump could preheat some of the water going to the scouring line, and the remainder would be re-injected into an injection well. See Figure 43, below.

The cooling efficiency would be good, and better than with a chiller/tower, although permitting may be a challenge. A rough estimate of cost is $650,000.00 for this type of system. (See Appendix G.)

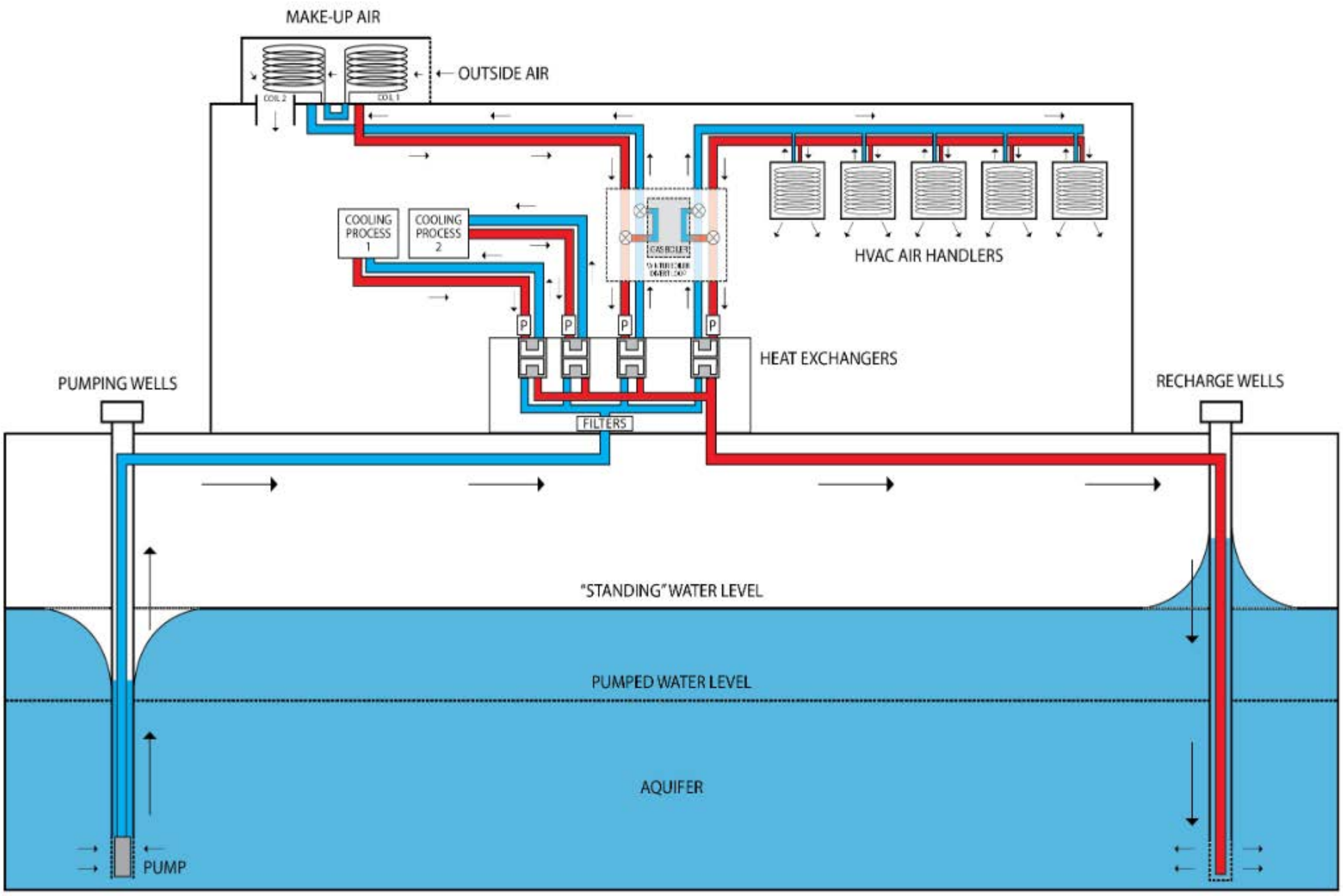


Figure 43: Geothermal Heat Pump—"Pump and Dump" System. Source: Multifilm Packaging.

HEAT RECOVERY SYSTEM

According to Meline Engineering's report to Fibershed, a heat recovery unit can simultaneously remove heat from return space cooling water and transfer this heat to incoming scouring line water. This transfer is at very low operating costs (two loads, heating and cooling, essentially served by one compressor circuit).

Furthermore, since the scouring line load is steady, the heat recovery unit always provides some cooling and the chiller and cooling tower can be downsized or completely replaced by the "Pump and Dump" system shown in Figure 43, above. A heat recovery system provides similar operating savings to a solar system and may cost less to install than a standard boiler/chiller/tower system. The heat recovery system provides approximately $12,000 per year savings at virtually no additional cost. (See Appendix G.)

MILL ENVIRONMENTAL PERFORMANCE

Life Cycle Analysis and GHG Performance

One of the objectives of this study is to provide the first-ever greenhouse gas based ‘Soil to Soil’ life cycle assessment (LCA) for all future cloth and garments produced by the California Wool Mill. The existing LCA research within the textile industry has been primarily conducted and paid for by industry members who stand to profit from the results (Tobassian, 2013). In contrast, the Study Team developed an in-depth systemic analysis to-date of textile creation through a collaboration with UC Berkeley’s Silver lab and Dr. Marcia DeLonge.

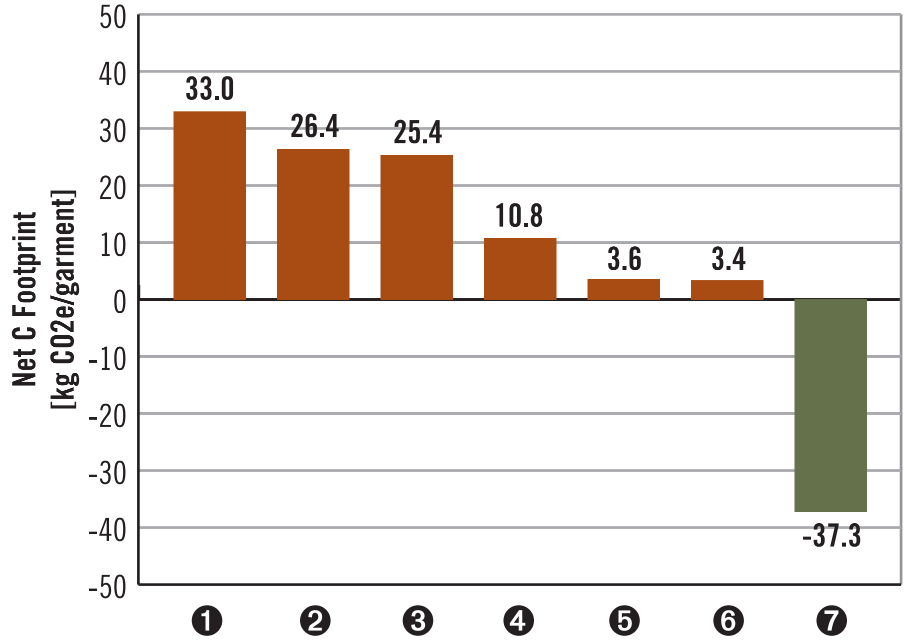
Dr. DeLonge expanded the scope of LCA work to include the gas exchange research on California rangelands (conducted over a 5-year period on a range of soil types). The current preliminary work (see Appendix H) bridges the published research of the rangeland soil science with the prospective California Wool Mill design, including details such as employee commute times, wool distribution estimates between farm and mill, and the renewable energy powered mill design. The LCA provides a more exact and in-depth view on the impacts of future production beginning with an understanding of the land and soil where sheep live and graze. In sum, the garments produced by the Mill using the recommended compost protocols for rangeland management provide a carbon sink ranging from 37kg of GHGe to 151kg of GHGe, depending on the variables used for milling operations and the amount of wool per sheep (which will increase with breeding optimized for wool production).

This data was also used to measure the greenhouse gas impact of the entire Mill itself. The Mill’s GHG performance is split into emission and sequestration. The sequestration comes from raw material, which is detailed further in the Life Cycle Analysis (LCA). The sequestration for the mill is significantly greater than the emissions, creating a net carbon sink. However, this value is based on the assumption that the wool suppliers will be following the compost protocols for adding compost to rangeland described in the LCA (see Appendix H).

Table 10: *GHG from Mill Operations*

GHG From Mill Operations	Cumulative (10 yr)
GHG from machines kg CO_2e	1,504,147
GHG from facility kg CO_2e	398,480
GHG from transport kg CO_2e	231,622
GHG from scouring kg CO_2e	552,378
GHG from employee commute	890,605
GHG from raw material kg CO_2e	-2,640,316,667
Total Greenhouse Gas Footprint	**-2,636,762,792**

Note: Mill Feasibility Study Team.



❶ **Conventional Realistic:** CA grid-derived energy, slightly higher C footprint relative to other cases due to loss in soil C, synthetic fertilizer use, higher transportation costs

❷ **Conventional Optimistic:** CA grid-derived energy, but no increase in soil C

❸ **Fibershed Neutral Soil:** geothermal-derived energy, but no increase in soil C

❹ **Fibershed Conservative:** geothermal-derived energy, good land management increases soil C at a more conservative rate than Case7

❺ **Fibershed Realistic:** geothermal-derived energy, conservative compost credit, good land management increases soil C at a more conservative rate than Case7

❻ **Fibershed Possible:** solar-derived energy, conservative compost credit, good land management increases soil C at a more conservative rate than Case7

❼ **Fibershed Optimistic:** solar-derived energy, optimistic compost credit, good land management increases soil C at optimistic rate, minor reductions in C footprint relative to other cases at several steps (transportation distances, commuter mgp, animal emissions, air-dried clothes, etc.)

Figure 44: Life Cycle Assessment of Fibershed & Conventional Fabric Production. Source: Dr. Marcia DeLonge, Silver Lab, U.C. Berkeley and Mill Feasibility Study Team.

Waste Performance

ORGANIC WASTE GENERATION

Wool scouring produces a large quantity of waste, as roughly half the weight of the greasy wool is due to dirt, vegetable matter, feces and suint (sheep sweat). We have determined that composting is the appropriate way to deal with scouring waste, as well as employee food scraps and other organic waste. The Study Team has identified that an aerobic windrow compost pile process using thermophilic microorganisms is the most appropriate method to turn the waste into rich, nutritious compost to be distributed to Fibershed ranchers. Will Bakx, owner of the locally-owned company, Sonoma Compost, and acclaimed soil scientist, and Jeff Creque, Mill Operations Supervisor for McEvoy Ranch, who received a PhD in rangeland ecology, have advised the Study Team in the most effective composting methods.

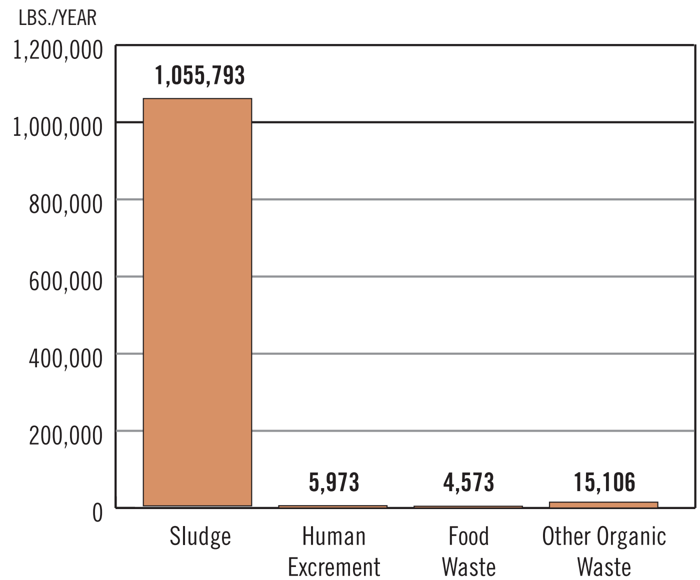


Figure 45: Average Annual Organic Waste/Compost Nutrients. Source: Mill Feasibility Study Team.

THE COMPOSTING PROCESS

As the wool is scoured, the first removal of dirt and solids takes place in the Wool Grease Recovery (WGR) Plant, with additional dirt and solids removed further along the scouring line in "heavy solids loops." In both cases, all of the recovered dirt goes to a primary recovery tank where it is allowed to settle, and becomes spadeable sludge. All of the effluent from scouring then goes to the Living Machine® (described on page 45) to be purified and recycled back to the scouring line. The sludge will be taken from the recovery tank and applied to the composting area. At the composting stage, a bulking agent like wood chips or garden prunings will be mixed with the sludge to create self-supporting structures to allow for proper airflow, and carbonaceous matter will be added to balance out the carbon/nitrogen ratio. This allows for effective and rapid composting.

Potential sources of carbonaceous material are sawdust, straw/hay, rice hulls, and/or chicken feathers. Saw mills can be found in Sonoma and Sacramento counties, and the Study Team will conduct a comprehensive comparison once the site has been selected to find the closest sources for bulking agents and carbonaceous material. In composting greenwaste and yard trimmings from Sonoma county residents, Sonoma Compost has found that the chicken feathers applied in the composting process reduced the time to final compost from 14 to 10 weeks (Bakx, 2013). Additionally, any paper hand towels or tissues collected in the onsite bathroom facilities can also be added to the piles as yet another carbonaceous source, as well as diverting these from the municipal waste stream.

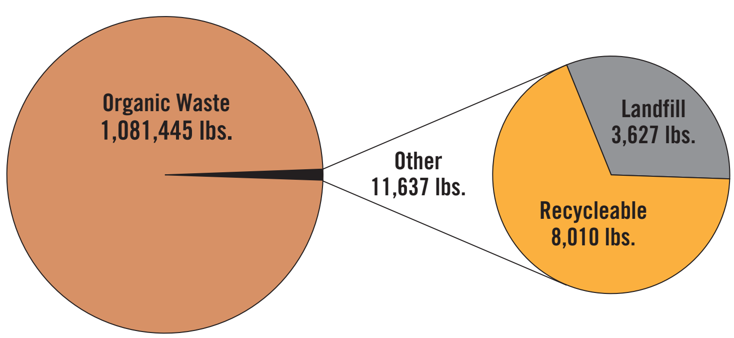


Figure 46: Waste Performance. Source: Mill Feasibility Study Team.

The Study Team has identified the two most feasible composting options are Aerated Static Composting or Actively-turned Windrow Composting systems (Misra, 2003). The main difference is that the aerated static composting system uses forced air, while the typical windrow composting system uses regular turning to aerate the pile. Both allow for less up-front capital investments in equipment and lower labor costs.

Middlebury College, in Vermont, elected for the Passively Aerated Compost system because of its low start-up and operation costs, minimization of odor or pest problems, and the fact that it requires little staff time and no specialized skills to be functional. Middlebury College estimates that approximately one acre of land is required for their system. Compared to the amount and composition of material that Fibershed's wool mill is estimated to generate, the college produces roughly half the quantity and a different composition (Middlebury College) than what would be composted at the proposed milling facility. Middlebury College estimates their passive windrow system costs them approximately $43/ton (or $48K over 10-12 years) compared $135/ton to landfill the waste — a very affordable approach (Carleton College, 2005).

Once the initial composition is achieved to ensure a successful composting cycle, the windrow is left to work its magic, and thermophilic bacteria begin to decompose the pile. After one windrow is completely filled, no more material is added to that pile, and it is left to compost and cure. The pile also must be kept sufficiently moist to allow the composting process to stay active.

The Study Team conducted moisture adjustment calculations and determined that based on a starting moisture content of 25%, and starting with 614.4 cubic yards, the water requirements for keeping the pile sufficiently moist will be approximately 1,000 gallons per week. This water could be supplied from a rainwater catchment system. After 6 months, the compost is ready for land application.

No matter which composting method the Mill ends up using, a highly-skilled and experienced team of composting advisors and agricultural engineers, including Bakx and Creque, will be brought in as consultants to determine more detailed calculations and processes once the site is identified. Proper attention to site preparation, visual screening, odor control and run off disposal/capture will be critical to maintaining an excellent compost model that acts as a beacon for other industrial composting operations.

PERMITTING

Because the amount of compost that will be generated onsite over a one-year period falls below the cap of 500 cy compost onsite at a given time, Fibershed's proposed wool mill does not appear to fall under the category of needing regulatory supervision. Nonetheless, Fibershed will file a notification with the Department of Environmental Health (the Local Enforcement Agency) to notify the agency that compost is being managed onsite. This process of notification protects Fibershed so that in the advent that there ever was a problem, it will be much easier to resolve in conversation with the enforcing agencies.

Excerpt from Chapter 3.1. Compostable Materials Handling Operations and Facilities Regulatory Requirements:

> "(4) Handling of green material, feedstock, additives, amendments, compost, or chipped and ground material is an excluded activity if 500 cubic yards or less is on-site at any one time, the compostable materials are generated on-site and if no more than 1,000 cubic yards of materials are either sold or given away annually. The compostable material may also include up to 10% food material by volume (Public Resources Code)."

The Study Team's goal is to create a 'Soil to Soil' system, whereby all waste streams are composted and returned to the rangelands where the nutrients and biomass generation from photosynthetic processes originally occurred and were the source of forage for the sheep. By composting the waste made on site, the facility is diverting a waste stream that could potentially be methane producing at a landfill, or would utilize large electrical draws to flush through sewage systems. With appropriate composting processes, the life cycle assessment of cloth produced by the Mill will be increasingly more carbon beneficial than if waste was not composted, and composting is cost-competitive to alternative modes of waste disposal.

ECONOMIC AND COMMUNITY IMPACT ANALYSIS

The Study Team found that *community benefits* of the proposed CA textile mill are plentiful and include growth in numbers of green jobs in the region, equitable distribution of the wealth generated by the mill, growth in bioregional self-reliance, regeneration of ecosystem services and improved overall community well-being. "Community impact" is defined as qualitative services accrued by civil society that are typically hard to quantify in dollar amounts, yet enhance the productivity and overall well-being of the population of a bioregion.

For much of manufacturing's history, but especially since the economic policies of the post-WWII era, manufacturing has been an extractive industry — the essential purpose was to extract natural resources from a given geographic region and turn them into consumer goods (Leonard, 2008). The idea of the California Wool Mill is built fundamentally on the opposite idea: the primary goal is to make deposits (as opposed to withdrawals) in both natural and human capital.

Localism Supports Community Wellbeing

As a result of approaching the business design from a perspective of Localism, and keeping in mind what is wealth-generating for the local community, the community's wellbeing improves. Jane Jacobs, renowned urban theorist and economist, has pointed to the importance of "import-replacement" as the engine of economic life (Schwartz, 2009). Import-replacement is characterized by what the Business Alliance for Local Living Economies (BALLE) calls "Localism," a region's commitment to finding ways to meet local needs, using local resources. Recent studies show that communities with economic climates characterized by strong independent businesses "beat cities dominated by large, absentee-owned firms on more than 30 measures of well-being, including such things as literacy, acreage of public parks, extent of poverty, and the share of residents who belonged to civic organizations" (Mitchell, 2013). Thus, the proposed vertically-integrated wool mill intends to catalyze a tipping point for green jobs in a region. In doing so, many community benefits have the potential to unfold including growing ecosystem services, regenerating the natural resource base, and lessening income inequalities while growing overall wealth and well-being of the community.

The Economic Multiplier Effect

As new enterprises bring employment to communities, those jobs in-turn provide a revenue stream for local goods and services, boosting the local economy. This is called the multiplier effect. There are three different types of multipliers:

1. **Employment Multiplier** represents the relationship between every job directly related to the mill and the number of other jobs created in the remainder of the economy due to related activities (trucking, sanitation services, etc.). This is measured by multiplying the employment multiplier by the number of jobs created at the mill.

2. **Income Multiplier** represents the total increase of labor income in the local economy from the income received by workers in the wool mill. This is measured by multiplying the Income Multiplier by the mill's payroll.

3. **Value-added Multiplier** measures the additional value added to the product as a result of related economic activity such as: employee compensation, indirect business taxes, payment for raw goods (wool), rents, etc. The Value-added Multiplier is measured by multiplying Value-added Multiplier by the operating expenses.

With no examples of a local wool mill multiplier, the multipliers used to calculate the economic impact must be derived from comparable processing operations that serve a similar type of community. Since the supply chain is small-livestock (sheep) based, the closest comparison is a mid-sized Northern California slaughter facility.

In 2009, University of California Cooperative Extension Mendocino County conducted a feasibility study for a 44,000 square foot beef, goat and lamb slaughter facility on the North Coast region of California, encompassing Mendocino, Lake, Sonoma, Marin, Napa, Glenn, Colusa, Yolo, Solano and Contra Costa counties. This study used the IMPLAN software to measure the direct effect value for employment related to a new slaughter facility in this region (Hardesty, 2009). The total capital costs for the facility are: $18 million, employing 44 people. In comparison, the California Wool Mill has a total capital cost of $26 million and will employ 38 people.

The Mendocino slaughter study measured both the direct effect value for cattle, sheep, pigs and goats. The employment multiplier for the slaughter facility is 2.9, the employee income multiplier is 2.1, and the value-added multiplier is 2.5 (Hardesty, 2009). The wool mill will use the 2.5 value add multiplier to calculate the cumulative multiplier effect for the California Wool Mill. The result is a total value returned to the local community of $452,874,374 over ten years (assume Santa Rosa scenario).

Community Benefit

Local sheep farmers have called loudly for a need for more processing facilities to bring an additional revenue stream that helps them stay in business (Mora Valley Spinning Mill, 2011). Helping to keep local sheep farmers in business ensures that existing agricultural land stays as farmland, which helps to conserve intact ecosystems across CA. While this has yet to be measured in a quantitative manner, the ecosystem services that Fibershed farmers currently provide include producing local, hormone-free meat, humane and healthy dairy products, and providing carbon sequestration through rangeland management. With an explicitly agricultural focus, Fibershed creates community benefits by bolstering the capacity for farmers to continue doing what they do best, an essential service to the surrounding community. By diversifying farmer income streams, the Mill helps farmers improve the viability of their businesses, which allows them to grow additional capacity to provide ecosystem services back to the community.

Additionally, wool is a renewable resource encompassing applications for building and insulation. The Cradle to Cradle certification institute each year uses criteria of Cradle to Cradle design to judge prospective environmental products. In September 2013, two of the ten C2C semi-finalist products had wool as their cornerstone material ingredient in building insulation and building fabrication.[2] Although the Study Team has not explored other applications of scoured and cleaned wool apart from knitting, it is the team's conjecture that a fiber mill in CA will be relevant to other industries, including shelter and insulation. The demand for processed and cleaned wool could increase beyond the fibershed movement, potentially in the form of ecological wool batts[3] for building insulation. This would be particularly relevant to coarser wool (30 micron or coarser) produced by smaller farms. This grade wool comprises approximately 5% of the wool in California.

Education and Awareness

Inspired by Living Building Challenge[4] principles, the benefit of the proposed mill will be manifold in terms of providing a national model and vision for what manufacturing can look like when it factors in more than just producing consumer goods. The surrounding demonstration garden of fiber and dye plants will provide recreation opportunities, habitat, and education. Nearby pasture will demonstrate compost application and grazing management for carbon sequestration for increased awareness around carbon emissions & solutions. The facility will be outfitted with educational signage explaining the concepts behind closed-loop manufacturing and ecological design, similar to the educational signage installed at Portland's Ecotrust building[5] that creates an experience for visitors to engage in learning how the building functions. The facility will be built with an intention to educate hundreds of visitors each year, transforming the way Americans understand their role as participants on this planet.

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[2] http://c2ccertified.org/challenge/finalists The Cradle to Cradle certification is widely recognized as one of the most important biomimetic design approaches to crafting products and services to meet human needs without compromising our collective future

[3] http://www.changemakers.com/project/ceo Priscilla Burgess, CEO of Bellewether Batts, estimates that they will help support (not pay for fully) up to 40,000 rural jobs.

[4] http://living-future.org/lbc

[5] http://www.ecotrust.org/ncc/

With the growing awareness and interest in learning about where our food and fiber comes from, this adds an additional relevant industry sector of ecological tourism, particularly if the Mill is located near an already existing tourist destination, like wine country. The goal of this entire facility, in addition to producing high-quality fabric, will be to act as an educational center that will drive demand for agriculture-based American Made products. The United Nations Environment Programme, UNEP, reports that more than 1/3rd of travelers in the tourism industry (which directly and indirectly employs 8% of the global workforce) are demanding the greening of tourism, meaning they favor environmentally-friendly tourism and are willing to pay between 2-40% more for this experience. The presence of such a cutting edge model of regenerative industry will likely create a whole new industry around eco-tourism, attracting visitors from all over CA to see the processing (United Nations Environment Programme (UNEP), 2013).

In order to regenerate the natural resources of a bioregion, Fibershed is committed to the principle of bioregional self-reliance where nutrients are cycled within a bioregion (for example, cycling compost from the mill back to the rangelands from which the wool was sourced). With respect to economic growth, the California Wool Mill goal is not solely to generate profits from selling garments, but to create ways for California farmers to sustainably generate diverse incomes to support their farms, and grow more green jobs regionally. In sum, the primary purpose for the proposed textile mill is to inject *true* wealth (defined by general prosperity, clean air and water, happy citizens, and comfortable income levels) *into* communities, as opposed to *extracting* wealth out.

Legal Considerations for Structure and Financing

COMMUNITY-OWNERSHIP

The Study Team's proposed vision rests on a model of community-ownership that has the potential to create healthier working conditions and improve quality of life for the mill's workers, local sheep ranchers, and dye farmers, while lowering unemployment and combating inequality throughout the region. The current structure of the US economy is perpetuating wealth inequalities by concentrating wealth increasingly into the hands of 1% of the American population (*The Economist*, 2013). Marjorie Kelly, author of *Owning our Future: The Emerging Ownership Revolution*, has named employee-ownership as the most revolutionary challenge to the current economic system. The Study Team extends this vision to capture a larger circle of *Community Ownership*. This transformative idea of ownership creates an economic landscape where environmental enforcement is not restricted to a single enforcement body. Instead, stewardship of the environment is decentralized into the hands of all shareholders in the community-owned companies, who are by design also stakeholders with an interest in preserving the environmental services of the region they live in. In short, place matters.

MULTI-STAKEHOLDER COOPERATIVE

A multi-stakeholder cooperative is a cooperative with multiple membership classes, with each class representing a different stakeholder. In the case of the California wool mill, there are several possible stakeholder groups that might make up membership classes of the cooperative:

1. The nonprofit Fibershed
2. Ranchers (producers)
3. Designers and artisans (consumers)
4. The mill workers
5. Mission-aligned supporters (investors)

Under California cooperative law (*California Corporations Code, Section 12200* et seq.), representatives of each of these stakeholder groups could be admitted as members of the cooperative, each with their own separate class. Each member class would have different rights and responsibilities.

The following are some suggestions for how this might be structured initially:

1. Fibershed should have its own membership class and should be responsible for representing the ecological interests that the mill is designed to steward and protecting fidelity to the mission. Fibershed should have the right to elect a certain number of directors and should have veto rights over major decisions such as dissolution, conversion to another entity type, sale of assets, and merger. In addition to its rights as a member of the cooperative, Fibershed could enter into a contract with the mill to ensure that the mill continues to maintain the highest ecological standards in exchange for Fibershed's continued support and licensing of intellectual property.

2. A small group of values-aligned ranchers could be the initial members of the producer class and a small group of designers and artisans could be the initial members of the consumer class. Each of these classes could elect a certain number of directors. For example, Fibershed could elect one-third, the producers could elect one-third, and the consumers could elect one-third.

3. Once the mill is established, the bylaws could be amended to create a worker class. There should be a candidacy period of six to twelve months before workers are admitted as members to ensure a good fit. It is possible that not all workers will be interested in being members, which is permissible.

4. Outside equity investors would also technically be members of the cooperative but they should not have voting rights as this would jeopardize the favorable tax treatment of the cooperative under Subchapter T of the Internal Revenue Code.

Thus, the initial structure would include four member classes: Fibershed, producers, consumers, and equity investors. The equity investors would receive preferred stock, entitling them to a preferred dividend that would be paid prior to any payment to the other co-op members (patrons[6]). Patronage dividends would be paid to the producer and consumer members (and some day to worker members). Patronage is a measure of each member's contribution to the co-op. So, if a rancher member supplies one-tenth of all of the wool supplied to the mill in a given year, that rancher would receive one-tenth of the total patronage dividends paid to the producers that year. If a designer purchased one-twentieth of all the wool purchased from the mill in a given year, that designer would receive one-twentieth of the total patronage dividends paid to consumers that year. The co-op will need to decide how to divide up its surplus revenues among its patron classes. It will also need to decide what payment, if any, will be made to Fibershed from surplus.

FINANCING

It is anticipated that financing will come from multiple sources:

1. Start-up financing from foundations and impact investors
2. USDA grant funding
3. Co-op member equity contributions
4. Direct public offering (DPO) of preferred stock

It is expected that start-up financing will primarily be in the form of loans. Co-op member equity contributions are likely to be minimal since there will not be a large number of initial members and California securities law requires more onerous compliance for member capital contributions greater than $300. Thus a relatively large portion of the start up capital could be raised in a DPO.

[6] "[T]hose who purchase . . . goods [or services] from . . . the corporation [and] . . . those . . . whose products or services are . . . marketed, processed, or handled by the corporation." California Corporation Code Section 12243. Patrons can also include workers. Workers' patronage is usually measured by the number of hours worked.

A DPO can serve multiple purposes. In addition to being a source of capital, it can generate excitement and a sense of ownership among the general public and be a great tool for publicizing the mill.

We recommend the following characteristics of the preferred stock to be offered in the DPO:

1. Annual dividend of 5-6% (if possible) – this can be cumulative or at the board's discretion – a cumulative dividend will be more attractive to investors
2. Optional redemption by shareholders in year X, with the value of X determined by reasonable projections for when the business would be able to redeem the stock; redemption is paid at the original issue price (or possible some multiple like 1.1X)
3. Non-voting except as required by law – preferred shareholders have the right to elect a majority of the board of directors if there is a default in the payment of cumulative dividends or redemptions (this is required under California securities law)
4. Preferred shareholders receive a liquidation preference (they get their original investment back before any of the other co-op members can share in the liquidation proceeds)
5. The preferred shares are not convertible into any other form of equity
6. The co-op should decide whether it wants its preferred stock to be transferrable – this would create another opportunity for exit (note that California imposes resale restrictions on securities sold in a DPO but this restriction can be lifted after the DPO is completed).

The DPO could be conducted in California only since the company is focused on California producers and consumers. This reduces the amount of regulatory filings required compared to a multi-state offering and also allows the mill to raise an unlimited amount of capital in its DPO (a multi-state offering must be capped at $1 million per year unless it is registered federally which is a very expensive and time-consuming process).

One important consideration when bringing in investors is the securities law principle of "integration." Under this principle, if an issuer conducts a private offering and then a public offering within a few months of each other, the two offers will be treated by the regulators as if they were a single offering which would likely result in a non-compliant securities offering. Offerings that are separated by six months will not be integrated. Therefore, it is important to carefully think through the timing of various aspects of the funding plan. One attractive aspect of the DPO is that investors of all sizes can invest in the preferred stock offered in the DPO so that there is no need to conduct a separate private offering to accredited investors (assuming the stock offered in the DPO is sufficiently attractive to larger investors).

CONCLUSION AND RECOMMENDATIONS

This analysis concludes that an ecologically and socially beneficial wool mill in California could be financially feasible in time, given certain shifts in the textile market. These include:

1. A clear demand from large and medium size buyers (brands) to pay 30-40% more for cloth production.
2. Test market viability and technical performance of California wool using East Coast supply chains and milling facilities.
3. Investigate the option for staging the mill—begin a proof of concept business with smaller yarn production facilities.

In the meantime, there is much work to support shifts in California ranching and farming practice to engage a shift towards soil restoration on our rangelands. Any mill in California would be reliant on a wool supply that is at risk due to the effects of climate change. Approaching our supply from the ground up is currently being accomplished through the work of Fibershed's non-profit arm and its collaboration with ranchers and farmers through its producer program. Through compost applications and grazing management plans—the soils that sheep rely on can be made more resilient against the effect of drought and erratic weather, while simultaneously becoming carbon sinks. This is the ongoing work that is essential for the success of any value-addition business in California.

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APPENDICES

A. Fibershed Producer Survey Data

B. Roswell 2012 Wool Auction Core Test Data

C. California Textile Demand Questionnaire

D. NSC Proposal

E. Building floor plan

F. Living Machine® Proposal

G. Meline Engineering Proposal

H. Life Cycle Analysis