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**TRANSFORMING
WASTE**

**TEXTILE DESIGN PROCESS
INTERVENTION: ADDING VALUE
TO WOOL WASTE.**

STACEY ELLIS



**TRANSFORMING
WASTE**

Transforming waste.
Textile design process intervention: adding
value to wool waste.

Stacey Ellis

An exegesis presented in partial fulfilment of
the requirement for the degree of Master of Design.
Massey University, Wellington.
2013

Issue- An investigation into textile waste to propose
alternative applications for reclaimed industry fibre
through the creation of textiles.

Research Question- How can value be added to
reclaimed industry fibre through the application of
textile knowledge, traditional craftsmanship, recent
technology and design?

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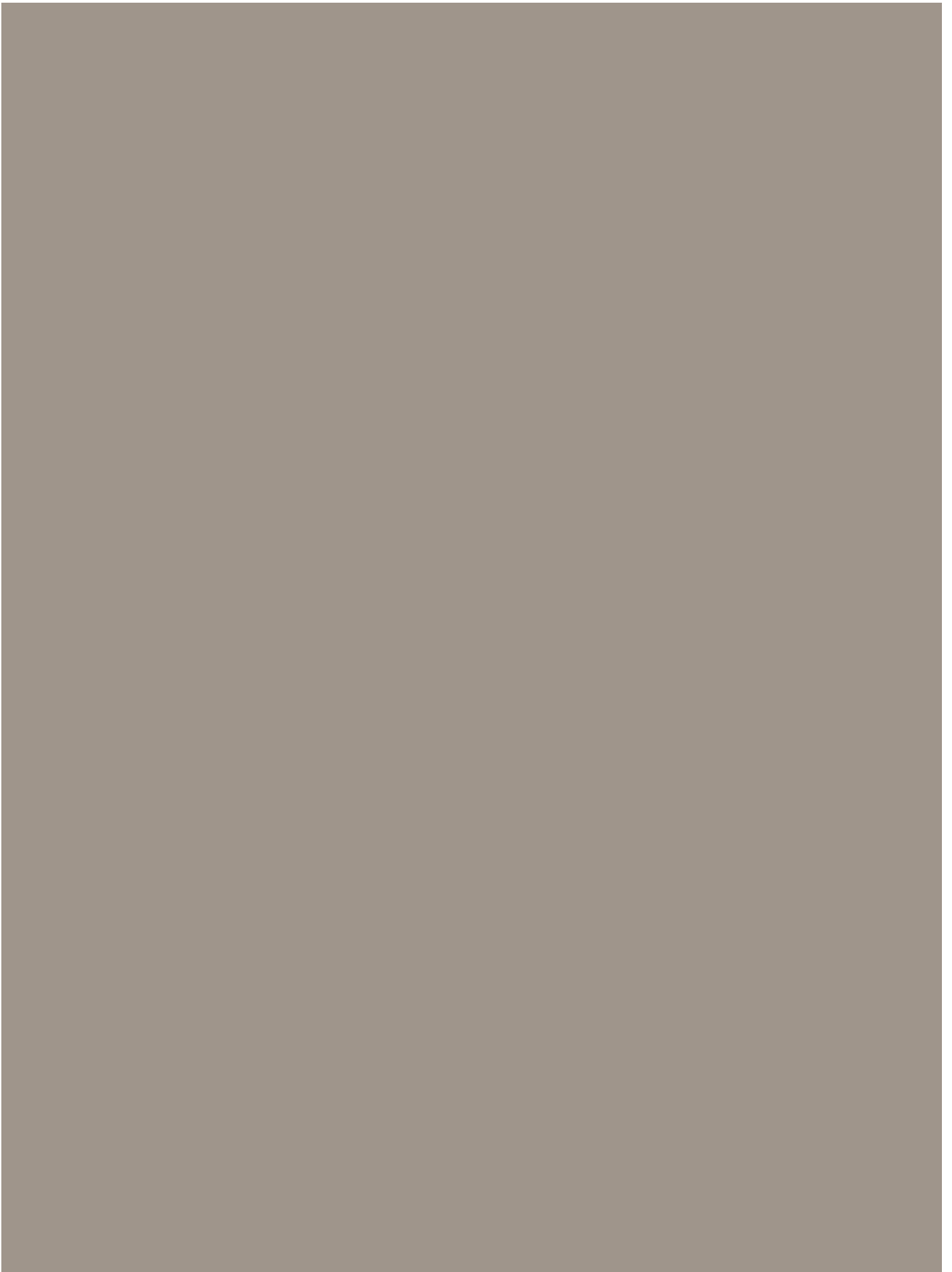


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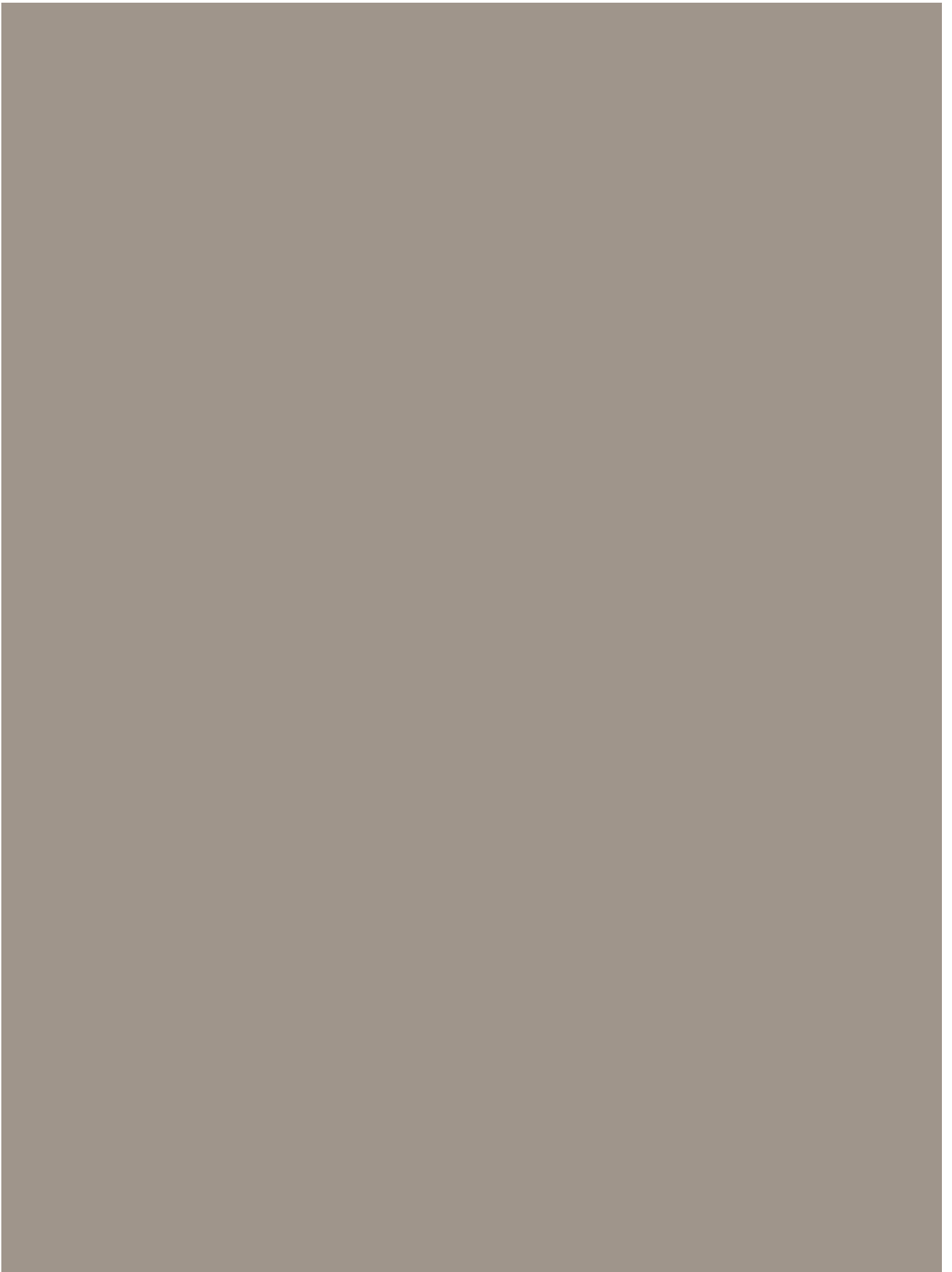
STACEY ELLIS





ABSTRACT

A design shift has moved towards a more honest materialization of design thinking, which is process. To that end, I use a material responsive, iterative design led process to explore the underdeveloped potential of reclaimed industry fibre from Woolyarns Limited (Wingate), Summit Wool Spinners (Oamaru) and Radford Yarn Technologies Limited (Christchurch). Reclaimed fibre is of high quality but low value compared to the original virgin fibre. Typically a New Zealand wool spinning company will sell the reclaimed fibre at a cost price (\$3/kg) to Auckland insulation manufacturers. In this research the potential of the fibre is explored using modern reinterpretations of traditional textile construction techniques and new non-woven and digital technologies. These processes have assisted to embrace the natural qualities of the fibre whilst adding value with the intention of producing innovative, high quality, high valued niche products as alternatives to the current 'downcycled' textiles produced in industry (insulation). To be completely sustainable is very difficult; but to eliminate and reduce waste to create value, minimize consumption and help prevent the premature disposal of this valuable natural resource offers another opportunity for design to support sustainable practice.





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Thank you.

I
—

INTRODUCTION

PAGE 13

1
—

CONTEXT

PAGE 17

2
—

GREASY WOOL

PAGE 25

5
—

SOFT WASTE

PAGE 41

6
—

FELTING

PAGE 43

10
—

WEAVING

PAGE 79

3

**MANUFACTURERS &
FIBRE PROCESSING**

PAGE 29

4

MY PROCESS

PAGE 37

7

**DIGITAL
EMBROIDERY**

PAGE 55

8

HARD WASTE

PAGE 71

9

HAND-SPUN YARN

PAGE 73

11

FELTED YARN

PAGE 91

C

CONCLUSION

PAGE 117

**“WHILE MOST TEXTILES
CAN BE RECYCLED IN
THE MAIN THEY ARE
DOWNGRADED ALMOST
IMMEDIATELY INTO LOW-
QUALITY END USES, SUCH
AS FILLING MATERIALS”**

(Fletcher, 2008, p. 35)



INTRODUCTION

Designers are constantly challenged to find new, innovative, eco-efficient, sustainable ways to use and reuse materials through design. The term eco-efficiency is described as “*doing more with less, a precept that has its roots in early industrialization*” (McDonough, M., & Braungart, M. 2002, p. 51). Sustainable initiatives have encouraged designers and industry manufacturers to reconsider how materials are produced and used and how this can be done more effectively using sustainable practice.

This exegesis explores the potential of reclaimed industry fibre from industry yarn manufacturers. The fibre sourced was natural fibre and yarn, predominantly strong wool from Woolyarns Limited (Wingate) Summit Wool Spinners (Oamaru) (100 kilograms of carpet yarn), Radford Yarn Technologies Limited (Christchurch) (fibre and felted yarns). Woolyarns were very generous throughout this research providing me with their expertise during on-site tours and vast quantities of fibre and yarn. I received soft waste and hard waste fibre. These are terms that were used on-site at Woolyarns and have been used throughout this exegesis. During a visit to Woolyarns Production Manager, John Hubbard (2012) expressed, “*We have what we call ‘soft waste’ which comes from the carding area: natural or dyed fibre not yet in yarn form. We also have ‘hard waste’ that has been spun into a yarn for knitting, weaving or carpet yarn. The fibre and blends are wool-nylon, wool-silk, wool-possum, wool-angora, wool-silk-possum or pure wool*”. The scale of Woolyarns production is vast with a fast product turnover. I recall John pulling large amounts of the waste fibre into large plastic bags, whilst doing so he would turn to me and say “*Do you want more*” and “*is this enough*” (J. Hubbard, personal communication, March 14, 2012). I was overwhelmed by the quantity and volume produced and given to me. The daunting task then became ‘what to do with the fibres sourced?’

“WE HAVE WHAT WE CALL ‘SOFT WASTE’ WHICH COMES FROM THE CARDING AREA: NATURAL OR DYED FIBRE NOT YET IN YARN FORM. WE ALSO HAVE ‘HARD WASTE’ THAT HAS BEEN SPUN INTO YARN FOR KNITTING, WEAVING OR CARPET YARN. THE FIBRE AND BLENDS ARE WOOL-NYLON, WOOL-SILK, WOOL-POSSUM, WOOL-ANGORA, WOOL-SILK-POSSUM OR PURE WOOL”

(J. Hubbard, personal communication, March 14, 2012)

Reclaimed fibre is an untapped commodity that holds the potential for sustained value to be added through reuse and design. The fibre has the physical properties to function however its value and worth is often not recognized, it is generally in the form of excess fibre, off-cuts or faults from the manufacturing process. With little attention in the past 200 years, (University of Cambridge Institute for Manufacturing, 2006, p. 69) the current method of reuse continues to be recycling. The issue with recycling is that *“while most textiles can be recycled in the main they are downgraded almost immediately into low-quality end uses, such as filling materials”* (Fletcher, 2008, p. 35). The potential of reclaimed fibre has significant scope for design to add value through industry and design process by *“extracting fibres with less shortening and for fibre separation from blended products”* (University of Cambridge Institute for Manufacturing, 2006, p. 2). The lack of development into fibre reuse proved the importance of this research and a subject worthy of attention and exploration.

This project profiles the role of design process to question the potential of reclaimed industry fibre. I used a material responsive, iterative designed process using reinterpretations of traditional textile construction techniques and new non-woven and digital technologies. Both traditional and recent textile processes were explored for their compatibility to each specific wool fibre type and its condition. Some textile technology processes were more appropriate than others. Integral to my process was the challenge of adding value to materials originally aligned to waste or low-quality 'downcycled' end uses (insulation).

My design process was developed while studying towards my Bachelor of Design at Massey University. I developed it further to include the research of yarn manufacturers, sourcing material, analysing fibre, documenting, recording, evaluating and responding to the fibre and processing, categorizing the potential of the fibre and methods of reuse, designing from technical trial results, re-evaluating and developing the findings through design. I constantly stood back from my design process, analysed the work as a whole and the samples in relation to each other and the overall message these conveyed. This enabled a thorough and extensive exploration of each particular fibre, process and its potential for added value.

This method ensured that the characteristics and properties of yarn influenced the process while being underpinned by sustainable philosophy, theory and concepts in an attempt to create an original, innovative, alternative design outcome for reclaimed fibre. My process aimed to use wool production waste and find alternatives to extend its lifecycle and better its performance through design research. This exegesis leads the reader on a journey through the theories that underpin my approach and my textile design process: trials, experiments, fabrics and product outputs.

**“HUMANITY HAS THE ABILITY TO MAKE
DEVELOPMENT SUSTAINABLE TO ENSURE
THAT IT MEETS THE NEEDS OF THE
PRESENT WITHOUT COMPROMISING THE
ABILITY OF FUTURE GENERATIONS TO
MEET THEIR OWN NEEDS”**

(Ostrom, E. 2012)

1



CONTEXT

This research uses sustainable design concepts to add value to industry waste fibre through process. ‘Sustainability’ or the ability to sustain is commonly used in conjunction with other terms and referred to definitions of sustainable practice. This has created a vast and confusing vocabulary of almost cliché terms that often result in the misuse of sustainable terms and phrases. The Brundtland Report for the World Commission on Environment and Development WCED, 1987 optimistically states *“humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs”* (Ostrom, E. 2012). Considering new ways of designing through material use and reuse offers the opportunity for design to enforce change within industry.

A situation of production waste has developed since the industrial revolution. Celia Stall-Meadows in the book *Fashion Now: a global perspective* outlines the impact of waste that has developed since the industrial revolution, when sustainability and the conservation of resources was common practice as materials were scarce and expensive. As demand increased, the manufacturing industry evolved and manual labour systems were replaced by mechanized manufacturing. This allowed textiles to be produced cheaper, quicker and in vast quantities. This has resulted in an overabundance of mass-produced, cheap and often poor-quality products and large volumes of textile fibre waste that has limited end use applications. It has become clear we are living far beyond our means *“with the world today consuming more than 68 million tons of fibre each year”* (Stall-Meadows, 2011, p. 176), we are largely borrowing valuable resources from future generations. This research aims to counter this problem. Using reclaimed fibre as an alternative to virgin fibre, sustainable concepts and design offer the potential for value to be added to through reuse while eliminating the concept of waste.



Figure 1. *Revealing the fabrics I wove to Bernadette Casey (The Formary). Author's own (2012)*



Figure 2. *Finishing the woven samples for Bernadette Casey (The Formary). Author's own (2012)*

Contemporary designers work to address these issues. Designer Rebecca Earley expresses “As a fashion and textile designer there is a need and urge to create and make, but this action is difficult to reconcile when you can’t help but notice the excess of unwanted and discarded textiles in our culture” (Earley, n.d.). Reusing waste, reclaimed fibre and bi-products companies and designers are beginning to use non-traditional innovative approaches to add value to waste through design.

In industry yarn spinning companies are searching for ways to make wool production more efficient and less wasteful. The Nürnberg, Germany based, Südvolle Group, a family owned yarn dyeing and spinning company is the largest manufacturer of worsted yarn worldwide for weaving, circular and flat knitted outerwear, socks, uniforms, special hosiery and technical yarns for automobile and aircraft applications. Made from pure wool, merino, silk, and

cashmere the products come in pure and mixed blends. Südvolle use sustainable and ethical materials, suppliers and production and manufacturing methods. They have transformed their processing methods to reduce water and electrical consumption through new treatment plans that work to create sustainable biological nutrients for the environment whilst consuming less. Creating a business that encourages sustainable solutions for future resource use. (Südvolle Group, 2011).

Weaving companies such as Yorkshire based, Camira claims to create new environmentally sensitive, fabrics using recycling and re-use cyclical loops. Camira develop and sub-contract agricultural cultivation of crops for the production of new fibre and yarn. Camira produce natural bast fibre products from stinging nettles and hemp, with their best selling fabrics made from recycled input materials. Camira minimize waste where possible, with reduced packaging, managing water, waste and energy use and fibre selvages are downcycled through recycling methods to produce insulation materials (Camira, 2011).

A different approach is taken by Wellington-based company The Formary who have created the only wool/waste bast fibre fabric. It has inspired my design process. They have adapted workable sustainable textile solutions for food and agricultural waste generated in industry. Collaborating with industries worldwide they turn waste into textile products for commercial consumption. A recent commercialized product is their WoJo® fabric. The Formary have used Jute from Starbucks coffee sacks, blended with high quality New Zealand wool to create a high performance upholstery fabric. Made from natural and renewable materials, sourced ethically, consider the environment and reduce disposal costs (The Formary, 2011). The fabric adds value to waste through design and reuse. Recently I worked alongside Bernadette Casey from The Formary to weave fabric for their wool/ rice straw project. Inspired by their process of fibre reuse I considered other fibres that could be reused and value added through design.

As well as these various industry approaches I was influenced by the sustainable philosophy of adhocism, described as “*a method of creation relying particularly on resources which are already at hand*” Jencks, (as cited in Silvester, 2007, p. 70). Local natural fibres and resources with the potential to add value through textile design were explored. Adhocism recognizes the ability for products to be functional and valuable resources outside their initial use. The ‘Adhoc’ approach allows for change in the way materials are currently used and allows for new innovative strategies for using products that were previously consigned to waste Jencks, (as cited in Silvester, 2007).

The University of Cambridge Institute for Manufacturing recognizes the potential of reclaimed fibre, ‘*reclaimed fibre is an untapped commodity, with reuse and recycling processes experiencing little attention in the past 200 years (The University of Cambridge Institute for Manufacturing, 2006)*’. This highlights significant scope for design and research development into reclaimed fibre reuse. Recycled and reclaimed fibres offer a low-impact alternative to other fibre sources, with reduced energy consumption, reduced resource consumption and reduced chemical consumption if the fibre is not over dyed. For example, renowned researcher, Kate Fletcher writes “*recycled pure wool fabric, energy consumption is thought to be half that needed to produce the virgin material*” (Fletcher, 2008, p. 35).

The issue with recycling is that it often involves ‘downcycling’ as materials are forced into uses they were never designed to endure.

“RECYCLED PURE WOOL FABRIC, ENERGY CONSUMPTION IS THOUGHT TO BE HALF THAT NEEDED TO PRODUCE THE VIRGIN MATERIAL”

(Fletcher 2008, Pg 35)

This can often require just as much energy and pollutants and generate as much waste as the original product (Fletcher, 2008). Fibre recycling and reuse often involves the blending of both recycled and virgin fibres, producing a hybrid of lower quality. Fletcher in her book *Sustainable Fashion & Textiles, Design Journeys* explains “*while*

most textiles can be recycled in the main they are downgraded almost immediately into low-quality end uses, such as filling materials” (Fletcher, 2008, p. 35). As textile volumes increase through mass manufacture downcycling and recycling are no longer sustainable practices. Recycling is the common practiced used for fibre reuse in industry today. I sort for alternative ways to add value to reclaimed waste fibre through the process of ‘upcycling’. Murray (2002), states that “*upcycling is about ‘not merely conserving the resources that went into the production of particular materials, but adding to the value embodied in them by the application of knowledge in the course of their recirculation’*” Murray, (as cited in Earley, 2010). Upcycling involves the re-

use of materials, as they exist opposed to the reconstituted products produced through recycling. Upcycling generally involves a hand’s on, labour intensive and intimate process. Upcycling was explored to add value, using traditional craft techniques, modern technology and textile design practice.

An overarching concept of my process was the ‘cradle to grave’ and ‘cradle to cradle’ principles. These principles outline the potential for reuse is possible post-production. The concept ‘cradle to grave’ is a term used to describe a product’s lifecycle from the materials raw state (cradle) to its disposal (grave). The ‘cradle to cradle’ design structure reflects a process that cyclically flows in an appropriate biological or technical nutrient cycle (Green Prophet, 2012). These processes work to eliminate the concept of waste, “*to eliminate the concept of waste means designing from the very beginning on the understanding that waste does not exist”* (Braungart & McDonough, 2002, p. 104). The Cradle to Cradle concept ensures that the product will

naturally regenerate or decompose at the end of the lifecycle and become valuable nutrients for the surrounding environment. This offers cheaper disposal costs and reduces environmental stress whilst consuming a lot less. By considering the material and fibres used ensures the potential for reuse was possible. Sustainable strategies Design for Recycling (DFR) and Design for Disassembly (DFD) were also explored to ensure this. Separation and post-production methods for reuse were considered by “developing products that are easy to take apart (by avoiding glues, for example) and recycling by promoting pure (non-composite) materials that have a high resale value” (Fletcher, 2008, p. 106). Today a technical disadvantage of recycling and reuse is that products are designed using multiple ‘hybrid’ materials that are often difficult or impossible to separate and reuse (McDonough, W. & Braungart, M. 2002). Influenced by sustainable practice “from an environmental viewpoint, how a product ends its life is a natural extension to considerations of how and from what is manufactured” (Braddock & O’Mahony, 1998, p. 132). Using compatible materials and easy separation techniques and processes enables reuse post-production for the production of downcycled textiles such as household insulation. It was important this was possible, as it is a current viable process for reuse in industry.

The authors, McDonough & Braungart (2002) explain “the best way to reduce any environmental impact is not to recycle more, but to produce and dispose of less.”

To be completely sustainable is very difficult, but to eliminate and reduce waste to create value offers another opportunity for design to encourage sustainable practice minimize waste and increase profit in industry.

—
**“TO ELIMINATE THE
 CONCEPT OF WASTE
 MEANS DESIGNING
 FROM THE VERY
 BEGINNING ON THE
 UNDERSTANDING
 THAT WASTE DOES
 NOT EXIST”**

(Braungart & McDonough, 2002, p. 104)

The challenge became to create a 'middle market' where value was maintained and added to reclaimed fibres through innovative design. The companies supplying the wool for this project, Woolyarns, Summit Wool and Radford Yarn Technologies are all working towards reducing costs where possible to ensure a more sustainable and profitable business and product. The use of these local resources opens the door for profitable local enterprise through reuse opportunities whilst promoting wool and design.

New Zealand (NZ) wool has provided income since the 1840s (Carter, MacGibbon, 2003) and was the country's most valuable export up until 1964 (Pickford 2010). With only one occasion when wool was not the strongest export; this was when gold was at its highest in the 1860's (Carter, MacGibbon, 2003). Since then however there has been a steady decline within industry due to lower wool prices (Wolfe, 2006). In 2006 wool made up 2.73% of New Zealand's exports. Following 2006, 2011's export prices rose to a 21-year high (Statistics New Zealand, 2012) with export receipts at \$718 million.

Wool can often be referred to as the original high performance fibre. It has exceptional performance properties such as: a natural fire resistance, inbuilt UV protection, good shape recovery, thermal insulation properties, combined water repellency and moisture absorption, ranges in grades; soft – coarse blends, holds up to 30% humidity without feeling damp, durable, renewable, recyclable, biodegradable and has a natural comfort. It was important to highlight these properties and ensure the state of the fibre remained the same or value was added was through process. NZ wool is premium quality a valuable natural resource yet design-led experimentation into ways of adding value through innovative design is the exception rather than the rule. This offers the potential to use these sustainable design processes, capture a larger target audience and take advantage of the growing trend and demand for more sustainable materials, resources and processes in design.

Boundaries 'limitless' for new eco-fabric

JAZIAL CROSSLEY
WELLINGTON BUSINESS

UPHOLSTERY fabric developed in Wellington by The Formary that blends Chinese rice production waste product with New Zealand wool will be sold in the United States next year.

During Wellington Mayor Celia Wade-Brown's business delegation to China last year, connections were made with the Chinese Ministry of Agriculture, which wanted new ways to recycle the millions of tonnes of rice straw being burned every harvest, creating pollution and visibility problems.

The Formary specialises in transforming post-industrial waste and has created a new fabric made from 70 per cent New Zealand wool and 30 per cent rice straw. It is working with a partner in Wellington's Chinese sister city Tianjin that is supplying the rice straw.

"We presented the prototype to our Chinese partner Grand Peak in June and they wanted us to roll it out at the next harvest in October, but that was too soon," The Formary director Bernadette Casey said. "We're looking at September or October 2013."

The Formary has developed a similar product from recycling jute coffee sacks with wool for cafe chain Starbucks' chair coverings.

"We've had strong market interest. A distributor in the States is requesting exclusivity of the fabric without even seeing it, but that will also be on the back of our project with Starbucks."

The rice straw blend fabric was no more expensive to produce than standard wool blend upholstery materials. Because of the straw having a high silica content it was highly anti-bacterial and highly flame resistant, enhancing the existing flame-resistant properties of wool. About \$300,000 had gone into



Recycling winner: The Formary's Bernadette Casey with the rice straw waste and wool fabric blend she has been developing.

Photo: DIEGO OPATOWSKI/FAIRFAX NZ

research, production and supply chain development so far, including \$150,000 of funding from New Zealand Beef + Lamb. It was now being refined at Massey University.

The United States was a target market in particular because the Government-backed energy

efficiency certification LEED programme meant businesses were given tax breaks in some states for using products with recycled material content.

The Formary could license and manufacture the wool blend products all over the world, which meant huge volumes

could be manufactured.

Stephen Fookes, spokesman for the Campaign For Wool In New Zealand, said the impact on the local wool industry could be very significant. "If it is driven by recycling the Chinese rice harvest it would use a heck of a lot of New Zealand wool, a very large amount.

I think the boundaries are almost limitless."

Gisborne wool merchant Peter Tate said partnering with China was a good way for the New Zealand wool industry to achieve scale. "I hope they make a fantastic success of this latest venture. It's a great idea."

Figure 3. *Boundaries 'limitless' for new eco-fabric.* (2012, December 6). The Dominion Post

**MY AIM WAS TO
UPCYCLE RATHER THEN
DOWNCYCLE OR RECYCLE
THE FIBRE. MY PROCESS
CAREFULLY ENSURED THE
CHARACTERISTICS OF THE
RECLAIMED FIBRE WAS
MAINTAINED.**

2

GREASY WOOL

Greasy wool is pure untreated wool that is shorn straight from the sheep. I received these off cuts as leftovers that were unwanted from a past student's work. The fleece was in short staple lengths, (3-5cm) full of dirt, grease, lanolin, bugs and dust. My aim was to upcycle rather than downcycle or recycle the fibre. My process carefully ensured the characteristics of the reclaimed fibre were maintained. I then decided to weave the short staple lengths individually. The fabrics produced are full of texture and character resulting in a quirky aesthetic, similar to the coat of a sheep. The different types of wool created different effects through texture, structure, colour and tone. The samples were made flat or textured depending on how the woven structure was formed. The flat woven samples show a colour gradient and the warp is shown throughout the fabric. The textured samples become 3D in surface and produce a very different aesthetic than the 2D woven samples. When washed and finished the structure of the weave remains structurally sound due to the small areas of fine woven plain weave holding the short lengths in place creating a viable 3D fabric.





Previous page: Figure 4. Greasy wool, weaving samples in progress. Author's own (2012)

**THE FIBRES SOURCED ARE
FROM WOOLYARNS LIMITED
(WINGATE), SUMMIT WOOL
SPINNERS (OAMARU) AND
RADFORD YARN TECHNOLOGIES
LIMITED (CHRISTCHURCH).**

3

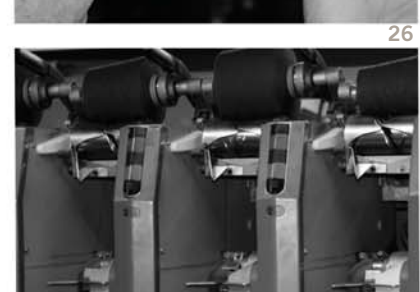
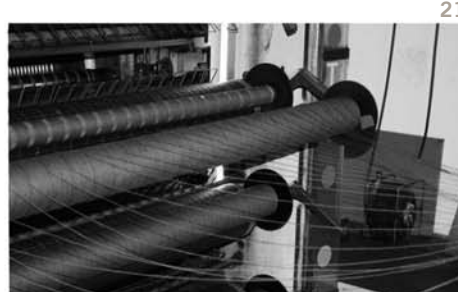
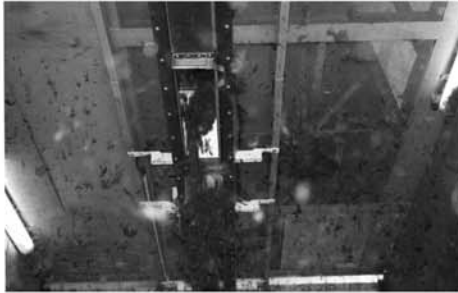
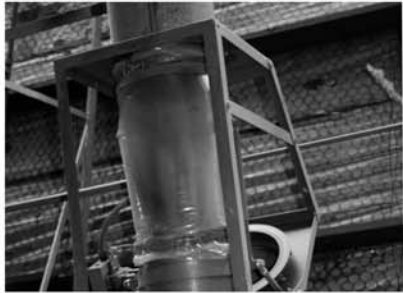
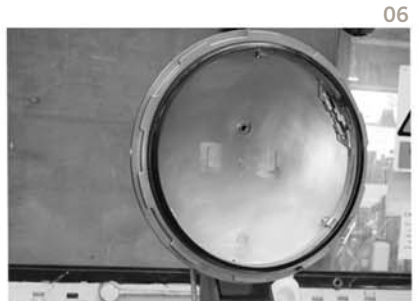
MANUFACTURERS & FIBRE PROCESSING

The fibres sourced are from Woolyarns Limited (Wingate), Summit Yarn Spinners (Oamaru) and Radford Yarn Technologies Limited (Christchurch). These companies produce yarn using natural fibres. The manufacturing process used is similar between companies although each company has different finishing methods to add strength to the yarn. This is dependant on the specifications of the product produced, e.g. Radford's felt their yarn to add strength and Woolyarns and Summit Wool spin their yarn, producing different aesthetics, properties and characteristics to the products produced. The following timeline and visual documentation is a record of the Woolyarns process recorded following a personal visit to the site and a documentary on Radford's.

Next Page: Figure 5. *Woolyarns and Radford's manufacturing process, visual narrative.* Woolyarns, Author's own (2012), Radfords, *Rural Delivery*. (2012, October 20). *Radford Yarn Technologies limited*. Retrieved from <http://tvnz.co.nz/rural-delivery/s8-ep33-video-5143031>



Woolyarns: 1. Oiling room 2. Oiling room 3. Oiling room 4. Fibre being transferred via 'cyclone vents' 5. The Dye house 6. The pressurized dye bath 7. Three different fibres, silk, merino, possum pre-blended / carded 8. Three different fibres, silk, merino, possum pre-blended / carded, fibre being sent to carding and blending room. 9. Sent to blending room via cyclone vents 10. Fibre being blended in blending room 11. The blended fibre 12. The blended fibre is sent to the



carding area via 'cyclone vents' 13. The carding machine 14. Cyclone vents, close up 15. The carding machine 16. Fibre being carded 17. Fibre being carded 18. Fibre is laid into 30cm wide continuous length 19. Fibre is sorted into soft yarn lengths 20. Close up of the soft yarn lengths 21. Close up of the soft yarn lengths 22. Strength is added to the yarn through spinning 23. Strength is added to the yarn through spinning 24. Mule spinning 25. Ring spinning.



Radfords

1. Woody Radford showing the lack of strength the soft waste has pre felting. 2. Woody Radford showing the lack of strength the soft waste has pre felting. 3. Woody Radford showing the lack of strength the soft waste has pre felting. 4. Woody Radford showing the lack of strength the soft waste has pre felting. 5. Soft waste being carded in the carding machine. 6. The carding machine 7. Close up of the carded fibre web 8. Fibre web split into soft yarn lengths 9. Soft yarn lengths are felted 10. Close up of felted yarn 11. Close up of felted yarn 12. Scale of production,



yarn being sorted after felting process. 13. Close up of felted yarn 14. Felted yarn 15. Woody Radford showing the strength added to the felted yarn
 16. Woody Radford showing the strength added to the felted yarn 17. Yarn being wound onto cones 18. Felted yarn 19. Felted yarn 20. Felted yarn
 21. Final felted yarn product- carpet sample.

MANUFACTURING PROCESS

1
—

Fibre is sourced from farmers

2
—

Sent to the oiling room, sorted, cleaned with water, oil is added to the fibre then dried. The oiling room can hold up to one thousand five hundred kilos at a time.

3
—

Sent to dye house. Fleece is dyed individually to ensure the colour remains consistent, (each fibre takes the dye differently).

7
—

The operator checks the colour to a control sample, if the colour is a match it will continue through the rest of the manufacturing process if not it is re-blended.

8
—

Fed through cyclone vents to the carding area. Carding is the initial process of sorting and laying the fibre before turning it into yarn.

4

The fibre is placed on a conveyor, fed through the carding machine via cyclone vents to the blending room. The blending room can hold up to a thousand kilograms of fibre at a time.

5

Fibre blends and colours are combined together for around 30-40 minutes to produce a specific colour and type of yarn.

6

A sample is made from the blended fibre.

9

Put into a trough at the front of the carding machine, conveyor picks up the fibre separates and weighs it into the 'hopper,' fed through combing rollers into the 'scribbler' and combed and sorted into flat layers of 'fibre web.' Transferred on conveyors to the 'inter' which combs the

fibre into a finer 'fibre-web', transferred on conveyors and carded into the 'scotch feed', laid into a roughly 30cm wide continuous length of slither (at this stage the fibre is called table waste), through the 'condenser', split into individual yarns (at this stage it becomes bobbin waste.)

Both the table waste and the bobbin waste are regarded as soft waste meaning it is carded fibre, pre-twisting and pre-spinning. At this stage the fibre can be put back into the machine re-carded and reused.

10

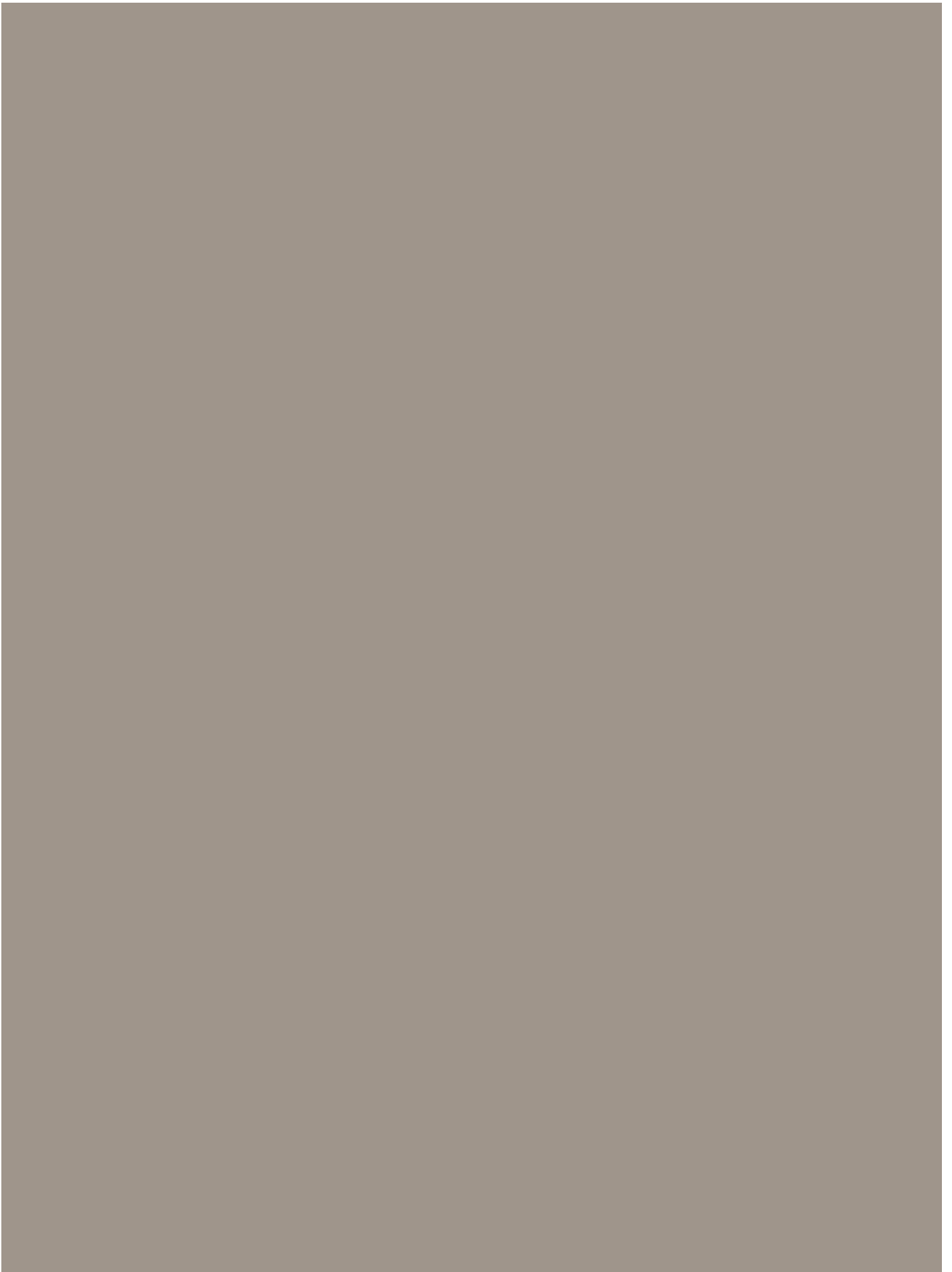
Twist is added to the yarn through mule spinning or ring spinning or felting is applied to add strength to the yarn and wound onto cones or spools depending on the type of yarn. At this stage it becomes hard waste.

11

The cones are taken to the auto winder where faults are removed, if the fibre has been spun.

12

The yarn is completed and the 'final package' is ready for the customer.



4

MY PROCESS

The waste fibre received from Woolyarns is in the form of Soft waste-Table waste and Bobbin waste and Hard waste- spun yarn. I have categorized the carpet yarn from Summit Wool Spinners and the felted yarn from Radford's also as hard waste. John Hubbard (Production Manager) and Neil Mackie (CEO) used the terms soft waste and hard waste during my trip to Woolyarns. John explained, *"We have what we call 'soft waste' which comes from the carding area: natural or dyed fibre not yet in yarn form. We also have 'hard waste' that has been spun into yarn for knitting, weaving or carpet yarn. The fibre and blends are wool-nylon, wool-silk, wool-possum, wool-angora, wool-silk- possum or pure wool"* (J. Hubbard, personal communication, March 14, 2012). This terminology has been used throughout this exegesis to identify the fibres used. To explore the potential of this fibre a material responsive, iterative design-led process was used. The following timeline is a record of my process.

MY PROCESS

1
—

Received the fibre.

2
—

Produced graphs recording and identifying:

- Properties
- Characteristics
- What its produced for
- How its produced
- Fibre type
- Burn tests

3
—

Experimented with the fibre – textile processing.

7
—

Developed the findings through design.

8
—

Analysed, evaluated and responded to the results

12
—

Explored end use ideas.

4
—

Analysed and documented the results

5
—

Developed and further pushed the findings through design.

6
—

Analysed, evaluated and responded to the results.

9
—

Developed the samples-produced bigger samples.

10
—

Evaluated the samples at a larger scale.

11
—

Responded and identified potential end-uses.

13
—

Evaluated the ideas and produced samples.

14
—

Produced final sample pieces in response to the knowledge gained and most successful fabrics and designs.

15
—

Analysed and evaluated final samples.

Figure 6. *Table waste at Woolyarns Limited (Wingate). Author's own (2012)*

Figure 7. *Bobbin waste at Woolyarns Limited (Wingate). Author's own (2012)*



**SOFT WASTE IS ANY FIBRE
PRE-SPINNING.
SOFT WASTE IS IN THE
FORM OF TABLE WASTE
AND BOBBIN WASTE.**

5

SOFT WASTE

Soft waste is any fibre pre-spinning. Soft waste is in the form of Table waste and Bobbin waste. At this stage the fibre can be reused and re-spun into yarn therefore there is little waste. I considered how the fibre is currently reused post-production (insulation) and ways that I could use similar processing techniques to add value through design and textile knowledge.



6

FELTING

The felting technique is currently used in industry to process waste fibre. Fibres are matted together into a felt sheet. The felt is a dense heavy, modest material concealed in the walls of the interior for insulation. My intention was to use a similar felt process to that which is currently used, but through design and textile processing produce felt that is designed to be viewed, appreciated and value added through design.

Designer Anne Kyyrö Quinn produces textile felt products and offers bespoke textile services for the interior. “*Cut sewn and finished by hand*” (Quinn, 2009, p. 168) the products have an organic hand quality. Quinn explores the natural properties of felt, “*it is environmentally-friendly, tactile, soft, durable and easy to work with*”, “*a simple material that has an impressive range of diverse functions*” (Quinn, 2009, p. 168).

The felt process was used to explore the properties and functions of wool. Using soft waste, ‘table waste’ and ‘bobbin waste’ varied sheets of pre-felt were produced which were then wet felted. Pre-felted sheets are easier to wet felt as they are in a sheet of fabric rather than individual pieces. Wet felting was explored to add both strength and structure. The felting processes offered varied results.

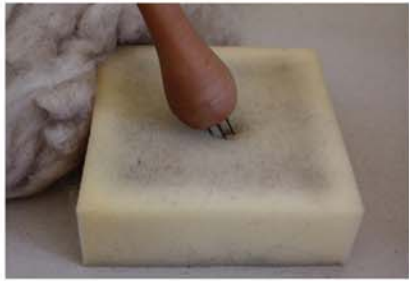


Figure 8. *A visual narrative of the hand-held needle felting process. Author's own (2012)*

HAND-HELD FELTER

Method:

- Laid fine fleece sheets on a thick sponge, continuously penetrated the needle felter through the fleece until it was flattened on the sponge.
- Pulled the fleece from the sponge- this distorted the fine structure. Controlling the consistency of weight was difficult because of this, especially across a greater surface area.
- Placed the pre-felt back on the sponge, added another layer of fleece.

I continued this process each time adding a layer of fleece (adding eight layers of fleece to the pre-felt).

Evaluation: As more layers were added the sponge degraded from the penetrating needles. As the pre-felt was pulled small pieces of sponge would be attached to the pre-felt.

Response: The fibre felted well but due to the inconsistencies in weight, structure and the sponge remnants I concluded the felting process was viable but using a hand-held needle felter was not. This led me to consider other felting processes. I decided to explore the use of the needle felt loom. To allow for the making of a greater surface area and create an even consistency in weight and structure.

NEEDLE FELT LOOM

It was through time, perseverance, constant analysis and evaluation of process I understood the fibres, my process and the ability and parameters of the technology. It became clear that variables influencing the process were: fibre type-condition and properties, the laying of fleece, needle speed and roller speed.

Method: I explored 2 ways of laying the fleece.

1. I laid 3 layers of 'table waste' fleece in one direction on top of each other.
2. I laid 3 layers of 'table waste' fleece alternating the direction vertically and horizontally
 - I set the felt loom at a generic setting of 50 for roller speed and 50 for needle speed.
 - I fed the fleece (3-layered) samples through the felt loom.
 - I fed the samples through 8 times. I found between the 6th and 8th time there was little difference to the depth of felt because the sample was so fine.
 - I then repeated this sample adding layers of fleece, up to 12 layers. From 5 layers to 12 layers the amount of times the fleece needed to be fed through the machine increased by 3.

E.g. 3 layers = 8x fed, 4 layers = 11x fed, 5 layers = 14x fed, 6 layers = 17x fed, 7 layers = 20x fed, 8 layers = 23x fed, 9 layers = 26x fed, 10 layers = 29x fed, 11 layers = 32x fed, 12 layers = 35x fed.

- I then used the both the 'table waste' and 'bobbin waste', sandwiching the bobbin waste between the table waste the resulting pre-felt was much more textured.

Evaluation: The resulting pre-felts varied from fine, fragile and translucent to thick, dense and strong depending on the amount of layers. The direction of the felt also determined how fast the fleece felted. The alternating – cross-hatched structure felted quicker and more evenly. After understanding the technology and process I explored ways to fasten the process by altering the roller speed and needle speed.

Response: Slowing the needle speed slowed the felting process; increasing needle speed increased felting process. Slowing the rollers increased the felting speed, fastening the rollers slowed the felting speed. To increase the felting speed I slowed the rollers to 20 and increased the needle speed to 65, this increased felting but resulted in a linear pattern of tiny needle holes. To reduce this I alternated the way the pre-felt was fed (horizontally and vertically). I increased the rollers to 35 and set needles at 65, this reduced the linear pattern and felted the fleece faster and more consistently in structure and surface. To add further strength wet felting was explored.



Figure 9. Merino possum fleece from Woolyarns Limited (Wingate). Author's own (2012)



Figure 10. Laying the fleece into fine layers to be needle felted on the felt loom. Author's own (2012)

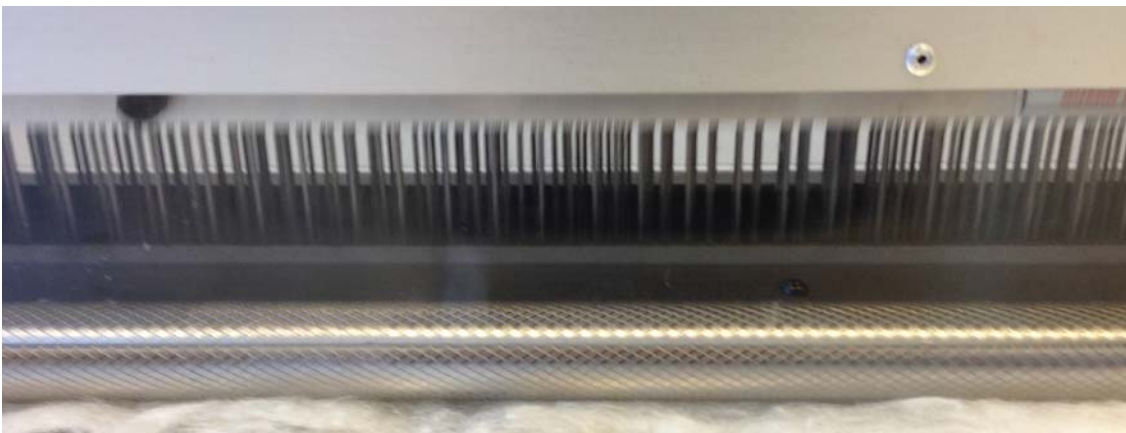


Figure 11. Close up of the needles penetrating the fleece. Author's own (2012)



Figure 12. The initial pre-felt after being fed through twice. Author's own (2012)



Figure 13. Final stages of the felt being fed through the loom. Author's own (2012)



Figure 14. Close up of the pre-felt before being wet felted. Author's own (2012)

Figure 15. Wet felting the pre-felt. Author's own (2012)

**USING THE TRADITIONAL
METHOD OF WET FELTING;
WOOL, HOT WATER, TIME,
ENERGY, AGITATION AND
HARD WORK.**



Figure 16. *The final stage of the wet felting process, working, fulling the fabric.* Author's own (2012)

WET FELTING

Using the traditional method of wet felting; wool, hot water, time, energy, agitation and hard work the process was explored.

- I used the existing needle felted pre-felt samples from the felt loom
- I laid the pre-felt on a bamboo mat
- Poured hot water over the fleece (lightly covering, not saturating).
- Sprinkled the damp pre-felt with soap detergent.
- Rolled the fleece up in the bamboo mat.
- When I could feel the mat cooling I unrolled the mat and poured more hot water over the mat, continuing this process until the fibres became completely matted together. The time this took depended on the layers of fleece.



Figure 17. *Table waste and Bobbin waste pre-felted on the loom.*
Author's own (2012)



Figure 18. *Table waste and Bobbin waste wet felted samples.* Author's own (2012)



Figure 19. *Table waste felted samples. Author's own (2012)*



Figure 20. *Table waste felted samples, close up. Author's own (2012)*

Evaluation: Fleece laid in one direction increased in length and decreased in width. Alternately laid fleece shrunk more evenly. Once wet felted the five layered fleece was very fine, the eight-layered fleece was more successful, stronger and consistent in weight. The table waste felted into flat sheets, the combined table waste and bobbin waste pre-felts were textured with a Nuno felt aesthetic.

Response: Influenced by the sculptural aesthetic of Anne Kjöro Quinn's work I began experimenting with form using pleating and ruching, tacking the pleats in place with a cotton thread. This was not structurally sound but aesthetically was worth developing. Influenced by sustainable design strategies design for disassembly and design for recycling, I did not want to use binding agents or glues in the design process. I considered alternative ways to create stable holes in the felt with the potential to develop this ruched aesthetic. This led me to explore digital embroidery to create a stronger structure and surface.



Figure 21. *Close up of the final wet felt samples.* Author's own (2012)



**REVITALISING CRAFT
TECHNIQUES COMBINED
WITH TECHNOLOGY WAS A
KEY COMPONENT OF THIS
MATERIAL RESPONSIVE
DESIGN-LED PROCESS.**

7

DIGITAL EMBROIDERY

The mechanization of embroidery was crucial to the development of mass produced fine embroidered textiles. Prior to this embroidery was time consuming and labour intensive. Crucial to this development was Schlaepfer's introduction of compose techniques in the early 1970s. Compose techniques were inspired by "*the prospect of revitalizing craft-orientated embroidery*" (Huddleston, Whittaker, 2010). Schlaepfer became famous for the design and manufacture of mechanized embroidery.



Figure 22. The TAJIMA automatic digital single head embroidery machine, TFMX series, Author's own (2012)

Next Page. Figure 23. Initial embroidery samples. Author's own (2012)

embroidery reacted across different materials, e.g. needle felting, wet felting and weaving. From this I gained confidence with the technology and was able to use my knowledge as a textile designer to explore the potential of the material and process. The woven embroidered sample was successful but not pushed further as the felt samples became more inspiring. From initial experiments the most successful motifs were: filled in spots using a running stitch in concentric circle mode; the circle motif did not distort like the satin stitch did and a circle outline using a 'bean' stitch, (a 'bean' stitch resembles a triple running stitch) the shape met at the beginning and end stitch and remained a consistent shape.

Revitalising craft techniques combined with technology was a key component of this material responsive design-led process.

Digital embroidery was explored using a TAJIMA automatic embroidery machine TFMX series, a single head machine with a 2 million-stitch memory. This allowed for a wide variety of patterns and stitches.

Through initial 'hands on' experiments I was able to familiarize myself with the machine, stitch types, digitizing and how the



sample 7



sample 9



sample 10

sample 11







Figure 24. Grey, 100% viscose embroidery thread. Author's own (2012)



Figure 25. Charcoal, 100% viscose embroidery thread. Author's own (2012)



**USING TEXTILE
KNOWLEDGE OF REPEAT
PATTERN I WAS ABLE TO
EXCEED THE MAXIMUM
PARAMETERS OF THE
MACHINE.**



Figure 26. Red, 100% viscose embroidery thread. Author's own (2012)

The circle motif was used for the potential to add structure as well as aesthetic as it is a continuous shape. The embroidery technology was new to me. To understand the machinery, process and parameters I had to work within was a challenge. Digitizing and the TAJIMA DG/ML by pulse software were difficult to understand and restricted me to more basic patterns and structures initially as this was a time consuming process. A greater understanding of the technology through time and perseverance enabled further design exploration.

Initial experiments were produced using a cotton and viscose thread. The cotton was matt in finish. The viscose was more desirable with a strong

lustre that lifted both the felt and embroidery. I continued to use a viscose embroidery yarn from Madeira. From these results I produced designs in Adobe Photoshop, made pre-felt on the felt loom and wet felted pre-felt samples to compare the different felts and the aesthetics they gave. I then digitized the Photoshop designs on the computer using the TAJIMA DG/ML by pulse embroidery software. To digitize means converting the designs into stitches.

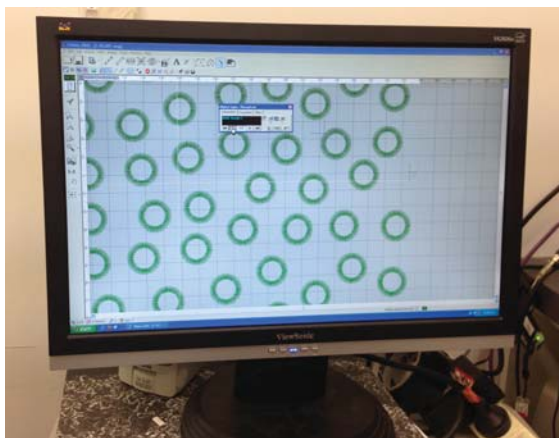


Figure 27. *The Digitized design being worked out on the computer.*
Author's own (2012)



Figure 28. *The Digitized design being stitched on the embroidery machine.*
Author's own (2012)

Once the design was digitized it was transferred via usb to the embroidery machine, the machine reads and stitches the pattern. A variety of fusing was explored to add stability to the fabric. A wash-away fusing was most successful because of its stretch and weight. This was placed on the back of each sample, giving the fleece added stability when embroidered and was later removed.

The machine could stitch to a scale of 47cm length by 29cm width maximum. This meant my design and end-use had a defined scale set by the machine. With the intention of developing the felted ruched sample I sort for a way to produce my samples on a larger scale. Spending time using the machine and digitizing designs I was able to combine my textile knowledge of repeat pattern with the technology to provide a greater surface area to work with using registration marks and a 'cut through line' to guide my design. This allowed two designs to be matched together into a length of 93cm by 29cm width. Using textile knowledge of repeat pattern I was able to exceed the maximum parameters of the machine, creating a surface area that was not previously possible.

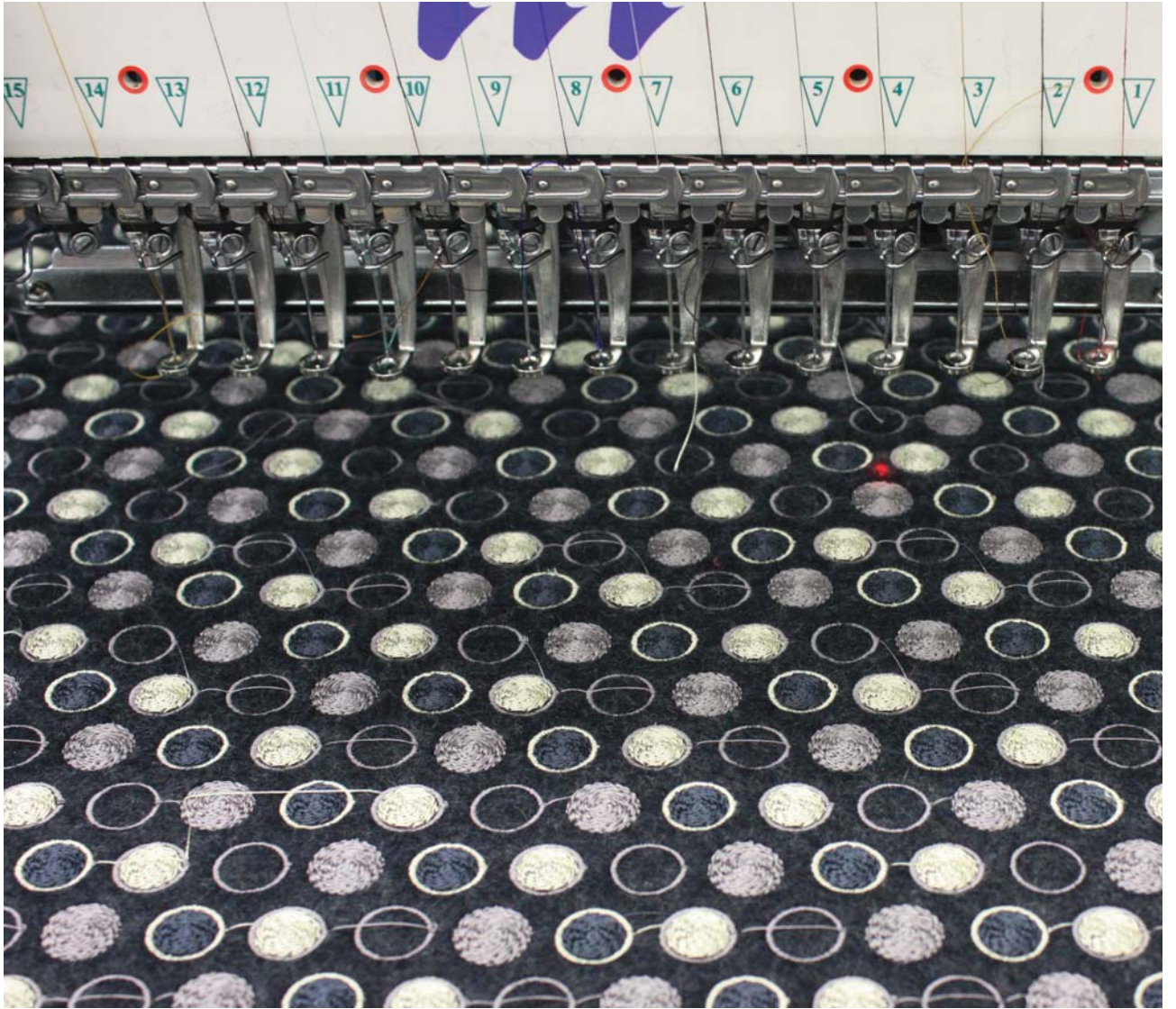


Figure 29. A multi coloured design being stitched out on the embroidery machine. Author's own (2012)

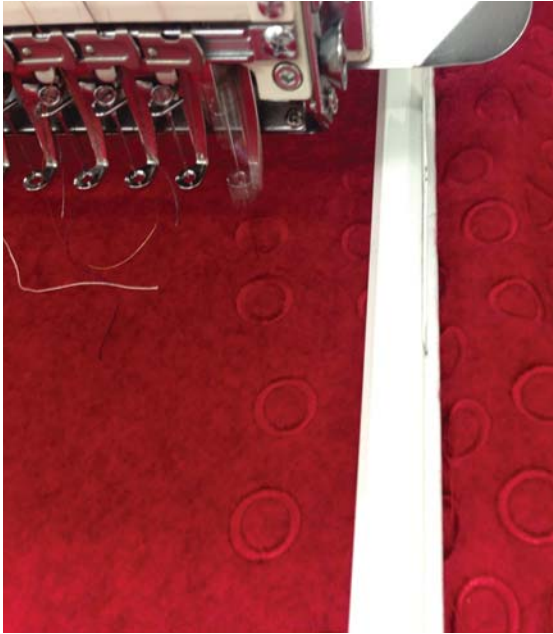


Figure 30. The two designs being matched using crosses to make a repeat. Author's own (2012)

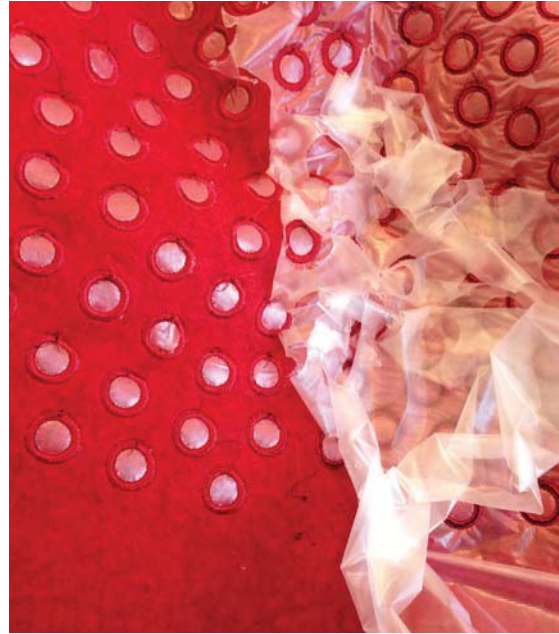


Figure 31. The wash away fusing being removed from the back of the sample. Author's own (2012)

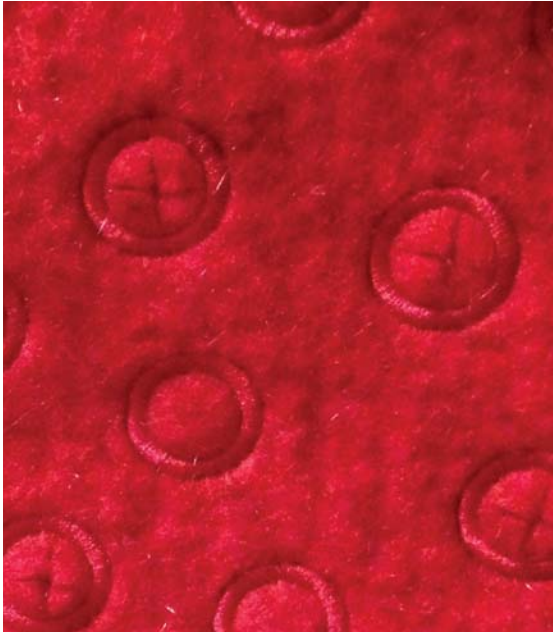


Figure 32. Crosses are made inside the circles so they can be cut away. Author's own (2012)

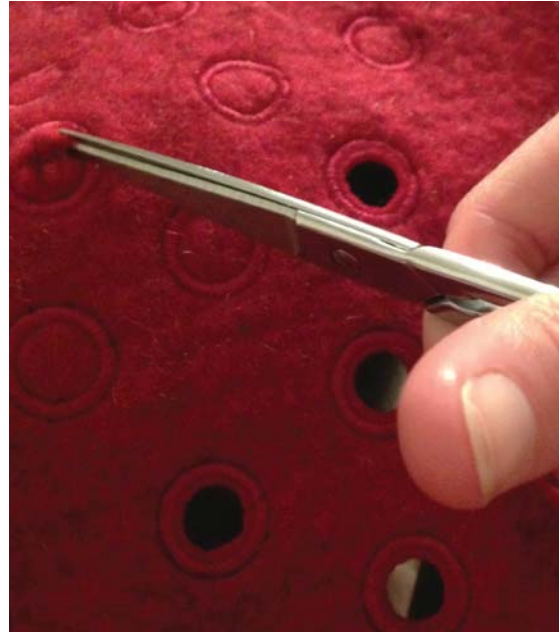


Figure 33. The core of the circle is removed. Author's own (2012)



Figure 34. Christie, R. (2012). *The final scarf length*.
Mount Cook, Wellington



Figure 35. Initial ruched sample. Author's own (2012)



Figure 36. Initial embroidered ruched sample. Author's own (2012)

Next Page

Figure 37. Final scarf ruched, close up. Author's own (2012)

Figure 38. Final scarf ruched. Author's own (2012)





Figure 39. Grey merino wool needle felted on felt loom with fill pattern embroidered. Author's own (2012)

Figure 40. Red merino wool needle felted on felt loom then wet felted and pattern stitched on top, raised cone effect. Author's own (2012)

The needle felt samples were less stable and needed a small pattern of dense structure to add strength. This was achieved using a fill pattern installed on the machine. This created a 'quilt like' aesthetic where the dense embroidery puckered the fleece into small 3D mounds. The embroidery produced a strong structure for the fleece that was not initially possible. The two processes then compliment each other to produce a fabric that enhances the characteristics of each process and material.

The wet felt was much denser and stronger. This affected the way the stitch was made and the effect it gave. The filled in stitches compressed and raised into small cones, were flat or inverted. This depended on the pre-felt weight and how taught the pre-felt was within the frame. The outlined circles remained flat with a small raised felt surface within the circle. The overall structure was very strong. The more condensed the pattern the stronger the fabric.

Wet felting allowed for larger more sparse patterns to be embroidered due to the structure of the felt. After resolving the issue of scale I developed the ruched felt idea into accessory pieces (scarves). I designed a scattered spot repeat using the 'bean' stitch to produce a circle outline; this meant the core of the circle could be removed leaving a stitched outline to emulate the original ruched sample on a larger scale. The circle design provides structure for the yarn to be threaded and aesthetic through pattern. The final scarf can be threaded in multiple ways providing variety from a single design.

Combining felting, embroidery and design the felt transformed from unstable, weak and uninspiring to exceptionally strong with added value through design process. The fabric uses the natural properties of wool, sound absorbency and climate control making the sample fabrics suitable as potential upholstery, furnishing fabrics, room dividers for the interior or fashion scarves accessories that use the tactile quality, softness and thermal retention properties of wool when worn to the body. Through rediscovery of the craft of felting by hand and a special attraction to the thinness, fragility, and potential of felt combined with technology the properties of wool, felt were pushed to their potential to add value through methods of upcycling.

Kate Goldsworthy is a London based designer working using similar processes. Using reclaimed mass-manufactured robust felt insulation; household textiles, medical bandaging and geotextiles the materials make for reliable secondary sources. Using basic waste materials as a starting point for design Goldsworthy uses both high-tech and low-tech textiles and technologies to 'resurface' the materials and 'upgrade' samples using experimental upcycling techniques, she expresses how "*New technologies make resurfacing a viable and sustainable method of producing 'up-cycled' textile products*". Goldsworthy explains, "*by revealing their hidden beauty, I can elevate them to a higher status and make them more desirable to consumers*" (Quinn, 2010).





Previous Page: Figure 41. *Close up of embroidered felt samples.* Author's own (2012)

Figure 42. *Hard waste at Woolyarns Limited (Wingate).* Author's own (2012)

Figure 43. *Close up of the Hard waste at Woolyarns Limited (Wingate).* Author's own (2012)



**HARD WASTE IS FIBRE
THAT IS SPUN OR FELTED
INTO YARN.**

8



HARD WASTE

Hard waste is fibre that is spun or felted into yarn. The hard waste received from Woolyarns was winding faults- fine wool in various colours and blends of fine-medium weight wool and carpet yarn. From Summit Wool Spinners I received carpet yarn and Radford's I received felted yarn. The yarn is viewed as waste as it cannot be re-spun because a twist or felting process has been applied to the yarn too add strength. Therefore is of little value to Woolyarns, with the fibre currently sold for \$3kg to Auckland insulation manufacturers. To reuse the hardwaste fibre it is shredded through recycling processes. This shortens the fibre, degrading it further. The shredding of fibre for reuse has remained almost identical to its original 'shoddy fibre' origins, shoddy traditionally refers to the historical process invented in 1813, using a rag grinding machine the fibre is shredded back into a fibre form and mixed with another fibre, commonly wool and re-spun into a recycled yarn (University of Cambridge Institute for Manufacturing, 2006). This process degrades the fibre through downcycling. My intention was to add value through upcycling. This would maintain the current state of the fibre and add value through reuse.

**“WE CAN PROVIDE YOU WITH
SOME OF OUR HARD-WASTE
FIBRES FROM PROCESSING,
BUT I DON’T KNOW IF
THERE’S ANYTHING MUCH
YOU CAN DO WITH ANY OF
THIS STUFF. ”**

(J. Hubbard, personal communication, April 12, 2012).

9

HAND-SPUN YARN

Throwing bundles of messy, tangled, multi-coloured, yarn into large plastic bags John Hubbard expressed: *“We can provide you with some of our hard-waste fibres from processing, but I don’t know if there’s anything much you can do with any of this stuff,”* (J. Hubbard, personal communication, April 12, 2012).



Figure 44. Christie, R. (2012). *Hard waste yarn, sorted and ready to be spun.* Mount Cook, Wellington

After pulling lengths of fibre from the tangled heap I realised the yarn contained a twist from processing, it twisted back on itself. I was able to pull out varying lengths of yarn before it broke. I then re-twisted the lengths wrapping them around my fingers, spinning the lengths back into a continuous strand of yarn. The hand-spun yarn I produced, ranged in lengths and weights. The yarn was then woven using plain weave and tassels.

Reusing materials to produce yarn to add value is a practice used by a limited group of individuals. Local and international designers Annie Sherburn, Greetje van Tiem and Nicki Gabriel are examples of this.

Annie Sherburn, (Eco Annie) a graduate from St Martins and Goldsmiths in 1994 has developed a recycled yarn using 50% recycled London textiles and 50% organic UK wool. Sherburn explains, *“it’s about much more than designing and making - it’s about creating change”, “we should take lessons from nature, in which there is no waste. That means separating materials derived from oil, minerals and metals from those which can be grown and replenished and biodegrade naturally”* (The Independent, 2007).

Next Page Figure 45. Christie, R. (2012). *Hard waste yarn, the spinning process*. Mount Cook, Wellington
 Figure 46. Christie, R. (2012). *Hard waste yarn, the spinning process*. Mount Cook, Wellington

Sherburn's design and material process has diverted "*two tons of waste from landfill so far*" (*Fibre2fashion, 2006*). In workshops Sherburn educates others on the potential of reclaimed fibre, with the intention to educate and inspire others to explore the potential of these materials.

Greetje van Tiem's 2007 graduation project 'Indruk', meaning 'print' hand-spins used-newsprint into yarn, to create various textiles including: rugs, curtains, toys, clothing and upholstery. Van Tiem is turning waste materials into bespoke products, the yarn is covered in history lined with the remnants of its past. Van Tiem "*cuts newspaper into narrow strips and spins it into a thick thread on a traditional spinning wheel, she does not use anything else in the process, the twisting gives strength to the yarn*" (*Green Design, 2009, p. 116, 117*). Van Tiem adds value to the reclaimed material through textile design process.

A New Zealand designer working in this field is Nikki Gabriel. From a small spinning mill, Design Spun, in New Zealand Gabriel processes 'recycled factory fibre remnants', Wool, Alpaca, Silk, Cashmere & Possum and re-spins the materials into a recycled bulky roving yarn called 'Wooli'. This is similar to my process of working and reusing valuable fibres, but compared with Gabriel I am both making and designing fabric with these reclaimed materials whilst adding value through process.





Figure 47. Christie, R. (2012). *Hard waste yarn, the spinning process*. Mount Cook, Wellington



**“I HAVEN’T EVER SEEN A FABRIC
LIKE THIS PRODUCED FROM
CARPET YARN, ITS CREATIVE,
INNOVATIVE, YOU COULD BE ON
TO SOMETHING HERE, WE ARE
ALWAYS LOOKING FOR NEW WAYS
TO USE OUR CARPET YARN, THIS
IS MARKETABLE.”**

(N. Mackie, personal communication, November 8, 12)

10

WEAVING

Weaving is a method used for creating fabric that is generally produced on a loom. The fabric is created using horizontal (weft) and vertical (warp) threads that are interlinked alternately to form a woven structure. A loom consists of the loom frame; warp beam, cloth roll, heddles, heddle levers and the reed. The threading of the warp yarn and the heddle levers control the pattern and structure of the cloth created.



Figure 48. Threaded warp on the table loom.
Author's own (2012)

The weaving process was used as a sustainable design strategy. Considering materials *“from an environmental viewpoint, how a product ends its life is a natural extension to considerations of how and from what is manufactured”* (Braddock & O’Mahony, 1998, p. 132). By considering how materials are used and what materials are used can enable further end-use opportunities through design. Influenced by Design for Recycling (DFR) and Design for Disassembly (DFD) these strategies enable the reuse of materials after their intended use as no glues or binding agents are used during the process. DFR and DFD prolong material use and can add value to materials through design, while enabling viable methods of recycling such as the

production of insulation to continue. This ensures successful reuse methods are still possible post-production. This was the underpinning and driving incentive of using weaving as a sustainable process.

The warp yarn was recovered excess fine wool on cones given to the Massey University Textile Department from industry. The warp was 120 total ends 35cm width and 340 total ends to weave two 35cm width samples at once. A length of 25 meters was woven throughout this process.





Previous page: Figure 49. *Winding the warp.* Author's own (2012)

Figure 50. *Tying the warp to the loom.* Author's own (2012)

Figure 51. *Sorting and organizing the warp threads.* Author's own (2012)



Figure 52. *Tying the warp on to begin threading.*
Author's own (2012)



Figure 53. *Threading the warp.* Author's own (2012)



Figure 54. *Close up of the threaded warp.*
Author's own (2012)



Figure 55. *Tying the warp to begin weaving.*
Author's own (2012)



Figure 56. *The threaded warp, ready to begin weaving.*
Author's own (2012)



Figure 57. *Lightly tasseled weave using hand-spun yarn.*
Author's own (2012)



Figure 58. *Large tasseled weave using hand-spun yarn.*
Author's own (2012)



Figure 59. *Plain-woven fabric using hand-spun yarn. Author's own (2012)*

Different weft yarns were used depending on the type of yarn and its condition. The weft yarn included:

- Greasy mixed wool
- Hardwaste yarn of mixed weights and colours
- Tangled mixed blend hardwaste, hand-spun yarn
- Carpet yarn

Hand-spun yarn was woven using plain weave and tassels. The plain-woven fabric was threaded through the warp in full lengths, when the length reached the end of the sample, or ran out another yarn was added to create a continuous length and

even surface structure. Once softly washed the sample felted and became a fine soft viable fabric, a strong contrast to the original yarn. The tasselled structure was created by individually threading the hand-spun yarn through the warp. The length of the tassel would depend on the length of the yarn. When washed the tassels remained structurally sound and added an element of texture and form to the plain-woven structure. This tasselled effect was developed through design, colour, contrast, texture and scale, providing fabrics with fine and heavier tassels. The hard waste was developed to a yarn (hand-spinning) and transformed into fabric through design and textile process.



Figure 60. *Initial felt resist samples on pre-felt.* Author's own (2012)

Felt resist printing was explored with the potential for further design and textile knowledge to add value to waste fibre. With a background in textile design I was aware of the performance properties of wool and its natural fibre characteristics. Having already

explored felting as a process I looked for alternative ways to extend the technique. Originally I used the resist printing method on pre-felt, felt loom samples. The resist print was successful but the fabric became weak through the process. This was because the felt was fine and was in a pre-felt form so structurally was not sound. After it was felted it became much denser during the process. Because the resist paste was applied in the centre of the sample when felted the middle did not shrink and the exterior shrank dramatically causing the sample to morph from 2D to 3D. Each sample resulted in a slightly different form. Aesthetically this gave a great effect but structurally it was not viable.

I then explored printing the resist on weaves that were produced using hard waste and end of line cones of wool. This created a very different aesthetic because of the strength of the weave structure. The resist print was screen-printed on the weave. Where the design is printed no felting occurs, with no change to the fibre, where there is no resist the weave felts, becomes denser, softer and fluffier through the natural characteristics of the fibre.

Therefore prints can be applied to the weave without the addition of other pastes that would cause problems for reuse. Dyeing the resist paste was also explored with little success as the dye bled and the pattern distorted, this was not visible without the dye. The un-dyed resist was more successful. This was used to produce simple geometric prints on larger sample pieces. The sample pieces show how the natural performance characteristics and felting process can enhance the resulting fabric through design.



Figure 61a. *Felt resist dyed sample*. Author's own (2012)

Figure 61b. *Felt resist sample*. Author's own (2012)

Figure 62. *Felt resist geometric sample*. Author's own (2012)



Figure 63, Carpet yarn samples- top two show stretch.
Author's own (2012)



Figure 64. *Hard waste yarn, woven using a twill pattern on a straight draft table loom. Author's own (2012)*



Figure 65. *Hard waste yarn, woven using a twill pattern on a point draft table loom. Author's own (2012)*

Hard waste yarn is end of line cones and yarn faults from industry. These were woven in a plain and patterned weaves using a straight thread and point thread warp. The same pattern can create different designs depending on the warp. Exploration of this led to both successful and unsuccessful results. The most successful patterns were developed further and woven into samples. The finer yarns were woven in a plain and patterned structure. Once removed from the loom and washed they were much more flat in surface and much softer. The resulting fabrics were ranged in weight and colour that were suitable for light furnishing fabrics for the interior. Process then enhanced the fibres natural properties and added value to the fibre through design.

The carpet yarn sourced was made from coarse wool, received on large cones of varying colours from Summit Wool Spinners and Woolyarns. The weft is woven using fine cream wool and a cream carpet yarn. The carpet yarn was woven in a variety of patterns and in a rib structure, both had surprising results. Stretch could be created through the pattern used. This was very unexpected, once taken off the loom the sample collapsed on itself and became three-dimensional but still structurally sound. This was surprising as both the wool warp and carpet yarn had no stretch originally.

To create the rib structure the carpet yarn is wound into a 40cm length loop of yarn from between 10 to 64 lengths. The yarns are threaded by hand using a plain weave alternating between shafts 1,3,5,7 and 2,4,6,8 with the edges left hanging either side of the weave. These loops were cut once the weave was removed from the loom before washing to create a tasselled edge. The yarns are threaded and beaten during the weaving process. This compressed the yarns creating a rib. The size of the rib varied depending on the amount of yarn inserted. After each rib-row was inserted a small



Figure 66. Close up of carpet yarn ribbed sample in progress on the table loom.

Author's own (2012)

Next Page: Figure 67. Carpet yarn ribbed sample in progress on the table loom.

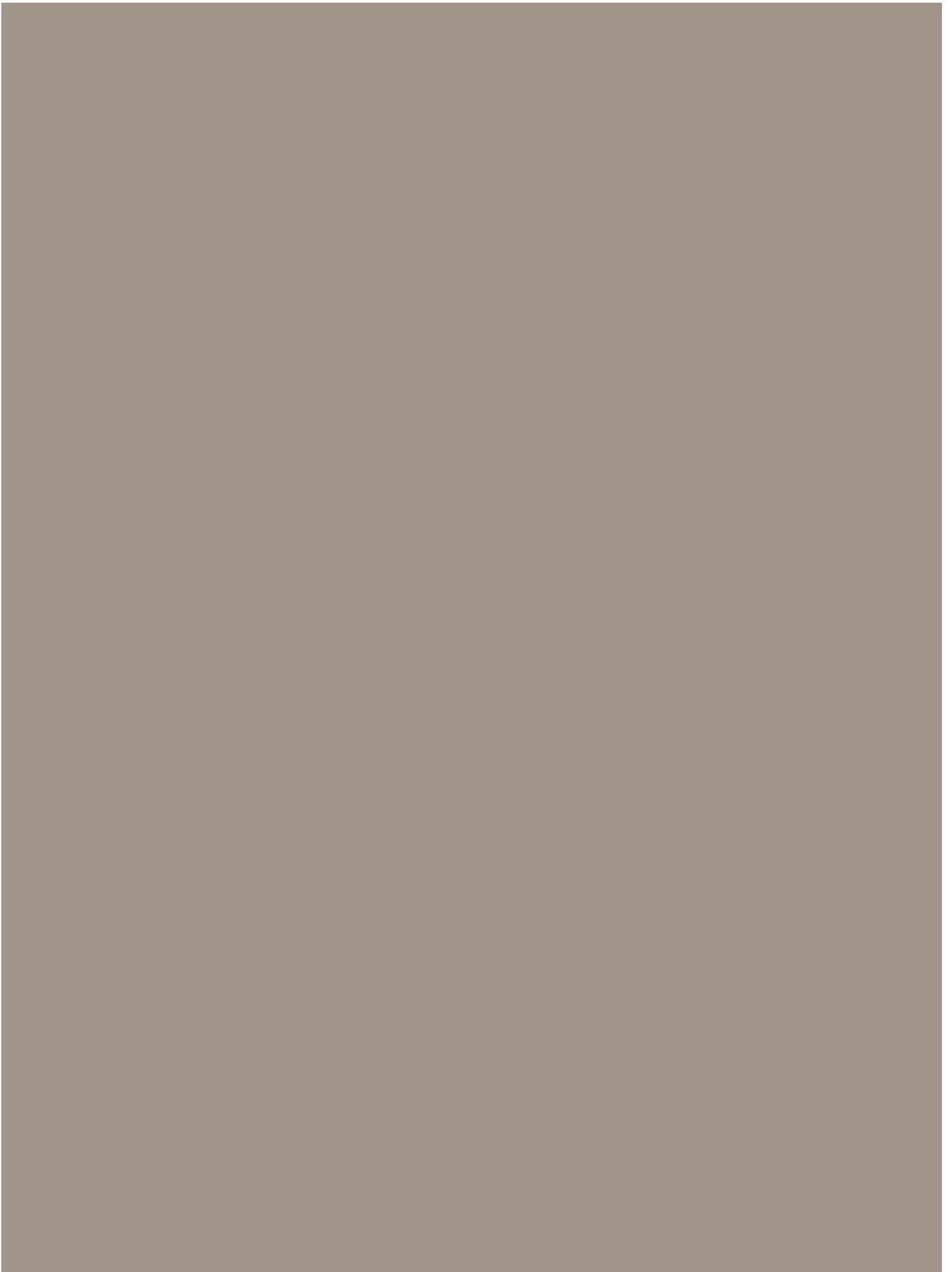
Author's own (2012)

amount of fine plain wool was woven to hold the rib in place and provide a stronger structure. Once removed from the loom the different sized rib affected the handle and strength of the weave structure. The finer the rib the more stretch the weave had, the larger the rib the stronger the structure. If the rib- weft yarns were over 64 lengths the structure moved too much between the fine wool, especially once washed. Washing the weave allowed for the weft yarns to move and the finer wool to lightly felt this made the finer wool-weave stronger but separated the distance between the rib and fine weave making the structure weaker overall. This meant a smaller rib structure and larger fine weave was needed to make the weave stronger. The desired rib size would depend on the application. The rib structure created a fabric with high stretch properties, a surprising characteristic for a material that has no stretch. The end use application was considered as a result of these characteristics. A throw was woven for interior

surface application (chair covering). The areas of higher use are woven in a stronger rib so more resistance is tolerated through less stretch.

During a visit to Woolyarns I showed the ribbed samples to Woolyarns CEO, Neil Mackie who expressed, *"I haven't ever seen a fabric like this produced from carpet yarn, its creative, innovative, you could be on to something here, we are always looking for new ways to use our carpet yarn, this is marketable"* (N. Mackie, personal communication, November 8, 12).





11

FELTED YARN

Felted yarn was received from Radford Yarn Technologies who produce felted yarns for niche felted rugs and carpets. Because of the integrity of the felting process the yarn has a superior technical strength and exceptional durability.

The yarn received consists of different weights, colours: a single colour or core colour with a contrasting exterior. The yarn was in

short lengths and small cones. After analysing the fibre and its properties I decided to explore macramé, a traditional decorative knotting technique used to create textiles. This process was explored to form a larger surface using short lengths of fibre.

Through a material responsive design-led process the yarn and macramé knotting techniques were explored for strength, structure, aesthetic and stretch. The most successful knots were the Larks head knot and Larks head Sennit knot.

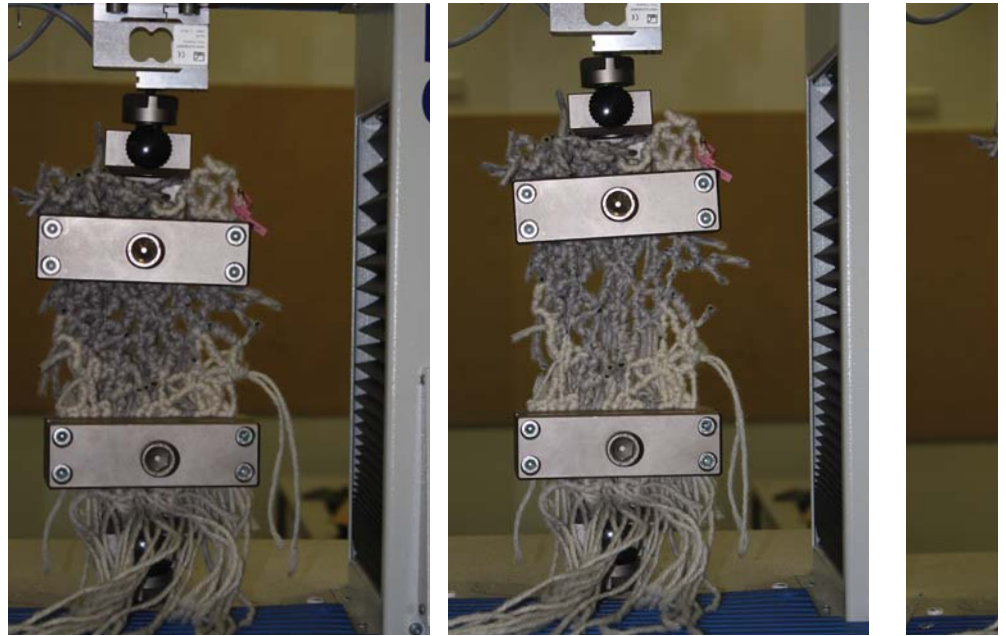
These knots were explored on a wooden square frame which allowed me to understand how the knots performed and how it reacted over a surface, due to the strength of the yarn and knot, the fabric sat horizontally without being attached to each side. Because each yarn is of the same diameter but different lengths this determined how long each piece could be knotted. This created an irregular pattern that was guided by the yarn. I then considered how each yarn was joined. The joining and strength of the

knots would determine if it was a viable fabric and potential product. The test samples were joined differently using the same knots with excess yarn left hanging at the back of the sample. Mixed yarns were also incorporated to analyse whether this made a difference to the structure.



Figure 68. *Rural Delivery*. (2012, October 20). Radford Yarn Technologies limited. Felted yarns Retrieved from <http://tvnz.co.nz/rural-delivery/s8-ep33-video-5143031>

Figure 69. *Rural Delivery*. (2012, October 20). Radford Yarn Technologies limited. Felted yarns Retrieved from <http://tvnz.co.nz/rural-delivery/s8-ep33-video-5143031>



**STRENGTH TESTS WERE CARRIED
OUT USING A MESDANLAB STRENGTH
TESTER- ACCORDING TO THE
STANDARD ASTM D5034.**

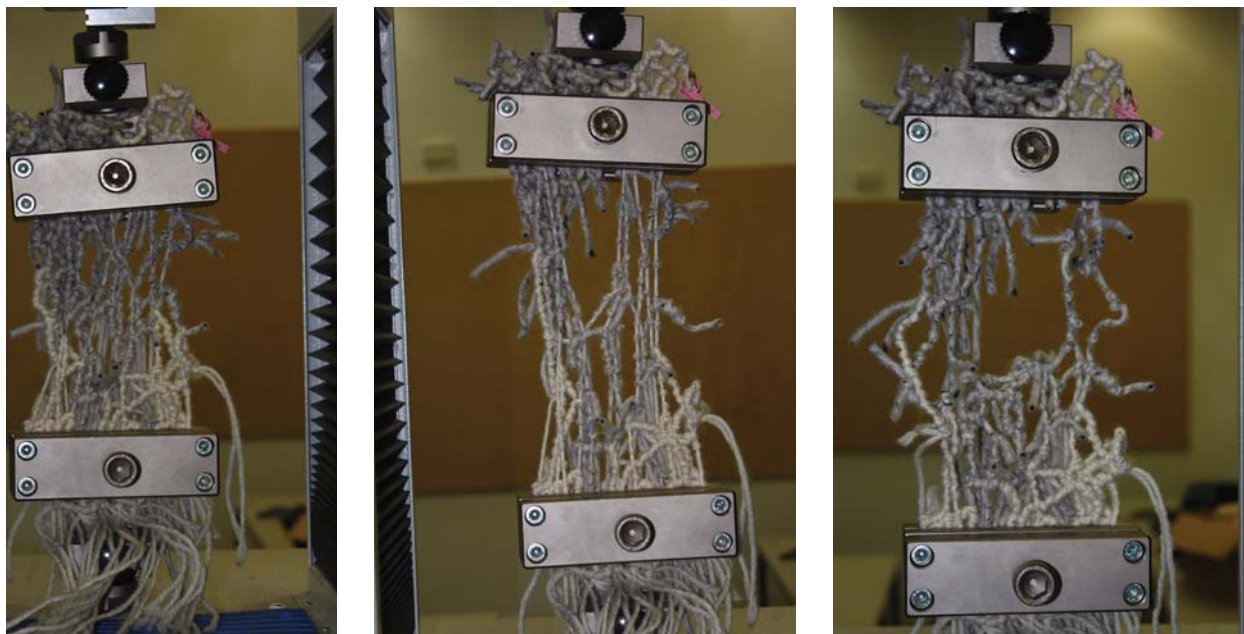


Figure 70-74. *MesdanLab Strength Tester tests.*
Author's own (2012)

Next Page:

Figure 75. *MesdanLab Strength Tester results.*
Author's own (2012)

Figure 76. *MesdanLab Strength Tester results.*
Author's own (2012)

Strength tests were carried out using a MesdanLab Strength Tester- according to the standard ASTM D5034. The strength tester stretches the fabric vertically until it breaks, then provides statistical results of the test. From examining the results I was able to find the strongest sample in relation to maximum force, elongation and the average time of breakage. Results showed that Sample 28 was the most successful, with maximum elongation of the warp recorded at 338.80% and the weft and 20.40%, the maximum force tolerated was 452.5 [N] and took 50.8 seconds do break.

Sample 28 was knotted in a continuous length, each yarn would cross another so that multiple yarns could be knotted from a singular point with excess yarn remaining attached and left hanging to the back of the sample. This meant the load was dispersed across a wider surface instead of a single point. This was successful. From these results I then applied this knowledge to an end-use application.

STATISTICAL STRENGTH TESTING RESULTS

Test di Trazione Tessuti with MesdanLab Strength Tester According to the standard ASTM D5034

Customer Code	TEST2	Test Code	123	Date	10/11/2012 Time 3:05:28 PM
Sample Description	28	Lot		Samples Number	2
Parcel					
Material					
Examiner					
Sample Length	75 [mm]	Load cell ID/FS [kg]		4 / 100	
Clamp Speed	300 [mm/min]	Pretension		0 [N]	
Test Machine					

Observations Method: G - Asciutto /

Statistical Results of the Test

Weft

Average Time of Breakage 26.9 [s]

	Force [N]	Elongation [%]
Maximum	452.5 (1)	338.800 (1)
Minimum	0.0 (2)	20.400 (2)
Average	226.2	179.600
Range	200.000 [%]	177.283 [%]
CV	141.421 [%]	125.358 [%]
Deviation	320.0	225.143
IC95%	443.4	312.026
IC99%	582.8	410.073

Results of Single Samples

Sample #	Max Force [N]	Max Elongation [%]	Time [s]
1 Weft	452.5	338.80	50.8
2 Weft	0.0	20.40	3.1

**Test di Trazione Tessuti with MesdanLab Strength Tester
According to the standard ASTM D5034**

Customer Code **TEST2** Test Code **123** Date **10/11/2012** Time **3:05:28 PM**

Sample Description **28** Samples Number **2**
Parcel **Lot**
Material
Examiner
Sample Length **75 [mm]** Load cell ID/FS [kg] **4 / 100**
Clamp Speed **300 [mm/min]** Pretension **0 [N]**
Test Machine

Observations *Method: G - Asciutto /*

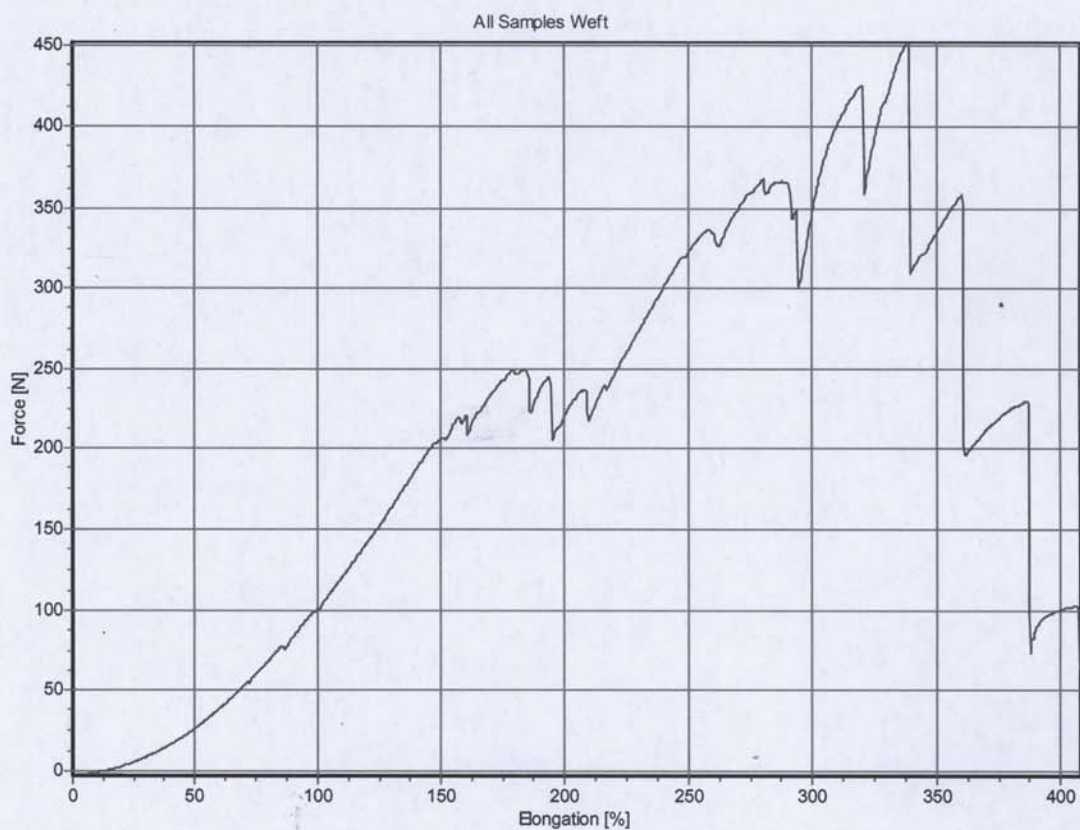




Figure 77. *Sampling on the wooden frame*
(Front). Author's own (2012)

A wooden chair frame was built from reclaimed timber on the concept of upcycling. The timber is native, Rimu found in a recycled furniture store. With existing nail holes and chips the wood shows stories of its past, the wood was sanded and varnished but still retains these marks. The chair shape was produced on the foundations of the original sample frame I was working to. On the square frame the yarns moved along the frame, to prevent this holes were drilled and sanded to prevent excess wear on the yarn and keep the yarns at an even distance. This would also help disperse weight across the fabric. I then created the fabric by directly knotting to the frame. Yarn was threaded through each hole to the middle of the frame, using the larks head knot as a mounting knot and I continued this, extending the surface to the middle of the frame. Another yarn was then stitched vertically around the frame in a running stitch creating a cross structure that covered the holes and was purely aesthetical.

The resulting fabric is taut and comfortable to sit in. Combining the knowledge of wool properties and design process to produce a viable method of reuse for reclaimed felted industry yarn.

A contemporary designer exploring the concept of upcycling and reuse is Natalie Chanin. Chanin's products are made by hand, using traditional craft construction techniques, "*many hours of work are devoted to each fabric, resulting in a level of craftsmanship*". The textiles produced explore the notion of craft to add value to salvaged materials. Chanin's reclaimed discarded ladder-back chairs are revived, value added through upcycling and extending use. The woven fabric is mounted to wooden chair frames using reclaimed silk neckties and shredded cotton (Quinn, 2009).



Figure 78. *Sampling on the wooden frame (Close up of front).* Author's own (2012)

Figure 79. *Sampling on the wooden frame (Back).* Author's own (2012)

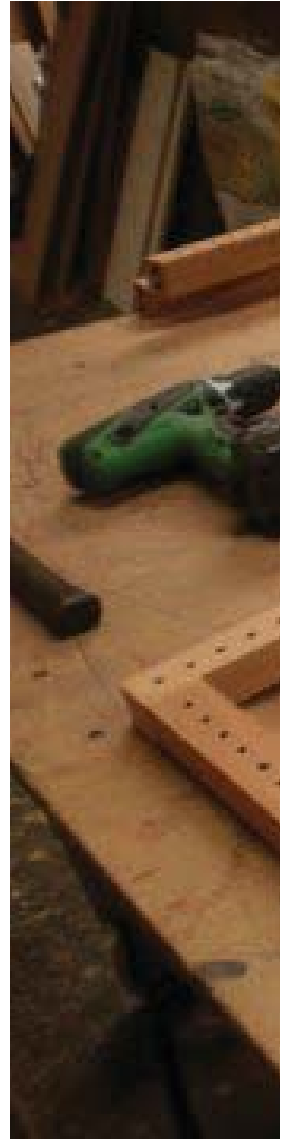


Figure 80. Reclaimed timber. Author's own (2012)

Figure 81. Chair construction from reclaimed timber. Author's own (2012)

Figure 82. Chair construction. Author's own (2012)



Figure 83. *Chair construction.* Author's own (2012)
Figure 84. *Chair construction.* Author's own (2012)



**A WOODEN CHAIR
FRAME WAS BUILT FROM
RECLAIMED TIMBER
ON THE CONCEPT OF
UPCYCLING.**

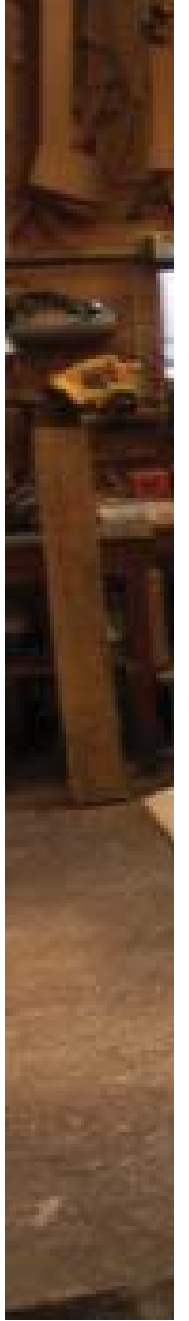




Figure 85. *Final chair frame.* Author's own (2012)



Figure 86. Close up of the mounting knots wrapped around the chair frame, showing a chip in the reclaimed timber. Author's own (2012)



YARN WAS THREADED THROUGH EACH HOLE TO THE MIDDLE OF THE FRAME, USING THE LARKS HEAD KNOT AS A MOUNTING KNOT, I CONTINUED THIS, EXTENDING THE SURFACE TO THE MIDDLE OF THE FRAME.



Figure 87. Close up of the mounting knots.
Author's own (2012)





Previous page: Figure 88. *Close up of the knotted fabric.* Author's own (2012)

Figure 89. *The knotted fabric being produced.* Author's own (2012)





Previous Page: Figure 90. Christie, R. (2012) *Threading yarn through holes in the frame for the base of the chair.* Mount Cook, Wellington.
Figure 91-92. Christie, R. (2012). *Close up of knots, creating the base fabric.* Mount Cook, Wellington

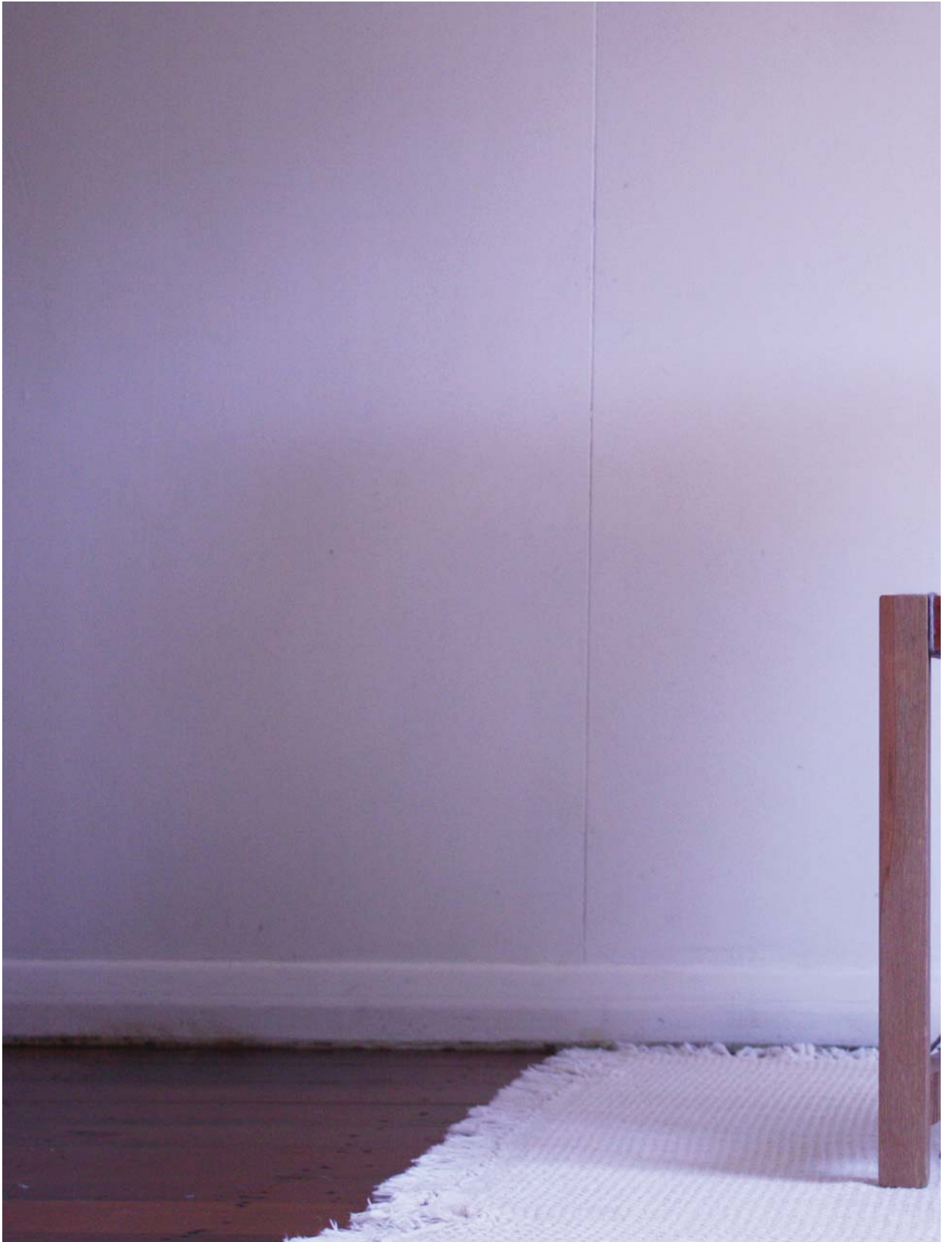


Figure 93. Christie, R. (2012). *Creating the base fabric*. Mount Cook, Wellington.

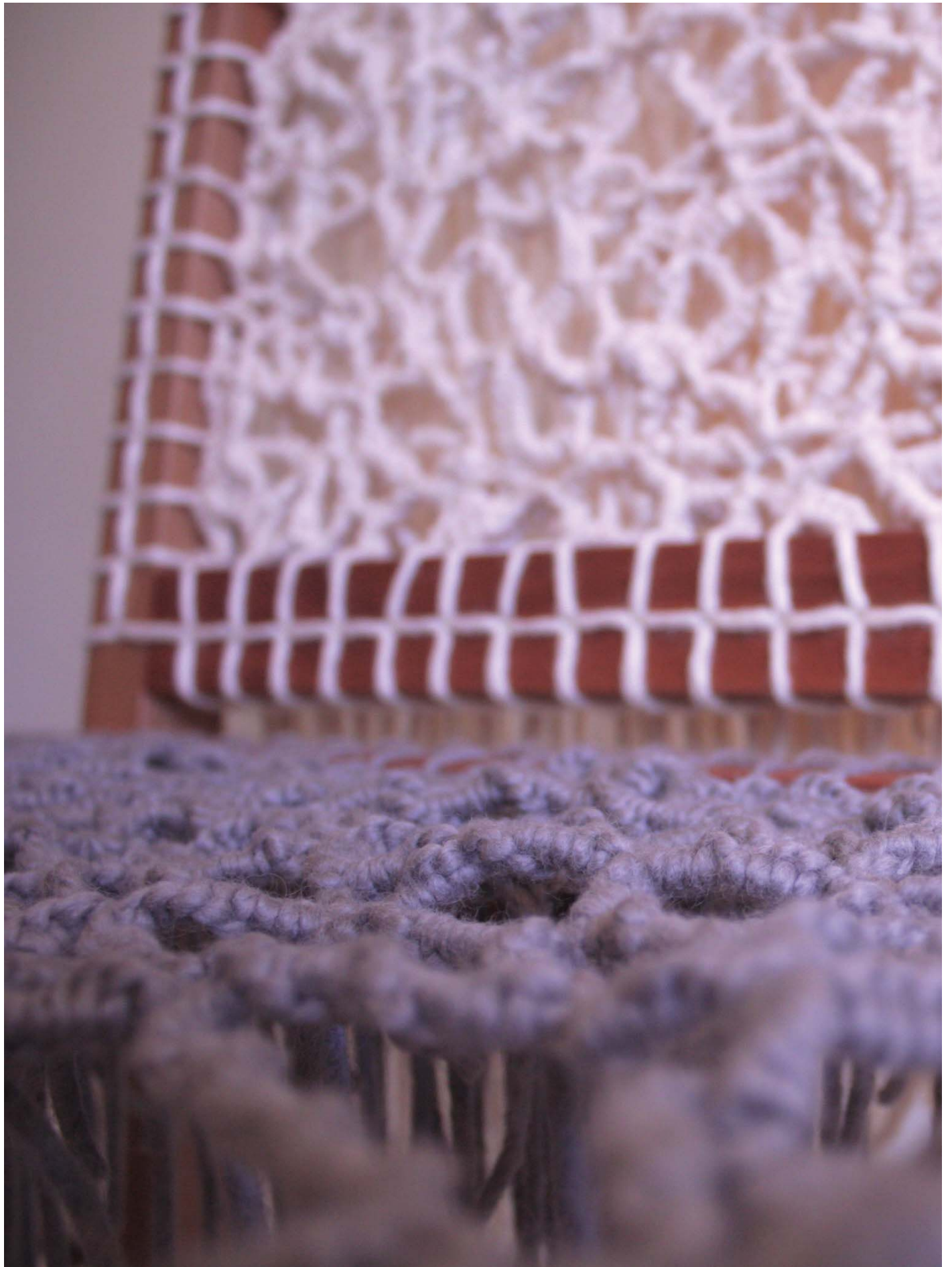


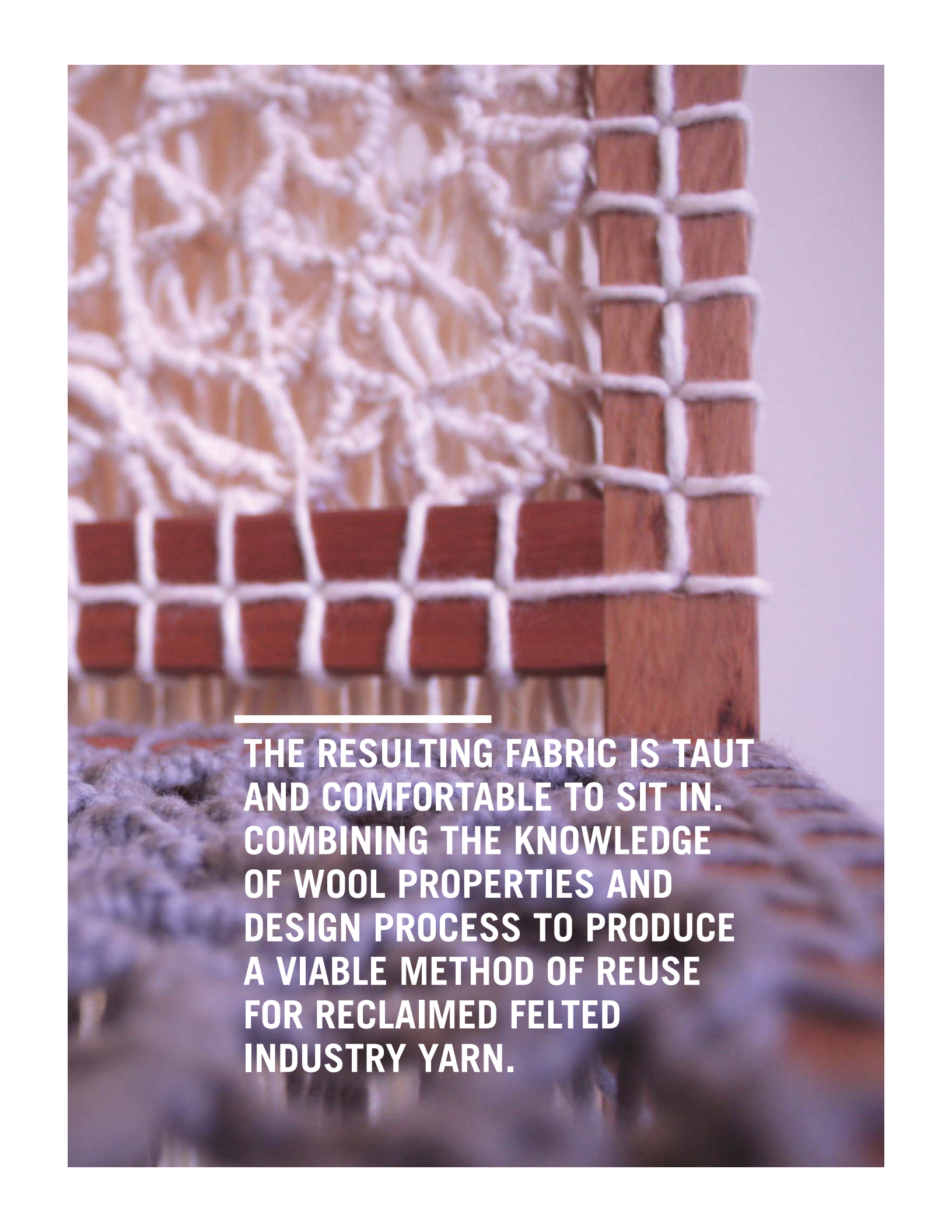


Figure 94. Christie, R. (2012). *An underneath perspective of the chair*. Mount Cook, Wellington



Figure 95. Christie, R. (2012). *The back of the knotted fabric*. Mount Cook, Wellington





**THE RESULTING FABRIC IS TAUT
AND COMFORTABLE TO SIT IN.
COMBINING THE KNOWLEDGE
OF WOOL PROPERTIES AND
DESIGN PROCESS TO PRODUCE
A VIABLE METHOD OF REUSE
FOR RECLAIMED FELTED
INDUSTRY YARN.**

Previous page: Figure 96. Christie, R. (2012).
Final chair. Mount Cook, Wellington

C

CONCLUSION

This body of work follows the experimentation and development of textile design processes to propose alternative fabric applications for reclaimed industry fibre. As I embarked on this project I began by asking: how could value be added to reclaimed industry wool fibre through the application of textile knowledge, traditional craftsmanship, recent technology and design?

The lack of exploration into this field and a personal realization of the potential this fibre possessed became the instigator for this research. New Zealand wool has lost the importance it once had. It was imperative to my process to explore new innovative applications for wool. New Zealand wool is a valuable natural resource that holds unlimited potential and rivals many other fibres both natural and synthetic. It was imperative to my process that the exceptional properties and characteristics of wool were honoured and incorporated into the textiles produced. With properties and characteristics including: natural fire resistance, inbuilt UV protection, good shape recovery, thermal insulation properties, combined water repellency and moisture absorption, ranges in grades; soft – coarse blends, holds up to 30% humidity without feeling damp, durable, renewable, recyclable and biodegradable and has a natural comfort. It was important to highlight these qualities and ensure the fibre remained the same or value was added that was through process.

During the early stages of this project the aim became to upcycle rather than recycle textiles. Upcycling was used in an attempt to create an economic argument for a practice that could benefit the environment and provide potential innovative applications for reclaimed industry fibre. This offers the opportunity for local economic benefit through alternative niche markets.

To examine and explore this question a material responsive, iterative design-led process was adopted. This guided my research through a process of analysis, experimentation, response, discovery, design, adaptation, continued evaluation and development.

As I analysed my process, fabric samples and final design applications it became clear that through design and process extended use and sustained value could be added to reclaimed fibre through design.

The different fibres and yarns resulted in different viable end use applications. Through process I have been able to successfully transform and forge new directions for waste- reclaimed fibre with added performance and value through the convergence between craft and technology.

The use of reclaimed fibre was at times difficult to my process. I had to take into consideration inconsistencies in colour, grade, type and blend. Each time I sourced new fibre it was different to the last. This forced me to keep an open-mind throughout the design process, an ever-changing outcome forged by the fibre received. The inconsistencies in material proved to be both exciting and at times a frustrating challenge. If this process was carried out on a large scale this could be controlled. In connection with the manufacturer, and on-site production knowledge could identify when specific yarns were produced and the collection of fibre could be in response to this. This would ensure a more accurate control of the type of yarn that would be sourced. Although for the process of this research it was important to explore multiple types of yarn and fibre to identify ways that the different fibre types could be reused and value added through design.

My process has identified specific traditional and digital construction and finishing processes suited certain fibres, fibre types. Through an understanding of process, knowledge and design I have intervened in the conventional approach to produce textiles from reclaimed fibre where the quality of the original fibre remains the same or is improved by the process. This process counters the common problem of recycling practices where the quality of a material is reduced through reuse; instead the material retains its inherent quality and recyclability for another lifetime. As remnants of past textiles the fabrics produced are influenced and determined by time, season and trends.

This process has opened up many other possibilities. With a strong understanding of the technology and successful methods and processes the potential for further design exploration and experimentation through colour, scale, pattern, contrast and application is possible. The potential and possibilities for reclaimed fibre is vast. This research offers new directions for reclaimed fibre honouring sustainable principles through textile design process.



Figure 97. *Final chair*. Author's own (2012)



Figure 98. *Final Masters Exhibition*. Author's own (2012)



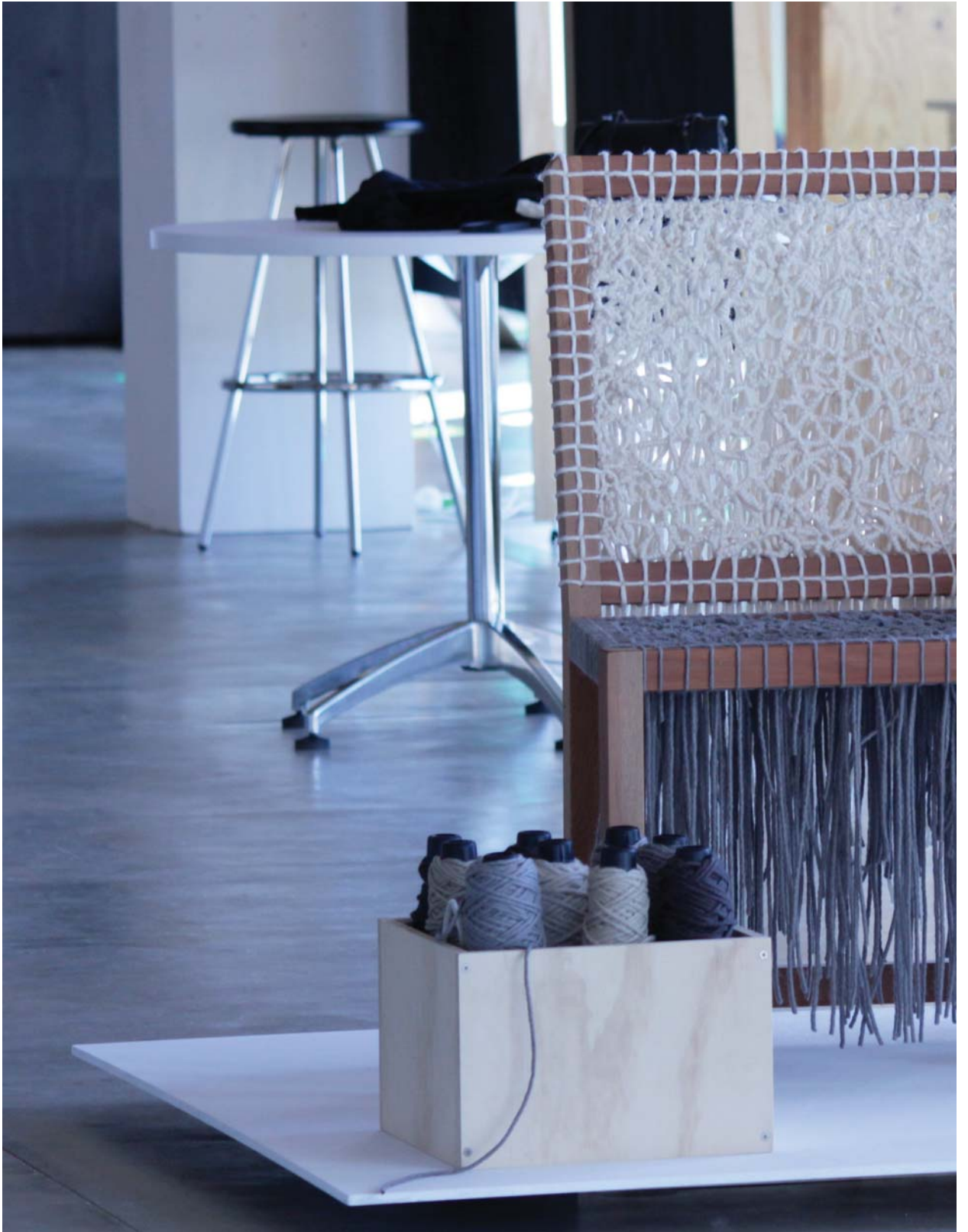


Figure 99. *Final chair at Masters Exhibition.*
Author's own (2012)



**THIS GLOSSARY IS A
PERSONAL PERSPECTIVE OF
THE MEANING OF WORDS,
PHRASES AND TERMS USED IN
RELATION TO THIS EXEGESIS.**

G

GLOSSARY

Adaptation- is to change something in a way that is beneficial to the survival or continuation of something.

Adhocism- is a method of creation that relies particularly on resources that are easily accessible and already at hand.

Bast fibre- plant fibres.

Bespoke- an item made to a buyer/customer's specification (personalised or tailored).

Biodegradable- means to be consumed by microorganisms and return to compounds found in nature (compostable).

Biological nutrient cycle- is a process whereby materials work cyclically to become nutrients for the environment.

Bi-products- are products, materials created as a result of the manufacturing and/or processing of something else.

Consume- means to 'completely destroy' or 'use up'.

Consumer- is somebody or something that uses and/or consumes a product or service.

Consumption- is the act of using something up.

Cradle to cradle- is a term used to describe a product's lifecycle that flows in a continuous cycle, designed to provide appropriate biological nutrients that will return to the organic cycle.

Cradle to grave- is a term used to describe a product's lifecycle from the material's raw state (cradle) to its disposal (grave).

Cyclical loops- is a method or process that work in a continuous motion.

Design for disassembly (DFD)- means products that are designed to be taken apart at the end of their lifecycle.

Design for recycling (DFR)- means products that are designed to be reused- often-producing low-quality textiles.

Design for sustainability- products that are designed to consider and pose little – no threat to the environment.

Design for the environment- products that are designed and managed so that minimum environmental impact is caused during cultivation, manufacture, production, post-production, consumption and disposal.

Digitize- is to turn a pattern/ motif into stitches using computer software so the embroidery machine can stitch the design.

Disposal- means the process of getting rid of something or transference of something to somewhere or somebody else.

Downcycling- is a process whereby materials are forced into extended uses they were never designed for, often resulting in the degrading of fibres and the creation of lower quality end-use products.

Eco-conscious- is being aware of the impact of our actions and consumption patterns on the environment.

Eco-efficient- means using sustainable renewable materials to their full potential whilst considering the implications of their use.

Eco-friendly- means being earth-friendly or not implementing harm to the environment. This term commonly refers to products that contribute to, or help to conserve resources like water, energy, air and pollution.

Eco-sustainable- means considering natural resources in design and manufacture and the influence they have on the environment.

Ethical design- is design that deals with ethical and moral principles or the principles of morality; pertaining to right and wrong in conduct.

Ethically sustainable- means having moral considerations to the human, environment, resources and materials used.

Fabric- is formed by assembling yarns and/or fibres into a cohesive structure. Most common structures are woven, knitted, and nonwoven.

Felt- is fabric created directly from wool fibres. The wool fibres are pressed into a flat sheet then subjected to moisture, heat, and agitation. The scaly structure of the wool fibre causes the fibres to interlock and mat.

Fibres- are fine hair-like substances that maybe natural or manufactured they are the smallest component of a textile product.

Flammable- means easy to ignite and will continue to burn.

Fleece wool- is fleece sheared from a sheep, also called sheared wool.

Fulling- is a term used to describe part of the felting process, it is the 'fluffing up' of fibres already woven or knitted piece of cloth.

Hard waste- is fibre after being spun or felted into yarn.

Heddles- is a set of parallel cords in a loom used to separate and guide the warp threads and make a path for the shuttle.

Hybrid- is a product made-up of multiple technical and biological resources, these products are often very difficult to reuse or recycle.

Industrial textiles- are woven, knitted, or nonwoven fabrics purchased for strength, stability, and chemical resistance; used for items like filters, roofs, insulation, and storage tanks. Made using mechanized equipment.

Landfill- is an area used for the controlled disposal of solid waste.

Lanolin- is oil recovered from wool during processing, a valuable natural bi-product of wool that is used in soaps, cosmetics, and creams.

Loom- is a machine that produces fabric by interlacing vertical (warp) and horizontal (weft/ filling) yarns.

Macramé- is a hand-knotting technique; often used to create wall hangings.

Manufacture- means to produce something industrially, mechanically.

Mass-manufactured- means to produce something industrially, mechanically on a large scale.

Materials- is something used in making something.

Natural- means produced by nature, something that is taken from the earth in its raw state.

Natural fibre- is fibre from vegetable, animal, and mineral sources.

Natural materials- are raw materials made from the environment.

Needle-punch felt- is a nonwoven fabric created using the needle-punch technique. Also called mechanical felt.

Nonwoven- is any textile that is not woven e.g feling

Photoshop- (Adobe Photoshop) is a photo/graphics-editing program.

Plain weave- is the simplest form of weaving. Made by passing a filling yarn over one warp yarn and under one warp yarn at a time across the width of the fabric. The next filling yarn is inserted so the warp yarns that were under are now on top. Plain weave is also called 'tabby weave'.

Post- production- is the process a product endures after production and manufacture.

Production- the making of something the manufacture and/ or production of goods or products.

Product lifecycle- is the process a product endures from beginning to end.

Raw materials- are materials created without human or technical interference, made from the earth and natural environment that are natural and pure.

Raw wool/Greasy wool- is wool sheared or pulled, before it is cleaned; it contains natural oils, dirt, and other impurities.

Reclaimed- means to get something back.

Reclaimed industry fibre- means the claiming of something back, extracting useful substances for an extended use and purpose, to divert substances from landfill or the creation of down-cycled products.

Recyclable- means the ability of something to be recycled and/or used for something else after its intended use.

Recycle/ recycling- is a process that products and materials endure to enable an extended use.

Recycled wool- Wool yarns and fabrics that have been shredded into a fibrous state and reused in products.

Reduce- means decreases the impact of something.

Renewable- is something that is not likely to run out and is able to be renewed.

Re-think- means to reconsider something.

Reuse- means to use something again.

Ruched- is a sewing technique in which fabric is gathered to form ruffles or pleats.

Scouring- is a process applied to wool, similar to boiling off.

Selvages- are the edges of woven fabric that run parallel to the warp yarns.

Soft waste- is any fibre pre spinning.

Sustainability- means something that can be maintained without effecting the environment with the ability to be used in the future.

Sustainable alternatives- means something that is more environmentally responsible.

Sustainable development/concepts- means something that is capable of being sustained with minimal effects on the environment. Sustainable development is an approach created to meet our present needs without compromising the needs of future.

Sustainable initiatives- work toward decreasing and /or eliminating waste.

Technical nutrient cycle- means nutrients that are taken from products after their lifecycle that continually circulates within a closed-loop, industrial cycle used for the technical metabolism.

Textile- is fabric, cloth, materials used to create fabrics.

Thread- is yarn that is used to sew garment pieces or other products together.

Twill weave- is a weave pattern identified by diagonal lines on the surface of the fabric. In the simplest twill these lines, or waves, are created by inserting the filling yarn over two warp yarns and then under one warp yarn. The next filling yarn also passes over two warp yarns and under one, but the pattern starts one warp yarn farther in.

Upcycling- is a term used to describe the return to industrial systems of materials with improved, rather than degraded, quality.

Use phase- is the time in which a product is in circulation before being disposed of.

Viable- means something capable of working successfully.

Virgin materials/ fibre- are raw materials that have never been used.

Warp- is a set of yarns that run lengthwise on a piece of woven fabric and parallel to the selvage, also called ends.

Waste- means any material, solid, liquid or gas, that is unwanted and/or unvalued and discarded or discharged.

Waste fibre- is fibre that is generated and not used or needed after production and manufacturing.

Waste minimization- refers inclusively to all activities aimed at preventing reducing, re-using or recycling waste.

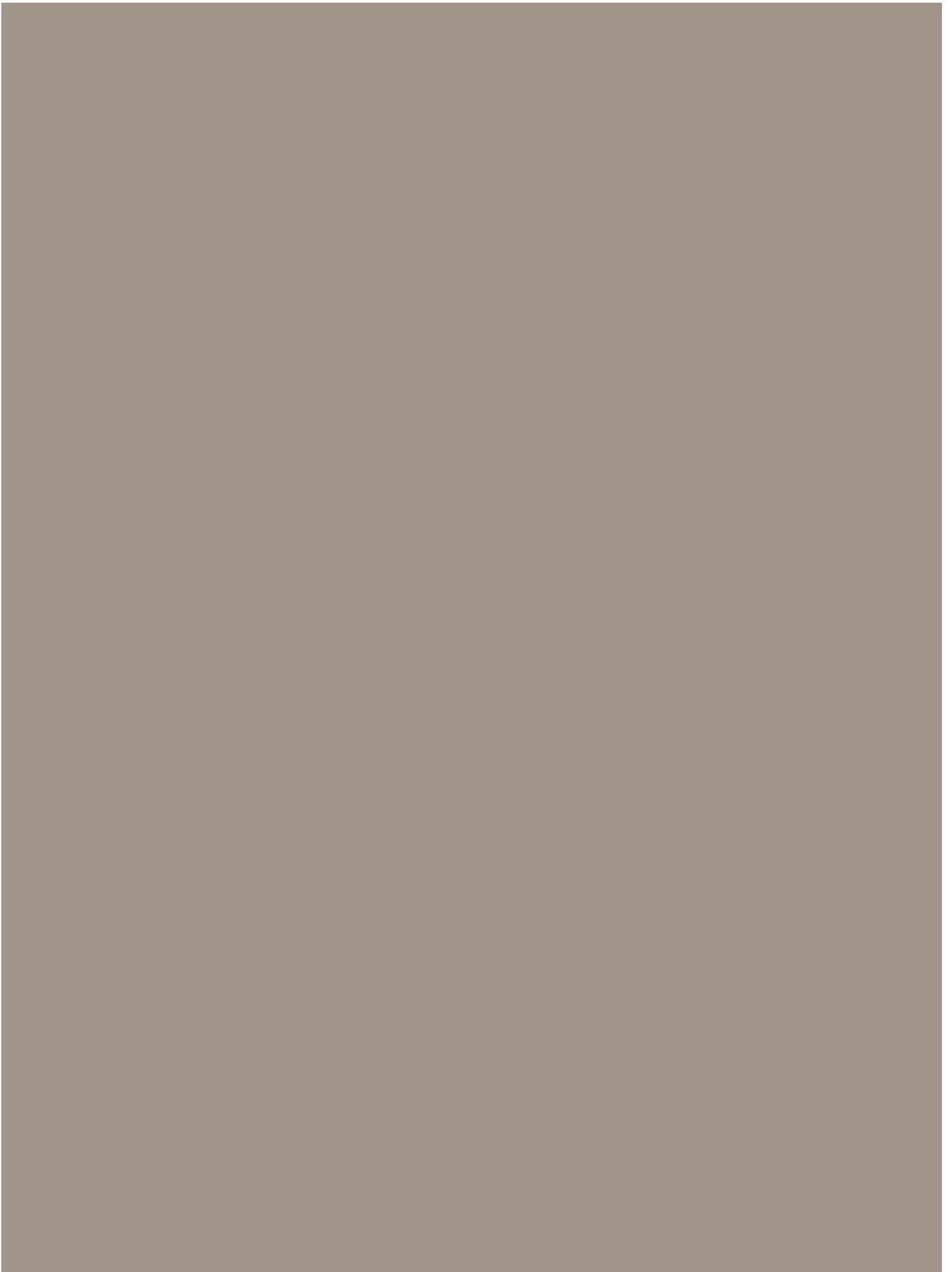
Weaving- is the process of producing fabric by interlacing warp and filling yarns.

Weft- is the yarn that run horizontally across the width of a piece of woven fabric and are perpendicular to the warp yarns. Also called filling yarns or picks.

Wool- is fibre from a lamb, sheep or alpaca and specialty fibres such as camel hair. Also called virgin wool or new wool.

Woollen yarns- is yarn produced from wool fibre, this ranges in weight and quality depending on the type of wool used.

Yarn- is a group of fibres that are combined to form a continuous strand that can be used to produce fabric.



R

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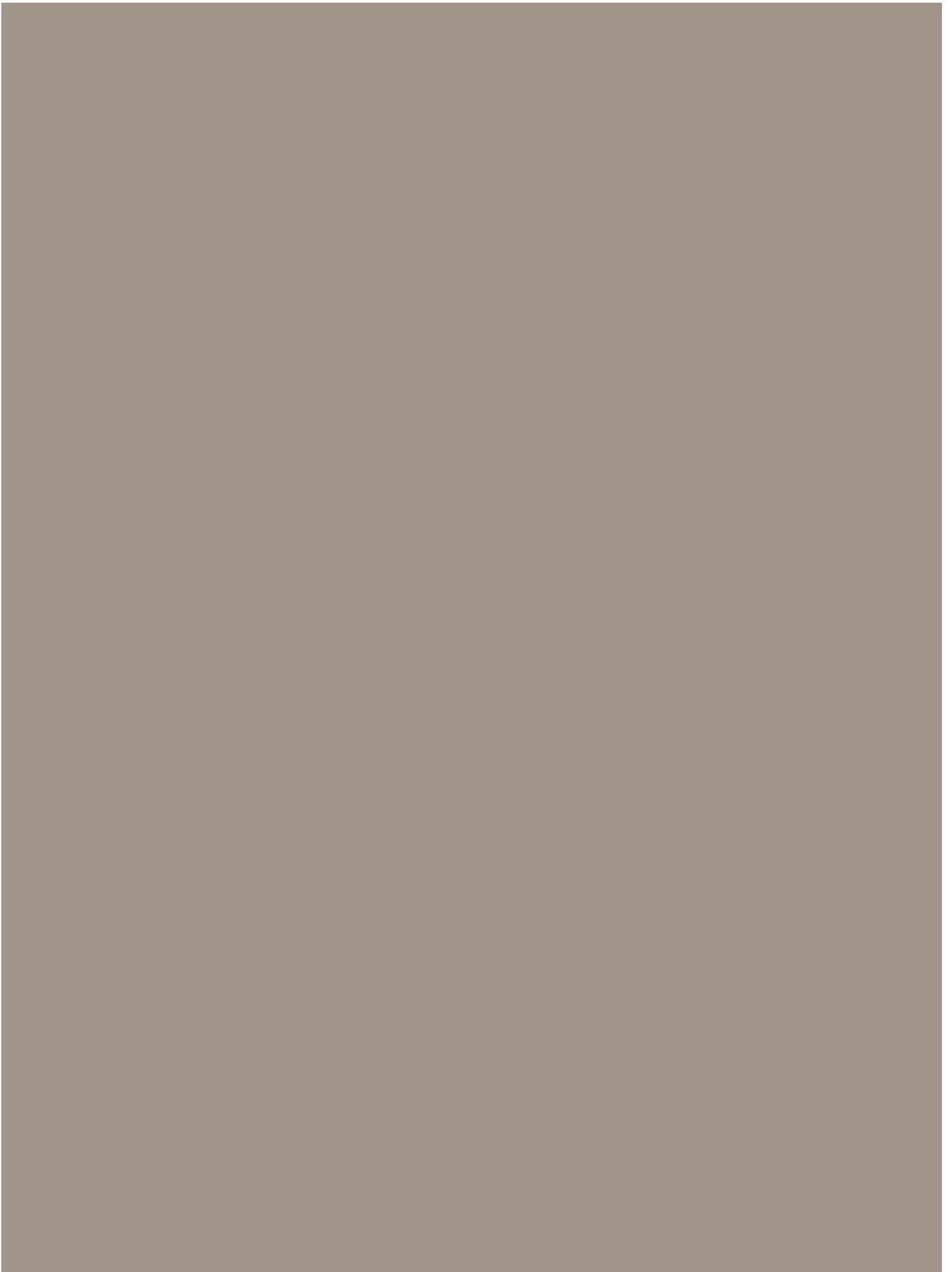




IMAGE CREDITS

Figure 3. *Boundaries 'limitless' for new eco-fabric.* (2012, December 6). The Dominion Post

Figure 5. *Woolyarns and Radford's manufacturing process, visual narrative.* Woolyarns, Author's own (2012), *Radfords, Rural Delivery.* (2012, October 20). *RadfordYarn Technologies limited.* Retrieved from <http://tvnz.co.nz/rural-delivery/s8-ep33-video-5143031>

Figure 34. Christie, R. (2012). *The final scarf length.* Mount Cook, Wellington.

Figure 44. Christie, R. (2012). *Hard waste yarn, sorted and ready to be spun.* Mount Cook, Wellington.

Figure 45-47. Christie, R. (2012). *Hard waste yarn, the spinning process.* Mount Cook, Wellington.

Figure 68. *Rural Delivery.* (2012, October 20). *RadfordYarn Technologies limited. Felted yarns* Retrieved from <http://tvnz.co.nz/rural-delivery/s8-ep33-video-5143031>

Figure 69. *Rural Delivery.* (2012, October 20). *RadfordYarn Technologies limited. Felted yarns* Retrieved from <http://tvnz.co.nz/rural-delivery/s8-ep33-video-5143031>

Figure 90. Christie, R. (2012). *Threading yarn through holes in the frame for the base of the chair.* Mount Cook, Wellington.

Figure 91. Christie, R. (2012). *Close up of knots, creating the base fabric.* Mount Cook, Wellington.

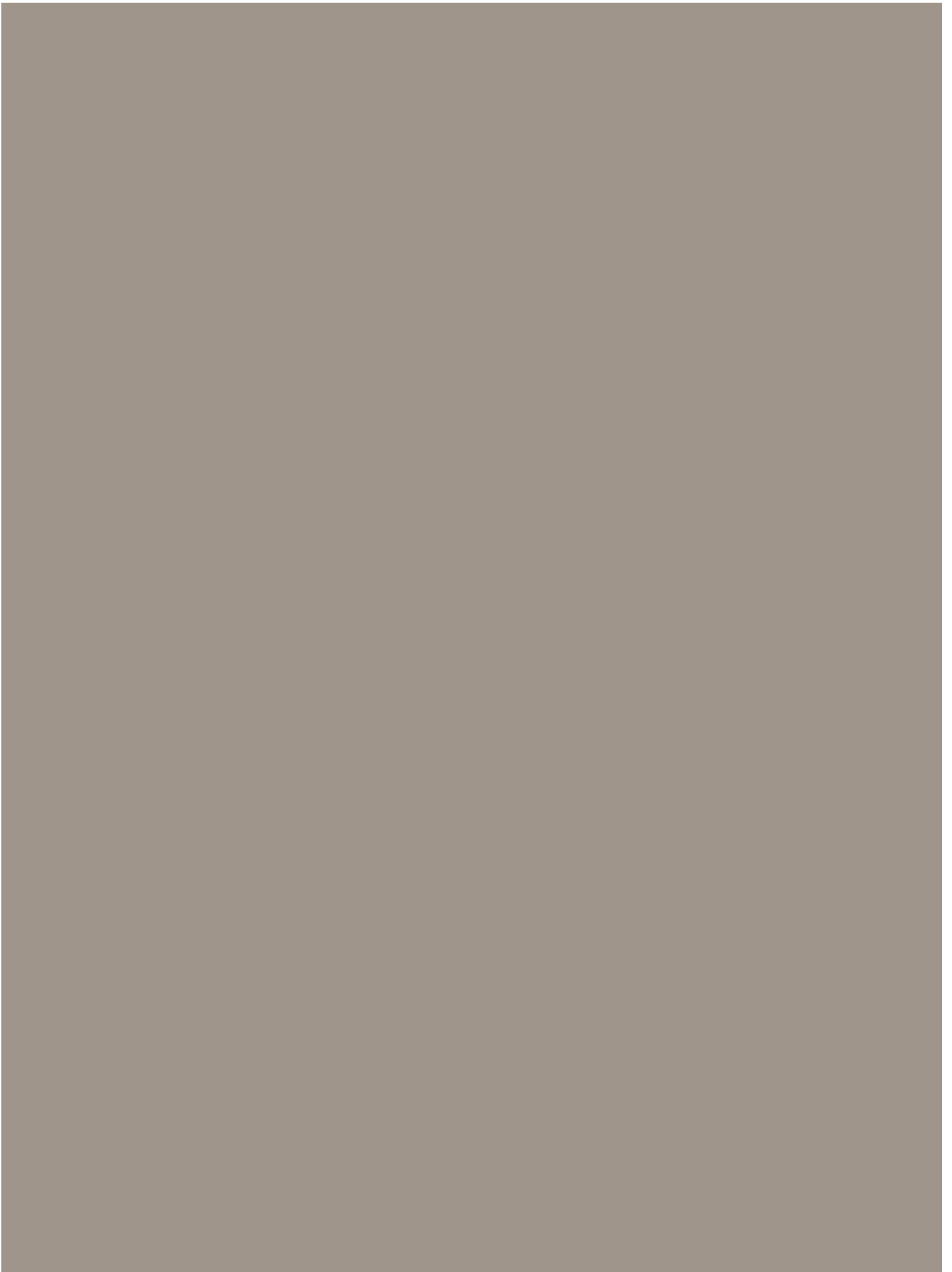
Figure 92. Christie, R. (2012). *Close up of knots, creating the base fabric.* Mount Cook, Wellington.

Figure 93. Christie, R. (2012). *Creating the base fabric.* Mount Cook, Wellington.

Figure 94. Christie, R. (2012). *An underneath perspective of the chair.* Mount Cook, Wellington.

Figure 95. Christie, R. (2012). *The back of the knotted fabric.* Mount Cook, Wellington.

Figure 96. Christie, R. (2012). *Final chair.* Mount Cook, Wellington



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APPENDIX

“This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University’s Human Ethics Committees. The researcher(s) named below are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the research(s), please contact Professor John O’Neil, Director (Research Ethics), telephone 06 350 5249, e-mail humanethics@massey.ac.nz”.

John O Neill (Professor)
**Chair, Human Ethics chairs’ Committee and
Director (Research Ethics)**

Mr Rodney Adank, Hol
Institute of Design for Industry and Environment
Wellington

Dr Sandy Heffernan
Institute of Design for Industry and Environment
Wellington

Dr Jessica Payne
Institute of Design for Industry and Environment
Wellington

