

ISSUE
02

02 Wool Notes

*A summary of wool textile information,
including notes and interesting wool facts.*

2020





These wool notes belong to:

.....

.....

.....

.....

If found, please return it to me and you will be handsomely rewarded in good karma and coffee.

Wool Notes 2020

- 1 Make a Difference – Choose Wool
- 2 Ancient Origins, Modern Luxury
- 3 It All Starts on the Farm
- 4 Wool Farm Economics
- 5 Caring for Wool Sheep
- 6 From Fleece to Fabric
- 7 Traceability – A Case Study
- 8 Chemicals in Wool Processing
- 9 Coming Around Again – Recycling Wool
- 10 Treading Lightly:
Wool's Environmental Footprint
- 11 Cradle to Cradle with Wool
- 12 The Ultimate Fibre –
Wool's Natural Benefits
- 13 Wool Directory
- 14 Glossary



01 Make a Difference – Choose Wool

Fun fact

A wool fibre can bend 20,000 times without breaking and has the power to recover – this is why wool products last for years.

The challenges we face today due to self-inflicted climate change and environmental pollution are manifold: rising sea levels, drought, microplastics, and scarcity of resources, to name but a few. It is no secret that how we produce and use textile products today has contributed to the devastating state of our planet.

At the same time the textile and fashion industry have a big responsibility in developing solutions for a sustainable future. Designers and retailers are committed to changing their sourcing and product strategies in order to reduce and even reverse environmental impacts.

In the global quest to quickly implement positive sustainable change, wool has a key role to play. From the sheep on the pastures all the way through the use and end of life, a well-designed wool product enables consumers to reduce their climate impact.

Wool is grown year-round, around the globe, on a blend of water, air, sunshine and grass.

Wool is made of **keratin**, the same protein substance as human hair. Like human hair, wool grows readily on sheep and is a **renewable resource**: the sheep are shorn usually once a year and then more wool starts to grow.

Wool will **biodegrade** when buried in soil, given the required levels of oxygen and moisture. Research indicates that wool fibre also **biodegrades in both fresh and salt water**, unlike synthetic fibres which disintegrate into micro-fragments and accumulate in landfill and our water.

On the other hand, thanks to the unique chemical structure of keratin and wool's tough, water-repellent outer membrane, clean and dry wool fibres do not readily degrade. This allows wool products to be **resilient and long-lasting** in normal conditions.¹

The eco-credentials of wool are enhanced by its **long service life** and suitability to be **recycled**.

Wool's smart structure has evolved along with sheep to produce an active fibre that naturally **wicks moisture, resists odour, and reacts to changes in the body's temperature** so that you stay comfortable in all temperatures.

Whether for fashion apparel, athletic wear, interiors or technical textiles, by choosing wool, you are choosing well in all senses of the word.

¹ With the right care, wool products can be used for decades or longer. But at the end of a product's serviceable life, under the right conditions wool biodegrades readily,

in as little as 3-4 months but the rate varies with soil, climate and wool characteristics



02 Ancient Origins, Modern Luxury

Humans have been washing, weaving, and wearing wool since 10,000 BCE.

There are more than 1,000 sheep breeds in the world. Merino or Rambouillet for example produce fine wools used mainly for apparel. Breeds like Romney or Scottish Blackface produce coarse wools used generally for interiors such as interior textiles, décor and carpets.

Merino sheep originated in Spain. In 1789 King Charles IV of Spain gave six Merino sheep as a gift to the Dutch government. These sheep found their way to South Africa, and then were sold to British army officer, politician, and entrepreneur John Macarthur, who took them to Australia.

Wool currently accounts for 1.1% of the world's global fibre market. As of 2018 around 1.1

billion sheep produced just over 2 million kilograms of raw wool for home and clothing textiles.

Today Australia produces 80% of the Merino wool used in luxury fashion and suiting around the world.²

Argentina, New Zealand, South Africa, the United States and Uruguay are also leading producers of the fine wool used in apparel. Wool's inherent properties lend itself to a perfect fit in performance, active and sportswear.

Wool goes far beyond fashion. It can also be used to produce carpets, other interior textiles such as bedding, upholstery and insulation, and protective garments worn by firefighters and soldiers.



Sheep Shearing, Flanders c.1510 from the Grimani Breviary

² Business Insider referencing *The Suit: A Machiavellian Approach to Men's Style* by Nicholas Antongiavanni

Notes

Lined area for taking notes, consisting of multiple horizontal lines.

○
Use these boxes throughout to make your own wool notes

03 It All Starts on the Farm

When was the last time you visited a farm? Chances are, you are one of the 54% of people in the world who live in a city³, and maybe took a trip to a farm once or twice in elementary school.

There has been a massive shift away from rural life since the Industrial Revolution, but agriculture remains a key basis of most societies around the world.³

Agriculture is a business and wool sheep farming is no exception. Like all of us, woolgrowers multitask many activities throughout the year, managing their sheep and pastures to produce plenty of wool and keep their livestock and natural resources healthy.

Farm management skills include:

- 01 best practices in animal husbandry and preserving biodiversity
- 02 financial skills such as budgeting and managing cash flow
- 03 ongoing professional development such as workshops or courses on the latest production methods and technology
- 04 maintaining infrastructure: fences to care for, water troughs and pumps and machinery to be checked, cleaned and repaired
- 05 skilful forward planning
- 06 staff management and development

Because farming is a business, farmers work hard to maximise the return on their investment and labour.

A farmer's largest cost is **the land**. The value of agricultural land is directly linked to the availability of water, topography, natural weather patterns in the area and proximity to market.

High value land costs more and a farmer with highly desirable land will choose the crop that gives the greatest income. The top choices would be an edible crop such as rice, cow's milk, beef, pork, or chicken. The second top five choices are wheat, soybeans, tomatoes, sugar cane and maize.⁴

Wool sheep would not be a choice for land with high value. Wool sheep farming would not be the most successful business plan for a land with readily available water sources. **Raw wool prices cannot compete with the market value of edible crops.** Farmers are often in the business of wool sheep because it is the best option left for their type of farmland. Yet, wool sheep are still an expensive investment: in mid-November 2019, Merino ewe lambs averaged AU\$196 and for hoggets AU\$208 per animal.⁵

The careful management of livestock, including best animal welfare practices – along with scarce land and water resources – is therefore crucial for a successful wool farming business.

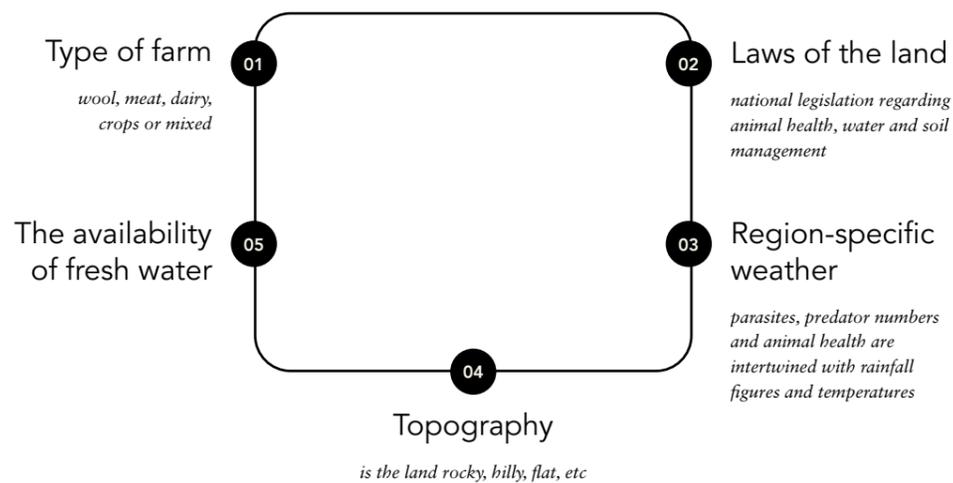
³ PBS News: *More than half the world's population lives in urban areas, UN report finds*

⁴ Food and Agricultural Organization of the United Nations
⁵ AuctionsPlus: *Weekly Livestock Market Comments*



04 Wool Farm Economics

Best practice in farming depends upon an interrelation of factors:



Woolonomics

The average Merino ewe delivers 4,5 kg of raw wool every 12 month.

At current prices⁶, the farmer sells the wool for 12 US\$ per kg (an average; the fleece's value also depends on what part of the sheep it comes from).

Thus the income for one year from this sheep's wool is 50-55 US\$.

On the expenses side, the purchase price for the sheep would have been approx. 196 US\$ at current prices.

Other costs include regular farm maintenance, overheads, labour costs, animal husbandry and shearing costs.

A Merino ewe on average will provide good wool for 5-6 years, as well as 1-2 lambs each year.

Sheep farms are often handed down from one generation to the next. Most woolgrowing families have been producing wool for generations.

Woolgrowers are skilled farmers who look after their livestock, pasture and the environment. Most have a lifetime of experience working on farms. Often they have degrees in agriculture from university or the equivalent. They use the latest technology and the most advanced management practices.

The average farm manager has at least 15 years' experience in a junior position before moving into a position of managing staff, infrastructure and sheep flocks successfully. As animal science and business practices change constantly, they must update their skills through continuous learning and at regular intervals.^{6,7}

Woolgrowers work hard to ensure their sheep are healthy, safe and have plenty of food, water and shelter all year round.

As well as looking after their sheep, growers care for the land and environment so it is protected for future generations. Woolgrowers fence off areas of bush to keep sheep out and look after waterways so rivers stay healthy. Sheep are moved between paddocks to protect the soil from erosion and ensure pasture lasts for many years.^{6,7}

The breed of sheep to be raised is based on the topography of the land, availability of natural resources and weather patterns specific to the area.



The chosen flock is then developed according to the carrying capacity of the different parcels of land within the farm. Even within a single farm there can be different rainfall patterns and topography.

Sheep graze on pasture and do not need supplemental feed unless conditions are extreme (such as drought). The size of the flock will match the carrying capacity of the land. Some woolgrowers develop a feed budget using their knowledge of pasture growth and information about expected seasonal conditions. A feed budget is a guide to how many sheep they can run at any one time and which paddock or pasture the sheep will move to next.

Constant calculations are done to prevent overgrazing of natural vegetation. Rotation grazing is the usual practice, to give natural vegetation time to recover. The profit margin on wool farming is generally insufficient to cover supplemental feed on a continuous basis. Maintenance is an ongoing task: securing fences, removing alien vegetation, ensuring fresh water is in supply and natural shelter as needed, as well as protection from predators.

Poor maintenance will result in stock losses, a reduced carrying capacity and ultimately a reduction in profitability – something no farmer wants to risk.

○
Things to Remember

⁶ See generally, AWI Education and Extension, <https://www.wool.com/education-and-extension/> and Sheep 201: A Beginner's Guide to Raising Sheep

<http://www.sheep101.info/201/index.html>

⁷ Cape Wools Code of Best Practice for Sheep Farming

⁸ For current information on wool prices, see the Australian

Wool Exchange's market reports

05 Caring for Wool Sheep

Global apparel businesses are increasingly focused on sustainability and traceability.

Individuals and companies alike are paying more attention to the raw materials in consumer goods, and the processes that occur at each step of production.⁹

For wool, the main points of focus are the environment, life cycle assessment, and wool sheep welfare.

It cannot be stressed enough that **ensuring each animal's best welfare is in the wool grower's best interest.**

Apart from the land, the flock of sheep is the woolgrower's largest business investment. Everything the woolgrower does is designed to keep the flock in the best possible condition, so that the best possible wool can be obtained.

Rough handling, stress through hunger or thirst or untreated disease and illness will cause the condition of the wool sheep to deteriorate and as a result lower the quality of the wool.

Much as your hair stylist can observe that you've been stressed from the state of your hair, stress in sheep will lead to breaks in the wool staple, which reduces the market value of the wool.

Mulesing is a surgical procedure primarily practiced in some regions of Australia which are prone to flystrike. The fly *Lucilia cuprina* is attracted to the breech area of the sheep and lays its eggs in the wool and when the eggs hatch, the maggots start eating the sheep alive. To prevent this cruelty to the sheep, some of the skin around the rear of the sheep gets cut away once when it is still a little lamb – this procedure is called mulesing.

No farmer who muleses does so callously and the procedure is done to prevent disease, suffering and death of the sheep.

Where possible wool growers in Australia have stopped mulesing on their farm. In areas where sheep are in danger of flystrike due to the natural conditions, more and more wool growers are using pre- and post-operative pain relief or breed sheep over the course of several years which don't have any skin folds which makes mulesing unnecessary.



Animal Welfare Standards from the OIE

According to the World Organisation for Animal Health (OIE), animal welfare standards should be based on sound scientific findings, and optimal animal health should always be the basis of animal welfare.

The OIE is the global authority for standards on animal welfare, and its "Five Freedoms" for the care of animals are recognised internationally:

- 01 Freedom from hunger, malnutrition and thirst
- 02 Freedom from fear and distress
- 03 Freedom from physical and thermal discomfort
- 04 Freedom from pain, injury and disease
- 05 Freedom to express normal patterns of behaviour¹⁰

An animal experiences good welfare if the animal is healthy, comfortable, well nourished, safe, is not suffering from unpleasant states such as pain, fear and distress, and is able to express behaviours that are important for its physical and mental state.

Good animal welfare requires disease prevention and appropriate veterinary care, shelter, management and nutrition, a stimulating and safe environment, humane handling and humane slaughter or killing.¹¹

Animal Welfare Legislation by Country

Each woolgrowing country has its own legally binding animal welfare legislation. As well as the above principles, best practice is defined within each country based on country-specific production systems and the wool sheep breeds.

The major woolgrowing countries – Argentina, Australia, New Zealand, South Africa, the United Kingdom, United States and Uruguay – all have strict standards for wool sheep welfare, and criminalise serious offenses.

The relevant legislation for each country can be easily found in the International Wool Textile Organisation (IWTO)'s Specifications for Wool Sheep Welfare.¹²

The IWTO Specifications additionally provide concise guidance on best practices for wool sheep husbandry.

Collective Industry Action

Reflecting the significance of wool sheep welfare to the industry, more than 600 individuals and corporations have undertaken to support an environmentally responsible, sustainable and commercially viable wool industry through signing the Dumfries House Wool Declaration.



Join the Dumfries House Wool Declaration, formulated at the request of HRH The Prince of Wales

⁹ *Beyond the Bale*, Issue 76, September 2018 p 48, 53

¹⁰ OIE, World Organisation for Animal Health, Terrestrial Animal Health Code

¹¹ OIE Terrestrial Animal Health Code, Article 7.1.1

¹² IWTO Specifications for Wool Sheep Welfare

06 From Fleece to Fabric

Shearing

Shearing usually takes place once a year, but some farmers could shear up to 3 times in 2 years, depending on climatic circumstances. Most woolgrowers employ specialist shearing teams, who travel from farm to farm shearing sheep for a living.

Although the process varies by country, using Australia as an example, a shearing team can include two or more **shearers**, one or two **woolhandlers** and a **wool classer**.

Shearers remove the fleece – the main wool covering the sheep’s body – in one large piece. After the belly, leg and face wool have been removed and collected by the woolhandler, the body of the fleece comes off as one piece.

As soon as the fleece has been shorn, the woolhandler gathers up the fleece and throws it across a large table. The woolhandlers “skirt” the fleece, removing the lower-quality edges of the fleece which are kept separate from the main fleece wool. The remaining fleece is given to the wool classer.

The wool classer sorts the wool into five main categories — fleeces, double cuts, pieces, bellies and locks. Fleeces are also sorted into lines (groups) according to their micron. The classed wool is placed in nylon bags and compressed in the wool press to make **bales**.

All the bales are sealed and marked with a brand that identifies the woolgrower, the classer and the type (breed and category) and quality of wool inside.¹³

The Wool Fibre¹⁴

Not all wool is the same — it varies in colour, quality (fibre diameter) and length.

Fibre diameter and staple length are important measurements that determine the use of wool. Diameter is measured in microns and fibre length is always recorded in millimetres.

Wool can be divided into five main groups based on micron: Extra fine, fine, medium, broad and coarse.

Wool Micron Grades & Uses ¹⁵	
Micron (μ) /Grade	Use
14.5 μ and finer – Extrafine	Next-to-skin baselayers & garments such as shawls, scarves, hats, babywear, gloves, underclothing
14.6-16.5 μ – Ultrafine	
16.6-18.5 μ – Superfine	
18.5-20.5 μ – Fine	Next to-skin apparel and high-quality fashion; high-quality, soft-handling fabrics & knitting yarns <i>(NB: Merino sheep produce the finest wool, which is used for high-quality, soft fabrics and yarns by leading fashion designers)</i>
20.6-22.5 μ – Medium 22.6-25 μ – Broad	A variety of woven apparel cloths, knitting yarns and furnishings such as thicker sweaters, socks, blankets, rugs and industrial felts. <i>(NB: Many different sheep breeds produce broader wools and often they are dual-purpose breeds used to produce both meat and wool)</i>
26-32 μ - Coarse	Rugs, upholstery and insulation
32-48 μ	Carpets

Testing

Once the wool is shorn the wool bales are shipped to a warehouse.

At the warehouse, the wool bales from a single property are grouped into sale lots of similar types. Core samples are taken from each bale to ensure test results represent all the types in the sale lot. Samples are tested for fibre diameter (micron), vegetable matter, staple strength, length and colour. A pre-sale **certificate** is issued that lists all the results from the testing and stays with the sale lot right through to processing. (For more information on testing and traceability, see chapter 07).

Sale

Most of the world’s wool is sold by **auction**. Auctions generally take place every week. Here the price per kilo is determined based on demand, quality and volume on offer.

Once sold, the wool begins its journey to becoming fabric. There are several steps in this pipeline, described below.

First Stage Processing

Scouring – Carbonising: The wool is cleaned¹⁶, removing grease (lanolin), vegetable matter (sticks, grass), and dirt (sand, soil). Some wool lots require carbonising, involving an additional treatment with diluted sulphuric acid and placing in a very hot oven; the acid attaches to the vegetable matter and in the drying oven this becomes dry and brittle. The wool is passed through rollers which crush the dry vegetable matter, leaving only clean wool behind.¹⁷

Carding – Combing: These processes prepare wool for spinning. **Carding** removes tangles by passing the clean wool over sets of short wire teeth to open, straighten, and separate the fibres into a uniform mass. The result – a long rope of wool – can be referred to as a combed sliver. Carded fibres are generally used for producing **woollen** yarn.

Combing separates out the fibres of the wool through long metal teeth or tines. The fibres become aligned and parallel to each other. Fibres that are too short, **noils**, are removed by this process. The sliver will be wound into a ball and this is known as wool top.

This preparation is generally used in preparation for making a **worsted** yarn.

Woollen and Worsted Processing

Wool is a versatile natural fibre, and can be made into a wide range of **woven** or **knitted** fabrics. Depending on the **length** and fibre diameter (fineness) of a fleece, it can be processed through either the **woollen** or **worsted** processing system.

The worsted processing system requires long staple fibres to produce very fine yarns, which can be woven to make extremely smooth and lightweight fabrics.

Worsted-spun woven fabrics are used by fine tailors around the world for clothes such as business suits, trousers and skirts.

Worsted-spun knitted fabrics are super-soft, incredibly versatile knits that are used for baby clothes, underwear, t-shirts and sportswear, leggings, dresses and other light-weight knitwear.

Woollen spun woven fabrics are thicker and heavier and used mostly for outerware. New spinning innovations have produced wind and waterproof wool fabrics.¹⁸

Woollen-spun knitted fabrics are bulkier than worsted-spun knitted fabrics. They are used for items such as jumpers/sweaters, scarves and socks.

Fun fact

Wool grows about 6mm per month; the average for human hair is 10mm.

¹³ The Woolmark Company: Shearing
¹⁴ The Woolmark Company: Wool fibre

¹⁵ See Fine Fleece Shetland Sheep Association Grading Chart and The Woolmark Company: Wool – The Fibre

¹⁶ Australian Wool Testing Authority: Scoured Wool

¹⁷ Australian Wool Testing Authority: AWTA Fact Sheet – Scoured & Carbonised Wool

¹⁸ <https://www.woolmark.com/news/textile-innovation/water-resistant-wool>

07 Traceability – A Case Study

Traceability is of high importance along the wool supply chain as brands, retailers and consumers want to know where their wool comes from. All major wool growing countries offer different traceability systems. Read here how it is done in Australia.

Approximately 80% of the fine Merino wool used for clothing textiles is sourced from Australia¹⁹ and sold through The Australian Wool Exchange.²⁰

Every wool bale offered on auction is tested to confirm the wool's quality and characteristics. Testing is performed with a grab sample, a sample of the wool taken from the centre of the bale.

Wool is a natural fibre and each batch will vary largely in length, colour, fineness and content.

Your Keys to Traceability

Wool Test Certificates

Wool is tested to international standards and according to the wool testing specifications set out in the **International Wool Textile Organisation's White and Red Books**.²¹

Wool-testing laboratories are audited annually and conform to the international standards set by their local standardisation body.²²

IWTO licenses laboratories around the world to issue IWTO test certificates, the "gold standard" in the industry.

Most bales of wool will be offered to the prospective buyers with an IWTO test certificate.²³

01 Test Certificate Number

02 Total Bales Tested (stipulating the weight of each)

03 Yield of Each Bale (how much clean wool will the bale deliver, after vegetable matter is removed)

04 VM = Vegetable Matter %

05 LSCAN = Measuring the micron of the wool in that bale (how fine it is)

06 Mulesing Status (MS)

- NM = The wool comes from non-mulesed sheep
- M = Some or all of the sheep in this flock have been mulesed
- PR = All the sheep in the flock were mulesed using a registered Pain Relief product
- CM = Ceased Mulesing, meaning no lambs born on this property in the last 12 months have been mulesed and no new sheep are mulesed



Wool Declarations

Most wool is sold with an IWTO Test Certificate. In Australia, the IWTO test certificate will report how that wool has been declared through Australia's National Wool Declaration (NWD) programme.²⁴ South Africa has a similar system in place.

The NWD includes information provided by the woolgrower on various items, including the mulesing status of the sheep the wool came from. This information flows through the supply chain in a traceable manner, via the NWD and the test certificates:

01 Top-makers buy wool on the basis of the AWTA Combined Certificate (a combination of the various sale lots that go into one order). This reports the mulesing status of each component lot. In this way the NWD is fed into the supply chain

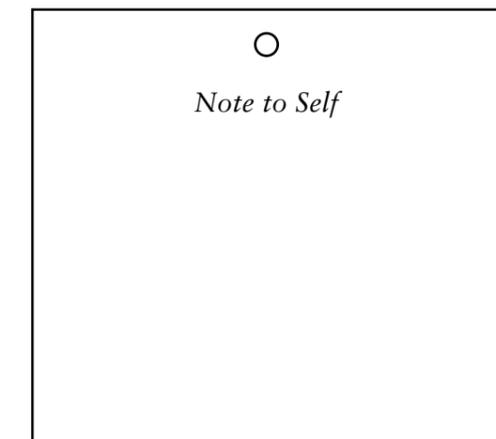
02 If the spinner or other later-stage processor demands the mulesing declaration information the AWTA Certificate or a summarised Mulesing Status Report is passed along the supply chain

AWTA provides an online Certificate Verification service that can be used to check the authenticity of the report. Making false declarations in trade or commerce is an offence in Australia and the Competition Regulator will prosecute this if necessary.

Stipulating Origins

For each yarn order, the combler will select wool that meets the demands set by the spinner and the client. The combler's wool buyer will source wool accordingly. It is likely that the raw wool will be sourced from different farms and possibly even different countries, and blended in the spinning process to produce the order's specifications.

If a buyer wishes to stipulate the wool's origin, this must be confirmed with the combler and the spinner in advance, in order to track the many lots of wool in the particular blend.



Fun fact

Spain so valued its Merino sheep that until the 18th century, exporting sheep was an offense punishable by death.

¹⁹ Learn about Wool – the wool market AWI
²⁰ The Australian Wool Exchange AWEX

²¹ IWTO Wool Testing Summary
²² IWTO Certificate validation

²³ IWTO Certificate

²⁴ For more information on the National Wool Declaration, visit www.awex.com.au/publication/national-wool-declaration-nwd/. For more information on AWTA's Wool Testing, visit www.awtawooltesting.com.au/index.php/en/

08 Chemicals in Wool Processing

The processing of wool, like the processing of any other textile fibre, requires the use of chemicals. Eco-friendly versions of all chemicals can be specified if required.



Early Stage Processing – Cleaning:

- 01 **Scouring:** Warm water and non-ionic detergents which do not contain alkylphenol ethoxylates.
- 02 **Carbonising** - For wools too short to comb the vegetable matter is removed using a bath of dilute sulphuric acid, then soda ash and hydrogen peroxide; all very common chemicals.

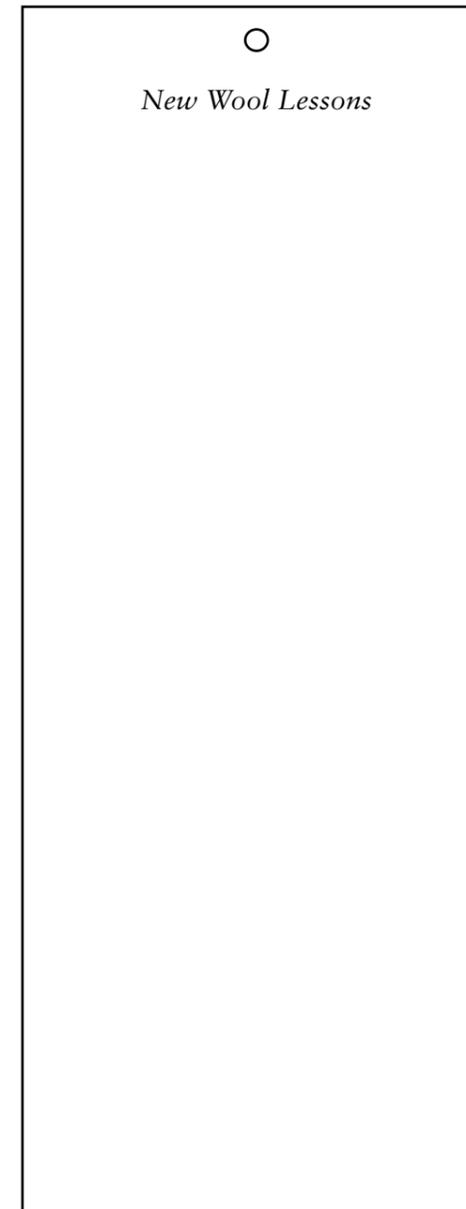
Subsequent Processing:

- 03 **Carding, gilling & combing:** Mechanical processes which require very little water and lubricants to reduce the friction between the fibres as they are carded and combed.^{25, 26, 27}
- 04 **Drafting:** A mechanical process in which a thick strand of fibres is reduced to a thin one, no additional chemicals used.²⁷
- 05 **Spinning & Twisting:** Both involve twisting a strand of wool mechanically. No additional chemicals used.
- 06 **Dyeing:** The wool can be dyed at one of several stages during production i.e. fibre stage, yarn stage, fabric stage or even garment stage. The dyeing process is carried out using acetic acid, levelling agents, and synthetic dyestuff which do not need heavy metal mordants to fix them to the fibre.
- 07 **Softening:** Most wool products will be softened at some stage with a wax-based or silicone-based softener.

²⁵ Carding and Combing
²⁶ Gilling

²⁷ Drafting

Optional Processes (For Additional Functionality):



²⁸ EXP Schoeller
²⁹ Naturetexx Plasma

- 08 **Shrink-resist treatment** - Some wool tops will be treated with shrink-proofing process. The top will be given a two-stage treatment, first with an oxidising agent to chemically etch the fibre, followed by a very thin film of a polymer to mask the scales; so that during washing the garments do not shrink.
- 09 **Alternative shrink-resist treatments** - For some specific types of yarns the oxidising stage of top-treatment can be replaced with a plasma-based process, for example the Naturetexx process from Südwole, which does not require as many chemicals, or as much water, to process the tops.^{28, 29}
- 10 **Flame-Retardant:** Although wool is inherently flame-retardant, in some high-risk situations an additional treatment with a zirconium-based flame retardant is necessary.
- 11 **Water & stain repellency:** Although wool is inherently water and therefore stain repellent there is sometimes a desire for higher levels of repellence in which case a fluorine-based, silicone-based, or wax-based chemical can be applied to wool during the final stages of production.



09 Coming Around Again – Recycling Wool

Wool textiles have high economic worth and consumers have valued this through the ages. Garments and décor items made from wool look better for longer, need less laundering, are easy to care for and often are passed from one generation to the next. Textile manufacturers in the late 1800's established a 'recycling culture' in Prato, Italy and their expertise are sought after in the current circular economy business model.³⁰

To measure the environmental footprint of a textile item, it is important to do this over the full lifespan of such an item and consider the recycling capacity as well. Can this item be fully recycled, to live another life in a different form? Wool items can and often are recycled, as the yarn is viewed as highly valuable and not easily discarded. Wool's cradle-to-grave reality can involve two or three lives and a total active lifespan of 20-30 years.³¹

Wool accounts for up to 5% by weight of total clothing donated by consumers. The mechanical recycling of wool textiles yields fibres of sufficient length to be carded and re-spun into yarns of pure wool or used for blends. The average wool garment is used for 2-10 years, in comparison to 2-3 years for a garment made from synthetic fibres.³²



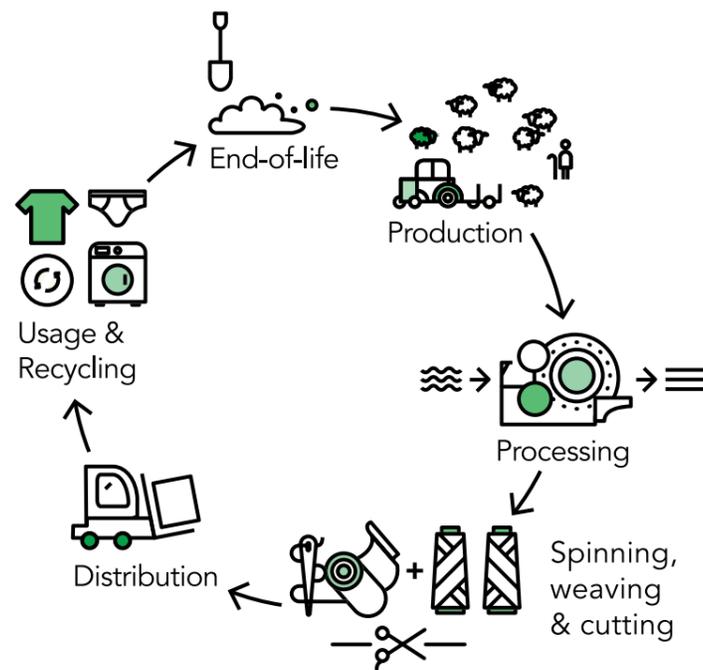
³⁰ Cardato

³¹ Recycled Wool IWTO

³² Circular Economy IWTO

10 Treading Lightly: Low Environmental Footprint

Wool's Life Cycle Assessment



poorly against competing synthetic fibres. However, there are **severe shortcomings** to the ratings. They consider only a limited part of the supply chain and only consider some environmental impacts.

By working with the apparel ratings agencies, providing contemporary data and sound methodology, the wool industry seeks to improve the accuracy of the ratings, ensure fair treatment for all fibres, and ultimately provide accurate information to the consumer.

Why Ratings Don't Always Tell the Whole Story

LCA is a tool that attempts to tell the environmental story of products across the entire supply chain, including raw material acquisition, manufacturing, use, recycling, end-of-life and disposal.

LCA has proven especially useful in helping manufacturers understand and improve the efficiency of factory processes where inputs and outputs can readily be measured.

However, lifecycle assessments are **less comfortably applied in biological systems**, and especially in comparison of **different products** such as where wool (a natural, renewable biological material) is compared against a fibre such as polyester (an oil-based synthetic fibre).³³

When determining textile purchases for the coming season, many factors will play a role. Predicted fashion trends and accompanying production costs are always going to be very important.

But as environmental pressures mount, **pertinent questions about sustainability ratings and environmental footprints** come into play.

There are many ways to assess environmental sustainability. Life Cycle Assessment (LCA) is one popular method.

LCA for Wool Textiles

Despite wool being **100% natural, renewable and biodegradable**, environmental ratings agencies have historically rated wool

The Carbon Cycle

All life on earth is based on carbon. Sheep and their wool are part of the natural carbon cycle that underpins all life on our planet.

Grass and natural vegetation act like straws, absorbing carbon from the air. Sheep turn that carbon into wool, when they eat the grass.

Sheep return CO₂ to the atmosphere through respiration, and also methane (CH₄) which breaks down to CO₂.

Farmers around the world contribute to the natural carbon cycle by influencing the amount of carbon stored in plants and soils and by managing agricultural animals. Good management practices can increase the carbon stored in pastures and agricultural soils and thus make a positive contribution to mitigating climate change.

LCA underpins many footprinting tools, resulting in several weaknesses:

01 Comparing fabrics without considering the whole supply chain

Apparel ratings agencies **only assess the supply chain up to fibre or fabric production and exclude the Use Phase and end of life.**

There are important offsets for wool in the use phase and at end of life: wool is a superior fibre that **lasts longer**, requires **less washing** than other fibres and is **frequently recycled** – all of which should be counted.

What the Ratings Leave Out

One leading rating tool only quantifies four impact categories – climate change, eutrophication, water scarcity and abiotic resource depletion. What's left out?

- **Microplastics** – despite growing evidence of the impact of microplastic pollution from synthetic fibres on waterways and marine life, microplastic pollution is not considered by current ratings systems
- **Use phase, end-of-life and biodegradation**
- **The question of carbon** (see box, above)

02 The use phase strongly affects overall impact

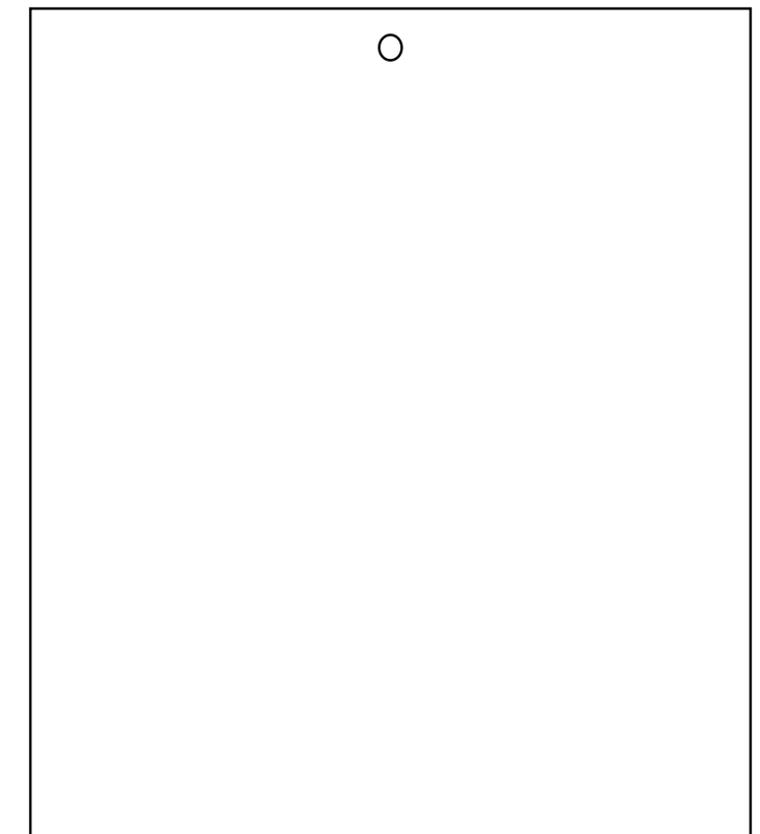
A comprehensive survey (The Nielsen Company, 2012) established that the **average lifetime of wool garments was more than 50% longer than cotton garments**, and that **items of wool clothing are washed less often.**

A longer life and less washing mean garments are replaced less often and require less energy, water and detergents during use.

03 Assumptions about end-of-life for wool are inaccurate

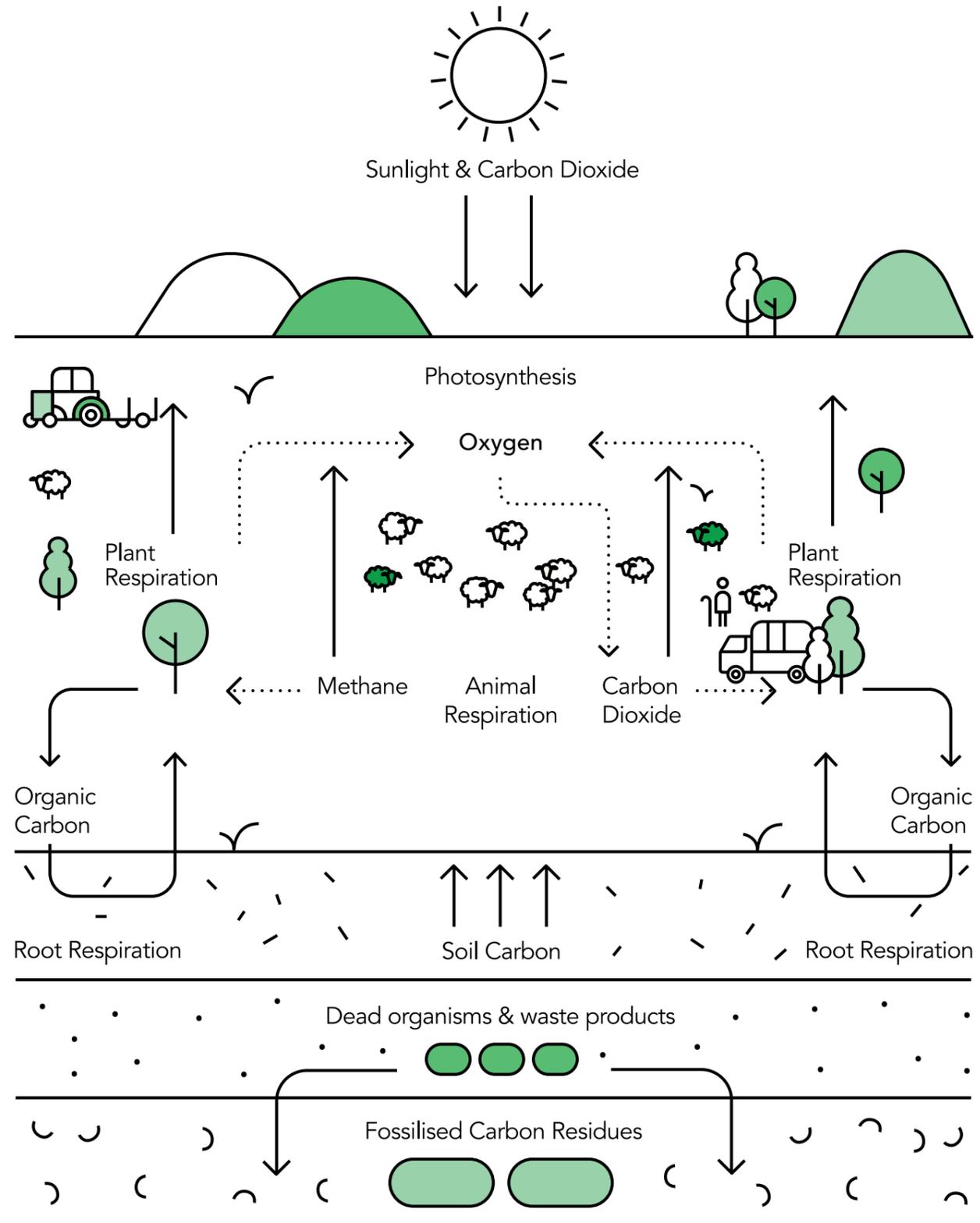
LCA studies to date **assume** that at the end of a wool product's life, it is immediately disposed of in landfill, **ignoring the level of reuse and recycling of wool garments/ products.**

Research shows a **5% donation rate of wool garments** – which far exceeds wool's **1.3% share of virgin fibre supply.**



³³ For more information, visit <https://www.iwto.org/work/wool-LCA>

Contemporary Atmospheric Cycle:



11 Cradle to Cradle with Wool

All materials of animal and vegetable origin have some degree of biodegradability, meaning that they are capable of being decomposed by the action of living organisms, such as fungi and bacteria.

Wool is composed of the natural protein keratin, the same protein that is in our hair.

When wool is disposed of, microorganisms will naturally break down the keratin with enzymes and release valuable nutrients back into the earth. Essential elements such as nitrogen, sulphur and magnesium are able to be taken up by growing plants, completing the natural cycle.

Wool can naturally decompose in soil in a matter of months or years in warm, moist conditions or when buried in soil.³⁴

While research has shown that processing treatments such as dyeing and antishrink treatment can result in the wool taking slightly longer to biodegrade, this is a short-term effect, typically not persisting beyond eight weeks.

Due to the unique chemical structure of keratin and the wool fibre's tough, water-repellent outer membrane, clean and dry wool fibres do not readily degrade. That's why under normal, everyday living conditions, wool products are resilient and long-lasting.

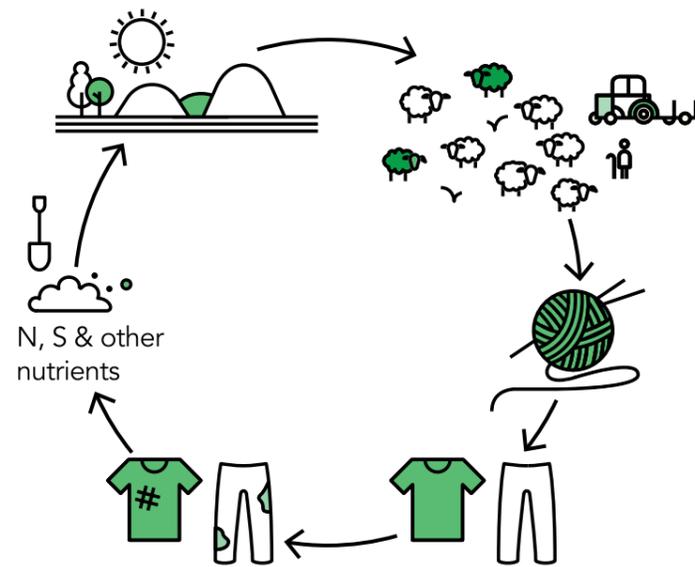
Choose Well, Choose Wool

Natural fibres biodegrade naturally in a relatively short period in soils and aquatic systems.³⁵

In contrast, synthetic textiles can be extremely slow to degrade and can disintegrate to the small fragments known as microplastics. Microplastics are defined ranging in size between 1 nanometre and less than 5mm in diameter. These fragments accumulate in the world's oceans, lakes, rivers and other water systems, as well as landfill sites. The microplastic can be perceived by other living creatures as food, with negative consequences for these life forms and the food chain. It can lead to death through starvation for these creatures as stomachs fill with plastic instead of food.³⁶ Once in the food chain, microplastics potentially also affect human health.³⁷

A single polyester fleece garment can produce more than 1,900 fibres per wash.³⁸

Biodegradation of Wool



We turn grass into wool.
What's your superpower?

³⁴ Hodgson A., Collie S. (December 2014). Biodegradability of Wool: Soil Burial Biodegradation. Presented at 43rd Textile Research Symposium in Christchurch – AWI Client Report.

Canterbury, 1994, 2.

³⁶ Wright, S.L., Thompson, R.C., Galloway, T.S. (2013). The physical impacts of marine organisms: A review. *Environmental Pollution* 178, 483-492.

Environmental Pollution 193: 65-70

³⁸ Browne, M.A., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T., Thompson, R., 2011. Accumulation of microplastic on shorelines worldwide: sources and sinks. *Environ. Sci. Technol.* 45, 9175-9179.

³⁷ Van Cauwenberghe L, Janssen CR. (2014) Microplastics in bivalves cultured for human consumption.

12 The Ultimate Fibre – Wool's Natural Benefits

Wool is ...

01 Natural – renewable – resilient – stain-resistant – anti-wrinkle – flame-resistant – odour-resistant – can help you sleep better (and can help babies sleep better)

02 A natural temperature-regulator: it can keep you warm, and it can keep you cool

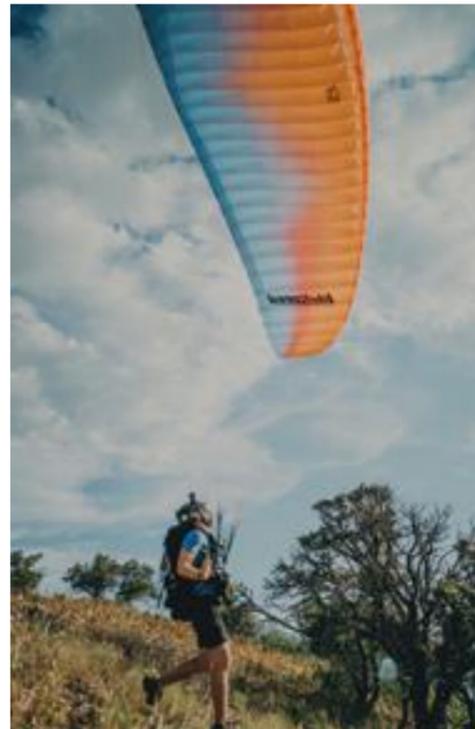
03 Worn by soldiers, fire fighters, astronauts, athletes and mountain climbers all over the world because of its unique properties

04 Able to absorb up to 35% of its own weight in water, more than cotton (24%), nylon (7%) and polyester (1%). Wearing wool when you play sports can keep you cooler and drier by absorbing moisture from your skin as you sweat

05 Easy to care for: wool garments can be 'refreshed' by airing, or by hanging them in a steamy bathroom. They will be fresh and ready to wear the following day

06 Protective: wool naturally absorbs UV rays

07 Loved by designers the world over for its elegance, handle and drape, colourfastness, versatility (available in a wide choice of weaves, weights, and textures), and ease (doesn't fray, isn't marked by pins, responds to ironing and doesn't crush with handling)



Breathability

Wool clothing is extremely **breathable** — wool fibres can absorb large quantities of moisture vapour (such as sweat), then move it away from your skin so that it evaporates into the air.

Wool reacts to changes in body temperature *all on its own*. It's a naturally active fibre. Synthetics have been trying to replicate this quality for years – manufacturers call it "technical innovation". But wool has always had this characteristic.

Moisture Management

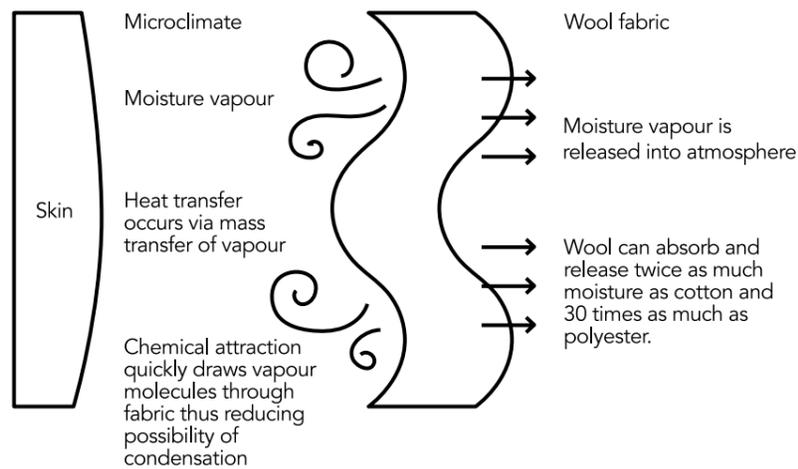
When worn next to the skin, wool works as a dynamic buffer in the micro-climate between the fabric and the skin, smoothing out the humidity and temperature.

This makes us feel more comfortable whether we're working out or running for the bus – adding to our overall sense of well-being.

Wool's ability to **manage moisture** is so good that it even helps people who suffer from eczema – research shows that wearing superfine Merino wool next to skin will reduce the redness, itchiness, and cracking of the skin that are symptoms of the condition.³⁹

A two-year study recently concluded in the United States has shown that not only does wearing superfine Merino wool help ease the eczema but improves the wearer's quality of life. Some participants told the researchers that they **still wear the Merino wool clothing even though the study is finished**.⁴⁰

Moisture Management



Prickle?

The same research that shows Merino wool assists those suffering from eczema has challenged the common misconception that all wool is prickly and itchy. We understand now that the "perception of prickle" has to do with the diameter of the fibre in a garment, not the type of fibre.⁴¹

Odour

Sweat itself has no odour, but if it remains on the skin, the humid environment is perfect for bacterial growth, leading to body odour.

Wool's **natural breathability** helps defer the onset of sweating, which keeps the skin drier. **When sweat does occur, wool absorbs the moisture** but not the salts or other waste products in the sweat.

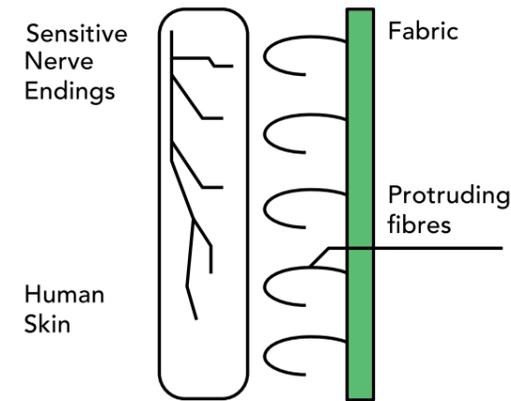
Finally, wool's complex chemical structure enables it to **absorb and lock away odours** within the fibre, where the bacteria that cause odour cannot thrive.

These odours are then significantly released by wool garments when laundered – or simply aired out. The garment will feel fresh again the next day.

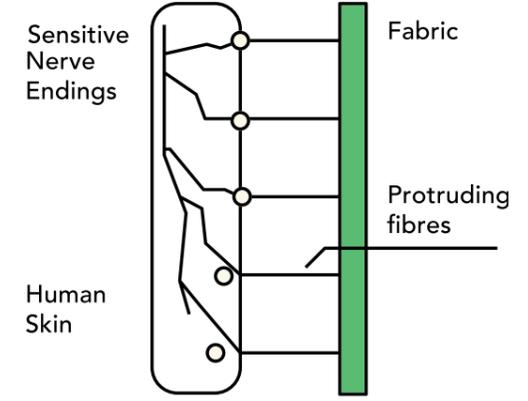
Odour-wearer trials conducted by the CSIRO⁴² show that Merino wool socks are preferred for both lack of odour after wearing, and also for lack of odour after washing, especially when compared to synthetic socks. And athletes such as mountaineers, who wear clothing for long periods without washing, report less odour build up with wool apparel than with synthetics.

Prickly? It isn't what you think

Superfine Merino



Course Fibres



Care

Because of wool's ability to lock in odour, plus its ability to retain and regain its shape in between wears, wool garments do not need to be laundered as frequently as those of other fibres.

General care: After wearing, brush woven garments lengthwise to remove surface soil, which could become stains later. To remove food odours, lay wool clothing flat on a bed or towel for an hour. Woven garments may be hung in fresh air on a suitable hanger. Rest wool clothing for 24 hours before wearing again. This gives the natural resilience and spring in the wool fibre time to recover and return to its original shape.

Before storing your wool clothes help your wool clothes keep their shape by emptying pockets and removing belts, jewellery and other accessories, and closing zippers and buttons. Hang woven clothing on shaped or padded coat hangers. Gently fold knitted wool clothes before storing in drawers.

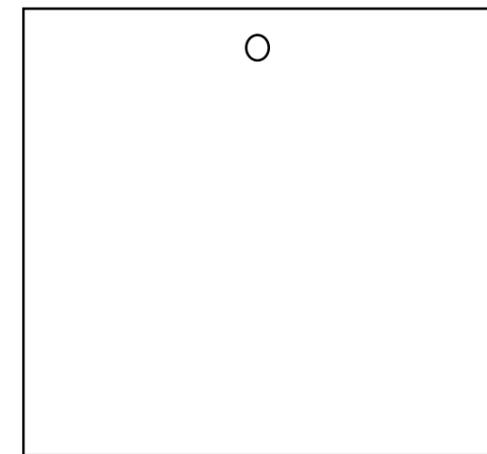
Ensure your wool clothing is clean before packing in airtight containers for storage. Food stains and body oils attract moths.

Pilling occurs in all fibres and is caused by abrasion on the fabric surface. Friction causes any loose fibres on the surface of a fabric to start

becoming entangled with one another until little balls of fluffy fibres have formed, which are known as pills. Pills can easily be removed from wool fabrics and in many cases drop off.

When washing wool use a detergent that is specifically developed for wool that has a low pH. Avoid bleaches and "biological" detergents that may have enzymes. Aim for a warm wash/40° C and a gentle cycle (hot temperatures alone will not shrink wool, but agitation will cause it to shrink and felt).

The Woolmark Company has a handy Wool Care app: download it free of charge via the Apple App Store or Google Play.



Fun fact

Whether it's hot, cold, humid or dry, wool garments can absorb and release twice as much moisture vapour as cotton and 30 times as much as polyester.

³⁹ J.C. Su et al. Determining Effects of Superfine Sheep wool in Infantile Eczema (DESSINE): a randomized paediatric cross over study, British Journal of Dermatology, 2017. See also L. Spelman et al. Queensland Institute of Dermatology/Australian Wool

Innovation, An assessment of superfine merino wool as therapeutic in the treatment of Atopic Dermatitis for children and young adults, 2016 (unpublished).
⁴⁰ Beyond the Bale, Issue 76, September 2018 p. 34.
⁴¹ Michaela Zallmann et al. Debunking the Myth of

Wool Allergy: Reviewing the Evidence for Immune and Non-immune Cutaneous Reactions, Acta Dermatologica, 2017.
⁴² CSIRO Odour and Toxics Absorption, 2006. See also Beyond the Bale, Issue 74, March 2018.

13 Wool Directory

	Country Contacts	Industry Contacts
Argentina	FLA Federacion Lanera Argentina	
Australia	Wool Industries Australia	Australian Wool Innovation Australian Wool Exchange Australian Wool Testing Authority Kettlewell Consulting
Bulgaria		Vitex Troyan AD
China	China Wool Textile Association	
France	FFILC Fédération Française Industrie Lainière et Cotonnière	NSC Schlumberger
Germany	Deutsche Wollvereinigung	DWI Interactive Materials Research IVGT LanEster Südwolle Group Raymond Limited Oswal Woollen Mills Limited
India		International Wool Textile Organisation
International		
Italy	Sistema Moda Italia	Benetton Group Città Studi Biella
Japan	Japan Wool Industry Association	
Korea		Youngone
Lesotho	Lesotho National Wool & Mohair Grower Association	
Mongolia	Mongolian National Committee	
New Zealand	National Council of New Zealand Wool Interests Inc.	The Campaign for Wool NZ
Norway	Norilia	
South Africa	Cape Wools SA	
Switzerland	Swiss Textiles	Saurer
Thailand		Indorama Ventures PLC
Turkey	Turkish Textile Employers Association	
United Kingdom	British Wool	The Campaign for Wool Interwoollabs Standard Wool
USA	American Wool	Cashmere & Camelhair Manufacturers Institute
Uruguay	Secretariado Uruguayo de la Lana	Cámara Mercantil de Productos de País

Learn more about the IWTO members here: <http://www.iwto.org/members>

14 Glossary

Alternative shrink - resist treatment — For some specific types of yarns the oxidising stage of top-treatment can be replaced with a plasma-based process, for example the Naturetex process from Südwolle, which does not require as many chemicals, or as much water, to process the tops.

Animal welfare — the humane treatment of animals to ensure their health and wellbeing.

Auctioneer — the person who runs the wool auction and keeps a tally of the bids until the highest bid is reached.

Biodegradable — a substance that will decompose naturally.

Belly — short wool underneath the stomach of the sheep. This wool is kept separate from the fleece as it is less valuable and is processed differently.

Carbonising — For wools too short to comb the vegetable matter is removed using a bath of dilute sulphuric acid, then soda ash and hydrogen peroxide; all very common chemicals.

Carbon footprint — the sum of greenhouse gas emissions and removals of a product system, expressed as CO₂ equivalents

Cradle-to-gate — a partial assessment of a product life cycle, from resource creation (cradle) to the factory gate — that is, omitting the use and disposal phases of the life cycle.

Cradle-to-grave — assessment of a product life cycle from creation to disposal.

Cradle-to-cradle — an approach to the design of products and systems modelled on natural processes, viewing materials as nutrients that will eventually be recycled or reused.

Core test — a sampling method taken from the centre of a wool bale, to measure the fibre diameter, staple length, staple strength, yield, vegetable matter and colour.

Crossbred — an animal whose parents were of two different breeds. For example, Merino and Border Leicester.

Crutching — removing wool by shearing around a sheep's bottom to prevent flystrike

Decompose — to break up or separate into simple parts.

Drenching — treating sheep with pesticides to prevent intestinal worms.

Dual-purpose — breeds of sheep used to produce both wool and meat.

Environmental impact — any change to the environment, adverse or beneficial, wholly or partially resulting from an organisation's activities, or from any part of the life cycle of products or services

Ewe — mature female sheep over the age of two years.

Eutrophication — excess of nutrients, mainly nitrogen and phosphorus, in water or soil.

Fibre diameter — the thickness of a single wool fibre.

Fleece — the main wool covering the sheep's body. The fleece usually comes off in one large piece, by shearing.

Flystrike — a condition in sheep where blowflies lay their eggs into soiled wool. Fly larvae hatch and burrow into the flesh of the sheep. In severe cases sheep can die from flystrike.

Grab sample — samples of wool (about 3–4kg each) from a sale lot that can be inspected by potential buyers before auction.

Graze — feed directly on growing grass, pasture or forage crops.

Greasy wool — "Raw" wool, before it is cleaned.

Greenhouse gases (GHGs) — gases in the earth's atmosphere, both natural and originating from human activity, that absorb and emit radiation from the sun, leading to warming of the earth's surface.

Hogget — a young sheep, about 1-16 months of age.

Lamb — a young sheep from birth until about 10-16 months (when the first two adult incisors appear).

Lanolin — a natural wool grease or wax which often is used in cosmetics, animal food and lubricants.

Life cycle — consecutive and interlinked stages of a product system, from raw material acquisition/creation to final disposal.

Life Cycle Assessment (LCA) — compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle.

Merino wool — wool sourced from a breed of sheep called Merino

Micron — a millionth of a metre and the unit of measurement used to describe wool fibre diameter.

Mulesing — surgical removal of woolly skin around the sheep's bottom. When the wound heals, no wool can grow for flies to lay eggs into.

