The Sheep Value Chain and 'Wool Out' Sheepskin as a Sustainable Material
- Sarah Morehead - Northumbria University

TRANSITION: RE-THINKING TEXTILES AND SURFACES:
HUDDERSFIELD TEXTILE SOCIETY
UNIVERSITY OF HUDDERSFIELD – CONFERENCE - NOVEMBER 26TH & 27TH 2014

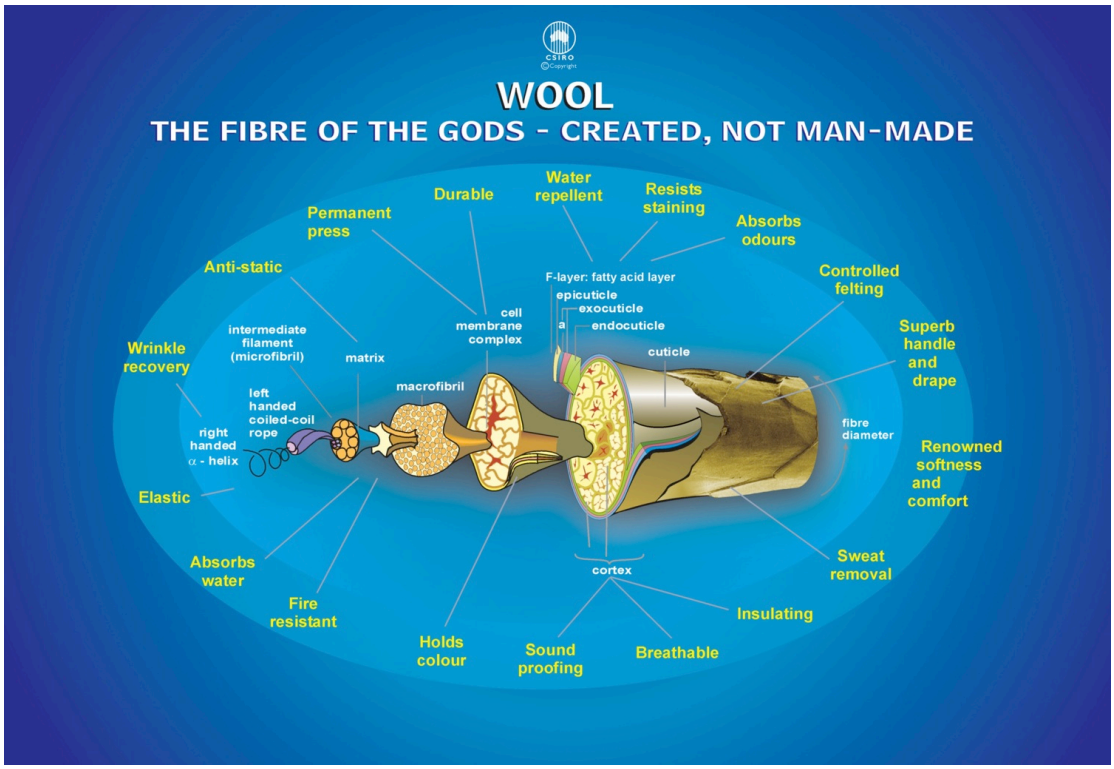
This research looks at sheepskin as a possible sustainable material from a design academics understanding and if this material still has application for fashion, lifestyle and well-being. My initial inquiry took me to wool-out tanning in the UK from the micro tannery in Skye, the larger commercial wool-skin tannery in Devon and to the Organic sheepskin tannery in Hertfordshire. From this exploration it became apparent that in order to ask the question is sheepskin sustainable it was first necessary to ask is sheep rearing in the UK a sustainable proposition?
This has led me to probe all aspects of the sheep value chain Can 'wool skin' or wool on leather sheepskin be a sustainable material and how is it co dependent with the food market as sheepskin is a by-product of the meat industry?
Over the last four years I have interviewed and taken oral history accounts from different stakeholders - farmers, veterinary surgeons, smallholders, agricultural merchants, farming journalists, tanneries and skin merchants. This work tries to unpick the sheep value chain in the United Kingdom from land use, farming, husbandry, and tanning and discover its implications for garment design.

There is an increased awareness in fashion design of the importance of ethical design in regards to labour and a growing understanding of ecological and sustainable importance in fibre production. However there is little explored of how land apportion contributes to the geo political, social and economic impact on ecological and ethical sustainability of fibres. More research has been undertaken in water and chemical requirements and carbon footprint a fibre imposes on the planet from cradle to gate but an analysis on the connection of fibre with the land as a resource in association with livestock has not been examined in so far as the author is aware.

Sheep have been a key animal in the history of farming and have a deeply entrenched place in human culture. They were one of the first animals to be domesticated along with man's best friend the dogs they were easily trained and formed an animal companion and sheep as they have a natural herding instinct and could be easily managed in groups. This was particularly useful when man started to move from being a hunter-gatherer and nomadic to a more pastoral lifestyle and more settled agrarian society groups.

Wool out sheepskin has been used in different arenas for its distinct properties. It absorbs perspiration and enables skin to breathe; provides pressure relief, has excellent insulating properties, is hypoallergenic, is resistant to flame and static electricity. For these reasons it has long been used for interiors, the automotive industry, aviation, health and well-being and also as a fashion material.
'The Wool fibre is able to absorb moisture of up to 35% of its weight without feeling wet. The exterior cells of wool have a waxy coating, making it water repellent, but microscopic pores allow water vapour to pass through into the inner core where it is absorbed. This buffer zone is key to the comfort of a garment: as the wool absorbs

the moisture it produces heat, so that the moisture is passed through the outer fabric as vapour. Perspiration can be absorbed until it is transported through the outer layer thus keeping the wearer's skin drier and hence warmer.' (Kitchman and Morehead)
The structure of the inner cells also gives the wool its flexibility and crimp allowing the fibres to trap insulating air.



http://imgarcade.com/1/wool-fibers/

The softness and fineness of the wool fibre is measured on the Bradford wool count. The lower the count the coarser the wool. Wool for clothing starts with medium grades that are not normally lower than 46 on the Bradford wool count or 37 microns. The qualities of high spring recovery, resilience, of wool fibre and water vapour management in sheepskin have made sheepskin a material of choice for medical, automotive and aeronautical use. Those who are lying or sitting for long periods of time are prone to put stress on areas of the body that bear consistent weight and pressure when static and in one position for any length of time. These pressure points can cause pain and sores on the skin and around bone areas that bear weight. Using medical sheepskin relieves the pressure and helps individuals maintain steady body temperature. These same qualities make sheepskin a tactile immersive fabrication to wear around the body in "fashion" garments. I put fashion in quotations here as many garments made in sheepskin are kept and maintained over a longer period of time from the nominal fashion cycle. This is partly due to the comfort qualities of real sheepskin and partly due to the investment costs of owning such garments and products.

Sheep have played a crucial role in the development of the British economy over the centuries providing food and clothing and wool was the significant export of the British economy in the 12th and 13th Century. Wool was also pivotal in the industrial revolution. The role of sheep in society changed during the proto-industrial revolution from being the Golden Fleece, the prized wool exported to European mills for great profit to that of meat production. Britain had several key advantages in the early stages of the industrial revolution. England was a wealthy country due to its trade networks and exports, wool being the most significant. England's agriculture was three times as profitable as the Continent. Her financial and capital flow were equally as successful enabling investment in the new inventions that were to happen in the industrial revolution. There was gradual move away from the cottage industries to organized labour and mechanical production and from rural life to towns. Sheep played an important role in industrial revolution gradual changes made through mechanization and the inefficiency of craft skills in proto-industrialisation, the rise of cotton fibre that suited the new textile machinery and the need to produce more meat for an increasing population. The role of sheep changed in the UK from being the Golden Fleece to meat production. From the historic monastic flocks where land owning abbeys and monasteries governed the land and agriculture exchange of ideas in sheep farming and breeding through visiting European orders. To the development of new breeds and new style of farming bought about by individuals such as Robert Bakewell and Robert Ellman. Robert Bakewell was to be pivotal in establishing new methods of breeding sheep and gaining more meat from each animal. He created a new breed of sheep, the new Leicester's that had long hair, a larger carcass and importantly could survive efficiently in cold British climates. The Leicester pedigree livestock was an early maturing animal ready for market more quickly and therefore more profitable. Robert Ellman developed the short wool Southdown Sheep that was able to feed on heath land to similar acclaim. Both breeds still have impact on the unique sheep stratification system still used in the UK today.

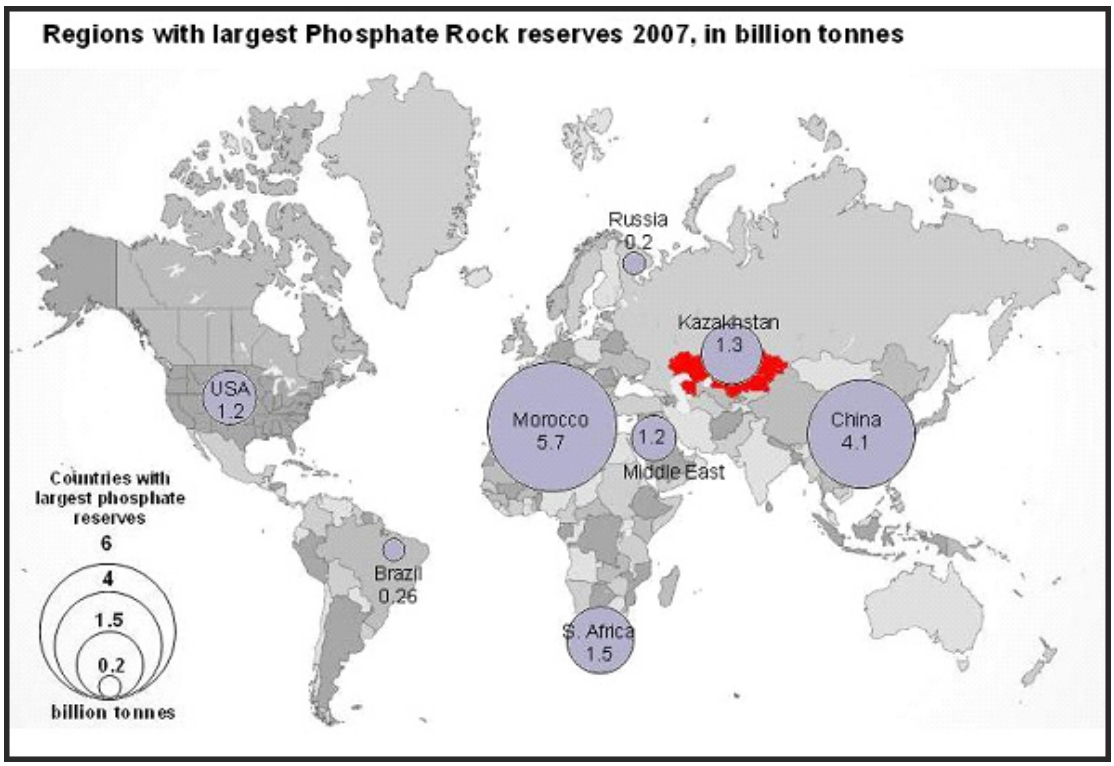
It was from the agrarian, to industrial society and now the technological society we now face that Alivin Toffler named the 'Third Age'. An age, Toffler argues, when we will need to develop a different mind set to consider our future selves and the planet. Part of that future is reappraising our natural resources and our relationship with nature.

Alvin Toffler in his book the Third Wave written in 1980 talks about our mental and physical transitions from being an agrarian culture, First Wave to being an Industrial culture, Second Wave. He observes the psychologies and human codes that aided this transition and forecast our intransigence in moving from Second Wave industrialisation to the Third Wave society that embraces technology, and the micro, and explores amongst other advances the use of science to bioengineer new products. Toffler talks of Techno rebels and parallels these rebels with those from the First Wave when industrialisation took hold.
'The basic questions asked of new technologies during the past 300 years, in both capitalist and socialist nations, have been simple: do they contribute to economic gain or military clout? These twin criteria are clearly no longer adequate. New Technologies will have to pass far stiffer tests – ecological and social as well as economic and strategic.'

Toffler talks at length on issues of ecology, energy and new types of production. His main thrust is that we must rethink from the bottom up how we wish to live in the future and make considered choices in the technologies and resources we use now and for our future selves. He parallels the use of the mechanical clock as aiding Second Wave citizens into factory life and how the notion of a physical mechanical clock, a product of industrialisation itself, ordered society from rural notions of rising with the sun and bedding when the darkness fell, to keeping time with the machines of production. Toffler values the techno rebels as providing the basis of humanising technological thrust and asking the right questions in how we progress our future. 'At its heart we will find a fusion of sophisticated, science based "high stream" industries, operating within much tightened ecological and social controls, with equally sophisticated "low Stream" industries that operate on a smaller, more human scale, both based on principles radically different from those which governed the Second wave Techno-sphere. We are transforming our own psyches through the info-sphere. We are forced to continually revise our image file at a faster and faster rate.'

The low stream, human scale, is part of this research into how we use our land in this change to a more technological world. How do we synthesise new technological and farming advances on the large scale and still make space for the small, innovative and retro intelligence to proceed in the future. To think through philosophical and causal effects of how we engage with and integrate new and old thinking on farming in both arable and livestock production. How we use land is becoming a critical factor in what we produce, whether that is meat, fibres or crops for food or biomass for energy. Not all land qualities or climates can support every type of produce and some land will have *'one'* optimum use. Increasingly we will have to make choices in how our land is used and these choices will have political, social and economic impact. How we select crop and land use will be exacerbated by the rising impact of peak oil and peak phosphates. Our synthetic fibres are produced from oil and our crops for food and plant fibres need phosphates in the form of fertilizers to aid successful yield. Both are in limited supply.

Peak Oil is an event in time when the maximum rate of extraction of petroleum is reached and is the theory of M. King Hubbert. After this proposed event in time, oil reserves will be in terminal decline. The date of when this event should occur is in dispute but many feel that since we know oil reserves are limited we should plan for alternative uses in energy and material use. Oil is used in its many guises in fabrics such as polyester, nylon plastics and other complex synthetic fibres. Peak oil relates to the point of maximum production and depletion to the period after when reserves and supply fall away.
This theory has been abstracted and applied to other key chemicals and minerals and in particular Peak Phosphates.
Professor Petter Jensen UMB (Norwegian University of Life Sciences) and Dr Danna Cordell view peak phosphate as a more critical debate than peak oil in understanding and managing world resources especially in relation to food production and food security for our immediate and long-term futures. There is no substitute for peak phosphate but there are possible alternatives to peak oil.



http://www.sunkarresources.com/en/pages/fertilizer_industry

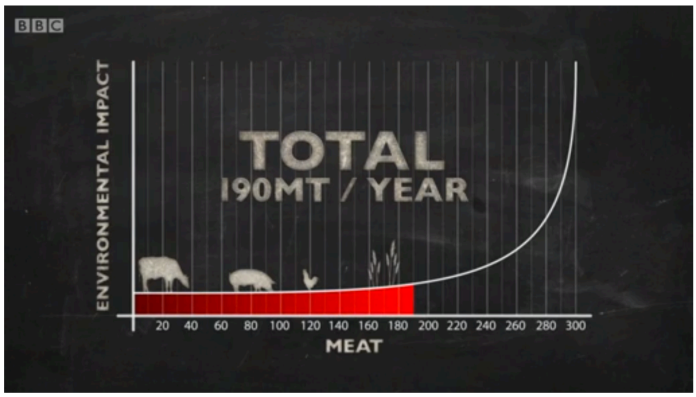
Phosphorous is a critical part of our DNA and is used for energy storage and metabolism, for proper muscle and nerve function and maintaining healthy bones. Phosphates are a key nutrient for living matter to grow and develop and are thus a key chemical and compound with nitrogen and potassium in fertilizers that assist crop production and increase yields.

There are key areas in the world where phosphates are mined with Morocco and China having the greatest reserves.

Estimates of when peak phosphate is depleted range from 20 – 35 years. Different groups with differing political agendas contest the dates cited for both peak oil and peak phosphates.
Arguments abound in whether to increase and maximize on extensive farming or move back to more organic natural farming methods. In the past decades we have used fertilizers containing metals and phosphates to gain greater yields from our crops. Excess phosphates not taken by the plants leach into our waterways. We eat meat, dairy and plants. The excess phosphates we do not use in our bodies is excreted and discarded through the sewage system. Again these phosphates can build up in our rivers and waterways destroying the ecological balance. The arguments and solutions in this domain are complex where stakeholders such as scientists, politicians and farmers try to interpret data to make positive decisions and policies that help evolve the economy, farming and public health as well as leading to sustainable outcomes. Parts of these discussions revolve around the production of meat, the carbon and methane emissions of livestock and the growing world populations demand for meat protein. Meat protein forms an integral part of our diet from which we can readily access micronutrient that are more difficult to obtain

through plant food. How much meat we eat and from which source has health implications
Should we eat less rich dairy and meat diets with higher phosphate content? Should we retrieve phosphates from domestic sewage as Professor Petter Jensen proposes?
Should we, as Simon Fairlie suggests, look at traditional methods of crop rotation and Leys where nitrogen-fixing plants such as clover and peas add nutrients to the soil?
My main thrust of exploring phosphates in relation to sheepskin and wool is that we have geo political, social and economic choices in the future in how we use land and fertilizers not only for food production but also for biomass and fibre production. Food security and food sovereignty are of great concern in a world with a growing population. In 2007 food riots occurred in Italy and other countries where biomass had diverted land traditionally used for durum wheat crops. How we decide on a local and global level what to grow in the future will be important and affect different populations in varying ways. Price might be the tool to differentiate - or political will. What fibres and materials will we be willing to produce not only in relation to chemical, water and energy consumption as the Brown and Wilmanns Environmental Materials Sustainability Index and the Stockholm Environment Institute explore but also in relation to land use. Sheep are intertwined in this choice of land use as part of protein (meat consumption), fibre, sheepskin, milk and manure. In the UK Simon Fairlie states in Land Magazine that there are optimum uses for different landmasses. The barren hills and upland spaces of the British, Scottish and Welsh hills with rugged terrain make arable farming on this land difficult. He argues that in these areas it would be prudent to use ruminants, the sheep being the most adaptable and agile, which can convert rough grasses and brackens into valuable protein. There is a tipping point when using land for livestock becomes undesirable. Fairlie indicates this tipping point is when we allocate land to grow crops to feed for livestock instead of crops for human consumption.

Fairlie's 'hockeystick' graph shows that consuming just less than 40 kilos of meat a year could be sustainable if we use our land resources wisely and graze animals on non-arable land where only grass and leaves can be grown. At present we are consuming nearly 80 kilos of meat a year. He argues that 85% of non-arable land fodder enters livestock to be excreted and used as manure - a valuable nutrient for the land and ruminant livestock's "greatest talent and resource we can use".



Horizon - 2014-2015 2. Should I Eat Meat - How t…

by Scott Kilgour

+ Follow 23

596 views

Share 47 Tweet 3

Simon Fairlie - BBC Horizon 2014 Should I eat meat – How to feed the planet.

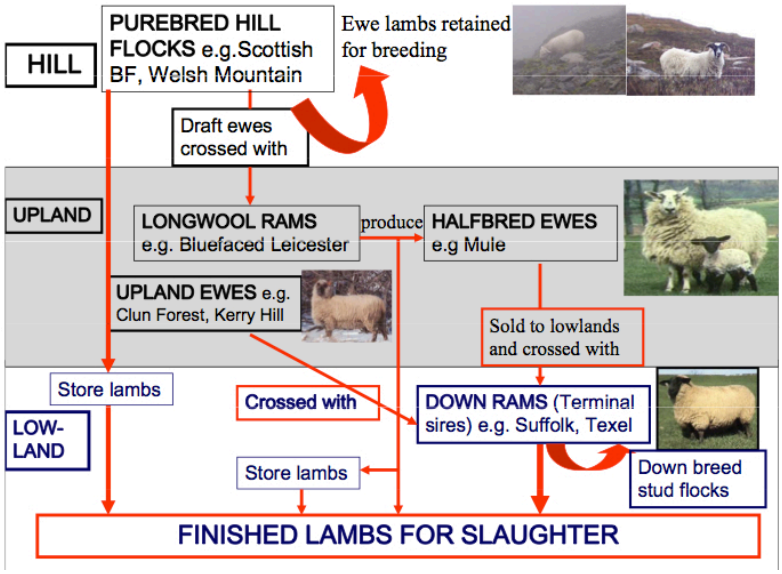
Land use in 21st century?

The initial hypothesis in exploring the potential for sustainable 'wool out' sheepskin was that sheep required minimal intervention in add-on costs in terms of food and healthcare. This is true in part but a more complex picture emerges when exploring different breeds and their attributes. Differing breeds have evolved through farming and creative husbandry to benefit the needs of the market through history. This work explores how different land qualities and sheep breeds work in a symbiotic partnership. How breed varieties not only give different wool, fleece and qualities but also variety in 'wool out' sheepskin.

"In the UK the national flock of around 35m sheep (rising to 43m at the peak of summer of which 21m are breeding ewes) there are 70 pure breeds and 12 recognised crosses adapted to climate and topography and are grouped into 3 main types – short wool and down; long wool and lustre; mountain and hill.
Between them they constitute a genetic library of innumerable cross breeding over centuries of farming, to arrive at ideal fitness for purpose – prolificacy, carcass, conformation, fleece length/weight/Bradford count, milkyness, growth rate, birth weight/ vitality, hardiness, mothering instinct, temperament, disease resistance – and turned into a science by the 18th century pioneering work of Robert Bakewell with the Dishley Leicester – the dolly sheep of the day."
http://www.realsheepskin.org.uk/downloads/sheep_industry_report_m.pdf

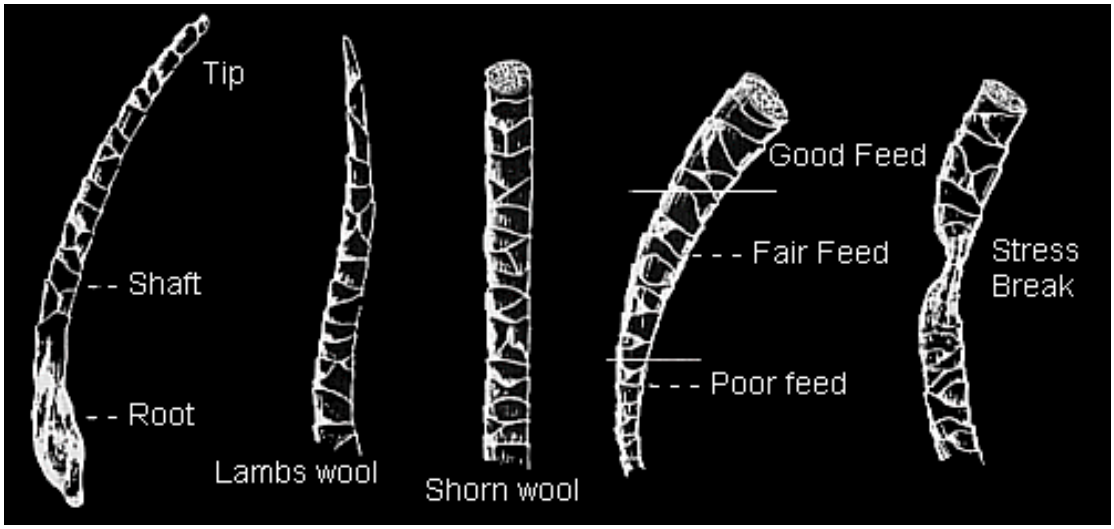
This cross breeding has proliferated from this time where farmers across the UK use the sheep stratification system with particular breeds grazing in environments to which they are adapted. The Hill breeds of sheep such as the Welsh Mountain, Scottish Blackface, Swaledale, Rough Fell and Hill Cheviot are hardy breeds. They are easy care management, can self replicate, survive on in areas where the land has not been improved and live off heathers and bracken when no grass is available. They deposit layers of fat when food is abundant ready for harsh winters. They normally produce one lamb that matures and grows late. The ewes have strong mothering instincts, a trait prized in flock management.

These breeds are then crossed with Upland sheep or long wool sheep such as the Border Leicester, Blue faced Leicester, Teeswater or Lincoln long wool. Typically these breeds are fast growing, have a large carcass, milky and are prolific having two or more lambs per gestation. The cross of mixing a Swaledale with a Blue faced Leicester is typically called a Mule or half bred. These animals are typically good mothers and the ewes are kept for further breeding with a terminal sire. The males are sold as store lambs.
The Mules are then crossed with a terminal sire such as a Suffolk, Texel or Charollais. These Lowland Breeds have good carcass characteristics and are fast growing and large. Increasingly farmers are using the Texel as a terminal Sire because of its double muscle hindquarter on the carcass adding additional value and profit.



http://bvetmed1.blogspot.co.uk/2013/03/sheep-1-production-and-reproduction.html

In each animal a different wool-skin is produced. The qualities of the wool and the skin combined are dependent on many details but primarily the breed and the wool characteristics. Down breeds of sheep can only be tanned to best effect if they are slaughtered in the year they are born and best before the middle of October. Beyond this time frame the lamb starts to grow its second fleece under its first and wool leakage of the first fleece may occur during the tanning process leaving a skin that has bald patches. Hill breeds should be slaughtered by the first week of November. Tanning is a seasonal trade, however skins can be kept if well salted for up to six months in some cases, easing the flow of production in tanning. The environment the sheep has been exposed to and the level of nutrition also impacts on the skin and wool quality. If a sheep is exposed to harsh climate, has suffered injury in gestation or after they may ‘leak’ wool fibre from their skin. The diagram below shows how the fibre can suffer under these conditions. Young lambs' wool is prized in wool-skin and as shorn fleece as it retains the tip, the soft fine end of the shaft.



http://whrhs-forensic-chem-spring-2010.wikispaces.com/Fiber+Analysis

The skin quality also varies in quality and is affected by breed and age of the animal. Hill breeds such as the Herdwick sheep put on weight in the spring and summer months when the pastures are sweet storing fat ready for the inclement weather of the winter. The sheep loses weight through the winter and its skin retracts back. Putting on and losing weight affects the skin thickness and resilience. Creases from weight gain and loss are evident around the back of the neck and other areas where the sheep's body bends and flexes. These crease lines are evident in a finished tanned skin that the designer for interiors or garment production needs to work around. The most pliable skin for use in design for garments are the younger animals.

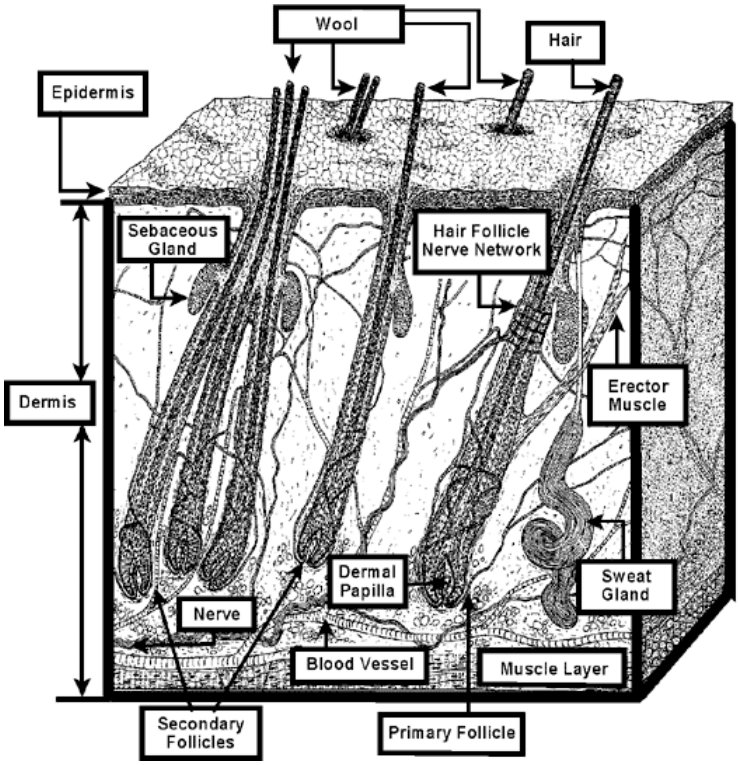
Injury and disease can affect the skin in different ways, from the scarring of barbed wire to that of healing skin after infections and infestations such as fly strike. Depending on the length of the fleece and size of the injury many of these scar marks can go unnoticed and used as first quality skins. Deep scarring may cause a weakness and possibly cause the skin to tear. Expert cutters will avoid and plan how to work around these areas.

The curl, staple length, colouring of the wool as in normal wool qualities of a fleece are the same as a wool-skin. However the way the wool is embedded into the collagen and upper epidermis of the skin can make the wool appear different and in itself offer other aspects such as spring and resilience, which is shown in how densely the fibres are packed together and how many follicles there are per square millimeter. The chart below from "info vet" illustrates the difference between breeds.

Breed	**No. of Follicles/mm^2 (Primary and secondary)**	**Number of Primary Follicles/mm^2**	**S:PRatio**
Fine Merino	71.7	3.56	19.1
Medium Merino	64.4	2.93	21.0
Strong Merino	57.1	3.27	16.5
Corriedale	28.7	2.43	10.8
Southdown	27.8	3.9	6.3
Dorset	18.5	2.9	5.4
Suffolk	20.4	3.5	4.8
Romney	22.0	3.4	5.5

Border Leicester	15.8	2.9	4.4
Lincoln	14.6	2.3	5.4
Cheviot	14.6	2.7	4.5
Wiltshire	11.4	2.6	3.3

The image illustrates the skin construction and why sheepskin has unique properties that are more than the sheep, leather and fleece but offer a different material substrate.



http://www.infovets.com/books/smrm/A/A965.htm

The Wensleydale breed and other curled wool sheep such as the Gotland and Lincoln Long Wool do not make easy tanning as they lose wool in the process. Each tanner indicated the same problem from different companies and each stated there was a short window of opportunity to tan these skins effectively.

Wool-skin tanning has waned in the UK over the last 3 decades as China has increased its capacity to tan skins on a large industrial scale importing wet skins from Australia, Argentina and UK. Devonia is the last wool-skin tannery of scale in Britain using traditional crafts and knowledge in the tanning processes. Wool-skin tanning is not an odorous process as some believe as no chemicals are used to 'de-hair' the skin. Each stage of producing a cured skin is a craft from salting, soaking, fleshing, washing, pickling, tanning, drying, recovery of lanolin, buffing and carding, to ironing and finishing. There is respect for each skin at each stage of the process as the farmer has for the live animal in his/her care. This respect goes beyond the understanding of cost implications for damaging the skins.
Tanning does require a relatively high use of water for cleaning and as a carrier for the tanning agents. Traditionally tanneries have been located near rivers in Britain. This paper does not look at the water, energy or carbon footprint. Others have looked at some of these issues but currently the author cannot find data regarding

wool-skin tanning which has fewer processes than de-haired skin. This research looks at where each stage of value occurs and how the end product of sheepskin from the animal and the associations the animal has with the land and other inter relating aspects.
There is one organic Sheepskin tannery in Herefordshire run by Nicki Port. The company is the first tannery to be given organic status by Biodynamic Agricultural Association. She uses Mimosa extract from plantation grown trees in South Africa. These trees are grown as a renewable crop specifically for the tanning trade. Tannin from vegetable origin is environmentally friendly as it is biodegradable. The grey water is fed into their reed bed that cleans the water and supports it's own eco system.

The plants 'Phragmites Australis' reeds have three functions. Firstly, extensive root systems create channels for the wastewater to pass through. Secondly, the roots introduce oxygen down into the body of the soil and provide an environment where aerobic bacteria can thrive. These organisms are necessary to break down many types of compound, in particular the oxidation of ammonia to nitrate. Ammonia can be found in high concentrations in sewage and other nutrient-rich wastes. Finally, the plants themselves take up a certain amount of nutrients from the wastewater, which acts as a natural fertilizer. Microbes are the most important part of the process. These bacteria and fungi can use organic pollutants as a food source, degrading a wide range of organic chemical products and turning them into harmless components.

Eco Profiling of textiles in relation to water carbon and other chemical pollutants has been investigated by differing commercial and academic organisations such as the Stockholm Environment Institute and Sustainable Apparel Coalition (SAC). 'The MSI is a cradle-to-gate index informed by life cycle assessment (LCA) derived inventory data to engage designers and the global supply chain of apparel and footwear products in environmental sustainability.' Currently the MSI measures Chemistry, Energy and GHG Intensity, Water and Land Use Intensity, and Physical Waste. Whereas these reports do take into account aspects of land use they by no means look at the prospect of how smaller niche materials and farming can add value and diversity to material understanding and utility. There are many in commercial industry that take advantage of young designers lack of judicious inquiry and purport that a fibre and fabric is sustainable. A fibre may have sustainable aspects in how it is grown and cultivated but not necessarily in its processing and transformation into a fabric. These large fibre and fabric industries are at present a large part of many peoples livelihoods, as with the manufacturing of mass-produced clothing. Each decision in fibre and materials use will have an ecological and ethical impact and also social and geo-political impact. Cotton has different effects and impact on world land and chemical use as discussed earlier in how we use phosphates and fertilizers.
Polyesters have a high cost in extraction of oil, processing and release of toxic gasses from production. However these are the fibres that also give us amazing flexibility of use in stretch yarns such as spandex and lycra that when used wisely can enable beneficial use in lifestyle and health care garments. Wool in itself has pollutant problems in its processing with scouring and use of chemicals in sheep dipping and is not the panacea.

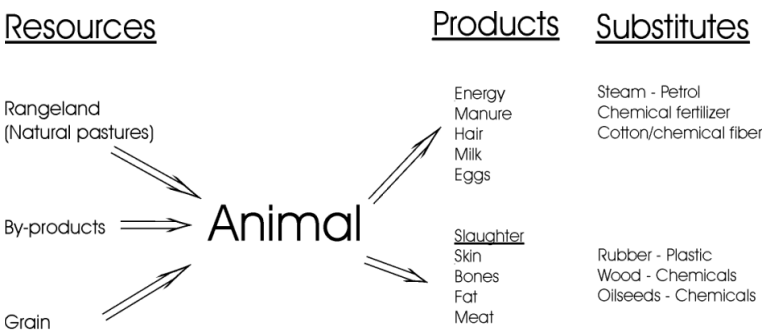


Figure 1. Nature of animal husbandry

Boutonnet, J.P. INRA/ESR, 2, place Viala, 34060 Montpellier Cedex 1, France

It is the ‘wool out’ sheepskin that interests me as a designer and the challenges and opportunities it offers in fabric handle. It is part of a physical dialogue in the design process that explores the differing breeds and varieties of sheepskin in respect to constraint, flow, drape, volume, tactility, lustre and the somatic presence of how the user will feel the differing surfaces when using the garment.
When the garment or medical sheepskin no longer meets the required needs for the user it can be safely disposed of on the land to naturally decay and provide further nutrients to the soil. This is particularly so of organically tanned skins as animal protein gives a slow release source of nitrogen, a virtuous circle.

Discussion
This study looks at one vertical chain of production Sheep, exploring the impact of land use, husbandry, some aspects of processing, quality of materials from livestock that by its very nature is not standardized as are chemical fibres.. In relation to a growing concern of how other fibres and materials are made and produced it is by no means a complete picture but indicates how we might reexamine the local within a global context where small has economic value in a milieu of large petrochemical and mass-produced goods. We have trodden the silk-road and stretched out our hand and invited new practices in material production and moved from the local to the global and realised cultural difference and made changes to realising the local. Are we moving to a new paradigm where economic costs, slow growth and rising diaspora force us to be more creative and pragmatic at looking at old techniques in material production and new ways of consuming fashion and buying less? Can re-looking at how we value our farming intelligence bring about new breeds in sheep that give a wider array of valued products? Will the new Swiss sheep the Black Nose sheep recently imported to Scotland and Devon bring about changes in breeding and livestock for a different future. Can the rare breed the white faced Woodland be used more for its ability to survive wilder pastures like the Herdwick but give soft wool as the Spanish merino and as choice meat as the Texel?
As Toffler indicates do we need to develop a new mind set in how we educate, use and share knowledge, food and materials in the Third Wave? What should that mind set look like?

Key words: Wool Out Sheepskin, Sheep, Sustainability, Land Use, Design

Image References

Figure.1 http://imgarcade.com/1/wool-fibers/

Figure.2 http://www.sunkarresources.com/en/pages/fertilizer_industry

Figure.3 http://www.dailymotion.com/video/x24c9mg_bbc-horizon-2014-should-i-eat-meat-how-to-feed-the-planet_lifestyle Accessed 6.11.2014
BBC Horizon 2014 Should I eat meat – how to feed the planet.

Figure.4 http://bvetmed1.blogspot.co.uk/2013/03/sheep-1-production-and-reproduction.html

Figure.5 http://whrhs-forensic-chem-spring-2010.wikispaces.com/Fiber+Analysis

Figure.6 http://www.infovets.com/books/smrm/A/A965.htm

Figure.7 http://www.infovets.com/books/smrm/A/A965.htm

Bibliography

BBC Horizon 2014 Should I eat meat – how to feed the planet. http://www.dailymotion.com/video/x24c9mg_bbc-horizon-2014-should-i-eat-meat-how-to-feed-the-planet_lifestyle Accessed 6.11.2014

Beadie, N. (2014) *Education and the Creation of Capital in the Early American Republic*. Cambridge University Press.

Boutonnet, J.P. 1999. Achieving Economical Sustainability in Sheep and Goat Husbandry: A question of Markets and Land Use. INRA/ESR, France.

Brown and Wilmanns Environmental Materials Sustainability Index MSI. BWE Accessed 6.11.2014

BWE MSI Handbook. http://static.squarespace.com/static/5050bf2ee4b03f467b8fe9ff/t/52aa2013e4b0ac8cd8b083a8/1386881043481/BWE_MSI_Handbook_5pgs.pdf Accessed 6.11.2014

Ecological Footprint and Water Analysis of Cotton, Hemp and Polyester. Cherrit,N. Barrett,J. Clemett,A. Chadwick,M. Chadwick,M.J. http://www.sei-international.org/mediamanager/documents/Publications/SEI-Report-EcologicalFootprintAndWaterAnalysisOfCottonHempAndPolyester-2005.pdf Accessed 6.11.2014

Fairlie.S. (2007-2008) *Can Britain Feed Itself*. Issue 4. The Land an occasional magazine about land rights. http://www.thelandmagazine.org.uk/articles/can-britain-feed-itself Accessed 6.11.2014

Kitchman.F, Morehead.S. (2013) A Sheep in Synthetic Wolf's Clothing: Creating a Hybrid of Natural and Man-Made Materials to Combine Protection and Aesthetics in a Cold Climate. Praxis and Poetics.

Meat South West for the South west of England Regional Development Authority (SWARDA) (2006).The Great Sheep industry and its Juicy Fifth Quarter. http://www.realsheepskin.org.uk/downloads/sheep_industry_report_m.pdf Accessed 6.11.2014

Montossi,F. Font-i-Furnols,M. del Campo,R. San Julián,G. Brito,C. Sañudo. (2013) *Sustainable sheep production and consumer preference trends: Compatibilities, contradictions, and unresolved dilemmas.* The official journal of the American Meat Science Association. Meat Science 95 (2013) 772–789

Natural Fibre Symposium. http://www.commonfund.org/uploads/tx_cfc/CFC_Natural_Fibre_SymposiumPart_II.pdf Accessed 6.11.2014

Organic Sheepskins http://www.organicsheepskins.com/index.php/information-tanning_service/?k=19799:6

Pollott, G.E. Stone, D.G. (2003) The breeding structure of the British sheep industry Defra

Sheep Industry. http://www.ukagriculture.com/livestock/sheep_industry.cfm Accessed 6.11.2014

Soil Association Organic Standard. *Reed Beds-a brief guide.* Fact sheet 2006 http://www.soilassociation.org/LinkClick.aspx?fileticket=e%2FOUEgT%2FUsI%3D&tabid=151 Accessed 6.11.2014

Toffler,A. (1989) Third Wave. Bantam Books

Wool History. http://en.wikipedia.org/wiki/Wool#History Accessed 6.11.2014