Shear Destruction: Wool, Fashion and the Biodiversity Crisis

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A report by the Center for Biological Diversity and Collective Fashion Justice's CIRCUMFAUNA Initiative

Introduction

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Note: this document was updated in 2023 to remove a few small references to the Higg Material Sustainability Index which is now considered controversial as a reliable source.

Wool is a mass-market commodity that operates stealthily under many layers of mythology, from legends of the golden fleece to bucolic images of sheep peacefully grazing in open pastures. Aesthetics often prevail over the hidden reality of wool production, both in the way we view pastures and in the visual and tactile world of fashion.[1] But wool is not a fiber simply provided by nature — it is a scaled product of modern industrial, chemical, ecological and genetic intervention that's a significant contributor to the climate crisis, land degradation, water use, pollution and biodiversity loss.

While the environmental impacts of the meat industry have gained significant attention, the role of farmed animals used in the fashion industry has not. Even in contexts where sustainability is a central focus, farmed animal "production" is often omitted from the conversation or, worse, greenwashed.[2-3]

Farmed animals and their feed are responsible for 16.5% of greenhouse gas emissions and consume almost one third of all fresh water.[4-5] Animal agriculture is a leading cause of water pollution and habitat destruction, which in turn is the leading cause of species extinction.[6-8] Yet a primary animal product like wool, the leading global source of animal fiber, has evaded data-driven critique in and out of critical fashion discourse.

Despite industry claims of sustainability, there is no centralized data to track, report or evaluate the impact of wool on land, water, climate and biodiversity. For this report, we looked at available data from the Food and Agriculture Organization (FAO), Australian and U.S. government agency reports, industry sources and scientific papers to evaluate the environmental impact of wool.

Wool by the Numbers

In 2019 global wool production represented 1.1% of the total fibers produced globally, at 1.148 million kilograms from a herd of 1.177 billion sheep.[9] From 2018 to 2019 the global total of sheep increased by 30 million.[10] This is the most sheep reported globally since the United Nations FAO began documenting in 1961. The 10 top producers of wool globally are Australia (25% at ~478,492 metric tons), China (18% at ~235,927 metric tons), the United States (17% at ~150,873 metric tons), New Zealand (11% at ~102,457 metric tons), Argentina (3% at ~88,897 metric tons), Turkey (2% at ~74,294 metric tons), Iran (2% at ~56,990 metric tons), the United Kingdom (2% at ~49,623 metric tons), India (2% at ~31,783 metric tons), and Sudan (2% at ~20,739 metric tons).[11-12]

China is responsible for importing almost 50% of the global wool supply and exporting a whopping 37% of all woven wool clothing and wool knitwear in the world. In 2018 the United States led global imports of woven wool clothing at 18%, followed by Japan (10%), Germany (8%) and the United Kingdom (7%).

When it comes to the top countries that consume wool at retail, they are: China, United States, Japan, Italy, Germany, South Korea, UK and France, which together represent 65% of world consumption of apparel wool.[13] The five major types of wool apparel that drive the market are women's overcoats (26.8%), men's trousers (15.6%), men's suits (15%), men's jackets (14.6%), and men's overcoats (14.5%).[14] Globally, wool is valued at U.S. $4.72bn, while sheep meat is valued at U.S. $6.7bn.[12, 15]

The wool industry has successfully promoted a false perception of fabric made from sheep hair as natural, traditional and sustainable. Woolmark, an organization representing 60,000 Australian wool growers, calls wool "a friend to the environment."[16] In 2020 the prince of Wales (a patron of The Campaign For Wool) stated that "wool's sustainable and biodegradable properties provide a unique natural option for us all to reassess for environmental values and purchases."[17] But the reality of this global industry is much darker.

Before shearing, sheep must be selectively bred, raised, fed, watered, treated, tracked and measured. Contrary to popular belief, they don't simply live out their lives in pastures, occasionally shorn until they die of old age. As discussed later in this report, wool is a slaughter industry working hand-in-hand with the meat industry. And after shearing, wool must be heavily processed before it can be used as fabric. Wool clothing comes with a heavy price tag of greenhouse gas emissions, land use, biodiversity loss and pollution. Compared to other materials used in similar types of knitwear, thermal layers, and suits, the climate cost of sheep's wool is 3 times greater than acrylic and more than 5 times greater than conventionally grown cotton.[18]

Moving away from wool toward materials that are better for the planet and biodiversity can help companies meet the growing consumer demand for more environmentally responsible products. Positive consumer attitudes toward innovative and sustainable fabrics are surging. A 2020 McKinsey survey about sustainability in fashion found that two thirds of respondents believe it's important for the fashion industry to limit impacts on climate change, and 88% believe the industry should pay more attention to reducing pollution.[18]

In 2020 biodiversity was named "the next frontier in sustainable fashion," but an honest conversation about sustainability, circularity and ethics in fashion is impossible without confronting the impacts of wool on wildlife and the environment.[19] In this report we cut through industry-funded mythology using data to assess the ecological impacts of wool throughout the supply chain from grazing to scouring. We'll also discuss the way forward for the fashion industry with truly sustainable materials that allow nature to flourish.

This report refers to Australia and the United States when talking about geographical impacts of the wool industry for consistency with the data and policies referenced throughout. However, we recognize that these are occupied territories of Aboriginal and Indigenous peoples who have stewarded these lands for generations and that sovereignty was never ceded.

Environmental Impacts of Wool Production

Climate Change

The climate crisis is an existential emergency for public health and safety, economic and racial justice, global stability and security, and biodiversity. If we don't dramatically reduce greenhouse gas emissions, more than a third of the world's plant and animal species could face extinction by 2050.[1] The devastating effects of the climate crisis on ecosystems are accelerating, increasing threats to wildlife as well as to public health and safety, economic and racial justice, global stability and food security.[2-3]

Animal agriculture is responsible for 16.5% of global greenhouse gas emissions, with the majority of those emissions coming from ruminants like sheep and cattle.[4-5] Feed production and land conversion for grazing are important sources of greenhouse gases, but nearly half of the sector's emissions come from methane, with more than 90% of that methane attributed to ruminants.[5] Animal agriculture

Small ruminants, including sheep and goats, are responsible for 474 million metric tons of CO2e each year, the equivalent of taking 103 million cars off the road for a year — that's more than 5 times the number of cars registered in Australia.[5, 8-9.]

is one of the two largest sources of anthropogenic methane in the world, virtually on par with fossil fuels.[6] Methane is a potent, short-lived greenhouse gas with 86 times the impact of carbon dioxide over a 20-year period. Since methane only stays in the atmosphere for about 12 years, reducing it is a powerful and necessary means of addressing the urgent climate crisis.[7]

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The discussion of emissions associated with animal farming are often food-specific, and

exclude accountability required from the fashion industry. However, especially in the case of sheep rearing, this is a mistake, since the sheep industry relies on wool and likely could not exist without the fashion industry. Thus, the greenhouse gas emissions associated with sheep production are also the responsibility of those who produce and use wool in their products.

The greenhouse gas emissions associated with wool vary between production systems, based on the breed of sheep and how long they are alive before being slaughtered for meat. According to CSIRO (Australia's national science agency) one kilogram of unprocessed, or "greasy," wool from "prime lamb" meat production exploiting young animals is equal to 8.9kg of CO2e, whereas one kilogram of greasy merino fine wool from a sheep who is alive and regularly shorn for a longer period is equal to 30.6kg of CO2e.[10] Another study based in Australia's greatest wool-producing state, New South Wales, documents a kilogram of greasy wool from a farm producing both meat and wool to be equal to 24.9kg of CO2e.[11]

Although the emissions vary, even lower-impact wool is a significant contributor to the climate crisis.

Although the emissions vary, even lower-impact wool is a significant contributor to the climate crisis. At the low end of the range for Australian wool, producing one kilogram of greasy wool is equivalent to driving 22 miles. Producing one kilogram of greasy wool from merino sheep is equivalent to driving more than 75 miles.[8] Wool produced in the United States can be as high as 41kg CO2e per kilogram, which is equivalent to driving more than 100 miles.[12, 8] These are the emissions associated only with the weight of wool, not including additional wool processing, meat

One Australian merino wool sweater is responsible for 27 times more greenhouse gas emissions than an Australian cotton one. One lightweight knit made from the same Australian wool contributes 12.81 kilograms of CO2e, compared to about 476 grams of CO2e for the same knitwear made of Australian cotton.

production or other co-products, so sheep farming overall has an even greater impact on the climate than these numbers indicate.

It's important to note that these analyses are for wool in its raw form as it's shorn from sheep. Greasy wool is not what is knitted into sweaters or woven into materials sewn into suiting. The scouring process, which removes the grease and dirt from wool shorn off of sheep, is energy intensive and thus causes further greenhouse gas emissions. When we consider the conversion of greasy wool to clean, usable wool, the greenhouse gas emissions associated with our knitwear increase further.

According to the Australian Wool Exchange, only 68% of the weight of greasy wool is usable fiber for fashion use once it's been cleaned.[13] When that conversion rate is taken into account, one Australian merino wool sweater is responsible for 27 times more greenhouse gas emissions than an Australian cotton one. One lightweight knit made from the same Australian wool contributes 12.81 kilograms of CO2e, compared to about 476 grams of CO2e for the same knitwear made of Australian cotton. The difference is even greater when compared to wool produced in other systems, particularly in the "luxurious" fine wool systems.[10, 14]

Wool production's contribution to the climate crisis also creates risks for the industry itself. Rising temperatures reduce the quantity and quality of pasture available, increase disease transmission, and negatively affect the overall health of the animals, which would, in turn, affect the quality of wool.[15] Shifting from wool to materials with lower carbon footprints will improve the fashion industry's environmental responsibility and resilience in the face of the climate crisis.

The False Promise of "Regenerative" Wool

In response to the high carbon footprint associated with wool, claims of "carbon neutral," "carbon positive" and "regenerative" wool have been springing up. However, relying on sheep to sequester carbon in the soil fails to live up to its promise as a climate solution.

There is no evidence that carbon sequestration can be successful across diverse geographic ranges at current industry scale, or that it can fully offset the emissions created by the animals and the production of animal-based products.[16] Furthermore, the presence of sheep poses a serious threat to native wildlife and ecosystems, which is rarely addressed or measured by those claiming to produce environmentally beneficial wool.

Even if sheep could contribute to the storing of carbon in soil, after a few decades the land will reach soil-carbon equilibrium. At this point, no more carbon will be sequestered using these methods.[16] A more effective and long-term strategy for carbon sequestration would be rewilding, something that could take place during a just transition away from wool.[17]

Land Use

Habitat loss tied to land-use changes, including deforestation and land degradation, is the greatest threat to biodiversity.[1] As the largest cause of habitat loss, animal agriculture is driving the wildlife extinction crisis.[2] Rather than growing and developing materials and protein for direct use, animal products create an additional step in fashion and food supply chains as we grow crops and use land to feed animals, creating a very inefficient system. By cutting out this middleman, we could conserve land and other resources.[3]

The destruction of land-based ecosystems also causes enormous greenhouse gas emissions, with 22% of global emissions associated with agricultural land use, forestry and land clearing. Inversely, ecosystems such as native grasslands and forests are natural carbon sinks, absorbing the equivalent of about 22% of emissions globally — a number that could increase with conservation and rewilding.[4]

The wool industry uses 20% of agricultural land in Australia.[5-6]

Wool is a land-intensive fiber, with its production requiring far more land than many other materials. The wool industry uses 20% of agricultural land in Australia.[5-6]

Despite being significantly more land intensive than cotton, wool is significantly less productive. Collective Fashion Justice's CIRCUMFAUNA initiative calculated that a single bale of Australian wool requires 44.04 hectares of land to be kept cleared for production. In comparison, just 0.12 hectares is kept cleared to produce a single Australian cotton bale. Thus wool uses 367 times more land per bale compared to cotton. With about 84.4 million hectares less land cleared for production, the Australian cotton industry is capable of producing millions more bales of fiber without contributing so significantly to habitat loss.[7]

Today half of all habitable land on Earth is used for agriculture,

Wool uses 367 times more land per bale compared to cotton.

with 77% of this land being grazed by cattle, sheep and goats.[8] Both land clearing and grazing non-native animals leads to severe land degradation, including soil erosion and desertification, and devastating threats to wildlife as native animals are displaced and often ultimately killed by the loss of food, water and shelter. Not only does this have a significant impact on current biodiversity, but destroying healthy ecosystems diminishes our chances of restoring biodiversity.

In Australia, hard-hooved animals like sheep contribute to this land degradation and have since they were first introduced during British invasion.[9]

Transitioning away from animal agriculture, and in turn over time removing these animals from the land, is essential for land regeneration and revegetation. Wooleen Station, a large rangeland in Australia, once had tens of thousands of grazing sheep. After serious degradation of land and vegetation death, the Station sought permission to remove all animals from the land. It found that removing sheep and "destocking" the land resulted in important vegetation and land regeneration.[10] Even an Australian government program has recognized the benefits of "destocking."[11]

A similar story has played out in Patagonia, Argentina. During the 20th century, Argentina was the world's second largest wool producer. This intense ranching resulted in widespread desertification in Patagonia.[12] When officials at Patagonia Park decided to "destock" or remove sheep from the land, project biologists said that as they watched the "land heal" they were "impressed with the speed at which these grasslands have regained their vitality."[13]

Wool and Waterways

Wool production also has a significant negative impact on freshwater and marine habitats, from the enormous amount of water needed to raise sheep and produce wool, to the pollution that enters waterways. Sheep require large amounts of water to hydrate, and when economically beneficial, pastures are irrigated.[14-15] Grazing is commonly supplemented with other feed, like that fed to sheep being fattened up or "finished" on feedlots before slaughter.[16] Animal feed crops rely on chemical-intensive processes, driving demand for pesticides classified as highly hazardous for people, animals, and ecosystems.[17] All of that food is digested into phosphorus-rich fecal waste, which pollutes waterways, causing widespread water contamination that makes it toxic for human and nonhuman animals, and results in eutrophication and "dead zones" where aquatic life cannot survive.[18-20]

Biodiversity Loss

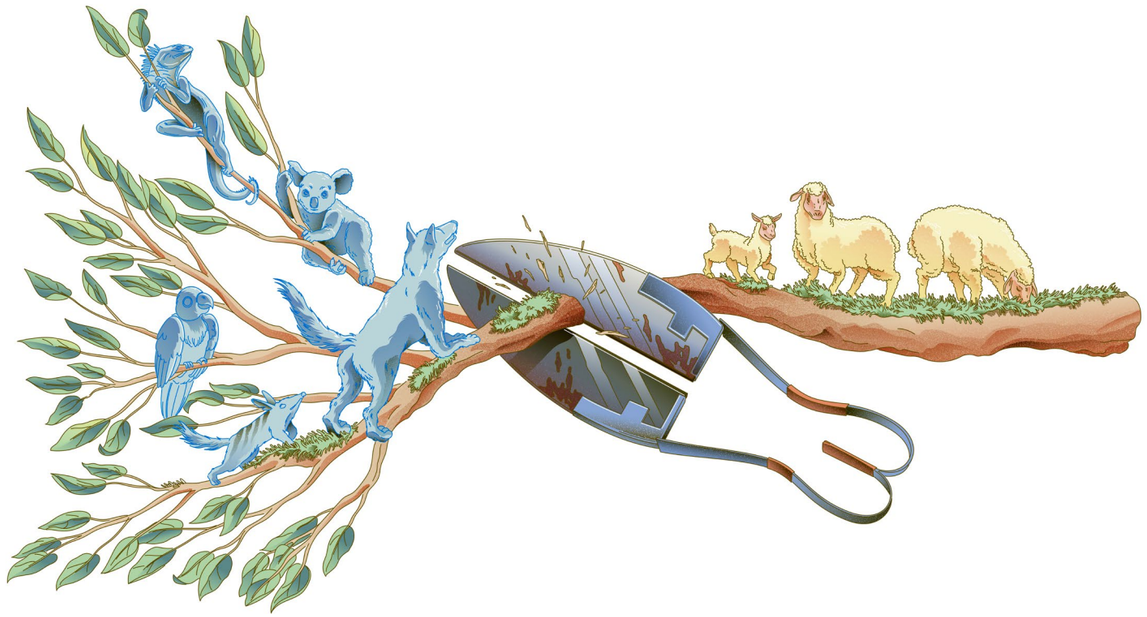
The wool industry's environmental impacts are more than just harms to the climate, land and water — they threaten healthy ecosystems and the survival of wild plants and animals. Domestic sheep are not a natural part of the environments where they're raised, as they're often portrayed to be, but rather an introduced species that puts native wildlife from wolves and koalas to birds and tortoises at risk.

The presence of sheep in natural environments is responsible for a wide range of harms to wildlife across different ecosystems. Grazing sheep trample vegetation and burrows, degrade habitat, and compete for forage. Fencing can provide raptor perches that increase predation on smaller species as well as promoting weed invasion (which can lead to habitat abandonment), habitat fragmentation, and injuries caused by collisions with fencing. And fear of conflicts with sheep can lead to the killing of animals like wolves and grizzly bears. It is estimated that 50 million native animals are killed each year in Queensland and New South Wales due to land clearing. More than 90% of deforestation in Queensland, Australia is caused by the conversion of Indigenous land to pasture for cattle and sheep industries — producing meat, skins and wool — causing significant habitat loss for native species such as Australia's iconic koalas.[1] There are 22.9 million sheep in Australia's primary wool-growing state of New South Wales alone, yet only, at most, about 30,000 koalas left.[2] Habitat destruction and deforestation are the major threat to koala populations, which fell by 42% in the decade leading up to 2010, and which may see koalas extinct in eastern Australia by 2050, according to WWF.[3]

Native bird species are also at risk due to land clearing in the sheep-wheat belt of Australia. In an Australian Parliament published paper, it was reported

that many once-common bird species in areas where sheep are known to over-graze are now in decline. The report stated that at least 20 species of previously common woodland birds were in decline in the New South Wales sheep-wheat belt at the time of the report. These include emus, hooded robins, speckled warblers, diamond firetails and crested bellbirds, to name a few. Some of these birds, like the hooded robin species, require plenty of fallen trees for their continued survival. This habitat requirement is at odds with the cleared pastures farmers tend to keep for grazing sheep flocks.[4]

Among all land bird species in the sheep-wheat belt, 85 species, or 35%, are identified in at least one study to be locally extinct, declining or otherwise at risk. This threat to avian populations caused primarily by agricultural clearing is largely associated with animal agriculture, as is the majority of land clearing in the country.[5]



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On desert public lands in the United States, illegal sheep bands trample desert tortoise burrows and compete directly for forage in the spring.[6] In mountain terrains, bighorn sheep are exposed to disease carried by domestic sheep, particularly pneumonia, which can devastate wild herds.[7] And rather than remove the source of disease, it has become common practice to kill bighorn sheep showing signs of illness to prevent further spread.

The U.S. Sheep Experiment Station in the Centennial Mountains is part of a government program that conducts research on behalf of the meat and wool industries. Prior to a 2021 ruling on a lawsuit brought by the Center for Biological Diversity and allies, sheep from the station were allowed to graze freely without considering the impacts on vulnerable wildlife including grizzly bears, bighorn sheep and greater sage grouse.[8] As a result, the grazing sheep created wildlife conflicts, spread deadly disease and degraded vital habitat.[9] There was even a suspected poaching of a grizzly bear near the station.[10] The sheep station also genetically isolated lynx, wolves and grizzly bears in Yellowstone National Park, because the station includes lands that form a corridor of habitat between Yellowstone and the wildlands of central Idaho.[11]

Another issue is the "culling" of wild animals for killing sheep or "encroaching" on farmed land. Wildlife that are considered pests to the industry are killed with impunity. In Australia, indigenous canines, dingoes, are baited and poisoned, and kangaroos are shot for the supposed sake of sheep industry protection.[12-13] In America, coyotes and wolves are often the targets. When free-roaming animals threaten the bottom line of industry owners they're wiped out, often with government support.[14] In 2009 the eight-member Sage Creek wolf pack was killed by the U.S. Department of Agriculture's Wildlife Services program due to depredations that had begun with the killing of a single sheep from the sheep experiment station.[11]

The raising of sheep and lambs for wool is a direct threat to wildlife populations that will only worsen as the demand for products such as animal meat and fibers continue to grow. One study warns that in 30 years up to 37% of wild species will be "committed to extinction" as a result of climate change and land use change, with the latter likely including accommodations for increasing domesticated animal populations such as sheep in order to meet demands for animal-derived products.[15-16]

The Cautionary Tale of the Tasmanian Tiger

A number of species are already extinct due to the wool industry, such as the Tasmanian tiger. Indigenous to Australia, the now-extinct species was a carnivorous marsupial that looked somewhat like a cross between a hyena and a small tiger. These animals, also known as thylacines, were hunted out of existence because of false claims that they were killing farmers' sheep. The last Tasmanian tiger died in captivity in 1936, mere months after the Tasmanian government extended protection to the species. The extinction of this species should act as a clear warning for the fate of other carnivorous animals who are shot for the same wool-profit driven reason today.[17]

From Farm to Fabric

Wool clothing is often portrayed as clean, green and natural, with little awareness from consumers or designers about what happens to sheep after shearing and the processing required for wool to become a usable fashion material.

Slaughter

Wool is often portrayed as "renewable" because sheep can be sheared multiple times. However, the wool industry is a slaughter industry.

In Australia more than 70% of sheep are pure-bred merinos, with other breeds and crossbreeds with merinos making up the remainder. Sheep who are cross-bred with merinos, such as Border Leicesters, Corriedales and other species, are used for both wool and meat production. These breeds, as well as merinos, are considered to be dual purpose because they're exploited for both wool and meat. Although merinos are primarily and specifically bred for their high-quality wool fiber, lambs and older sheep sold for meat add value to the industry.[1]

Sheep farmers using dual-purpose breeds decide when to kill a sheep based on weight and wool quality. Wool is always a factor in decision-making and is produced in the following ways:

▶ **Many lambs are shorn just before their slaughter at about nine months old. Depending on the market at the time, some sheep may be slaughtered with wool attached, because their skins with long wool (also used for fashion) are more profitable.**[2-3]

▶ **Some sheep are kept older for wool-growing, and regularly shorn, based on the quality of their wool. When their wool quality decreases, they are slaughtered. This normally occurs at 5-6 years of age, when they are "cast for age."**[3-4]

▶ **Breeding sheep, who help keep the flock self-replacing, are regularly shorn. Ewes are kept longer on farms, while male lambs are normally slaughtered sooner, unless their genes are of such a high quality they are kept as mating rams. Normally mating rams are bred for this purpose, and male lambs are castrated (without pain relief).**[3-4]

If water is not properly treated, it can cause eutrophication, soil contamination impacting soil fertility, and biodiversity loss.[7] It can even harm the health of surrounding human communities.[8]

The slaughter process requires a lot of water. A case study released by Meat and Livestock Australia found a slaughterhouse killing sheep used more than 15.4 million liters of water each week.[5]

Slaughterhouses also produce huge amounts of wastewater that pollute nearby waterways. The wastewater from slaughterhouses is full of contaminants from the dead animals, including pathogens, proteins, lipids and fibers, as well as frequent contamination from significant levels of antibiotics and other pharmaceuticals fed to the animals. In wool production, insecticide residues in the fleece creates particular problems in treating wastewater.[6]

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In addition to these challenges inherent to treating slaughterhouse wastewater, slaughterhouses are notorious for insufficient wastewater treatment and violating pollution permits. In a study of U.S. slaughterhouses, a facility that processes sheep had 15 effluent violations and was found discharging wastewater into an impaired waterway.[9]

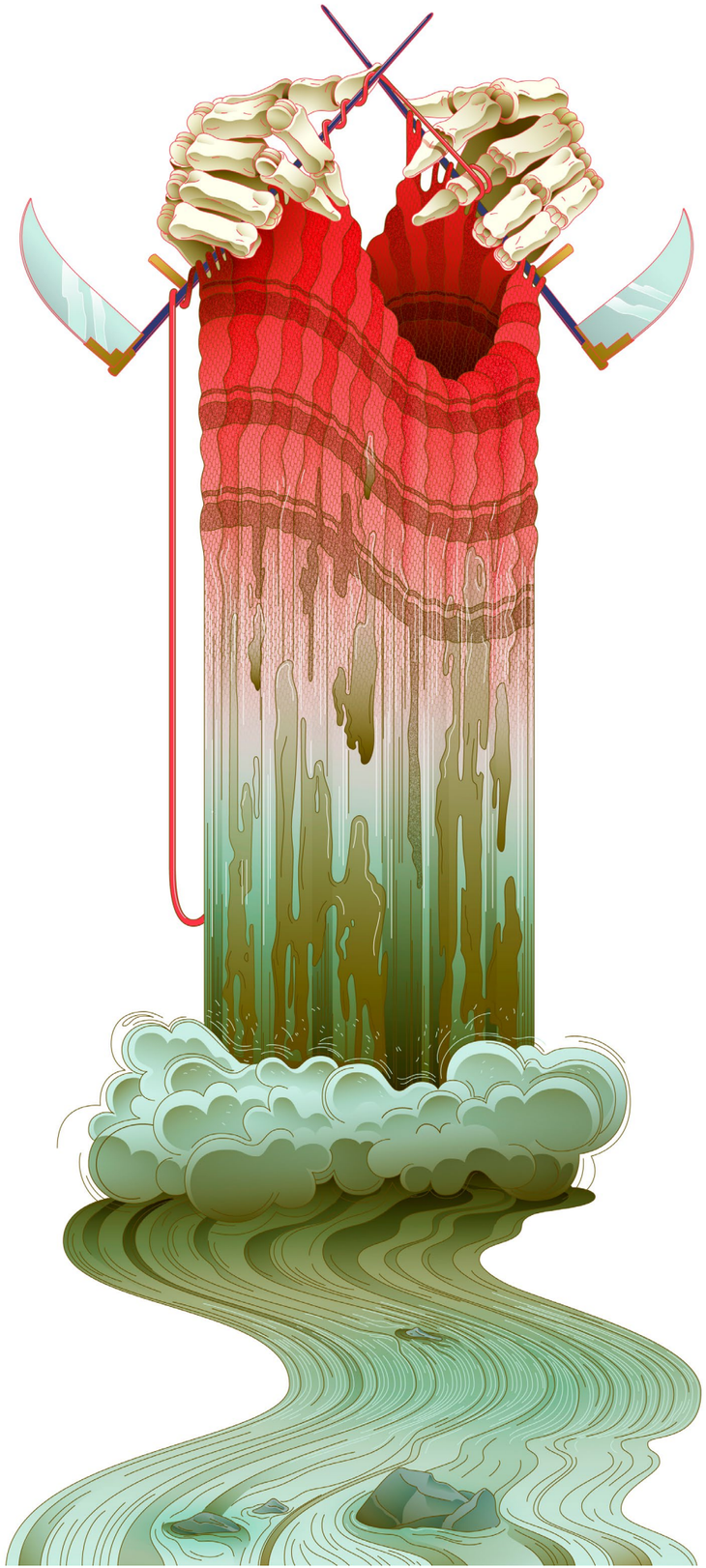
Scouring

Between 35% to 60% of the weight of shorn wool is contaminated with impurities such as wool grease (also called lanolin, a wax produced by sheep skin glands), suint (dried sheep sweat) and surface soiling (dirt, dust, feces and vegetable matter), though 40% is considered the Australian industry average. Traces of chemical compounds from pesticides used to prevent fly strike or lice can also be present in wool before processing.[1-3]

In order for wool grease to be removed, since no one wants to wear an oily sweater, wool must be scoured.

Wool scouring cannot be achieved simply with water, or any substance that will not permeate the greasy layer covering wool fibers. Surface active detergents and cleansing agents must be used to ensure wool grease is removed and emulsified.[3]
Wool is scoured with these surfactants in hot water, between 60 - 65 degrees Celsius / 140 - 149 degrees Fahrenheit, to allow the wool grease to melt. Significant water use and energy are required for this common form of aqueous scouring, to run the machinery used, and to heat the baths or bowls of scouring liquor and wool-drying areas.[3]

If the vegetable matter in wool is high, as is mostly the case, wool must also be carbonized, a process that turns vegetable matter into carbon through chemical and heat processing. Wool is submerged in a strong solution of sulphuric acid, followed by baking in a dryer set to 95 - 125 degrees Celsius / 203 - 257 degrees Fahrenheit. Hydrogen peroxide is often used to bleach and brighten wool at the end of this process. Sometimes insect resistant, moth-proofing chemicals are added during this stage, too.[3-4]



Scouring Pollution

This scouring process results in a highly polluting effluent that is difficult to biodegrade and harmful to wildlife. For every kilogram of processed wool produced by the common aqueous cleaning process, about 17 liters of effluent with a high chemical oxygen demand (COD) value is generated.[2] High COD reduces the amount of dissolved oxygen in waterways, which can disrupt ecosystems, promote bacteria growth and algal blooms, and kill aquatic life.[5-6]

Wool industry reporting states that 'the organic effluent load from a typical wool scour is similar to that of the sewerage from a town of 30,000 people.' Even today, with stricter regulations around pollution from these facilities, only a small portion of about 30% of effluent is recovered by treatment systems, with the remaining contaminants released as waste water.[3]

Wastewater is especially concerning when we consider that alkylphenol ethoxylates (APEOs) are common ingredients in wool-scouring surfactants and detergents.[7] Some brands have put restrictions and even bans on APEOs in their supply chains, while EU countries have considered a ban, though they still can be found widely in wool and leather production.[8] APEOs are endocrine disruptors, which are potentially damaging to human fertility and very toxic to aquatic life.[9] These chemicals can feminize fish, in turn devastating their populations, as has been recorded in contaminated waters.[10-11]

The vast majority of Australia's wool is processed in China, where labor is less expensive and too often exploitative, exporting much of the pollution associated with preparing wool for use in fashion.[12]

Environmental inspectors in northern China found that nearly 70% of the businesses they examined — which included wool-processing facilities — failed to meet environmental standards for controlling air pollution.[13] In addition to greenhouse gases, common air emissions from wool-scouring processes include those from arsenic, chromium, mercury, lead, cadmium and other toxic substances.[14] Without proper emissions control technologies these substances can cause great harm to air quality, the environment and, in turn, biodiversity. Yet even the best technologies can only reduce output; it's far more effective to prevent pollution from wool processing in the first place.

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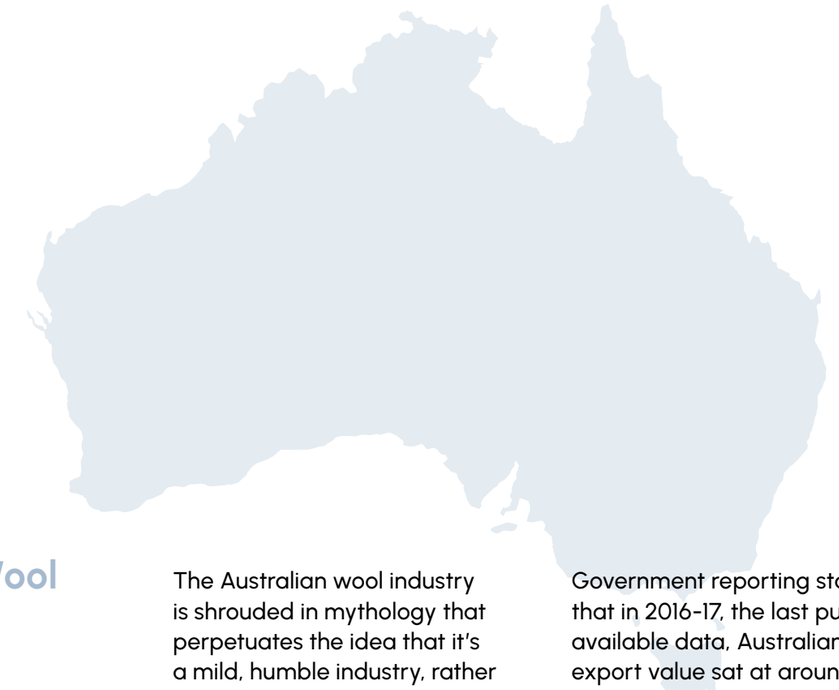
Spotlight on ...



Australian Wool Production

The Australian wool industry is shrouded in mythology that perpetuates the idea that it's a mild, humble industry, rather than one that's unsustainable, inherently violent and often unethical toward sheep and people. This is because, historically, it is said that Australia "rode on the sheep's back," with those involved in wool production thought of as the epitome of Australian.[1]

What is historically "Australian," including sheep production, is tied to the colonial genocide of Aboriginal people and the land they cared for. It is time we move forward with more just and respectful practices.

Australia is one of the largest producers of wool in the world, producing around 25% of all greasy wool sold globally, as well as the self-proclaimed leading producer of premium-quality fine wool used in fashion.[2-3]

Government reporting states that in 2016-17, the last publicly available data, Australian wool export value sat at around $3.615 billion Australian (about U.S. $2.8 billion), with over 74.3 million sheep shorn.[2]

Alongside the environmental issues associated with Australia's wool industry come ethical issues. Sheep in the Australian wool industry are still legally mulesed — an archaic, mutilative practice that slices the skin on the rears of young lambs off with knives, in the name of fly-strike disease prevention.[4] This is not the only method of prevention available, but it's considered the cheapest.[5] The flystrike issue exists largely due to the wool industry selectively breeding sheep to produce more wool, in turn resulting in more folds of skin where flies are attracted to lay their eggs.[6] It is also legal, standard practice to tail dock and castrate young lambs without any

pain relief, commonly by using a sharp or hot knife or tight bands that painfully cut blood circulation and cause these body parts to eventually drop off.[4,7]

Issues of unethical treatment in the Australian wool industry also affect workers in the supply chain, particularly shearers. Shearing sheds are often found in rural areas where jobs are limited. Shearers are paid per sheep or by weight of wool, rather than per hour, so speed is incentivized.[8] This speed not only increases the risk of extensively documented violent and careless shearing of sheep, but poses a problem of unfair payment for workers, who are also placed in danger in shearing sheds.[9]

Shearers have reported to unions that they are being paid with drugs and cash, and other reporting suggests that the wool and shearing industry has a problem with methamphetamine, a drug found to cause a "dose-related increase in violent behaviour."[10-12]

Meanwhile the Australian Broadcasting Corporation has said that dozens of the only 3,000 shearing workers left in Australia have reported increasingly poor conditions in shearing sheds. One of these shearers, 57-year-old Rob Harrowfield, said: "As far as conditions for safety... it's just getting progressively worse... Not having toilets, not having fresh running water rather than washing in a bucket, not having proper harness holders, not having equipment that [has] safety buttons."[10]

Some shearers have been reportedly scalped by outdated, unsafe equipment and disabled due to injury.[13]

Australian wool production has exploited humans, non-humans and the environment for centuries. As early as the 17th century, invader colonists reported the severe impact imported sheep had on land and edible vegetation Aboriginal people cultivated and ate.[14] The land sheep rearing leaves cleared today is Aboriginal land.

The Australian wool industry has, in fact, never been one we should be truly proud of.

U.S. Wool Production

The United States is among the top five wool producers in the world, producing about 24 million pounds of greasy wool annually. There are more than 100,000 sheep operations in the United States, rearing a combined total of more than 5 million sheep and lambs per year.[1] More than 60% of those sheep are shorn for wool.[2] While most U.S. farmed animals, like cattle, pigs and chickens, are produced primarily for meat, lamb and mutton have historically been considered a byproduct of the sheep industry, with wool being the primary product.[1] Thus the wool industry is directly responsible for the degradation of wildlife and wildlands caused by sheep production.

According to the USDA, sheep grazing often occurs on arid western lands "with few alternative uses."[1] These arid and semi-arid lands may not be suitable for intensive agriculture, but the unique landscapes of the American West are rich with

biodiversity and important wildlife habitats. The trampling of non-native sheep causes significant damage to vulnerable wildlife and delicate ecosystems, harming burrows of imperiled species and damaging or destroying soil crusts and vegetation.[3] Domestic sheep can also transmit fatal disease to wildlife, which is a particularly high risk for native, endangered bighorn sheep.[4]

The American Sheep Industry Association has a history of opposing environmental regulations and protections, particularly where wildlife is concerned, even as it promotes wool as a "sustainable" material. The association has called for the delisting of wolves and grizzly bears under the Endangered Species Act and opposed the designation of Bears Ears National Monument, a diverse, majestic landscape that's home to hundreds of wildlife species and sacred to five Native American tribes.[5-6] The group has also called for an increase in predator control and aggressively opposes any effort to restrict funding for Wildlife Services, a USDA program that recklessly kills millions of wild animals each year for the animal agriculture industry with little oversight or accountability.[7-8]

Wool production has a significant impact on wildlife and the American West, yet sheep represent only a small part of the country's economy. Demand for wool has been steadily waning in recent years, and sheep account for less than 1% of animal production in the United States. In 2019 the inventory carryover was the highest it's been in years, at 20% to 30% of the annual clip. That same year 62% of American wool was exported.[9]

The single biggest consumer of American wool is the Department of Defense, which purchases 10% to 20% of the wool produced in the United States each year. The Defense Logistics Agency spent more than $100 million of taxpayer funds on wool fabrics in 2019, including nearly $3 million on berets. In fact, the American Sheep Industry Association reports that the DoD "provides stability for the entire domestic wool industry."[9]

The high environmental and wildlife costs of wool are disproportionate compared to its relatively small role in the U.S. economic and agricultural system. This creates an opportunity for investment in innovation, sustainable alternatives, and a just transition for American producers.

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Industry Greenwashing

In a 2017 study[1] 87% of consumers surveyed perceived wool as "safe for [the] environment." In a similar study from the same year, wool was perceived by thousands of consumers in the United States, UK, India, Mexico, China and Italy as the most sustainable fiber, along with cotton.[2] Despite the significant amount of chemical processing and environmental harms in wool production, the industry has thoroughly greenwashed its products by marketing them as "natural" and "sustainable." Yet there are no U.S. or Australian regulations guaranteeing any environmental standards behind those labels.[3]

There is a popular, yet false, perception that wool production is not only harmless but even beneficial to the environment. Brands working with the wool industry claim that "regenerative" wool production "gives us a real shot at solving climate change if it's done on a large enough scale."[4] Woolmark, the most influential wool trade group in the world, goes as far as stating that woolgrowers are "custodians of the land" who aim to "leave the environment in a better way than how they found it."[5] The last claim is especially outrageous, particularly if viewed through the lens of colonization.

These claims by the industry mislead consumers who care about sustainability and distort the conversation about sustainable fashion and material innovation. Here are a few examples of how pervasive wool industry greenwashing is:

The Campaign For Wool, backed by its patron Charles, Prince of Wales, makes broad, unsubstantiated claims about sustainability. In a 2014 speech for the campaign, the prince stated that "Wool [is] one of the most resilient, ecological and sustainable natural fibers in the world."[6] The official campaign website pushes several eco-buzzwords without referencing any studies or data.[7]

Fibershed, a North American organization with a mission to develop "regional and regenerative fiber systems" has a special focus on wool producers. It has trademarked Climate Beneficial™ Wool, which claims that wool production can not only be harmless but can heal environmental damage.[8] These types of wildly overstated claims about carbon sequestration have been widely debunked by research, including Oxford's Grazed and Confused, which cites over 300 sources.[9] Rewilding would sequester more carbon than grazing systems like Climate Beneficial™ Wool and would allow for species threatened by sheep grazing to recover.[10]

Allbirds, a popular New Zealand-American footwear brand that gained attention with its ads featuring photographs of sheep with the word "shoe" superimposed over them, relies on the assumption that wool is sustainable to make its profits. In an interview with Fast Company,

cofounder Joey Zwillinger claimed the company's use of wool will "reduce the carbon footprint of every shoe it produces" with no reference to how that claim is measured or even whether their environmental performance is independently audited.[11] Allbirds says it uses only ZQ Certified Merino Wool, a standard by The New Zealand Merino Company which claims that its wool growers "stand for a more natural world," but does not address or measure climate impacts, biodiversity harm, or other related metrics.[12] In fact, the only section on the ZQ website making any claims about sustainability at all simply states that "healthy animals rely on a healthy environment."[13] Finally, Allbirds claims that it uses 60% less energy compared to synthetic shoes, yet it fails to publicly provide the data behind that claim.[14]

There is little pushback or regulation of the wool industry's greenwashing. For many consumers and designers, the idea that wool has significant environmental impacts — or even that it requires intensive processing — is counterintuitive to the ubiquitous "sustainable" claims the industry hides behind. By challenging false, misleading, and unsubstantiated claims and educating themselves on the impacts of wool, fashion professionals can begin to have a genuine discussion about using truly sustainable materials.

The Misleading Label Landscape

In February 2021 The Fashion Law reported on the European Commission's findings that 42% of companies making green claims were "exaggerated, false or deceptive" in their nature.[15] According to the report, the UK's Competition and Markets Authority and International Consumer Protection Enforcement Network's assessment of companies making unclear claims found regular mention of "natural products" and the hiding or omission of certain information that would disrupt eco-friendly appearances.

Collective Fashion Justice's CIRCUMFAUNA project researched 50 brands that use greenwashing terms for wool products; who rank highly in searches about "sustainable knitwear" and "sustainable wool"; who feature in fashion publication listicles about these; who are stocked in sustainable fashion boutiques; who are supported by Woolmark; or who are in the Fashion United top 100 list.[16]

Of the 50 recorded brands making greenwashed claims, only 28% of them backed up their claim with any kind of reference, regardless of the quality of that reference or if it provided genuine data to support the claim.

Multiple brands used the exact same phrases, such as wool being produced by sheep simply "consuming a simple blend of water, air, sunshine and grass" and talk of wool "releasing valuable nutrients into the earth" when discarded, because wool is "100% biodegradable, natural and renewable." It was found that these statements had all originally been published by Woolmark itself.

Fast Fashion and Wool

We cannot move toward sustainable fashion systems while maintaining fast fashion. Fast fashion occurs when major retailers race at dangerous speeds to create huge volumes of trendy and cheap versions of clothing seen in celebrity culture and on designer catwalks. The fast fashion business model produces poor-quality clothes that don't last and are destined for the landfill. It is inherently unsustainable and unethical, also requiring the exploitation of workers in sweatshop conditions, the mass abuse of animals, and the intensive polluting of ecosystems, especially aquatic ecosystems.

Newness is sought and manufactured at an accelerating rate. Following the weather, there used to be four fashion seasons; now there are 52 micro-seasons. Global clothing production has doubled in the past 15 years, while on average, garments are being worn less and discarded faster. Across the globe, humanity consumes 400% more clothing than we did just two decades ago.[1] To make matters worse, planned obsolescence is common in fast fashion, meaning clothes are designed to wear out or become unfashionable faster than ever. Consumers are throwing clothes in the trash at a rate of 92 million tons per year (expected to be 148 million tons by 2030), and brands are burning and destroying excess clothing rather than repurposing them.[2-4] Worshipping newness and accumulating large, disposable wardrobes is a modern phenomenon enabled by the profit-driven, fast fashion system.

Inherent to the rise in fast fashion is the rise of cheap and plentiful synthetic textiles. These materials have significant impacts, especially due to their reliance on fossil fuels and microplastic pollution.[5] According to Statista, in 2019, 107.5 million metric tons of textile fiber were produced across all categories. Synthetic fibers made up 73.5 million metric

tons while cellulose fibers made up seven million metric tons.[6] Synthetics constitute the majority of textiles manufactured, at 68%, while wool represents 0.95%.[7]

Wool finds its way into a much larger portion of the fast fashion market than may be expected given its decreasing production, as wool is increasingly not used by itself, so the percentage of textiles doesn't accurately reflect the amount of clothing produced by fast fashion brands. Brands today often produce synthetic knitwear blended with a small percentage of wool. Once that wool is blended with synthetic materials, it is no longer biodegradable. Fast fashion is also a response to people wanting to care less for their clothing. This is why we've seen the invention of superwashed wool (the chlorine hercosett process), which is coated in polyaminoamide plastic resin to allow for machine washing. It takes 220 metric tons of resin to treat 1200 metric tons of wool, and this process also renders wool non-biodegradable.[8]

It's worth noting that the microplastic problem is not unique to synthetic raw materials, but all textiles. According to a 2020 study that compiled a global dataset from 916 seawater samples collected in six ocean basins, only 8% of oceanic plastics were synthetic polymers.[9] The researchers concluded that many so-called synthetic plastic microfibers were actually cellulosic or animal fibers that had been dyed and visually misidentified as synthetic in the absence of a comprehensive chemical characterization. Similarly, a study from Plymouth University found almost 80% of microfibers in deep sea sediments off Europe to be cellulosic and one from the University of Nottingham that found 93.8% of 223 freshwater and airborne samples taken over the course of a year were natural textile fibers.[10-11]

These studies don't mean that synthetic plastic microfibers are not a problem in need of solutions, but that the problem may be overestimated and all fibers treated with non-biodegradable dyes and other substances could pose a threat to marine ecosystems.

When it comes to textile waste, 73% is incinerated or ends up in landfills, contributing to habitat loss, pollution, choking and entanglement hazards and other harms to wildlife. Less than 1% is closed-loop recycled and only 12% is even downcycled.[12] With biodiversity being a crucial measure of overall sustainability, the fashion industry must radically shift away from status quo systems.

There are opportunities for this shift to take place, including slowing down fashion production and consumption patterns, reducing the number of seasons produced per year, producing higher quality and longer-lasting garments that can be repaired, establishing more stringent ethical standards, putting responsibility

on (and incentivizing) producers and manufacturers to include repair, recycle and buyback programs, and most importantly, using materials that have the smallest cradle-to-gate impacts and that will biodegrade or can be recycled infinitely without downcycling.

The Way Forward

Alternative Materials

In order to address the large-scale impacts of global demands for wool apparel, there must be alternatives readily available as well as innovative solutions in development. The number and volume of circumfaunal materials (those that intend to bypass animal inputs in fashion) are growing, with wool replacements becoming a major category.[1] This section will outline wool circumfauna, the decline in the wool market before and during the COVID-19 pandemic, and the opportunity for innovation that goes beyond conventional fibers like polyester, nylon or acrylic.

The best available data shows us that wool production is an environmental crisis, contributing massively to our climate and biodiversity crises. Yet when businesses move away from wool for the sake of sustainability, ethics, or even cost, wool trade groups argue that this is an unsustainable decision. Often this claim is based on the assumption that wool is being traded out for man-made plastic-based materials like polyester or acrylic, which shed micro-fibers and are derived from fossil fuels.

While the use of materials derived from fossil fuels are cause for serious concern, we should not fall into a false binary of choosing between harmful synthetics and harmful wool production. Furthermore, animal-derived fibers are still reliant on fossil fuels at every stage, including feed production, transportation, slaughter, and processing. More importantly, these plastic-based materials are far from the only alternatives to choose from when brands shed wool from their supply chains and are neither necessary nor desirable in a sustainable textile transition.

Wool is an industry in decline, which opens up exciting opportunities for circumfaunal innovation. Following the COVID-19 crisis, collapsing prices and surplus stockpiles of wool threaten to immobilize the entire wool

industry. The Western Indicator, a barometer of Western Australia's wool industry, indicates that wool had dropped 35% in value by August of 2020.[2]

Not in 50 years had global wool production fallen to the 2020 level. Wool apparel production declined another 4% in 2020 after a huge 6% fall in 2019. In comparison to cotton, man-made cellulosic and synthetic staple fiber production, wool production fell from a 2.2% market share in 2019 to only 1.9% in 2020 due to shifting attitudes and trends in the market, an increase in production of all three competitors and the reasons outlined above. Global trade in wool-rich woolen fabric (fabric created with between 50% and 99.9% new wool) showed an overall reduction of 10% in 2019 while export volumes fell 20%.[3] Alongside the significant reduction in wool production, consumption, export and import lies an opportunity for alternative textile economies to emerge, especially since the interest in sustainable fashion has been growing for years. LYST, the largest global fashion search platform releases some of the largest annual consumer-behavior studies available. Their 2018 study of 80 million shoppers showed a 66% increase in searches for sustainable fashion. LYST's 2019 study (104 million shoppers) showed "searches including sustainability related keywords increased 75% year-on-year," and the 2020 study analyzed a whopping 100 million shoppers' activity, with searches for sustainable sneakers jumping 89% year-on-year.[4-6] Their 2020 Conscious Fashion Report further revealed, since the beginning of 2020:

- **A 37% increase in searches for sustainability-related keywords has been documented**
- **Sustainability-related keywords average monthly searches increased from 27,000 in 2019 to over 32,000 in the year-to-date.**
- **Searches for "organic cotton" have risen by 23%**
- **Searches for "recycled plastic" have seen a 35% rise[7]**

Data released by the Boston Consulting Group and Pulse of the Fashion Industry Report (2019) revealed that more than one third of surveyed consumers reported switching from their preferred brand to another for reasons related to responsible practices.[8] Given the culmination of market forces and external factors, it would seem the time is optimal for brands to shift to circumfaunal materials, especially those with environmental performance that is superior to wool, not just for reasons of responsibility, but in response to increasing demands and potential profits.

According to Material Innovation Initiative's 2021 "State of the Industry: Next-Gen Materials" report, $1.29B in investments have been made between 2015 and May of 2021 in companies developing circumfaunal materials. Furthermore, 38 out of 40 leading fashion brands are actively searching for these solutions.[9]

It's not enough for these materials to simply have a smaller environmental impact; they must also be able to compete on aesthetics, tactility and performance. Also, the bulk of these alternative materials should not be fossil fuel-derived fibers (such as acrylic, polyester and nylon), because they come associated with their own harmful climate and environmental consequences. There is a range of categories and production methodologies using innovative materials and blends — such as plant-based cellulosic fibers made from bananas or wild-gathered calotropis, high-tech recycled fibers made from diverted waste, bio-based synthetics and even biofabricated proteins grown or formulated in laboratories — that can meet the needs and increased demand from consumers for better alternatives. (See Appendix A).

Just Transition

Environmental destruction on largely stolen, Indigenous land, exploitation of workers and the widespread inhumane treatment of sheep make it clear that the wool industry needs to transition into greener, more equitable alternatives. Looking specifically at the impacts of the climate crisis, particularly on farmers and marginalized communities, demands significant changes to the way we produce clothing.

However, while there may be a growing list of alternative materials for fashion designers and innovators, we acknowledge that sheep farming is rooted in traditions and complex practical, economic and emotional factors that create challenges to transforming an entire industry, even if it is necessary and for the better. Governments, brands and other industry stakeholders must help ensure producers and workers have the economic security, technical assistance and other support needed to transition their livelihoods to just, sustainable materials.
Most Australian wool farms are owned by families who have passed down their work across many generations, and sheep farming has long been tied up with colonization in the country.[1-2] Sheep also played a central role in colonization and conflict in the American West.[3] Although this history is fraught, the sentiment tied to the traditions of sheep farming needs to be navigated in addition to ensuring economic opportunity for workers and respect for tribal land.

The wool industry regularly states that sheep farmers have a deep connection to land.[4] Amongst the complexities of farming and dealing with harsh landscapes, farmers' well-being is often tied to the well-being of the land. When the land fails to thrive, often due to land degradation from sheep grazing, it can have a devastating effect. Research in Australia and the United States has found that farmers are more likely to have suicidal

ideation or to complete suicide compared to other occupations.[5-6] Depression surrounding economic security fears and the struggle which comes with watching environmental degradation has been shared by animal farmers, with some of these feelings improving when the environment they are surrounded in improves in health.[7]

This connection to land, and to healthy land, does not need to be broken in a just transition away from wool — in fact, it can be strengthened.

The majority of wool farmers in Australia run mixed farming systems, which means they don't only raise sheep. Most of these farmers grow crops too, such as wheat. By diversifying their portfolio, farmers protect themselves and their economic security.[8] Those farmers running mixed farming systems are already capable of growing crops on their land, so a transition to entirely plant-based agriculture is plausible.

This connection to land, and to healthy land, does not need to be broken in a just transition away from wool — in fact, it can be strengthened.

Entirely plant-based agricultural systems are more land efficient, and far more effective in sequestering carbon. In fact, on a global scale, such a system would require 75% less land be devoted to food production, while still providing enough for us all.[9] Similarly, it would allow for rewilding so immense that vegetation could help us sequester 99%-163% of the carbon emissions budget consistent with limiting warming to 1.5 degrees Celsius, if such a transition took place by 2050.[10]

Beyond the sentimentalities of tradition, there are practical and economic challenges to a just transition for wool producers. Given the urgency of the climate and extinction crises, supporting this transition should be a priority for agricultural policy. A bill in California, for example, would provide grants and technical assistance to grazers who want to transition to plant-based agriculture.[11] Climate policies must recognize that restoring native grasslands as carbon sinks is more effective for sequestration than managed grazing.[12] Public agencies can also support projects like the Rancher Advocacy Program, which helps convert animal-based businesses to a plant-based future.[13]

Some farmers who own large swaths of land may choose to sell portions of it to the government to be returned to Aboriginal people or Native Americans to care for their land as they know best. Farmers may also choose to volunteer their land into conservation easements and registered wildlife protection schemes. Government funding for such ecosystem restoration and sequestration efforts would benefit both farmers and indigenous communities. These funds could be covered in part by current wool industry direct and indirect subsidies and other financial assistance.

A farmer's connection to the land could be not only maintained, but improved, through efforts that support rewilding and benefit our climate and biodiversity. If a portion of land is used for a diverse range of cropping that is rotated or mixed for soil health, income can be maintained alongside thriving native wildlife that benefits the planet, and perhaps in turn, the mental health of farmers connected to the well-being of their land.

Creating Sanctuary

In Joseph Poore's New Scientist cover story, "Back to the wild: How nature is reclaiming farmland," he describes a place northeast of Perth, Australia, where there was once a 69,000-hectare sheep farm. As wool prices dropped, the farm became unprofitable, and a conservation charity called Bush Heritage bought the property. After some time managing the land, the now-named Charles Darwin Reserve is full of salt lakes, old river systems, open acacia shrubland, eucalyptus forests, and so on. This biodiverse land is sanctuary for about 700 plant and 230 animal species, including some that are threatened, like the malleefowl and shield-backed trapdoor spider.[14]

Conclusion

There has been incredible material innovation in recent years that can increasingly meet the needs of both consumers and designers. But in order to accelerate the production and adoption of truly sustainable materials, we must challenge the greenwashing claims that obscure the reality of wool's impact on biodiversity, climate, land use, water use and chemical use.

While there are suggestions and examples throughout this report to guide industry transformation, we recommend the following immediate actions:

- **Fashion industry associations, initiatives and certifiers should update their sustainability language to acknowledge the harms to biodiversity caused by wool.**

- **Clothing and textile brands should publicly commit to phasing out or reducing wool by at least 50% by 2025.**

- **Large clothing and textile brands should invest in the research and development of wool alternative material innovation.**

- **Fashion designers should commit to phasing out or reducing wool by at least 50% by 2025 and supporting material innovation by using alternative materials in their clothing lines by 2023.**

- **In phasing out wool, the industry should embrace alternatives that do not depend on fossil fuel-derived fibers (such as acrylic, polyester and nylon) because they come associated with their own harmful climate and environmental consequences.**

While moving the fashion industry away from wool may seem daunting, it's important to know that the move can be profitable and sustainable. According to the 2018 Pulse of the Fashion Industry Report, improving a fashion brand's environmental and social performance actually boosts profitability[1]. Investments in resource efficiency, secure work environments, and sustainable materials go beyond counteracting projected losses to increase profitability.

Shifting from wool to non-animal materials is not only profitable and ethical, it's necessary for the future of the industry and the planet. In the midst of a climate crisis and an extinction crisis, the fashion industry can no longer sit on the sidelines. The industry must take responsibility for its environmental impacts and take action to create a world where people, wildlife and beauty can thrive.

Appendix and References

Company	Product Name	Material Use	Content	Location
EcoPel	Cannaba	"Shearling"	Hemp blended with recycled polyester.	France
Orange Fiber	Orange Fiber	Fiber	Citrus juice byproduct "pastazzo" (citrus cellulose).	Italy
Flora Fur	Flora Fur	Fiber and "shearling"	Milkweed and linen blend yarns.	USA
KD New York	Vegetable Cashmere	Fiber	Soy protein spun from pulp borne from tofu production.	USA
Faborg	Weganool	Fiber	70% organic rain-fed cotton, 30% Calotropis fiber (wild gathered).	India
Toray	Ecodear®	Fiber	"Ecodear® PET is a plant-based polyester, biodegradable fiber created through polymerization and melt spinning of plant-derived ethylene glycol, extracted from sugarcane (saccharum officinarum) molasses, and petroleum-derived terephthalic acid. It conforms with Green Public Procurement (green purchasing) standards for plant-based synthetic fibers, as well as being an ISO14024 type 1 environmental label (ecomark) certified product."	Various
EcoSimple	EcoSimple	Woven fabric	Recycled PET, recycled cotton, recycled yarns (cotton and polyester) and recycled raw materials, which dispense with chemical processes, water.	Brazil
Econyl	Econyl	Thread	Recycled nylon from fishing nets.	Italy
Sustainably Sourced Cotton	Various	Various	Cotton grown organically, more sustainably and even carbon positively (Good Earth Cotton), upcycled or recycled cotton, etc.	Various
OSOMbrand	OSOMtex®	Thread	Upcycled yarns and fabrics (made with trash).	USA
Spinnova	Spinnova	Fiber	The OSOMTEX® proprietary process uses no water, no dyes and no harsh chemicals.	Finland
Pyratex	PYRATEX®	Fabric	Chemical-free wood cellulose. The wood comes from FSC and/or PEFC certified tree farms. Pulp is treated only mechanically to create micro fibrillated cellulose, the feedstock for the process. Modal- Kapoc blend. Kapoc is 100% cellulosic mono-material with moisture- management properties. The modal fiber in the fabric comes from sustainable managed woods, certified by FSC and PEFC.	Spain
Bananatex	Bananatex	Fabric	A durable, waterproof fabric made purely from banana plants, it requires no chemical treatments. Its self-sufficiency has made it an important contributor to reforestation of areas once eroded by palm plantations, whilst enhancing the prosperity of local farmers.	Various
National Nonwovens	Xoticfelt	Felt	Bamboo-rayon felt (see rayon viscose)	USA
Lenzing	Tencel™ Lyocell and Modal	Fiber	Lyocell and Modal fibers originate from the renewable raw material wood, created by photosynthesis. The certified bio-based fibers are manufactured using an environmentally responsible production process. The fibers are certified as compostable and biodegradable.	Austria
Hemp	Various	Various	Hemp fabric is made from the fibers in the herbaceous plant of the species Cannabis sativa. It's a high-yield crop that can produce more fiber per acre than either cotton or flax.	Various
Recycled Synthetics	Various	Various	A generic category of products that can be made by any synthetic textile recycler, including blends of recycled cellulosic and synthetic fibers.	Various
Kintra	Bio-based synthetics	Fiber & fabric	"A "farm-to-fiber" approach for synthetics, using 100% bio-based sources and creating materials that are 100% compostable, leaving no microfiber pollution."	USA
Algiknit	Algiknit	Yarn	"Durable yet rapidly degradable yarns from kelp, one of the most regenerative organisms on the planet."	United States
Furiod	Wooloid		Lab-grown wool follicles/hair.	Europe

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Environmental Impacts of Wool Production

Climate Change

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Conclusion

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