

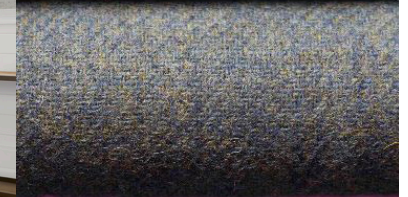
THE CAMPAIGN FOR WOOL
Patron: HRH The Prince of Wales

THE CAMPAIGN FOR WOOL CANADA

The Wool Plan 2021-26

CONTENTS

WELCOME	3
CEO's Report Co-Author's Report	
ABOUT THE ORGANIZATION	4
About Campaign for Wool About the Canadian Wool Council	
EXECUTIVE SUMMARY	8
Executive Summary Strategic Planning Process	
THE REIMAGINED SUPPLY CHAIN	14
STRATEGIC FRAMEWORK	18
Three Goals Five Outcomes Ten Tactics Wool Innovation and Technology Future Directions in Research	
ACKNOWLEDGMENTS	29
Advisory Panel Organizations Individuals	
APPENDIX	34
Research	
i. Canadian Flock	
ii. Canadian Wool	
iii. Environmental Considerations	
Glossary Round Table Summaries	



WELCOME

CEO'S REPORT

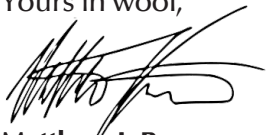
For the past eight years, The Campaign for Wool in Canada has promoted the benefits of wool. We began this work with a simple mission, to educate consumers and to find opportunities for Canadian wool. While we generated millions of media impressions with our partnerships, we were struck by the broken supply chains and the profound disconnect between stakeholders across our domestic industry. We resolved to - not only talk about making things better, but to take meaningful action.

For example, our 2020 interior design and art projects saw 100% Canadian wool transformed into stunning showroom rugs and a sculpture that captured the imagination. These pieces prove that Canadian wool can compete with the best in the world in creating beautiful high value items. It was a good start but to measure improvement we needed to study the problems, talk to the players and come up with a 21st Century plan for our industry.

This five-year strategic plan, a first for our organization, is the result of those efforts. It is the product of consultations with wool growers and a mix of talented stakeholders from both in and outside the wool industry. It details our ambitions and laying out three goals which we will implement through several strategies and tactics to deliver results.

Most importantly it is a plan that draws its strength from collaboration. We need the support of the entire value chain to realize our full potential and invite everyone with a stake in wool to join us in building a stronger, more sustainable Canadian wool industry.

Yours in wool,



Matthew J. Rowe

CEO

The Canadian Wool Council

CO-AUTHOR'S REPORT

Collaborating with the Campaign for Wool and the Canadian Wool Council to produce this strategic plan had been a rewarding and thought provoking experience. My own research into the world wool industry began several years ago and has taken me through many countries and on countless road trips where I could engage with stakeholders across the value chain and explore their needs from a regional, provincial, national and international perspective.

The conclusions I've drawn for a reimagined, revitalized Canadian wool industry hinge on creating the right size and configuration of infrastructure and brokerage systems for our existing wool clip, so wool producers, innovators and intermediaries can begin to see immediate benefit. Proceeding conservatively and systematically, we can build a reliable foundation on which to capture new opportunities and emerging trends sustainable fibre.

I'm especially excited to see wool innovation in the semi-industrial sector, the interiors market and the emerging trends of sustainable fashion design blending wool with other crop fibres to make clothing textile more versatile. Equally exciting is seeing wool producers and manufacturers experimenting with genetics, technology, AI and robotics to improve wool quality, accessibility and value.

And at the heart of it all, we get to work with sheep!

Yours in wool,



Jane Underhill

Co-Author

The Wool Plan 2021 - 2026

ABOUT THE ORGANIZATION

ABOUT THE CAMPAIGN FOR WOOL

The Campaign for Wool is a global endeavour initiated by its patron, His Royal Highness The Prince of Wales, to raise consumer awareness about wool's unique, renewable and biodegradable benefits. The Campaign brings together major fashion designers, woolgrowers, retailers, manufacturers, artisans, and interior designers to celebrate wool's endless myriad of uses. The Campaign was launched in the UK in 2010 and currently operates in 13 countries. The Canadian Campaign was launched by TRH The Prince and The Duchess of Cornwall in Nova Scotia, during their 2014 tour. It was first fostered by HRH's Prince's Charities Canada before being transferred to the Canadian Wool Council in 2018.

GLOBAL LEADERSHIP

HRH THE PRINCE OF WALES
Patron

NICHOLAS COLERIDGE, CBE
Chairman of the Campaign for Wool

PETER ACKROYD, MBE
Chief Operating Officer,
The Campaign for Wool Ltd.

MARSHALL ALLENDAR
Manager,
The Campaign for Wool Ltd.



THE CAMPAIGN FOR WOOL
Patron: HRH The Prince of Wales

“The primary aim of the Campaign is simply to increase the demand for wool by explaining its many benefits to consumers. It is the most remarkable fibre”

**- HRH THE PRINCE OF WALES,
PATRON, THE CAMPAIGN FOR WOOL**



ABOUT THE CANADIAN WOOL COUNCIL

The Canadian Wool Council (CWC) is a federal non-profit corporation with a mission to revive the Canadian wool value chain for the benefit of creators, rural communities, and all Canadians. As official implementing partner of the Campaign for Wool, the CWC educates the public on the benefits of wool, the challenges facing producers, and nurtures opportunities for developing the Canadian wool clip through proactive media outreach and targeted programs. The CWC is supported by a team of talented staff, board members and advisors who lend a diverse range of talent and skill. As a non-profit corporation we are accountable first to our board and our donors but more broadly we feel a deep responsibility to the wider wool industry and look to build partnerships with every level of the wool value chain.

THE BOARD OF DIRECTORS

Our Board is made up of accomplished individuals from a variety of sectors.

MATTHEW J. ROWE

Chief Executive Officer, The Canadian Wool Council
Board Member — Chair

JESSICA BENTLEY-JACOBS

Director of Social Impact, Hydro One
Board Member — Secretary

BRIAN BLACKBURN

Accountant, KPMG
Board Member — Treasurer

ASTRID-MARIA CIARALLO

Manager, Corporate Communications - TD Bank
Board Member — Board Member-at-Large, Fashion & Communications

ANDREAS KYRIAKOS

Business Analyst, AlixPartners (UK)
Board Member — Board Member-at-Large, Governance

THE CAMPAIGN FOR WOOL TIMELINE

2010

The Campaign for Wool debuts in London with a launch event that saw London's Savile Row transformed into a sheep pasture.

2011

HRH The Prince of Wales opens the Wool Modern Exhibition in London. The Campaign expands rapidly adding a presence in Australia, Spain, Netherlands, Germany, Norway and Japan.

2012

The Campaign launches in China while in London the Campaign presented the first ever 'Wool House' the World's biggest celebration of wool featuring 10 days of interior design, fashion, craftsmanship and textile excitement.

2013

The Campaign launches in Italy, Korea, and the Shetland Islands. In North America it makes a splash in the United States with an installation in Manhattan's Bryant Park.

ADVISORY BOARD

The Advisory Board is a sounding board for the organization working primarily with staff as a source of perspective, feedback and inspiration on both strategy and operations.

JOHN MUSCAT

President, LINE the Label — Chair

ERIC BJERGSO

General Manager, Canadian Cooperative Wool Growers — Vice-Chair

JENNIFER MACTAVISH

General Manager, Ontario Sheep Farmers — Vice-Chair

JANE UNDERHILL

Business Consultant — Secretary and Special Advisor

RICK BLICKSTEAD

President & CEO, Phoenix 360 Solutions — Special Advisor

ADRIA MINSKY

Senior Advisor, Cumberland Strategies — Special Advisor

JUSTIN MORIN-CARPENTIER

Business Consultant — Special Advisor

BRADEN ROOT-MCCAIG

Director of Communications, Ontario Centres of Excellence — Special Advisor

AMBER WATKINS

Freelance Creative Director — Special Advisor

SERVICE PARTNERS

Service partners provide crucial support and administrative services which enable our small team to achieve big things.

BARABARA JESSON & ASSOCIATES

Communications & Public Relations Support

CUMBERLAND STRATEGIES

Government Relations

TORY'S LLP

Legal Services

KPMG

Accounting Services

DANIEL PINESE

Graphic and Document Design

MADESON DARCY

Graphic Design

For a complete list of all those who contributed to the strategic planning process, please see the Acknowledgements on page 29.

2014

TRH The Prince of Wales and The Duchess of Cornwall launch The Campaign in Canada during an official event in Pictou, Nova Scotia.

Designer Kimberly Newport-Mimran becomes the first Advisory Council Chair. The first Canadian Wool Week launches in Toronto.

2015

The Campaign launches an exhibition on the Wonders of Wool at the Royal Ontario Museum. The Campaign launches in South Africa.

Montreal plays host to The Campaign's Quebec debut with events at the historic Ogilvy Department store. In Paris, The Campaign takes over the Palais de Tokyo for France's first wool week.

2016

The first ever Wool B&B opens its doors in De Beauvoir Town, London.

John Muscat, President and Designer at Canada's LINE Knitwear takes over as Advisory Council Chair.

2017

A Wool Room is created at The Royal Winter Fair as The Campaign begins a three-year sponsorship commitment to support all the sheep and wool related activities.



2018

The Canadian Wool Council is created to take over The Campaign from Prince's Trust Canada and to grow its work with a focus on developing opportunities for Canadian wool.

2019

The Campaign debuts in Vancouver with a special pop-up sheep farm at Vancouver's Secret Location boutique in Gastown.

The Campaign's first designer capsule collection debuts at Holt Renfrew featuring LINE, Smythe, and Mikhael Kale using fabric from historic British mills Abraham Moon and Harris Tweed.

2020

Wool Week is expanded to Wool Month. The Campaign in partnership with Sarah Richardson and Creative Matters creates a designer capsule collection of 100% Canadian Wool Rugs using yarn from Briggs & Little Mill of New Brunswick.

The Campaign celebrates its global 10th Anniversary and to celebrate commissions Canadian fibre artist Rosemarie Péloquin to create a sculpture of our Patron entirely out of Canadian wool.

2021

A new five-year strategic plan is completed with the support of The Ontario Water Centre, The Dalglish Family Foundation, Clearwater Farm and the University of Guelph.

Looking ahead, Canadian Wool Month 2021 will see the creation of a 100-mile blazer by Canadian-label Smythe using wool grown, processed, woven, designed and sewn within 100 miles of the City of Toronto.

EXECUTIVE SUMMARY

WOOLS' NATURAL PREDATOR

Wool's natural predator is not an animal, nor is it mother nature. Like many countries around the world, Canadian wool's greatest natural predators are apathy and myth. Apathy settled in amongst producers after half a century of decline and decay in the domestic wool industry. The advent of synthetics and offshore processing caused demand and pricing to plummet. And until recently, the sense of hopelessness solidified into confirmed indifference. In parallel, a series of myths, turned into "believed facts," which justified producer apathy. Namely the myth that Canadian wool is not valuable and not usable because Canada lacks the quantity and quality required to rebuild a domestic industry.

The climate crisis, and the race for sustainability and environmental ethics, has drawn innovators from sectors outside agriculture toward our renewable, natural resource. Since the reawakening interest in wool, it has been proven through early-stage research and development that Canadian wool is the perfect grade and quantity for a great many applications. Commercialization of these applications justifies inherent value and price increases.

WHY CFW/CWC AND WHY NOW

The Campaign for Wool and the Canadian Wool Council have an unparalleled capacity to build bridges, alliances, and strategic partnerships between wool value chain stakeholders domestically and internationally. An established network of supporters and experts across industries remain on stand-by to the CFW and CWC to consult on vision, strategy, and approach. These two partner organizations

already have over a ten-year track record of expedient response to challenges and opportunities. They are the right advocates to move the industry forward.

The timing is also right for Canadian wool because our country is an engaged partner of the Paris Agreement to fight climate change. Thus, government support for sustainability initiatives, especially within the semi-industrial sector, is increasing at an unprecedented rate.

Canada is also an emerging leader in the tech sector. Significant investment is being made in green technology, robotics, and artificial intelligence. Subsidies, grants, and federal, provincial, and regional initiatives, coupled with incubator programs, angel investors and green venture capital offer Canadian wool a prime starting point for a revived industry.

Timing is also right with Canadian agriculture. The next generation of farmers is poised to take over the industry with a new philosophy, vision, and methodology. In many cases, next generation farmers are blending technology with holistic farming practices to renew their land and to improve animal and crop health. Wool is an integral part of "new agriculture's" value chain.

STRATEGIC PLANNING PROCESS SUMMARY

The strategic planning process spanned five months and was broken down into three phases: Research, Analysis and Conclusion.

The research phase was a deep dive into the environment, land and water management, agriculture, sheep, wool, other natural fibres, processes, machinery, technology, economics both in Canada and internationally. The research phase also included a supply chain mapping to identify challenges and opportunities.

With data collected, our analysis led to the understanding

that our industry had five significant obstacles to overcome for a viable industry to evolve. The proposed solutions to the obstacles were tabled at five strategic panel discussions in March 2021. Each table session gathered between 9 and 15 global experts to discuss, debate, and challenge the proposed solutions.

The strategic planning team was satisfied that the proposed solutions withstood the stress-testing panels. Our conclusions were re-analyzed, adjusted, and are documented in the following pages.

STRATEGIC FRAMEWORK SUMMARY

The strategic framework of this plan defines three goals, five outcomes and ten tactics, along with a brief discussion of additional opportunities.

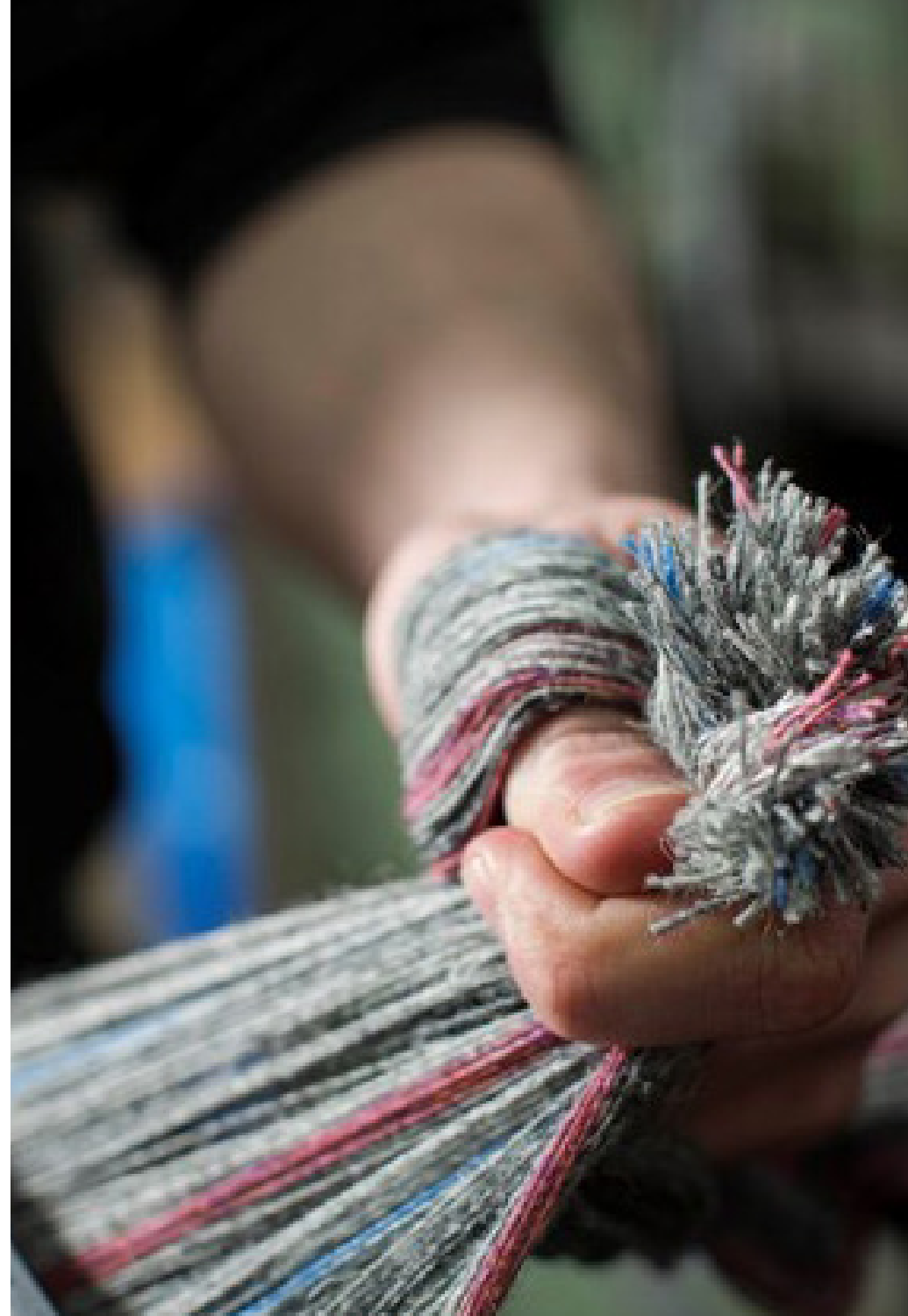
Three Goals

The plan's three goals blend to support stakeholders of the Canadian industry. They consist of:

- Rebranding and Revaluing Canadian Wool to improve prices, quality, quantity, and stakeholder buy-in.
- Advocating for the Entire Canadian Wool Value Chain. This accounts for, among other things, for the supply chain which accounts for, among other responsibilities, support to stakeholders through regulatory and governance challenges.
- Giving Canadian Wool a Voice on the International Stage to create awareness for Canadian wool and to build strategic alliances and partnerships to better our Canadian wool industry.

Five Outcomes

The five outcomes are a response to the five obstacles impeding the viability of the industry. They include roadblocks with **Education, Outreach** (or **Wool Awareness**),



Brokerage, Infrastructure and “Proudly Canadian” Products made of Certified Canadian Wool.

- Education proposal involves creating a Shearing Guild to help wool producers access affordable shearing and support for their wool.
- Outreach proposal involves strategic initiatives to bring attention and value to Canadian wool and to support value chain stakeholders.
- Brokerage proposal involves a phased integration with the existing wool pipeline to eventually achieve profitability.
- Infrastructure proposal involves establishing the right size and style of infrastructure required to manage the existing Canadian wool inventory. Where necessary, a plan to outsource aspects of processing to countries who’ve already mastered environmental footprint, waste management, processing capacity and cost efficiency.
- “Proudly Canadian” Products proposal involves early stages of incubation, research and development into products created using certified Canadian wool. For the next five years, research into the development of “Proudly Canadian” Products will focus on the interiors market, the semi-industrial market and the agricultural products market.

TEN TACTICS

The ten tactics are steps or initiatives being undertaken by the Campaign for Wool in Canada, with the support of the Canadian Wool Council, to overcome the obstacles addressed in the five outcomes. Many of the tactics are already in progress, others are timed to roll-out over the life of the strategic plan.

RESEARCH SUMMARY

Sheep

As of January 1, 2021, Canada’s sheep population sits at

780,200 head on 9,390 farms. Ontario is Canada’s largest producer of sheep (30.5%) followed by Quebec (22.5%) and Alberta (18.5%). Canada produces 42% - 45% of its lamb demand. The balance of lamb in the Canadian market is imported from New Zealand, UK and US. The Halal meat market represents the largest lamb sector demand with lots of room for growth.

A booming Halal market could result in an increase in wool availability, however the Halal market prioritizes lean lamb meat such as that produced by hair breeds of sheep. An increase in Halal demand therefore would not necessarily produce more wool.

Growing Trends

- Halal market boom
- Small-scale, family, and/or subsistence farming
- Traceability and biosecurity



- Genetic marketing
- Buy local initiatives

Wool

Canada ranks 36th in the quantity of greasy wool production globally. The largest capture of Canadian wool happens through the Canadian Cooperative Wool Growers (CCWG) in Carleton Place, Ontario. CCWG has collection points across Canada. Periodically, wool from the collection points is shipped by rail or transport truck to the CCWG warehouse in Ontario. There it is recorded, weighed, graded, baled, and warehoused until sold.

On average, Canada produces around 1200 tonnes of wool per year. The most common micron range of Canadian wool is between 29 and 33 microns. The bulk of Canadian wool is sold to export where it is blended with fibre for higher- or lower-value textiles. Canada saw an uptick in volume of sales to China when China and the US entered a trade war.



Wool is a versatile, natural fibre with myriad qualities and applications. Very fine wool is primarily used for clothing while coarser wool is used in carpets and furnishings such as curtains or bedding. A single sheep provides around 6.5 lbs of wool per year, the equivalent of 10 or more metres of fabric, which is enough for six sweaters, three suit and trouser combinations, or to cover one large sofa.

Environment

In 2015, 195 countries joined the Paris Agreement to mitigate the 'global warming gridlock' as a proactive step for the UN Framework Convention on Climate Change. Canada is an active partner in the Paris Agreement. Modifications to Canadian farming practices, especially on the Canadian Prairies, is responsible for a carbon sink totalling more than 10% of the Canadian agriculture industry's total carbon emissions.

Regenerative Agriculture practices are growing in Canada. Described as a holistic farming approach, focused on developing the biology and fertility of soils. Beneficial land management practices vary depending on the region. The most common practice involves intensive no-till pasture management with reduced or eliminated pesticide and herbicide use.

Although very little research is devoted to understanding the benefits of sheep farming on regenerative agriculture and beneficial land management practices, Canadian sheep farmers often use strategic grazing methodology to encourage soil health.

In Canada, sheep farming happens either entirely outdoors, entirely indoors or a hybrid of indoor/outdoor habitation. Depending on the region, climate, soil, and farm goals, some sheep production happens entirely indoors. Most farmers agree that sheep pasturing is ideal, however climate extremes between heatwaves and subzero temperatures, coupled with soft soil can create an environment that negatively impacts prolificacy in sheep and make pasturing unviable.



STRATEGIC PLANNING PROCESS

THREE-PHASED APPROACH TO PLANNING

Phase 1:

December 15 to January 30

Research

The primary objective of phase one was to contextualize the wool industry within the larger framework of agriculture, environment, and manufacturing, and to identify systemic barriers facing our wool industry.

Phase 2:

February 1 to March 12

Stress Testing

Our research identified five significant obstacles to a thriving, economically viable and sustainable domestic wool industry. Each of these obstacles, with proposed solutions, formed the subject-matter for each of our five table sessions with panel advisors.

Phase 3:

March 15 – April 30

Conclusions

Drawing on the research and feedback from phases one and two, our strategic plan concluded the basic need for reinvigorating the Canadian wool industry. They break down into three pledges, five outcomes, and 20 actional initiatives.

STAKEHOLDERS & SOCIAL LICENSE

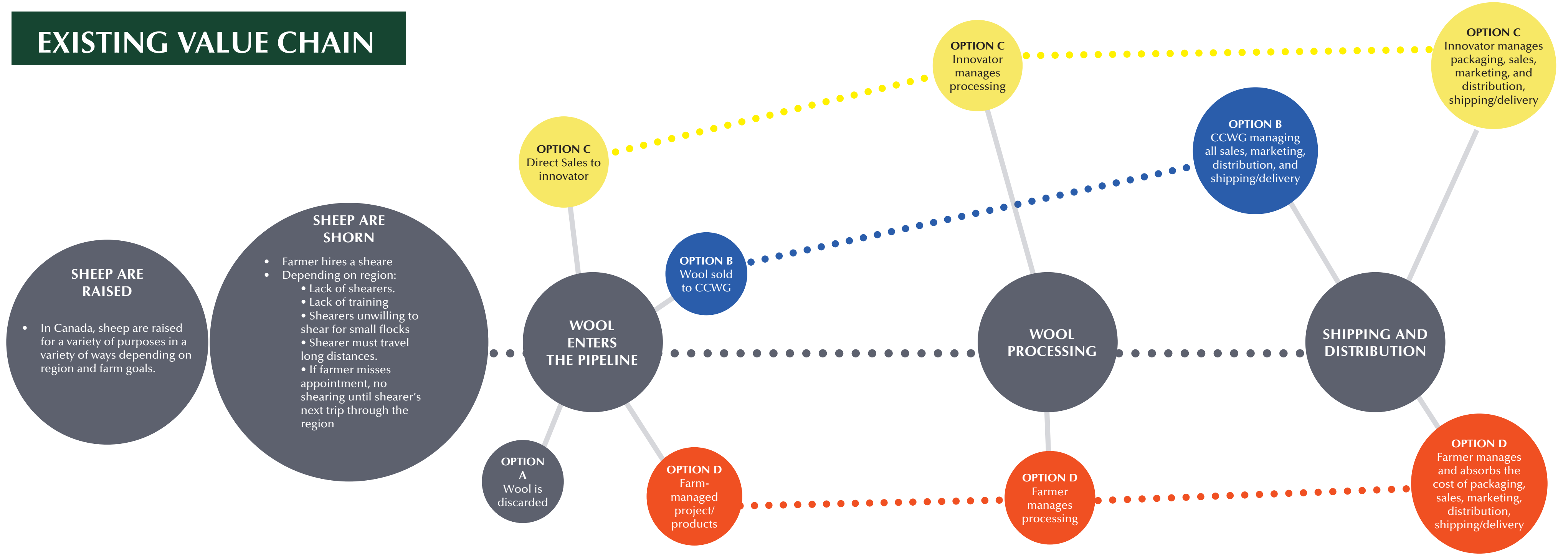
A VOICE FOR WOOL

When the Campaign for Wool was first established in 2010, the global wool industry was at a crossroads. All around the world, farmers struggled to get a fair price for their wool, while consumers embraced inexpensive synthetics. The solution was an international effort, bringing together the wool value chains of 13 different countries under a common banner.

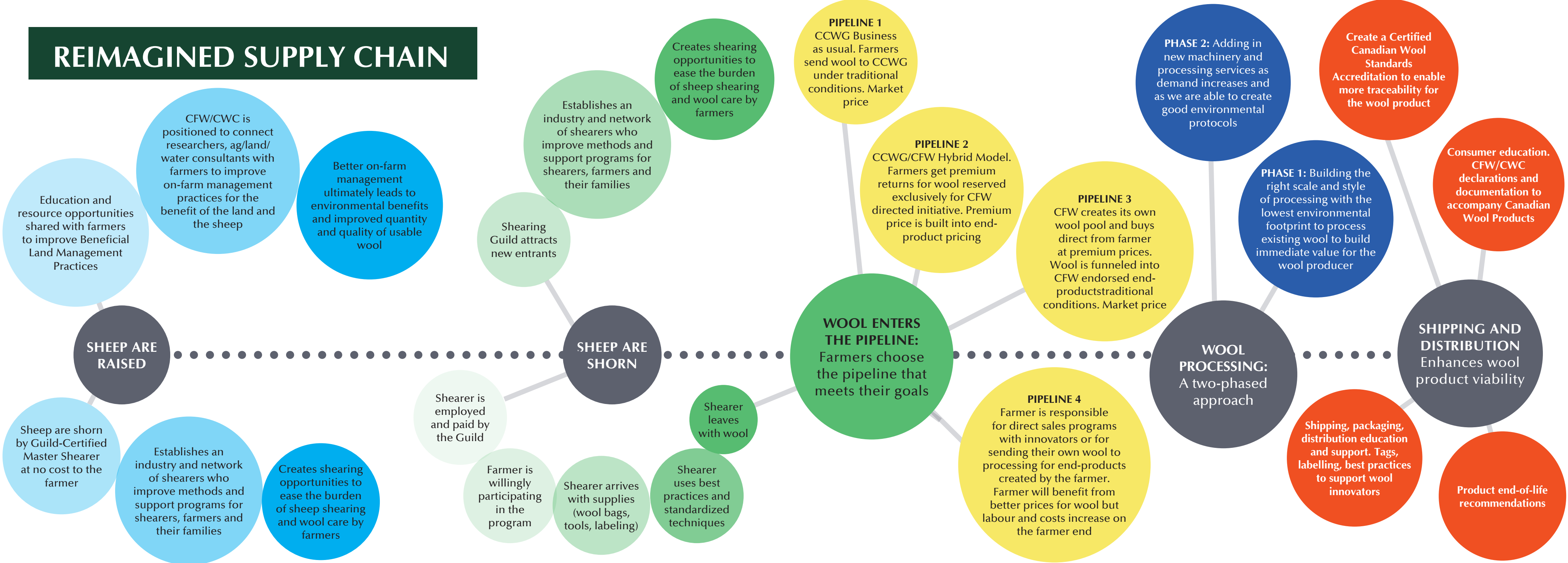
In Canada, the Canadian Wool Council, builds on this mission with the specific goal of elevating Canadian wool, alongside the livelihoods of all those who work with it.



EXISTING VALUE CHAIN



REIMAGINED SUPPLY CHAIN



STRATEGIC FRAMEWORK

OUR THREE GOALS

Canada produces a niche-quantity of high-quality, medium grade wool. Under the current supply chain model, the bulk of our wool clip is exported to foreign countries at record-low, commodities market pricing. Except for smaller, artisanal lots, Canadian wool rarely reaches Canadian consumers in any meaningful way.

Our commitment and our strategic framework seek to redirect existing Canadian wool into domestic pipelines for more profitable applications, where its value can be realized to the benefit of Canada. This strategic plan makes 3 commitments:

1. To rebrand and revalue Canadian wool

Rebranding and revaluing Canadian wool will help stakeholders recognize the impressive potential of our wool when matched with new business modelling, creative sales strategies, innovation, and educated consumers who prioritize environmentally safe and sound products derived from sustainable materials.

2. To advocate for the entire Canadian wool value chain

Using our network, resources, and know-how to advocate for the needs of Canadian wool stakeholders at every level of the supply chain. Through special initiatives, collaborations and an innovative communications network, we are positioned to support the industry, develop partnerships and represent its interests to all levels of Government.

3. Giving Canadian wool a voice on the international stage

Giving Canada a voice in the global wool trade. We will use that international platform to develop Canada's wool brand, forge strategic partnerships, develop opportunities for Canadian wool producers and innovators and provide a Canadian lens to global policy and advocacy work.

OVERVIEW

Development of our strategic framework was the outcome of research identifying five significant obstacles in the existing Canadian wool supply chain.

These obstacles and their subsequent recovery strategies fall into five “Strategy Zones.”

1. Education
2. Outreach
3. Brokerage
4. Infrastructure Needs
5. “Proudly Canadian” Products

1. EDUCATION STRATEGIC FRAMEWORK

CURRENT CONDITION

The industry requires an adequate supply of wool shearers, and new entrants, at all levels of the supply chain. In addition, the cost of shearing is seen as a burden by producers rather than an opportunity.

STRATEGIC INITIATIVES

This strategy calls for the creation of a national Shearing Guild which will:

- Partner on a top-tier accredited national shearing certification program
- Create an Authorized “Guild-Shearers” work stream
- Roll out a Free-to-Farmers Shearing Program for qualified farms
- Build a national network of Guild Master Shearers and develop recruitment and retention programming as well

as international training and employment opportunities

- Additionally, the strategy has the potential to develop apprenticeship/internship/placement opportunities for young people in businesses and industry organizations across the wool value chain.

STAKEHOLDERS BENEFITS

Both the Shearing Guild and the Youth Employment Opportunities help to address producer concerns and costs while improving the quality of the clip available for other products and providing opportunities and new entrants to the industry.

FINANCIAL CONSIDERATIONS

Existing shearing training programs are not expensive but the quality and cost vary and would be improved through a certification process supported by industry.

In terms of youth employment there are numerous existing provincial and federal youth employment programs that could be accessed to leverage industry and private sector investment in creating opportunities.



2. OUTREACH STRATEGIC FRAMEWORK

CURRENT CONDITION

Currently Canadian wool is not well understood globally and the industry itself is disconnected. While the Campaign for Wool provides a national and global media platform for consumer education, there remains a need to grow those efforts while building deeper connections across the domestic value chain as well as with the global industry. Equally, there is an imperative to promote and market Canada's wool heritage in support of wider industry revitalization.

STRATEGIC INITIATIVES

This strategy calls for initiatives to strengthen its domestic and global connections while honouring the historical role played by Canada's wool industry. The idea is to bring wool out of the proverbial cedar closet and place it squarely in the face of Canadians, in an enticingly modern way.

These include:

- Leading Canada's application for membership in the International Wool Textile Organization
- Expand the role of the Advisory Council by creating task groups covering Canada's wool value-chain. open communication with task groups enables us to understand and intervene on emerging issues expediently. Task groups include (see Appendix for our offer to task groups):
 - Agricultural producers
 - Industry Associations
 - Makers, Innovators & Commercial partnerships
 - Infrastructure & Technology
 - Government & International Relations,
 - Wool Industry Shepherds
 - Future Leaders Circle
 - Legacy Circle

- Honouring Canada's Wool Legacy including developing strategic partnerships with Canadian institutions like the Royal Canadian Mint, Canada Post, Hudson's Bay Company and others to celebrate Canada's wool heritage (ie. coins, stamps, heritage products)

STAKEHOLDERS BENEFITS

These initiatives will result in a more deeply integrated and globally connected Canadian wool industry more in tune with the latest innovations and design trends. Honouring the rich history of wool in Canada will also serve to both build pride throughout the value chain while leveraging heritage for building a desirable Canadian brand.

FINANCIAL CONSIDERATIONS

The costs of membership, policy support and administration for both the IWTO membership and the task groups will be modest and should be supported from across the groups they represent. This should be borne across producer associations, business and Government at all-levels. Legacy work can be accomplished as specially funded projects or as potential social ventures.



3. BROKERAGE STRATEGIC FRAMEWORK

CURRENT CONDITION

Currently the majority of wool sold by Canadian producers ends up with the CCWG. With a venerable history, CCWG was set-up to market the Canadian clip and look after the interests of wool growers. With a model focused primarily on commodity sales of greasy wool in addition to a retail arm, the returns to farmers can often act as a disincentive to properly care for wool or even bother selling it in the first place.

STRATEGIC INITIATIVES

The basis of a revitalized Canadian wool industry will be built on wool product innovation and creating a meaningful “Proudly Canadian” brand.



This strategy calls for the development of a service agreement between the Canadian Wool Council and Canadian Cooperative Wool Growers, as well as other national and provincial sheep organizations to provide research and development (R&D), as well as marketing functions on behalf of the Canadian industry.

STAKEHOLDERS BENEFITS

The strategy proposes a collaboration with CCWG to stimulate market demand for Canadian wool by establishing floor pricing for wool and reserving a specific lot size of wool to funnel into “Proudly Canadian” wool projects where the floor wool price is embedded in the business model. The products would be promoted and marketed using the Campaign for Wool (CFW).

FINANCIAL CONSIDERATIONS

While product development and branding costs will need to be funded by a mixture of industry and government, what is clear is that over the past eight years the Campaign for Wool in Canada has delivered great value for money leveraging high-level partnerships and bringing Canadian wool to the world. We can only imagine improving on this already impressive track record by virtue of our accumulating experience.

4. INFRASTRUCTURE STRATEGIC FRAMEWORK

CURRENT CONDITION

Wool infrastructure in Canada doesn't measure up to that of other wool producing nations however, while not entirely without means, the current infrastructure is limited in terms of opportunity for growth. This framework proposes creating infrastructure that estimates the right scale and skill for the Canadian industry over the next 5 - 15 years.

STRATEGIC INITIATIVES

Our strategic initiatives for Infrastructure are modest but realistic and impactful:

- Support rapid prototyping laboratories and facilities as a low-risk path to commercialization
- Outsource washing solutions to nations who have infrastructure, capacity and mature grey-water management practices in place.
- Create a directory of semi-industrial processing facilities with the aim to connect innovators with processing services.

STAKEHOLDER BENEFITS

By focusing first on pathways to commercialize the existing wool clip, we're allowing ourselves time to test, promote, rebrand and revalue Canadian wool to eventually evolve and diversify the Canadian wool industry.

FINANCIAL CONSIDERATIONS

Canada is not without its pressure from stakeholders to justify the purchase of scourers, super-wash machines and other high efficiency processors. We have heard and

understood the argument that "if we had super-wash... we could do more with our wool."

After extensive research and consultation, our conclusion is that Canada cannot justify industrial-scale equipment at this point in the industry's evolution. We are optimistic that by rebranding and revaluing Canadian wool, we will eventually arrive at a place to justify a wide variety of machine options.

At this point in time however, even if we did invest in a super-wash machine, the cost of operating the machine and the subsequent levels of approval required for its operation and pollution management would render the machine unusable.

We have a better opportunity, with lower risk to all stakeholders, by creating strategic partnerships with international allies who've already mastered wool infrastructure and by prioritizing wool innovation projects that require minimal processing/transformation.



5. “PROUDLY CANADIAN” PRODUCTS STRATEGIC FRAMEWORK

CURRENT CONDITION

With our wool being mostly exported for foreign manufacturing, there is a limited connection between Canadian wool and Canadian wool products with a few notable exceptions including the MacCausland Blankets, Ulat dryer balls and Briggs & Little Yarn. Even the iconic Hudson’s Bay Blanket and RCMP red serge fabric are made of British wool.

STRATEGIC INITIATIVES

Canada has developed strong product recognition with maple syrup, arctic char, and the beaver. Likewise, Scotland has developed recognition with Harris Tweed, scotch whiskey and haggis and France has le pain quotidien, le fromage, et du bon vin. We propose adding Canadian wool to Canada’s portfolio of iconographic natural resources.

The most promising application for Canadian wool will be in “Proudly Canadian” products. Using rapid prototyping facilities, we have an opportunity to create a product incubator to test the commercial viability of Canadian wool products in the areas of:

Residential and Commercial Interiors Market

- Rugs
- Upholstery
- Drapery
- Blankets and Bedding
- Mattresses, Pillows and Upholstery Stuffing
- Wall Coverings

Semi-Industry

- Biopolymers
- Packaging and Product Insulation
- Semi-Industrial Felting
- Passive Filtration
- Marine Spill Clean-up and Waterfront Maintenance
- First Responder, Defense and Disaster Readiness (Ex: Coast Guard, Fire, Police, Military PPE)



Agricultural products

- Fertilizers
- Garden Bedding and Water Retention Products
- Beehive Insulation
- Stakeholder Benefits

By putting branded Canadian wool products in the hands of consumers we are not only providing a high-quality, sustainable product, we are creating an advertising opportunity for our valuable renewable, natural resource that supports Canadian sheep farmers.

FINANCIAL CONSIDERATIONS

Canada’s average-grade of wool could mean that our “Proudly Canadian” products have “less-iconic” applications but looking at the Canadian maple leaf stamped on Canadian wheat, we see that national pride is not compromised as a result of the product inside. It’s the branding and marketing opportunity that exists. Possibly, Canadian innovators would have better return on investment with semi-industrial innovation than more refined wool products.

OUR TEN TACTICS FOR 2021-2026

OVERVIEW

Our plan offers three commitments, five strategies and ten tactics for 2021 - 2026

1. Develop a national shearing guild
2. Create wool industry apprenticeship, internship and placement opportunities for young people
3. Lead Canada's application for membership in the International Wool Textile Organization
4. Honour Canada's wool legacy through strategic partnerships with Canadian institutions
5. Expand the role of the Advisory Council to include task forces covering Canada's wool value-chain
6. Develop "Proudly Canadian Wool" product incubator partnerships to test the commercial viability of Canadian wool products in strategic product sectors
7. Develop a Canadian Wool Trademark (ie. Woolmark for Canada) with associated standards that define Canadian wool as a premium product. Would include adherence to the principles of the Campaign for Wool's Dumfries House Declaration at every step of the way
8. Develop "Proudly Canadian Wool" marketing collateral and point of sale materials to support retailers in telling the story of Canadian wool
9. Establish partnership with an off-shore (UK-based) scouring operation to unlock short-term processing capacity (measuring and offsetting carbon footprint where possible) while building the case for investing in machinery in Canada
10. Develop plans for a national sheep and wool centre of excellence



THE CAMPAIGN FOR WOOL

Patron: HRH The Prince of Wales



WOOL INNOVATION AND TECHNOLOGY

Promising growth sectors for Canadian wool include:

- Residential or commercial interiors market
- Semi-industrial market
- Agriculture product market

Innovation using Canada wool should be focused on projects requiring medium micron range wool, with a contaminant rate of +/- 3%. Priority should be given to projects requiring the minimal amount of transformation. Using wool in its rawest form is the most cost-effective, efficient and environmentally sound approach.

Contaminants

To innovate within the wool industry doesn't necessarily involve new technology. Often innovation can happen with simple process adjustment. One of the areas where we can innovate in Canadian wool is by better wool care and management of contaminants.

Contaminants are the primary reason why wool is rendered unusable. Three types of contaminants will affect the usability, value and versatility of wool. These contaminants can be managed and reduced with better wool grower education and simple on-farm changes to sheep management.

1. **Natural contaminants which are produced but the sheep itself.**
 - Medullated or kemp fibres (hair fibres)
 - Coloured fibres or black spots
 - Stains from urine or feces
 - Yolk and Canary stains derived from trauma, bacteria or parasitic infection

2. **Acquired contaminants that are picked up by the sheep in its environment.**
 - Vegetable matter (feed, hay, straw, wood chips, burdock)
 - Mineral matter (dirt, soil, mud)
 - Animal matter (contamination from interaction with other livestock ex: manure)
 - Polypropylene (plastic baler twine, feed bags, synthetic fencing material)
 - Other matter (jute, sisal, string, raps, cigarette butts, teeth from cutters, blood or skin pieces)
3. **Applied contaminants are liquids in spray, paint or grease form, that are used in on-farm management**
 - Paint (coloured grease or sprays applied to sheep to identify mothers and babies)
 - Medications (copper sulfate to treat foot rot or phenothiazine for stomach worms)
 - Pesticides

Wool Technology

At present, the Canadian wool industry doesn't require significant investment in technology. Our research indicates future potential with robotics, artificial intelligence and machine learning to improve wool's versatility and viability. Canada wool industry experts remain pessimistic about adoption of technology as it relates to Canadian wool.

Experts conclude that the size and the demands of the Canadian wool industry are best met using people power. When machine testing or measuring is required, the Canadian wool industry has found it cheaper and easier to outsource testing to labs in the US and New Zealand. Experts cite a relatively low carbon footprint in outsourcing these services with a comparably short turn around time to get results. Prices are cheap in these international labs due to volume.

If our research could recommend one piece of technology, it would be the investment in a portable micron measuring machine. A micron measuring machine can be used to measure all animal fibres and provides impressive data output which tracks information along the entire fibre staple. (See Appendix for sample micron testing data)

Speculatively speaking, we could also imagine a smart phone app that uses artificial intelligence and an external, plug-in or bluetooth-style device that could measure fibres with immediate data output, thereby eliminating the need for costly, cumbersome machinery. We are unaware of any current plans to develop this technology however, with the speed of AI innovation, especially in areas related to metrics in agriculture and sustainability, it's not a far-fetched idea.



FUTURE DIRECTIONS IN RESEARCH AND PROGRAM DEVELOPMENT

Canada invests significantly in research related to important topics in sheep genetics, disease and parasite control, prolificacy, habitation, feed and animal handling. There appears to be a knowledge gap or an absence of research on the business of sheep farming and on the business of wool care.

Future research supported by private sector initiatives could be directed into the following channels:

- Impacts of sheep farming on the environment (in collaboration with environmental groups or universities)
- Understanding new trends and advancements in sheep farming
- Sheep farming as it co-exists with regenerative agriculture, permaculture, and the circular economy
- Incorporating technology into small scale farming for better profits and quality of life
- Understanding the positive impact that technology can play in sheep farm operations
- Business modeling for small scale (family) sheep operations
- Diversified revenue opportunities
- Family health on a small scale farm operation (work-life balance, stress and mental health)
- Learning from our ancestors / adapting pre-industrial revolution farming practices for the modern day small scale farmer





ACKNOWLEDGMENTS

EDUCATION TABLE SESSION

- Allison Duckman, Fashion Design Student, Parsons School of Design, The New School, New York, NY
- Alison Hope, Principal, Hope Communications, Toronto, ON
- Colin Dobell, Executive Director, Ontario Water Centre, King City, ON
- David Mastine, President, Canadian Co-operative Wool Growers, St-Félix-de-Kingsey, QC
- Eliza Mitchell, Sheep Rancher and Board Member of The Weston Family Foundation, Tatlayoko Valley, BC
- Grahame Lynch, Associate Professor, Associate Chair, Department of Fashion, Ryerson University, Toronto, ON
- Justin Morin-Carpentier, Consultant and Business Developer, New York, NY
- Philip Stark, Fashion Designer, Faculty, Seneca College, Toronto, ON
- Romy Schill, Founder, Revolution Wool Company & Partner, Circle R Lamb, Wallenstein, ON

OUTREACH TABLE SESSION

- Alison Duckman, Fashion Design Student, Parsons School of Design, The New School, New York, NY
- Alison Hope, Principal, Hope Communications, Toronto, ON
- Madeleine Hope-Fraser, Artist, Social Media Marketing, Creative Matters Inc., Toronto ON /Glasgow UK
- Barabara Jesson, President, Jesson + Company Communications, Toronto, ON
- Grahame Lynch, Artist, Chair, Fashion Design, Ryerson University, Toronto, ON
- David Mastine, President, Canadian Co-operative Wool Growers, St-Félix-de-Kingsey, QC
- Justin Morin-Carpentier, Consultant and Business Developer, New York, NY

- Romy Schill, Founder, Revolution Wool Company & Partner, Circle R Lamb, Wallenstein, ON
- Delana White, International Wool Textile Organization, Brussels, Belgium

BRAND CANADA PRODUCTS TABLE SESSION

- Martin Curtis, Chairman, Wool Carpet Focus Group Limited, Leeds, UK
- Allison Duckman, Fashion Design Student, Parsons School of Design, The New School, New York, NY
- Alison Hope, Principal, Hope Communications, Toronto, ON
- Andrew Legge, Founder and Managing Partner, Havelock Wool, Reno, Nevada, USA
- Eliza Mitchell, Sheep Rancher and Board Member of The Weston Family Foundation, Tatlayoko Valley, BC
- Justin Morin-Carpentier, Consultant and Business Developer, New York, NY
- Bastien Ouellet, Chargé de projet, Carrefour d'innovation sur les matériaux de la MRC des Sources (CIMMS), Québec, QC
- Maddy Purvis-Smith, Owner, Operator, Custom Woolen Mills, Carstairs, AB
- Romy Schill, Founder, Revolution Wool Company & Partner, Circle R Lamb, Wallenstein, ON
- Sir David Wootton, Master, The Worshipful Company of Woolmen, 684th Lord Mayor of London, London, UK

WOOL BROKERAGE TABLE SESSION

- Richard Blickstead, President and CEO, Phoenix 360 Solutions, Toronto, ON
- Eric Bjergso, General Manager, Canadian Co-operative Wool Growers, Carleton Place, ON
- Martin Curtis, Chairman, Wool Carpet Focus Group Limited, Leeds, UK
- Joe Dales, Co-Founder and President, RH Accelerator, London, ON
- Andrew Legge, Founder and Managing Partner, Havelock Wool, Reno, Nevada, USA
- David Mastine, President, Canadian Co-operative Wool

- Growers, St-Félix-de-Kingsey, QC
- Ruth Mathewson, 2nd Vice President, Canadian Co-operative Wool Growers, Central North River, NS
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- Romy Schill, Founder, Revolution Wool Company & Partner, Circle R Lamb, Wallenstein, ON

INFRASTRUCTURE TABLE SESSION

- Rick Blickstead, President and CEO, Phoenix 360 Solutions, Toronto, ON
- Elaine Corbett, Director, Sector Innovation and Programs, Ontario Genomics, Toronto, ON
- Astrid-Maria Ciarallo, Board Member, Campaign for Wool, Toronto, ON
- Martin Curtis, Chairman, Wool Carpet Focus Group Limited, Leeds, UK
- Joe Dales, Co-Founder and President, RH Accelerator, London, ON
- Colin Dobell, Executive Director Ontario Water Centre, Georgina, ON
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- Andrew Legge, Founder and Managing Partner, Havelock Wool, Reno, Nevada, USA
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- Justin Morin-Carpentier, Consultant and Business Developer, New York, NY
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- Romy Schill, Founder, Revolution Wool Company & Partner, Circle R Lamb, Wallenstein, ON

THANK YOU TO OUR SHEEP AND WOOL SECTOR ADVISORY PANEL

In addition to the Strategic Advisory Panel, our team has also undertaken direct discussions with leaders across the Canadian sheep and wool sector sharing our learnings, directions and outcomes and have incorporated their feedback and wisdom wherever possible. These discussions have been so important to understanding the rich history of the sector, past efforts to revitalize and ideas for the future from those closest to producers. We also undertook two public (online) sessions with the members of Ontario Sheep Farmers for input.

CANADIAN SHEEP & WOOL SECTOR CONSULTATIONS

- Eric Bjergso, General Manager, Canadian Co-operative Wool Growers, Carleton Place, ON
- Kim Doherty-Smith, Director, PEI Sheep Breeders Association, Belfast, PEI
- Ryan Grier, Chair, Alberta Lamb Producers, Airdrie, AB
- Joseph Leck, President, Sheep Producers of Nova Scotia, Brookfield, NS
- Pierre Lessard, President, Ovin Quebec, Tingwick, QC
- Jennifer Mactavish, General Manager, Ontario Sheep Farmers, Guelph, ON
- David Mastine, President, Canadian Co-operative Wool Growers, St-Félix-de-Kingsey, QC
- Corlena Patterson, President, Canadian Sheep Federation, Williamsburg, ON
- Allan Ribbink, Chair, Canadian Sheep Federation, Tiverton, ON
- Gord Schroeder, Saskatchewan Sheep Development Board, Saskatoon, SK
- Barbara Ydenberg, President, BC Sheep Federation, Langley, BC

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- Colin Dobell: Ontario Water Centre, Georgina, Ontario, Canada
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- Rhonda McCarron: Brooke Ridge Farm, Brierly Brook, Nova Scotia, Canada
- Lesley Prior: Tellenby Superfine Merino, Devon, United Kingdom
- Liz and Phil Smith: Breezy Ridge Farm, Georgina, Ontario, Canada
- Karine Thibeault: MRC des Sources, Val-des-Sources, Quebec, Canada

THANK YOU TO OUR STRATEGIC PLANNING TEAM

- Matthew J. Rowe
- Jane Underhill
- Courtney Harder



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APPENDIX

CANADIAN FLOCK

	2017		2018		2019		2020		2021	
	1-Jan	1-Jul	1-Jan	1-Jul	1-Jan	1-Jul	1-Jan	1-Jul	1-Jan	
Ontario	240	318	242	327	254	332	252	325	253	0
Quebec	198	236	195	231	187	228	182	225	170	0
Alberta	138	194	139	195	138	190	134	186	130	0
Saskatchewan	85	108	86	112	85	109	80	108	80	0
Manitoba	81	97	97	103	94	95	83	88	83.8	0
British Columbia	40	56	39	54	38	50	35	47	35	0
Nova Scotia	15.6	20.7	15.3	19.7	15.4	18.8	14.2	17.6	13.5	0
Prince Edward Island	8.2	8.8	8.5	9.2	8.5	9.2	8.2	9.1	7.8	0
New Brunswick	6	7.1	5.6	6.9	5.8	6.6	5.3	6.5	5.1	0
Newfoundland & Labrador	2.1	2.4	2	2.6	2.1	2.6	2.1	2.4	2	0
CANADA	814	1048	829.4	1060.4	827.8	1041.6	795.8	1014.6	780.2	0

Source: <https://www150.statcan.gc.ca/n1/daily-quotidien/210301/dq210301c-eng.htm>

Canadian Sheep and Lamb Population represents 0.06% of the global sheep population.

- Canadian Sheep: 780,200
- Canadian Sheep Farms: 9,390 farms

Top lamb producing provinces:

- Ontario (30.5%)
- Quebec (22.5%)
- Alberta (18.5%)

Global Sheep Population

Rank	Country	Sheep Production (000 head)
1	China	162,691
2	India	74,082
3	Australia	64,963
4	Sudan	59,518
5	Nigeria	46,901
6	Iran	41,081
7	Chad	35,382
8	Turkey	35,391
9	United Kingdom	33,600
10	Mongolia	32,300
<41	Canada	1,014.6



- Sheep headcounts happen on January 1 and July 1 each year. The January headcount being lower with the July headcount happening after spring lambing.
- Sheep are commonly raised on pasture or on dry lots within Canada with an average farm population of 112 sheep³.
- Sheep in Canada are primarily raised for meat, with dairy and fibre sheep considered as secondary, bi-product, diversified revenue or trends.
- At present, Canada fulfills 42% - 45% of its domestic lamb needs, hence growth potential. The balance of lamb meat is imported from Britain, New Zealand and elsewhere.
- Canada is home to 41 recognized breeds of sheep, with 20 breeds dominating the sheep population
- Breeding and crossbreeding selection are done for improvements in resiliency, prolificacy, mothering and meat/market characteristics.
- New or rare breeds are being regularly considered or introduced to the national flock.
- Strict regulations must be met for a new breed to be introduced into Canada.

COMMON LAMB PRODUCTION SYSTEMS:

1. Winter Lambing (December to March)

- Selling Time: Spring market
- Selling Price: Highest of year
- Labour Requirements: High but available
- Housing Requirements: Important for lambing
- Feed Requirements: High, good forage for lactating ewes
- Lamb Creep Feed Requirements: Moderate, weight important for spring sale
- Pasture Requirements: Ewes only
- Health Issues: Higher disease incidence due to confinement and weather

2. Spring/Grass Lambing(April/May/June)

- Selling Time: Late Summer/Early Fall market

- Selling Price: Fair prices, generates cash flow for accelerated
- Labour Requirements: Lower, condensed lambing period, stock and pasture skill important.
- Housing Requirements: Reduced
- Feed Requirements: Low for winter, coincides with spring pasture growth
- Lamb Creep Feed Requirements: None required, high quality grass used
- Pasture Requirements: High, lambs and ewes at pasture
- Health Issues: Higher predation & worm loads; less weather-related issues

3. Accelerated (3 lambings in 2 years or 5 lambings in 3 years)

- Selling Time: Throughout the year
- Selling Price: More consistent cash flow & less price risk
- Labour Requirements: Very high, intensive management required
- Housing Requirements: High, lambing and breeding indoors under controlled conditions
- Feed Requirements: Req't High, nutrition vital to success of accelerated lambing program
- Lamb Creep Feed Requirements: High, lambs in confinement fed creep
- Pasture Requirements: Low, some systems occur with 0 grazing
- Health Issues: Closely monitored, reproductive management (e.g. light control, drugs, etc)

4. Lamb Feedlot (wean to finish)

- Selling Price: Variable
- Selling Time: As lambs reach target weights, usually 100-120lbs live weight
- Labour Requirements: High, lambs fed in confinement or on pasture
- Housing Requirements: High, lambs fed in feedlot barns/ yards
- Feed Requirements: High, lambs fed to gain 0.5-1.0 lbs/ day
- Lamb Creep Feed Requirements: N/A, unless creep fed at

- pasture
- Pasture Requirements: Critical if feeding on pasture, N/A if confinement feeding
- Health Issues: Closely monitored

SHEEP GOVERNANCE, GENETICS, AND BREEDING

Governance

Management of Canada's National Flock adheres to the Animal Pedigree Act, overseen by Agriculture and Agri-Foods Canada as well as provincial and national sheep associations. The Canadian Sheep Federation leads several initiatives toward animal and industry management, health, welfare, biosecurity, and traceability.

The National Sheep Network is composed of the Alberta Lamb Producers, the Ontario Sheep Farmers and Les Éleveurs d'ovins du Québec. Together, the three provinces represent 75 percent of Canada's ewe flock.

The Canadian Sheep Breeders' Association and its respective provincial associations are responsible for the maintenance and integrity of the national purebred sheep flock.

The Canadian Livestock Records Corporation is mandated as the national purebred sheep registrar. CLRC maintains a centralized database of purebred sheep with recorded animals, their identification tag numbers, tattoos, parentage, breeders, producers and owners.

Other important organizations exist across Canada to manage provincial industries and regulations. The work of these organizations is critical to the success of lamb producers.

Genetics

Genetics evaluation makes it possible to effectively evaluate the genetic value of sheep based on important economic traits as expressed by parentage and other animals within the breed or crossbreed.

The GenOvis program, initiated by CEPOQ (Centre d'expertise ovine du Québec) is an on-farm sheep genetic evaluation program for all Canadian users.

The Centre for Genetic Improvement in Livestock at the University of Guelph has a mission to position the Canadian livestock industries as global leaders in animal genetic, products and genetic improvement technologies through world leading research and training in quantitative genetics, animal breeding and animal genomics. CGIL works in close collaboration with GenOvis and CEPOQ.

Breeding

Within Canada, the viability of sheep and their resilience to inclement weather is a primary concern. A study completed in Alberta suggests that prolonged cold inhibits digestibility, and therefore feed- efficiency, potential growth and length of productive lifetime (Christopherson, 1976) . Additionally, exposure to long periods of inclement weather causes higher maintenance requirements, reduced productivity, reduced food and water intake among other factors. Selecting for resilience to Canadian climates is important to ensuring our flocks are healthy and productive year-round and is reflective in our current flock. To mitigate potential thermal stress ruminant genetics have been studied for heat tolerant, thermoneutral and harsh cold temperatures and can be used to cross breed animals to be more fit for specific environments (Freitas et al., 2021; Joy et al., 2020; Osei-Amponsah et al., 2019)

Traceability

Canadian sheep traceability reduces risk, increases transparency, informs management decisions and can serve as a quality assurance measure. Three Canadian Initiatives, monitored through the Canadian Sheep Federation are in place

Canadian Sheep Identification Program (CSIP)

Traceability through the Canadian Sheep Identification Program (CSIP) centers around animal, premises and movement identification and reporting. All sheep raised within Canada are tagged with RFID tags and their associated animal identification number. Sheep are then associated with premises through their various stages of life. Each premises' information and location are utilized for disease control and biosecurity traceability. Finally animal movement or transport is recorded and each animal requires accompanying records through transport.

The Canadian Verified Sheep Program (CVSP)

The Canadian Verified Sheep Program (CVSP) is a voluntary program within Canada which models various exemplary practices in the areas of food safety, animal biosecurity and welfare management practices. On farm food safety is a common practice in other sheep producing countries and the implementation of this program is to provide a framework for safe and responsibly raised lamb.

Blockchain

Blockchain traceability is a digital form of record keeping that creates a permanent record connecting information on animals to allow for lifetime tracking of animals (Food and Agriculture Organization of the United Nations, 2019). This way of record keeping allows individuals to access up to date information at any time, and allows farm equipment to include any data it may collect (Westover, 2019).

The Canadian sheep federation launched a 'proof of concept' field trial utilizing SheepChain Ltd. which applied blockchain technology utilizing current traceable technologies alongside new equipment (American Certified Brands Canadian Sheep Federation Brookwater Farms Northumberland, 2019; Canadian Sheep Federation, 2019). Data collected from blockchain would be available as QR codes on meat

packages by utilizing the CSIP tag.

WHY IS TRACEABILITY IMPORTANT

Today's consumer has demonstrated the knowledge disconnect between producers and consumers on agricultural practices (Westover, 2019). The sheep industry itself has faced criticism and misunderstanding on how wool is shorn, processed and its afterlife.

A 2020 study by the Canadian Centre for Food Integrity, demonstrated the public's trust in food and the associated food supply. Canadians showed the most trust in the farmers information, overall, about food and food safety when compared to other knowledge outlets (The Canadian Centre of Food's Integrity, 2017, 2020a). Additionally, consumers confided that 45% of respondents were 'extremely concerned' about food safety. 39% of respondents were concerned about humane treatment of animals and 37% were concerned about environmental sustainability and the availability of quality food (The Canadian Centre of Food's Integrity, 2020a, 2020b). Reviews of their previous studies have shown that the public is gaining more trust in the agricultural system as well as farmers (Food and Agriculture Organization of the United Nations, 2019; Sutherland et al., 2020; Westover, 2019).

19% of consumers believe that sustainable food can be tracked throughout its lifetime and 100% of industry participation believed that public trust was the highest priority issue (The Canadian Centre of Food's Integrity, 2020b). A previous study completed by CCFI also showed that demonstrating transparency in the food industry was the best way to improve the public's trust of their food supply (The Canadian Centre of Food's Integrity, 2017).

CONSIDERATIONS

The future of agriculture relies on the use of research, technology and increased adoption of data-capturing practices

for management decisions and on farm record keeping. Some areas with encouraging research and more information to be discovered include environment management, wool management and breeding decisions.

On-boarding of a national wool strategy requires we acknowledge and accept that meat production is the driving force behind the Canadian sheep industry. Also important to acknowledge that our meat industry doesn't begin and end with only the farmer. There is a complex series of interdependent stakeholders and sub-industries around the sheep industry which are vital to the Canadian economy. From producer, transporter, sales agencies, abattoirs, processors, buyers, packagers, distributors, and end consumers - these stakeholders are constantly adapting to dynamic market changes.

For a Canadian wool initiative to be successful, it must make every effort to integrate into the complex chain of lamb distribution. And it must first find applications and uses for Canadian wool as it is. Medium grade, high-quality wool from meat-breed sheep. As we discover more applications for existing Canadian wool, we'll be able to easily justify infrastructure and industry needs for fibre-centric sheep production.

COMMON SHEEP TERMS TERM DEFINITION

- **Average Daily Gain (ADG):** The gain in one day of the animal in lbs or kgs
- **Cull Ewe:** A ewe at the end of its reproductive life
- **Dressing Percent:** Percent of carcass from live weight (carcass wt/live weight)
- **Ewe:** A female sheep that has lambed at least once
- **Ewe Lamb:** A female lamb retained for breeding and has not lambed
- **F1:** In grading up it's the first generation cross
- **F2:** In grading up it's the second generation cross
- **Feed Conversion:** Amount of feed dry matter to allow 1 lb or kg of gain
- **Feeder Lamb:** A lamb that requires more growth and finish before it is a suitable size and weight for a particular slaughter market
- **Flushing:** Increasing the ovulation rate of a ewe through nutrition
- **Gestation:** Length of time from conception to lambing
- **Grading up:** The sequential use of purebred animals over a series of generations to provide a "nearly purebred" result.
- **Hair Sheep:** Tropical (or temperate derived) sheep breeds with hair rather than wool
- **Hogget:** A yearling ewe
- **Lamb:** A sheep that is normally < 1 year of age
- **Market Lamb:** A lamb that is ready for slaughter
- **Maternal Breeds:** Sheep breeds used for mothering, milk and/or reproductive capacity
- **Prolificacy:** Number of lambs born/ewe/lambing
- **Ram:** A male breeding sheep
- **Ram Lamb:** A male lamb retained for breeding
- **Terminal Breeds:** Sheep breeds used for their ability to produce high meat yielding offspring with rapid gain
- **Tup / Buck:** A ram in the U.K / U.S.
- **Wether:** A castrated male sheep

RECOGNIZED SHEEP BREEDS IN CANADA

- Berrichon du Cher
- Blackface
- Blue Faced Leicester
- Border Leicester
- Border Cheviot
- British Milk Sheep
- California Red Sheep
- Canadian Arcott
- Charollais
- Clun Forest
- Columbia
- Corriedale
- Cotswold
- DLS
- Dorper/White Dorper
- Dorset Horned and Polled
- East Friesian Dairy
- Finnsheep
- Hampshire
- Icelandic
- Ile De France
- Jacob
- Katahdin
- Lincoln
- Merino
- North Country Cheviot
- Outaouais Arcott
- Oxford
- Polypay
- Rambouillet
- Rideau Arcott
- Romanov
- Romney
- Rouge de l'Ouest
- Shetland
- Shropshire
- South African Meat
- Southdown
- Suffolk
- Targhee
- Texel
- Valais Black Nose and Wensleydale breeds are presently being introduced and graded up.

Information courtesy of the Canadian Sheep Breeders Association



CITATIONS

- American Certified Brands Canadian Sheep Federation Brookwater Farms Northumberland. (2019). SheepChain Demo. <https://sheepchain.azurewebsites.net/Animal>
- Australian Wool Innovation Limited. (n.d.). Genetic Evaluation Services.
- Bowles, D. (2015). Recent advances in understanding the genetic resources of sheep breeds locally-adapted to the UK uplands: opportunities they offer for sustainable productivity . In *Frontiers in Genetics* (Vol. 6, p. 24). <https://www.frontiersin.org/article/10.3389/fgene.2015.00024>
- Canadian Sheep Federation. (2019). Canadian sheep industry moves lambs on blockchain. https://www.cansheep.ca/documents/PR_CDN_sheep_industry_moves_lambs_on_blockchain_Feb2019.pdf
- Canadian Sheep Federation, & Canadian Co-Operative Wool Growers. (n.d.). Wool Production in Canada.
- Christopherson, R. J. (1976). EFFECTS OF PROLONGED COLD AND THE OUTDOOR WINTER ENVIRONMENT ON APPARENT DIGESTIBILITY. 212(June), 201–212.
- Climate Action Tracker. (2020a). Climate Action Tracker - Canada. <https://climateactiontracker.org/countries/canada/>
- Climate Action Tracker. (2020b). Climate Action Tracker - Global Overview.
- Colley, T. A., Olsen, S. I., Birkved, M., & Hauschild, M. Z. (2020). Delta Life Cycle Assessment of Regenerative Agriculture in a Sheep Farming System. In *Integrated Environmental Assessment and Management* (Vol. 16, Issue 2, pp. 282–290). <https://doi.org/10.1002/ieam.4238>
- Falkner, R. (2019). The Paris Agreement and the new logic of international climate politics. September 2016. <https://doi.org/10.1111/1468-2346.12708>

- Food and Agriculture Organization of the United Nations. (2019). E-agriculture in action: Blockchain for agriculture.
- Freitas, P. H. F., Wang, Y., Yan, P., Oliveira, H. R., Schenkel, F. S., Zhang, Y., Xu, Q., & Brito, L. F. (2021). Genetic Diversity and Signatures of Selection for Thermal Stress in Cattle and Other Two Bos Species Adapted to Divergent Climatic Conditions . In *Frontiers in Genetics* (Vol. 12, p. 102). <https://www.frontiersin.org/article/10.3389/fgene.2021.604823>
- Government of Canada. (2021). Sheep Farming - 11241 - Summary - Canadian Industry Statistics - Innovation, Science and Economic Development Canada. <https://www.ic.gc.ca/app/scr/app/cis/summary-sommaire/11241>
- International Wool Textile Organization. (2021). Market Information edition 16 - Statistics for the Global Wool Production and Textile Industry.
- Joy, A., Dunshea, F. R., Leury, B. J., Clarke, I. J., DiGiacomo, K., & Chauhan, S. S. (2020). Resilience of Small Ruminants to Climate Change and Increased Environmental Temperature: A Review. In *Animals* (Vol. 10, Issue 5). <https://doi.org/10.3390/ani10050867>
- Karrow, N. A., Goliboski, K., Stonos, N., Schenkel, F., & Peregrine, A. (2014). Review : Genetics of helminth resistance in sheep. 1, 1–9. <https://doi.org/10.4141/CJAS2013-036>
- Kijas, J. W., Lenstra, J. A., Hayes, B., Boitard, S., Neto, L. R. P., San, M., Servin, B., Mcculloch, R., Whan, V., Gietzen, K., Paiva, S., Barendse, W., Ciani, E., Raadsma, H., Mcewan, J., & Dalrymple, B. (2012). Genome-Wide Analysis of the World ' s Sheep Breeds Reveals High Levels of Historic Mixture and Strong Recent Selection. *PLoS Biology*, 10(2). <https://doi.org/10.1371/journal.pbio.1001258>
- Knibb, H., & Klenk, N. (2018). The Ontario Wool Study: Phase 1 - Assessing the Needs of Ontario Wool Producers and Processors An Interim Report for the Ontario Sheep Farmers - Interim Report. 1–17. <https://www.ontariosheep.org/uploads/userfiles/files/Ontario Wool Study Interim Report.pdf>
- Ma, G.-W., Chu, Y.-K., Zhang, W.-J., Qin, F.-Y., Xu, S.-S., Yang, H., Rong, E.-G., Du, Z.-Q., Wang, S.-Z., Li, H., & Wang, N. (2017). Polymorphisms of FST gene and their association with wool quality traits in Chinese Merino sheep. *PLOS ONE*, 12(4), e0174868. <https://doi.org/10.1371/journal.pone.0174868>
- Mcdonald, M. (2012). WOOL422/522 Wool Marketing & Clip Preparation - 9. Selling Systems. <https://www.woolwise.com/wp-content/uploads/2017/07/WOOL-422-522-12-T-09.pdf>
- Osei-Amponsah, R., Chauhan, S. S., Leury, B. J., Cheng, L., Cullen, B., Clarke, I. J., & Dunshea, F. R. (2019). Genetic selection for thermotolerance in ruminants. *Animals*, 9(11), 948.
- Purvis, I. W., & Franklin, I. R. (2005). Major genes and QTL influencing wool production and quality : a review. *Genetic Selection Evolution*, 37(1), 97–107. <https://doi.org/10.1051/gse:2004028>
- Rogelj, J., Elzen, M. Den, Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., & Sha, F. (2020). Paris Agreement climate proposals need a boost to keep warming well below 2 ° C. 1–10. <https://doi.org/10.1038/nature18307>
- Safari, E., Fogarty, N. M., Gilmour, A. R., Atkins, K. D., Mortimer, S. I., Swan, A. A., Brien, F. D., Greeff, J. C., & Van Der Werf, J. H. J. (2007). Genetic correlations among and between wool, growth and reproduction traits in Merino sheep. *Journal of Animal Breeding and Genetics*, 124(2), 65–72. <https://doi.org/https://doi.org/10.1111/j.1439-0388.2007.00641.x>
- Stachowicz, K., Brito, L. F., Oliveira, H. R., Miller, S. P., & Schenkel, F. S. (2018). Assessing

genetic diversity of various Canadian sheep breeds through pedigree analyses. 749(May), 741–749.

Statistics Canada. (2018). Table: 32-10-0142-01 Sheep statistics, quantity of raw wool purchased, used on farms, price and farm value. <https://doi.org/10.25318/3210014201-eng>

Stiles, D., Corscadden, K. (n.d.). Investigating the Feasibility of Wool Value Chain Development. Retrieved November 30, 2020, from <http://nssheep.ca/wp-content/uploads/WVCDP-Final-Report-for-CCWG-14-01-2013.pdf>

Sutherland, C., Sim, C., Gleim, S., & Smyth, S. J. (2020). Canadian Consumer Insights on Agriculture: Addressing the Knowledge-Gap. *Journal of Agricultural & Food Information*, 21(1–2), 50–72. <https://doi.org/10.1080/10496505.2020.1724114>

The Canadian Centre of Food's Integrity. (2017). Tacking Transparency and How it Builds Trust. <https://www.foodintegrity.ca/research/download-current-research/>

The Canadian Centre of Food's Integrity. (2020a). 2020 PUBLIC TRUST RESEARCH. <https://www.foodintegrity.ca/research/download-ccfi-2020-research/>

The Canadian Centre of Food's Integrity. (2020b). Insight Report Backgrounder Alternative Sustainability Proteins. <https://www.foodintegrity.ca/research/download-the-sustainability-insight-report/>

Westover, J. D. (2019). Incentives for the Adoption of Blockchains in Ontario 's Agri -Food Sector : The Role of Risk and Information By (Issue July) [University of Guelph]. https://atrium.lib.uoguelph.ca/xmlui/bitstream/handle/10214/16781/Westover_Jamieson_201907_MSc.pdf?isAllowed=y&sequence=1

THE WOOL INDUSTRY OVERVIEW

Global Greasy Wool Production

Rank	Country	Greasy Wool Produced (tonnes)
1	Australia	359,801
2	China	334,716
3	New Zealand	136,800
4	Turkey	65,064
5	Morocco	64,948
6	Sudan	61,735
7	Russia	50,877
8	South Africa	49,064
9	Argentina	47,900
10	Pakistan	44,610
<36	Canada	1,135.5

Canadian Wool Quantities

Year of Production	Amount of raw wool (1,000 kg)
2016	1,203.4
2017	1,153.3
2018	1,263.8
2019	1,135.9

THE CANADA WOOL INDUSTRY

The Canadian wool industry is primarily built on meat-breed sheep with its wool being exported internationally. From 2008 to 2018, Canadian wool production had stabilized at 1.1-1.2 million kg of greasy wool with an associated 1.3-1.5 kg of wool/head sold (appendix CH). Our national flock of

780,000 head produced 1.26 million kg of raw wool in 2018 with an average price of \$1.10/kg (.50 cents/lb) (Government of Canada, 2021; Statistics Canada., 2018) . Although there was optimism for increased global wool prices in all micron ranges in 2019, COVID-19 has negatively impacted all wool prices and Canada has felt its proportional share of that effect.

Canadian wool is exported internationally through a brokerage system or moved through private outlets to mini mills or other processing facilities. Typically, about seventy percent (70%) of Canadian wool is exported to China, with the remaining being sold to the United States, India, Western Europe and mills within Canada (Canadian Sheep Federation; Canadian Co-Operative Wool Growers, n.d.) . Countries with larger wool supplies implement an auction-based system based on their volume, with processing and testing facilities readily available. Exported Canadian wool is thus obliged to compete with international market pricing.

Canadian wool is managed differently than larger wool producing countries based on our low volume, goals of our farmers and specific characteristics of our wool. Canada's extreme temperatures reduce the potential for fiber-breed sheep to be raised, and with the low return on wool through traditional international markets, meat-breed sheep are prioritized domestically. At present, Canada has minimal, reliable semi-industrial infrastructure to process wool which complicates the domestic wool production pipeline however, research has shown an opportunity and interest to utilize Canadian wool and implement environmental, social and economic benefits for our agricultural industry.

THE INTERNATIONAL WOOL INDUSTRY

Internationally in 2020, over 1,9 billion kg (1,937,184,000 kg) of greasy wool was produced from over 1,2 billion sheep (1,229,192,000), equating to 1.576 kg of greasy wool/sheep (International Wool Textile Organization, 2021) . Countries with different agricultural priorities and climates have diverse flocks with 37.14% of worldwide wool being under 24.5

micron, 21.64% between 24.6-32.5 microns and the remaining 41.21% above 32.5 microns (International Wool Textile Organization, 2021, Appendix CH1) .

Leaders in wool production include Australia (18.6%), China (17.3%), Commonwealth of Independent states (CIS) (10.7%) and New Zealand (7.1%) of greasy wool production (International Wool Textile Organization, 2021) . Countries with large wool yields and a diverse set of buyers commonly sell through open cry auctions. Within Australia, 80% of their wool bales are sold through seasonal auctions. Brokers sell bales of wool at open cry auctions with associated documentation for categorization (Mcdonald, 2012) . The remaining wool is sold through private sales, direct to processors or online (Mcdonald, 2012).

FIBRE SCIENCE

Genetics

Sheep genetics are a pertinent step in making effective breeding decisions to improve our future seedstock and ensure we are continuing to raise healthy and productive animals. Identifying genetic markers allows producers to screen potential breeding stock for specific qualities to improve or add to their existing genotypes. While genetic mapping for improved carcass, prolificacy, mothering and resilience characteristics are already industry practices in Canada, there's a strong potential to add wool characteristics into genetic evaluation.

Larger wool producing countries invest heavily in wool research which has a translational value to the Canadian industry. New Zealand, Australia and China have investigated the genetics of fine merino sheep and their fibre production (Australian Wool Innovation Limited, n.d.; Ma et al., 2017) . The UK is focusing on their flocks corresponding genetic markers to advance their productivity and sustainability (Bowles, 2015) . Currently, genetic selection for wool is required in wool-dominant countries, to follow the market

demands for finer wool, such as fibre diameter, staples strength and wool weight (Kijas et al., 2012; Purvis; Franklin, 2005; Safari et al., 2007) . Identifying correlations and specific productivity loci within sheep's genome allows for other countries to utilize this information with their own national flock or breed.

WOOL PROPERTIES

Natural and Renewable: It is a natural fibre. It has evolved to produce a fabric that has become one of the most effective natural forms of all-weather protection known to man. Every year sheep produce a new fleece, making wool a renewable fibre source. Woolgrowers actively work to improve efficiency and care for natural resources, endeavouring to make the wool industry sustainable for future generations.

Naturally high UV protection: Out-performs most synthetics and cotton.

Fire Retardant: A fabric made entirely of wool doesn't readily catch fire. Even if it does, it burns slowly and self-extinguishes when the source of the flame is removed.

Breathable: It has a large capacity to absorb moisture vapour and sweat next to the skin making it extremely breathable.

Performance and Durability: A single fibre can be bent 20,000 times without breaking and still have the power to recover and return to its natural shape. Woollen fibres have a natural protective layer which prevents stains or odors from being absorbed. Static resistant and collects less dust.

Natural Insulator: Provides consistent control to ambient temperature. Retains warmth in cool temperatures and reacts efficiently to cool when heat rises.

Elastic: The natural elasticity of the fibres allows it to stretch then return to its natural shape.

BIODEGRADABILITY

One of wool's greatest properties as a sustainable material is its biodegradability. Wool is made out of keratin, the same protein as human hair. Microorganisms in soil or water can break down woollen matter and in turn, these microorganisms also break down, sustaining a continuous biological life cycle.

In the right conditions, tests show that wool products will almost completely degrade after six months in the ground. Meanwhile, wool also biodegrades in aquatic environments. The latest research in New Zealand has demonstrated that by 90 days, different types of wool had biodegraded by 20%. In addition, wool can function as an effective soil conditioner and fertiliser, releasing sulphur, nitrogen, phosphorus and potassium as it degrades.

Wool's biodegradation properties are in sharp contrast to synthetic fibres, which take much longer to break down and also release microplastics into the environment. Crucially, wool's unique structure and water-repellent outer membrane mean that while a garment is being worn and cared for, the fibres are resilient and long-lasting. Wool starts to biodegrade in moist, warm conditions, which typically come into play after the lifetime of garments. (<https://iwto.org/sustainability/biodegradability/>)

APPLICATIONS

All wool finds its use. Wool can be used for different purposes, depending on the coarseness of the fibre and on other characteristics such as fibre length and crimp. But regardless of the breed that produced it, wool is a very versatile fibre, with many different qualities. All wool from finest to thickest finds its use. Very fine wool is primarily used for clothing while coarser wool is used in carpets and furnishings such as curtains or bedding. A single sheep provides around 4.5 kg of wool per year, the equivalent of 10 or more metres of fabric. This is enough for six sweaters,

three suit and trouser combinations, or to cover one large sofa. (<https://iwto.org/sheep/>)

- Grading, Classing etc...
- Accreditation Programs

OTHER NATURAL FIBRES

Wool competes with petrochemical textiles as well as other natural fibres. For environmental reasons, and with the rise of "slow-fashion" and "ethical-fashion", the global textile industry is seeing an uptick in natural fibre innovation and production. Petrochemical fabrics still dominate the textile industry but an emerging trend is seeing wool being blended with other natural fibres like milkweed, flax and hemp to create more versatile, durable, affordable, environmentally friendly fabrics.

The rise of natural fibre textiles is not without its dark spots. Alarming rates of human slavery and animal welfare issues are being recorded. Efforts to expose sellers of low priced cashmere, wool, and other luxury fibres are gaining traction but the road will be long because most consumers are only now becoming aware of the source of our clothing and its connection to the land. To layer on the responsibility to not only choose natural fibres over synthetics, but to then as consumers to forgo economically priced natural fibres because of social justice violations will require an important education campaign.

EMERGING TRENDS

The "Natural Fibre Blends" industry is in its infancy in Canada but a new generation of socially conscious fashion designers are working in direct collaboration with farmers to produce bioregional textiles in a circular economy. As technology and infrastructure evolve to process other natural fibres, there is a good possibility of seeing Canadian wool blended to produce more garment-ready products.

Natural versus Synthetic Textile Data (courtesy of the

International Wool Textile Organization)

- World fibre production increased by 3.3% in 2020 to a new record level.
- World man-made fibre production increased by 3.5% in 2020 to a new record level.
- Overall natural fibre production rose by 2.6%, headed by a 3% rise in cotton production.
- Synthetic filament fibre production and cellulosic fibre production lifted by 3.9% and 4.9% each.
- Synthetic staple fibre production rose by 2.2%.
- Natural fibres fell to 26.4% share of world fibre production in 2020 from 26.6% in 2019. Wool's share was 0.95%. Man-made fibres accounted for 73.5%.
- World fibre consumption decreased by 1% in 2019.
- This consisted of a 3.5% increase in consumption of synthetics offset by a significant decrease in cotton consumption by 15%. Consumption of wool fell by 1%.
- Production of other animal fibres declined by 5% in 2020, led by a large 24% drop in angora production and 6% and 7% drops in cashmere and mohair.
- The angora production drop of 24% comes on top of 18% and 29% falls in 2019 and 2018 respectively
- World production of superfine wool accounted for 72% of world production of luxury animal fibres. In 2020, world fibre production rose in 2020. While production of oil-based synthetic filaments and cellulose continued to lift to records, the production of cotton and silk also rose with production of other natural fibres falling marginally. Total world production of fibres increased by 3.3% in 2020 to 109,098 mkg. This is the fourth successive increase since the decline of 2% in 2016; with the rate of increase higher than the 1.7% lift in 2019.

CONSIDERATIONS

There are many factors influencing the viability of the Canadian wool industry. There's renewed interest in finding applications for Canadian wool. The key to building a thriving industry is in accepting the micron range of

wool in the Canadian inventory. We must accept, first and foremost, that in order to increase wool demand and wool prices domestically, we must turn to the "interiors" market (carpets, rugs, drapery, upholstery) and the "semi-industrial" market (technical products, passive filters, fertilizers, product insulation). Once a viable pipeline is built for our existing wool inventory, we can imagine moving quickly to expand sheep and textile production to include fibre-breed sheep and infrastructure for the natural textile garment industry. To accomplish these goals, investment in more education and innovation for all wool stakeholders. There is a lot of work that needs to be done to bring producer, transformer and consumer into a symbiotic relationship.

ENVIRONMENTAL CONSIDERATIONS

Climate Change and the Paris Agreement

In 2015, 195 countries joined the Paris Agreement to mitigate the 'global warming gridlock' as a proactive step for the UN Framework Convention on Climate Change (UNFCCC) (Falkner, 2019). Previously, the Kyoto protocol was established with the goal of reducing 1990 emissions by 5% for industrialized countries (Annex 1 countries). The static goals, lack of developing country involvement, and rigid target setting caused countries to withdraw from the protocol.

The Paris agreement was established to ensure the temperature increase would not exceed 2 degrees celsius of the pre-industrial levels while pursuing limiting the increase to 1.5 degrees celsius (Falkner, 2019; Rogelj et al., 2020). The agreement allowed for countries to set 'naturally determined contributions' (NDCs) for their independent climate initiatives to be updated on a consistent basis (Falkner, 2019). To meet this goal, CO₂ emissions need to be reduced to net zero between 2060 and 2075 with associated decarbonization.

Canada's place within the Paris Agreement

The effectiveness of this agreement is associated with global transparency, and a country's progress being recorded and shared based on the country's individual contributions to reducing the climate increase (Climate Action Tracker, 2020b). Canada has been categorized as reducing the climate increase to 3 degrees celsius. Other industrialized countries are equivalent or above 3 degrees celsius. Canada has a target of zero emissions by 2050, but the success of this goal is dependent on our speed of climate plan implementation. (Climate Action Tracker, 2020a)

Weapons against climate change

Regenerative Agriculture

Regenerative Agriculture is used internationally in numerous

ways, specific to each farming industry and producer. "By supporting the natural functions of the environment, regenerative agriculture is a holistic farming approach that focuses on developing the biology and fertility of soils as the basis of the entire farm ecosystem." One definition that is commonly practiced utilizes intensive no-till pasture management with reduced or eliminated pesticide and herbicide use (Colley et al., 2020). The aforementioned pasture management reduces supplementary feeding by including short rotations through small areas with perennial native grasses and long periods of rest before the area is utilized for grazing again. The benefits of implementing one or more of these practices includes improved soil fertility, resilience to climate change, improved biodiversity, welfare and profitability.

Regenerative agriculture has shown promise to help cope with climate change through increasing plant resilience, improved soil fertility and improvements in biodiversity and profitability. Grazing has shown benefits independently to soil carbon storage and in regenerative practices, biomass production and soil carbon sequestration offset farm emissions[6]. Sheep manure also has a potential for mitigating the effects of livestock's contribution to climate change. Sheep manure on average has a higher concentration of usable nitrogen in contrast to beef manure[7]. The increased Nitrogen availability in fertilizer has numerous benefits including, increased carbon allocation in roots, stimulatory effect on photosynthesis and increased water and nutrient absorption for grasslands[8]. Diet and genetic changes have been researched to help reduce methane emissions as well as nutrient excretion. Methane emissions from ruminants are continually being reduced by 0.3%/year[9]. Additionally, diet changes for reduced nutrient excretion allows for better feed conversion and efficiency as well as protecting the water sources around from algae blooms and the consequential greenhouse gas yield.

Beneficial Land Management Practices

In Canada, Agriculture and Agri-Foods Canada (AFFC) refers to Canadian regenerative initiatives under the banner

of Beneficial Land Management (BLM) practices. The latest statistics suggest the primary reason for declining net agricultural GHG emissions is “due to the change in carbon dioxide emissions from agricultural soils, which went from being a minor source (emitting CO₂) of about 1.1 Mt CO₂e in 1981 to a sink (indicating absorption of carbon) of about -11.9 Mt CO₂e in 2011. Agricultural soils, particularly in the Prairie Provinces of Canada, are now a significant sink for carbon dioxide.

In the Prairies especially, producers can increase their land’s carbon storage capacity by reducing summerfallow and tillage intensity and by converting annual crops to perennial cropping systems. Other innovations, such as dietary management to lower methane emissions or manure management to reduce nitrous oxide emissions, are encouraged. Canada is one of the founding members of the Global Research Alliance (GRA) on Agricultural Greenhouse Gases, an international network of more than 30 member-countries, devoted to collaboration in agricultural research on greenhouse gas mitigation and BMPs for farmers in Canada and around the world.

In 2010, AAFC launched the Agricultural Greenhouse Gases Program (AGGP) – a five-year, \$27-million program, to encourage ground-breaking research to provide Canadian farmers with technologies to manage their land and livestock in a way that will mitigate GHG emissions. This program has since been extended until 2021.

Sheep Farming and Land Management

Sheep farming can play an important role in land management in many areas in Canada. Using rotational grazing or strip grazing, sheep are pastured on controlled areas of land where they forage grass for a short period of time. Eating the grass down to approximately 2-3 cm encourages grass regeneration.

Rotational Grazing – The rotational grazing system is

developed by subdividing a large pasture into two or more smaller paddocks and grazing these paddocks in a planned sequence. This provides rest periods for plants while others are being grazed. Once all the paddocks have been grazed, the sequence restarts with the first pasture that has been rested the longest being grazed. If done correctly, rotational grazing has many benefits including increased forage production, animal performance, and overall profitability. Rotational grazing allows plants to remain healthy by renewing energy reserves, rebuilding plant vigor, and giving long-term maximum production. Manure nutrients are more evenly distributed across the field as well.

Strip Grazing – This technique involves utilizing moveable fencing to allot enough forage for a short time period and then moving the fence forward providing a new allocation of forage. Typically no back fencing is used in this method, and thus grazing should start in the area nearest to the water source to reduce waste due to trampling. Strip grazing can increase utilization and decrease animal selectivity. This method is often used when grazing stockpiled forages and annual forages. It can also be utilized during certain times of the year when grazing specific forage species like alfalfa in the late fall when resting the forage is not an issue. This method can be used in combination with rotational grazing.

Wool and the Environment

Wool is composed of 50% organic carbon and is a temporary store for carbon that is biodegradable without microplastics[10]. Wool’s degradable features, insulation value and sustainable production have made it a new point of interest for innovation and replacement of other materials that would not degrade or would release microplastics. Some of the more prevalent innovations include wool insulation, face masks, absorption for marine oil spills and new technologies for comfort in clothing.

Slow-Fashion and the Environment

The term Slow-Fashion was coined by Kate Fletcher of the Centre for Sustainable Fashion, following the phenomena of the slow food movement. As with the slow food movement, Fletcher saw a need for a slower pace in the fashion industry. Slow fashion opposes the fast fashion model that emerged around 20 years ago, in which clothes became cheaper and trend cycles sped up. With brands like H&M burning 12 tonnes of unsold garments per year in spite of its ongoing sustainability efforts to close the loop in fashion.

Pre-Industrial Revolution, garments were locally sourced and produced. People would buy durable clothing that could serve them for a long time or make their own from the textiles and resources available to them. Clothing reflected the place and culture of the people wearing them. Modern day slow fashion has seen a reemergence of some of these old ways. It encourages us to buy fewer garments, less often. Instead of purchasing dozens of cheap clothes, conscious consumers invest in higher quality pieces made from more sustainable processes that emphasize the art of clothes making and celebrate the skills of craftspeople. Slow fashion has seen increasing support in the last few years as consumers demand higher sustainability and ethical standards. As research shows, 19% of the top fast fashion-related searches are linked to the environment, ethics and sustainability.

Some characteristics of a slow fashion brand

- Made from high quality, sustainable materials
- Often sold in smaller (local) stores rather than huge chain enterprises
- Locally sourced, produced, and sold garments
- Few, specific styles per collection

Canadian Sheep and Wool Industry Growth Markers

Year of Data	Sheep Population (x1,000)*	% change in sheep population	Raw Wool Purchased (x1,000) kg	% change in raw wool purchased	Kg of wool/head	% change in kg wool/head
2018	829.4	1.90%	1263.7	9.57%	1.524	7.52%
2017	813.9	-0.15%	1153.3	-4.16%	1.417	-4.02%
2016	815.1	-1.12%	1203.4	-0.27%	1.476	0.86%
2015	824.3	-4.23%	1206.6	-0.02%	1.464	4.39%
2014	860.7	-3.61%	1206.9	0.68%	1.402	4.44%
2013	892.9	1.10%	1198.8	0.10%	1.343	-0.99%
2012	883.2	0.38%	1197.6	-6.72%	1.356	-7.07%
2011	879.9	2.88%	1283.9	6.00%	1.459	3.04%
2010	855.3	1.39%	1211.2	5.38%	1.416	3.94%
2009	843.6	1149.4	-0.96%	1149.4	1.362	1.64%
2008	849.5		1138.8		1.341	

*Sheep population is from January 1st of the year mentioned since the July 1st populations are larger because of lambing, but lambs do not produce wool within their first 6 months of life.

% Change= (Current year-Previous year) / Previous year

Data Retrieved from:

Government of Canada. (2021). Sheep Farming - 11241 - Summary - Canadian Industry Statistics - Innovation, Science and Economic Development Canada. <https://www.ic.gc.ca/app/scr/app/cis/summary-sommaire/11241>

Statistics Canada. (2018). Table: 32-10-0142-01 Sheep statistics, quantity of raw wool purchased, used on farms, price and farm value. <https://doi.org/10.25318/3210014201-eng>

Global Micron Distribution of Clean Wool

	2020 (tonnes of clean wool)	% of global wool supply
Fine wool ($\geq 24.5\mu\text{m}$)	383,079	37.14%
Medium wool (24.5-32.5μm)	223,202	21.64%
Coarse wool ($\leq 32.5\mu\text{m}$)	425,084	41.21%
Total kg	1,031,365	

Data Retrieved from:

International Wool Textile Organization. (2021). *Market Information edition 16 - Statistics for the Global Wool Production and Textile Industry*

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- [1] Statistics Canada (2021) The 2021 Census of Agriculture and sheep farming in Canada retrieved from: <https://census.gc.ca/resources-ressources/cst-tsc/agriculture/sheep-mouton-eng.htm>
- [2] Statistics Canada (2020) Wool disposition and farm value, 2018. Retrieved from: <https://www150.statcan.gc.ca/n1/daily-quotidien/200422/dq200422c-eng.htm>
- [3] Knibb H. and Klenk N. (2018) The Ontario Wool Study: Phase 1 Assessing the Needs of Ontario Wool Producers and Processors.
- [4] Colley, T.A., Olsen, S.I., Birkved, M. and Hauschild, M.Z. (2020), Delta Life Cycle Assessment of Regenerative Agriculture in a Sheep Farming System. *Integr Environ Assess Manag*, 16: 282-290. <https://doi.org/10.1002/ieam.4238>
- [5] Brown, C. (2013) Available Nutrients and Value for Manure from Various Livestock. Ontario Ministry of Agriculture, Food and Rural Affairs. Retrieved from: <http://www.omafra.gov.on.ca/english/crops/facts/13-043.htm>
- [6] Zhou, G, Luo, Q, Chen, Y, et al. (2019) Effects of livestock grazing on grassland carbon storage and release override impacts associated with global climate change. *Glob Change Biol.*; 25: 1119– 1132. <https://doi.org/10.1111/gcb.14533>
- [7] Allen, M.R., Shine, K.P., Fuglestedt, J.S. et al. (2018) A

solution to the misrepresentations of CO₂-equivalent emissions of short-lived climate pollutants under ambitious mitigation. *npj Clim Atmos Sci* 1, 16. <https://doi.org/10.1038/s41612-018-0026-8>

- [8] International Wool Textile Organization (2016) Guidelines for conducting a life cycle assessment of the environmental performance of wool textiles. Retrieved from: <https://iwto.org/wp-content/uploads/2020/04/IWTO-Guidelines-for-Wool-LCA.pdf>. Retrieved from: <https://espace.library.uq.edu.au/view/UQ:347ad14#>

ROUND TABLE SUMMARIES

ROUNDTABLE REVIEW
-EDUCATION-
1:00 PM – 3:00 PM EST
FEBRUARY 15, 2021

PANEL

Alison Duckman, Alison Hope, Colin Dobell, David Mastine, Eliza Mitchell, Grahame Lynch, Justin Morin-Carpentier, Philip Spark, Romy Schill

THE SHEARING GUILD

The idea began with the question “Why don’t Canadian farmers care about their wool?” The answers were consistent across regions, breeds, and size of farm operation. “The cost of shearing is higher than the wool is worth.” “It’s difficult to find good shearers.” “Canadian wool isn’t worth anything.” “We don’t know what to do with our wool after shearing.”

We table our suggestion of a “Shearing Guild”, including a national training program providing a practical way for people to learn the shearing trade. This included having a network of Master-Shearers as a liaison between the farmer and the industry, who would train and mentor individuals new to the trade. To facilitate the expediency of getting the wool off the shearing floor and out the farm gate into the wool pipeline, we proposed a program whereby participating farms would qualify for free shearing in exchange for the wool shorn. The “Free-to-Farmers” program would dispatch Master-Shearers to participating farms to shear at no cost to the farmer. After the shearing is complete, the Master-Shearer would take skirt, sort, and bag the wool and it would enter a guild-specific pipeline.

THE “GUILD” NAME

There were mixed opinions on the suitability of “guild” as part of our plan name. A member of our panel suggested a more nationally focused title, some notions of what the term “guild” were referenced and suggestions of testing the name more extensively were suggested.

IS THERE A NEED AND HOW WOULD IT BE DEPLOYED?

When discussing the need, some members believed that the current system of shearing was adequate while others were enthusiastic about the idea of a shearing education system. There was discussion whether this would be a private endeavour or if it could be possible to connect with vocational training organizations and potentially colleges. The targeted demographic was suggested with discussions surrounding age, including indigenous communities, and potentially recruiting individuals who could be interested in pursuing this part time. Our discussion also included the possible viability of introducing our education program to existing programs such as 4-H and potentially promoting the program to youth and recent high school graduates as a possible career.

POSSIBLE FINANCIAL VIABILITY

Our discussion then shifted into how viable this could be for the shearers, farmers, and other stakeholders in the industry. Our guild idea is planned to include a manufacturing or industrial partner to purchase and use our wool as Canadian and provide a consistent market for farmers. It was discussed that for those that diversify their farm income with selling wool may not find the guild system ideal for their farms as they currently utilize the extra return on wool for their sheep care. It was suggested that some farmers could shear themselves, but the investment of shearing equipment could be impractical for certain farms. We then proposed a subsidy program for Guild Certified Shearers to get shearing tools at an affordable price.

THE CERTIFICATION ASPECT

During our discussion, the group voiced opinions that the certification and education system could improve the current shearing industry, as well as potentially work with our idea. Micro certifications were suggested, as well as potentially local education for students in the fashion/textile industry and other industries that could benefit from learning more about wool production.

ROUNDTABLE REVIEW -OUTREACH-

PANEL

Allison Duckman, Courtney Harder, Alison Hope, Madeleine Hope-Fraser, Barbara Jesson, Grahame Lynch, David Mastine, Justin Morin-Carpentier, Matthew Rowe, Romy Schill, Jane Underhill, Dalena White.

CANADIAN WOOL AND THE WORLD STAGE

Canadian wool has long been regarded as a lesser product without a place in the international wool market. In these sessions we looked to troubleshoot how to create domestic and international brand awareness for Canadian wool, and how to ensure fair pricing for farmers. Foreign countries with more wool to sell utilize a commodity-based market for their wool, whereas Canada creates a niche quantity of wool that wouldn't benefit from the commodity-based system.

INCREASING THE INTERNATIONAL MARKET FOR CANADIAN WOOL

Canada doesn't currently sit on at any international wool tables. We feel that to adequately represent and advocate for the Canadian Wool Market, our presence in international discussions is imperative. The Canadian Wool Council is applying for a membership and a voting seat with the International Wool Textile Organization (IWTO). An international member at our meeting mentioned that they have no baseline understanding for Canadian wool like they have for larger wool-producing countries with more international presence. As part of our reach, we

hope to release collateral material that promotes wool in a memorable way. Some options included commemorative coins depicting the history of Canadian Wool, Canadian Stamps showcasing people who've had a tremendous impact on the Canadian Wool Industry, as well as limited edition products with traceable Canadian wool.

CREATING THE CANADIAN WOOL PACKAGE - TIED WITH A "RED BOW"

Canadian wool having a "red bow" was referenced many times throughout the meeting. The idea behind this phrase was for Canadian wool to have branding that combines researched, positive impacts and unique features, as well as some one-time projects to demonstrate the quality and potential of our wool. Some members of our panel suggested having traceability combined farmer stories for consumers. These initiatives have worked very well in other countries.

Some of our later conversations shifted to the potential of having transparency with the market we are trying to reach. Part of this could be accomplished by a declaration of the origins of our wool, outlining qualities of farms and the breeds of sheep shorn. Our panel discussed where our wool could fit in the market, and through recent Campaign for Wool work, we have demonstrated an interest in Canadian wool utilized in hand-knotted carpets. The production partners who helped create these carpets attested to the quality and consistency of the wool we used for this project. They described Canadian wool as better quality and easier to work with than New Zealand wool. The surprising softness of Canadian wool made it dye to a richer colour for a more robust outcome.

OUR WOOL LABELS AND MARKET

Part of our conversation centered around how we could inspire consumers to choose wool. There was a discussion around the perception that wool is not "ethical" - this coming from some marketing material from animal welfare groups or retailers claiming to sell "Vegan Leather", which in most cases is made of polyvinyl chloride or polyurethane,

both of which are plastic-based materials. Find an article or source for describing Vegan Leather and its negative impact. And man o'man, do we ever need to bridge the gap between farmer and fashion designer. Our panel brought forward a plethora of reasons that wool is ethical including its environmental sustainability, and carbon sequestration benefits. As well, shearing is an integral part of ensuring the sheep's welfare, and the potential for more frequent shearing to be beneficial in reducing sheep's stress levels 1.

REACHING THE PUBLIC

Finally, our conversation led to the language that potentially could be utilized to explain how wool is raised and cared for in Canada. Throughout our conversation, there was a disconnect on terms commonly used in Agriculture and the general understanding around the table. A member on our panel has suggested developing a "one-stop-shop" for Canadian wool including farmer's stories, a potential to sell Canadian products and host more information on Canadian wool.

ROUNDTABLE REVIEW

-"PROUDLY CANADIAN" / BRAND CANADA-

PANEL

Martin Curtis, Allison Duckman, Courtney Harder, Allison Hope, Andrew Legge, Eliza Mitchel, Justin Morin-Carpentier, Bastien Ouellet, Maddy Purvis-Smith, Matthew Rowe, Romy Schill, Jane Underhill, Sir David Wootton

CANADIAN WOOL AND THE POTENTIAL FOR BRAND CANADA PRODUCTS

Canada produces a high-quality, niche quantity of a valuable natural resource, the bulk of which is sold and exported to foreign countries at commodities market pricing. Except for smaller, "artisanal quantity" purchases, Canadian wool rarely reaches Canadian consumers in any meaningful or measurable way. Rather, it is exported to countries like China and India where it's blended with other fibres into higher- or lower-grade textiles, using environmentally damaging

processes, and causing it to completely lose its Canadian identity.

We believe the export business model is no longer viable because of changing international trade practices, because of the significant negative impact of world export to countries with poor environmental and human rights track records, because of the growing importance of creating a plan for domestic self-sufficiency, as COVID-19 has highlighted, because we have the innovation and technology to manage this process at home, and because we need a mechanism to pay farmers fairly for their wool.

Part of our strategic plan involves creating pathways to keep Canadian wool in Canada. The intention is to work with Canadian innovation on R&D and pilot projects that use Canadian wool as primary material. Once tested through a pilot-project management, these products would be manufactured to the highest social and environmental standards and would proudly bear the Brand-Canada Stamp.

CANADIAN'S WOOL POTENTIAL

Our wool is not being used in Canada for semi-industrial/ industrial uses because of the lack of infrastructure in processing. Many of the potential ideas for Canadian products could include a viability stage utilizing other country's industrial wool processing capacity to test the products before a larger investment of machinery. Canada is dominated by "mini-mill" infrastructure geared towards an artisanal market, but our current infrastructure would not be able to maintain an industrial volume of products. Beyond typical uses in fashion, interiors and art, Canadian wool could be used for insulation, packaging, biopolymers, oil spill clean-up and many other uses that are more environmentally conscious than their synthetic alternatives.

CANADIAN WOOL VS. INTERNATIONAL WOOL

One of our panel members discussed how they utilized New Zealand wool and why that wool is better for their use.

Part of this includes the low cost per pound of wool from New Zealand as well as the associated low vegetable matter percentage. Canadian wool has a higher vegetative matter percentage because of the need to house indoor or feed hay for a portion of the year, while sheep in New Zealand have the possibility of grazing year-round. The amount of vegetable matter influences the maintenance of machinery used to process one of the products mentioned in the panel.

CANADIAN WOOL'S FUTURE

Our group discussed ways that Canadian wool could be comparable to and potentially used as other international wool have been used in the industry. Firstly, our vegetable matter (VM) could be reduced with different management techniques, but farmers would need the price incentive to reduce vegetable matter in their wool. Much of the wool discussed in the international market is Merino wool, and Canadian wool has been thought of as less-than in comparison. Our group discussed the possibility of bringing some of Canada's strengths in research to better develop commercially viable products.

ROUNDTABLE REVIEW -BROKERAGE-

PANEL

Eric Bjerso, Rick Blickstead, Martin Curtis, Joe Dales, Justin Morin-Carpentier, Romy, Bastien, Courtney Harder, Jane Underhill, Matthew Rowe

CANADIAN WOOL MARKETING

Our Canadian wool industry only has domestic manufacturing for our mini-mill system which creates an importance on our brokerage system to send wool for grading, processing and export. When consumers commonly think of wool and next to skin uses, merino and fine micron wool is first to mind, and the broader wool Canada produces doesn't have the same established destination in the industry. Canadian wool is bundled into 1000 pound bales

with samples taken for testing dictating micron, vegetative matter and yield. Our wool reaches 7 countries through export of our raw wool, while the smaller industry associated with milling in Canada has a more domestic business approach.

WOOL PROCESSING

Our current infrastructure's capacity is not fit to stress test industrial uses of our wool, and processing is an important component of wool innovation. The bulk of our clip is 29-34 microns and the promotion of our clip was discussed, as some other countries may not understand the benefits and complexities of the wool we can supply. Additionally, our wool contains between 2.5-3% Vegetative matter (VM) which causes issues in machine maintenance if not processed previously. Australia has around 0.5% VM and the wool imported is cheaper than the wool we produce locally.

CANADIAN WOOL DESTINATIONS

Canadian wool can be dedicated to a processing and manufacturing stream for fashion or commercial/industrial products. Discussion occurred on the possible viability of shipping the wool for first stage processing to another country with an adequate processing capacity. Our commodity based brokerage system is ideal for direct exportation but could be modified to support initial processing as well.

ROUNDTABLE REVIEW -INFRASTRUCTURE-

PANEL

Martin Curtis, Allison Duckman, Courtney Harder, Allison Hope, Andrew Legge, Eliza Mitchel, Justin Morin-Carpentier, Bastien Ouellet, Maddy Purvis-Smith, Matthew Rowe, Romy Schill, Jane Underhill, Sir David Wootton

OUR WOOL ON THE WORLD'S STAGE

Canadian wool has great potential for consumers and processors, but as discussed at the previous meeting, isn't

as recognizable or promoted as New Zealand or Australian wool. Our wool in its raw form is not easily utilized with high fatty and vegetative matter, alongside only 10% of wool production in Canada is fine. Testing and certification is used in other parts of the production industry, and equivalent documentation for our wool is needed to compete with other countries' wool.

CANADIAN LAND AND WOOL TRANSPORTATION

Our shipping and mail outlets are commonly known as more expensive than other outlets and with wool's proportion, independent shipping of wool is not as feasible as hoped. Previously producers and mills would send and receive fibre on greyhound buses where they would only pay for the weight of their wool. When shipping with Canada post or another outlet, volume is a concern because of the potentially high prices for shipping within Canada. The Canadian Co-Operative Wool Growers has made a depot structure across the country, but sorting by hand or technology would not be plausible at each depot. Our group saw an area to improve that wool could be shipped more directly instead of crossing the country multiple times before it's final destination

MINI MILL VS. INDUSTRIALIZED USES

Mini Mills have a use and place in the industry that does not complement the industrial processing and usages the bulk of our wool is suited for. The infrastructure potentially needed for local processing and manufacturing is costly and difficult to create without other portions of the local supply chain being primed.

REFERENCES

- An Automated Device for Controlled Feeding of Sheep in Cages or Pens. (1985). *Canadian Journal of Animal Science*, 65, 273–277.
- Allen, M. R., Fuglestedt, J. S., Shine, K. P., Reisinger, A., Pierrehumbert, R. T., & Forster, P. M. (2016). New use of global warming potentials to compare cumulative and short-lived climate pollutants. 6. <https://doi.org/10.1038/NCLIMATE2998>
- Allen, M. R., Shine, K. P., Fuglestedt, J. S., Millar, R. J., & Cain, M. (2018). A solution to the misrepresentations of CO₂-equivalent emissions of short-lived climate pollutants under ambitious mitigation. *Npj Climate and Atmospheric Science*, February, 1–8. <https://doi.org/10.1038/s41612-018-0026-8>
- American Certified Brands Canadian Sheep Federation Brookwater Farms Northumberland. (2019). *SheepChain Demo*. <https://sheepchain.azurewebsites.net/Animal>
- Barge, P., Gay, P., Merlino, V., Tortia, C., & Leonardo, V. (2013). Radio frequency identification technologies for livestock management and meat supply chain traceability. *Canadian Journal of Animal Science*, 93, 23–33. <https://doi.org/10.4141/CJAS2012-029>
- Barioni, L. G., Dake, C. K. G., & Parker, W. J. (1999). Optimizing rotational grazing in sheep management systems. *Environment International*, 25(6–7), 819–825. [https://doi.org/10.1016/S0160-4120\(99\)00051-3](https://doi.org/10.1016/S0160-4120(99)00051-3)
- Batalla, I., Pinto, M., Unamunzaga, O., Besga, G., & Hierro, Ó. del. (2014). Integrating social and economic criteria in the carbon footprint analysis in sheep dairy farms. *Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector (LCA Food 2014)*, San Francisco, California, USA, 8-10 October, 2014, October, 88–95.
- Beaulieu, M. S., Bedard, F., & Lanciault, P. (n.d.). *Distribution and Concentration of Canadian Livestock* (Issue 47).
- Bowles, D. (2015). Recent advances in understanding the genetic resources of sheep breeds locally-adapted to the UK uplands: opportunities they offer for sustainable productivity . In *Frontiers in Genetics* (Vol. 6, p. 24). <https://www.frontiersin.org/article/10.3389/fgene.2015.00024>
- Cain, M., Allen, M., & Lynch, J. (2019). Net zero for agriculture (Issue August).
- Canadian Sheep Federation. (2019). *Canadian sheep industry moves lambs on blockchain*. https://www.cansheep.ca/documents/PR_CDN_sheep_industry_moves_lambs_on_blockchain_Feb2019.pdf
- Canadian Sheep Federation. (n.d.). *The Canadian Verified Sheep Program*.
- Canadian Sheep Federation. (n.d.). *Section 6 - Grazing*.
- Canadian Sheep Federation, & Canadian Co-Operative Wool Growers. (n.d.). *Wool Production in Canada*.
- Charlebois, S., Sterling, B., Haratifar, S., & Naing, S. K. (2014). Comparison of Global Food Traceability Regulations and Requirements. *Comprehensive Reviews in Food Science and Food Safety*, 13, 1104–1123. <https://doi.org/10.1111/1541-4337.12101>
- Chedid, M., Jaber, L. S., Giger-reverdin, S., Duvaux-ponter, C., Hamadeh, S. K., Mosar, I. U. M. R., Bernard, C., Mosar, U. M. R., & Bernard, C. (2014). Review : Water stress in sheep raised under arid conditions. 94, 243–257. <https://doi.org/10.4141/CJAS2013-188>
- Christopherson, R. J. (1976). Effects of Prolonged Cold and the Outdoor Winter Environment on Apparent Digestibility in Sheep and Cattle. 56, 201–212.
- Clark, R. D., & Wilson, D. B. (1966). Sheep Production on Irrigated Pasture as Influenced by Forage Mixture and Fertilization. *Canadian Journal of Animal Science*, 46.
- Climate Action Tracker. (2020). *Climate Action Tracker - Global Overview*.
- Climate Action Tracker. (2020). *Climate Action Tracker - Canada*. <https://climateactiontracker.org/countries/canada/>
- Copeland, C. (2006). *CRS Report for Congress Animal Waste and Water Quality : EPA Regulation of Concentrated Animal Feeding Operations (CAFOs)*.
- Corcadden, K., Stiles, D., & Biggs, J. (2017). Scale and sustainability : An exploratory study of sheep farming and adding value to wool in Atlantic Canada. *Agroecology and Sustainable Food Systems*, 41(6), 650–670. <https://doi.org/10.1>

080/21683565.2017.1310785

- Corscadden, K., & Conservation, F. E. (n.d.). CCWG Final Report Project Title : Investigating the Feasibility of Wool Value Chain Development Project Co-Applicants : 902.
- Dayrell, M., Ivan, M., & Hidirouglou, M. (1991). The effects of ruminal protozoa on selenium status in sheep. *Canadian Journal of Animal Science*, 1270, 1269–1270.
- DeLonge, M. (2014). Greenhouse gas costs and benefits from land-based textile production. 1, 1–4.
- Dengel, S., Levy, P. E., Grace, J., & Jones, S. K. (2011). Methane emissions from sheep pasture , measured with an open-path eddy covariance system. 17, 3524–3533. <https://doi.org/10.1111/j.1365-2486.2011.02466.x>
- Deramus, H. A. (2004). Grazing management of ruminant animals in sustainable agriculture. 33(2), 93–100.
- Doran-Browne, N. A., Ive, J., Graham, P., & Eckard, R. J. (2016). Carbon-neutral wool farming in south-eastern Australia. *Animal Production Science*, 56(3), 417–422. <https://doi.org/10.1071/AN15541>
- Doran-browne, N., Wootton, M., Chris Taylor, & Eckard, R. (2018). Offsets required to reduce the carbon balance of sheep and beef farms through carbon sequestration in trees and soils. *Animal Production Science*, 58, 1648–1655.
- Dougherty, H. C., Oltjen, J. W., Mitloehner, F. M., Depeters, E. J., Pettey, L. A., Macon, D., Finzel, J., Rodrigues, K., & Kebreab, E. (2019). Carbon and blue water footprints of California sheep production. *Journal of Animal Science*, 97(2), 945–961. <https://doi.org/10.1093/jas/sky442>
- Dwyer, C. M. (2009). Welfare of sheep : Providing for welfare in an extensive environment. *Small Ruminant Research*, 86, 14–21. <https://doi.org/10.1016/j.smallrumres.2009.09.010>
- Dyer, J. A., Vergé, X. P. C., Desjardins, R. L., & Worth, D. E. (2014). A Comparison of the Greenhouse Gas Emissions From the Sheep Industry With Beef Production in Canada. 3(3). <https://doi.org/10.5539/sar.v3n3p65>
- Falkner, R. (2019). The Paris Agreement and the new logic of international climate politics. September 2016. <https://doi.org/10.1111/1468-2346.12708>
- Falzon, L. C., Menzies, P. I., Vanleeuwen, J., Jones-Bitton, A., Shakya, K. P., Avula, J., Jansen, J. T., & Peregrine, A. S. (2013). A survey of farm management practices and their associations with anthelmintic resistance in sheep flocks in Ontario, Canada. *Small Ruminant Research*, 114(1), 41–45. <https://doi.org/10.1016/j.smallrumres.2013.06.007>
- Fissl, C. F., Kemp, R. A., & G, S. P. (1991). Factors affecting productivity of sheep flocks in Ontario. *Canadian Journal of Animal Science*, 9.
- Food and Agriculture Organization of the United Nations. (2019). E-agriculture in action: Blockchain for agriculture.
- Freitas, P. H. F., Wang, Y., Yan, P., Oliveira, H. R., Schenkel, F. S., Zhang, Y., Xu, Q., & Brito, L. F. (2021). Genetic Diversity and Signatures of Selection for Thermal Stress in Cattle and Other Two Bos Species Adapted to Divergent Climatic Conditions . In *Frontiers in Genetics* (Vol. 12, p. 102). <https://www.frontiersin.org/article/10.3389/fgene.2021.604823>
- Gagnon, B., & Simard, R. R. (1999). Nitrogen and phosphorus release from on-farm and industrial composts. *Canadian Journal of Soil Science*, 608.
- Greene, J. L. (2010). *Animal Identification and Traceability : Overview and Issues*.
- Greyling, J. (2017). *Achieving sustainable production of sheep*. Burleigh Dodds Science Publishing.
- Halde, C., Hammermeister, A. M., Mclean, N. L., Webb, K. T., & Martin, R. C. (2011). Soil compaction under varying rest periods and levels of mechanical disturbance in a rotational grazing system. *Canadian Journal of Soil Science*, 91, 957–964. <https://doi.org/10.4141/CJSS2011-026>
- Hao, J., Dickhoefer, U., Lin, L., Müller, K., Glindemann, T., Schönbach, P., Schiborra, A., Wang, C., & Susenbeth, A. (2013). Effects of rotational and continuous grazing on herbage quality, feed intake and performance of sheep on a semi-arid grassland steppe. *Archives of Animal Nutrition*, 67(1), 62–76. <https://doi.org/10.1080/1745039X.2012.761326>
- Hargreaves, A. L., & Hutson, G. D. (1990). Changes in Heart Rate, Plasma Cortisol and Haemocrit of Sheep during a Shearing Procedure. *Applied Animal Behaviour Science*, 26, 91–101.
- Harrowfield, B. (n.d.). *Innovations in wool*.
- Hewins, D. B., Lyseng, M. P., Schoderbek, D. F., Alexander, M., Willms, D., Carlyle, C. N., Chang, S. X., & Bork, E. W. (2018). Grazing and climate effects on soil organic carbon concentration and particle-size association in northern grasslands. *Scientific Reports*, January, 1–9. <https://doi.org/10.1038/s41598-018-28111-2>

- org/10.1038/s41598-018-19785-1
- Hofmeyr, H. S., Slabbert, N., & Pienaar, J. P. (1982). Partitioning of Methane Production Between Ruminant and Hindgut Fermentation Sites in Sheep. *Canadian Journal of Animal Science*, 1–2.
- Hosseini, S. H., Liang, X., Niyungelo, C., Miaomiao, H., Li, F., Khan, S., & Eltohamy, K. M. (2019). Effect of sheep manure-derived biochar on colloidal phosphorus release in soils from various land uses. *Environmental Science and Pollution Research*, 26, 36367–36379.
- Hynd, P. L., & Allden, W. G. (1971). Effects of High-Starch Diets on Ruminant Efficiency and Wool Growth. *Canadian Journal of Animal Science*, 1–2.
- International Wool Textile Organization. (2016). *Recycled Wool*.
- International Wool Textile Organization. (2021). *Market Information edition 16 - Statistics for the Global Wool Production and Textile Industry*.
- International Wool Textile Organization. (n.d.). *Wool Life Cycle Assessment*.
- International Wool Textile Organization. (2020). *Wool Fibres Readily Biodegrade in Marine Environments , Study Confirms*.
- International Wool Textile Organization, & Organisation, T. (2016). *Guidelines for conducting a life cycle assessment of the environmental performance of wool textiles*.
- Jones, A. K., Jones, D. L., & Cross, P. (2014). The carbon footprint of lamb: Sources of variation and opportunities for mitigation. *Agricultural Systems*, 123, 97–107. <https://doi.org/10.1016/j.agsy.2013.09.006>
- Jorgensen, G. H. M., & Boe, K. E. (2011). Outdoor yards for sheep during winter - Effects of feed location, roof and weather factors on resting and activity. *Canadian Journal of Animal Science*, 91, 213–220. <https://doi.org/10.4141/CJAS10062>
- Joy, A., Dunshea, F. R., Leury, B. J., Clarke, I. J., DiGiacomo, K., & Chauhan, S. S. (2020). Resilience of Small Ruminants to Climate Change and Increased Environmental Temperature: A Review. In *Animals* (Vol. 10, Issue 5). <https://doi.org/10.3390/ani10050867>
- Jun, P., Gibbs, M., & Gaffney, K. (n.d.). CH₄ and N₂O Emissions from Livestock Manure. In *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*.
- Karrow, N. A., Goliboski, K., Stonos, N., Schenkel, F., & Peregrine, A. (2014). Review : Genetics of helminth resistance in sheep. *Canadian Journal of Animal Science*, 1, 1–9. <https://doi.org/10.4141/CJAS2013-036>
- Kebreab, E., Clark, K., & France, J. (2006). Methane and nitrous oxide emissions from Canadian animal agriculture : A review. *Canadian Journal of Animal Science*.
- Keenan, T. F., & Williams, C. A. (2018). The Terrestrial Carbon Sink. *Annual Review of Environmental Resources*, 43, 219–243. <https://doi.org/10.1146/annurev-environ-102017-030204>
- Kosinski, S., Hosford, S., & Lane, W. (2013). *Managed Grazing An Introduction to for Sheep and Goat Producers*.
- Lal, R. (2002). Soil carbon dynamics in cropland and rangeland. 116, 353–362.
- Lambe, J. W., Bowman, G. H., & Rennie, J. C. (1965). Production Traits in Sheep as Affected by Breeds and Environment. *Canadian Journal of Animal Science*, 45(1).
- Larney, F. J., Sullivan, D. M., Buckley, K. E., & Eghball, B. (2006). The role of composting in recycling manure nutrients. *Canadian Journal of Animal Science*, 1.
- Lauder, A. R., Enting, I. G., Carter, J. O., Clisby, N., Cowie, A. L., Henry, B. K., & Raupach, M. R. (2013). International Journal of Greenhouse Gas Control Offsetting methane emissions — An alternative to emission equivalence metrics. *International Journal of Greenhouse Gas Control*, 12, 419–429. <https://doi.org/10.1016/j.ijggc.2012.11.028>
- Lee, C., & Beauchemin, K. A. (2014). A review of feeding supplementary nitrate to ruminant animals : nitrate toxicity, methane emissions, and production performance. *Canadian Journal of Animal Science*, 94, 557–570. <https://doi.org/10.4141/CJAS-2014-069>
- Li, B. T., Christopherson, R. J., & Cosgrove, S. J. (2000). Effect of water restriction and environmental temperatures on metabolic rate and physiological parameters in sheep. *Canadian Journal of Animal Science*.
- Li, Y., Xu, R., Wang, B., Wei, J., Wang, L., & Shen, M. (2019). Enhanced N-doped Porous Carbon Derived from KOH-Activated Waste Wool : A Promising Material for Selective Adsorption of CO₂ / CH₄ and CH₄ / N₂. *Nanomaterials*, 9(266). <https://doi.org/10.3390/nano9020266>

- Li, Y., Xu, R., Wang, X., & Wang, B. (2018). Waste wool derived nitrogen-doped hierarchical porous carbon for selective CO₂ capture. *Royal Society of Chemistry*, 19818–19826. <https://doi.org/10.1039/c8ra02701c>
- Lollo, N., & O'Rourke, D. (2020). Measurement without Clear Incentives to Improve: The Impacts of the Higg Facility Environmental Module (FEM) on Apparel Factory Practices and Performance.
- Ma, G.-W., Chu, Y.-K., Zhang, W.-J., Qin, F.-Y., Xu, S.-S., Yang, H., Rong, E.-G., Du, Z.-Q., Wang, S.-Z., Li, H., & Wang, N. (2017). Polymorphisms of FST gene and their association with wool quality traits in Chinese Merino sheep. *PLOS ONE*, 12(4), e0174868. <https://doi.org/10.1371/journal.pone.0174868>
- Magolski, J. D., Luther, J. S., Neville, T. L., Redmer, D. A., Reynolds, L. P., Caton, J. S., & Vonnahme, K. A. (2011). Maternal Nutrition during pregnancy influences offspring wool production and wool follicle development. *American Society of Animal Science*, 3819–3823. <https://doi.org/10.2527/jas.2010-3687>
- Martens, J. R. T., & Entz, M. H. (2011). Integrating green manure and grazing systems : A review. *Canadian Journal of Plant Science*, 91, 811–824. <https://doi.org/10.4141/CJPS10177>
- McDowell, R. W. (2008). Environmental Impacts of Pasture farming.
- Miller, D., & Jacobson, C. (2013). Effect of nutrition , body condition and liveweight change on efficacy of biological wool harvesting with epidermal growth factor (Bioclip). *Animal Production Science*. <https://doi.org/10.1071/AN12143>
- Montes, F., Meinen, R., Dell, C., Rotz, A., Hristov, A. N., & Oh, J. (2013). SPECIAL TOPICS — Mitigation of methane and nitrous oxide emissions from animal operations : II . A review of manure management mitigation options. *American Society of Animal Science*, 5070–5094. <https://doi.org/10.2527/jas2013-6584>
- Montossi, F., Font-i-furnols, M., Campo, M., Julián, R. S., Brito, G., & Sañudo, C. (2013). Sustainable sheep production and consumer preference trends : Compatibilities , contradictions , and unresolved dilemmas. *MESC*, 95(4), 772–789. <https://doi.org/10.1016/j.meatsci.2013.04.048>
- Moorhouse, D., & Moorhouse, D. (2017). Sustainable Design : Circular Economy in Fashion and Textiles Sustainable Design : Circular Economy in Fashion and Textiles. *The Design Journal*, 6925, S1948–S1959. <https://doi.org/10.1080/14606925.2017.1352713>
- Morris, S. T., & Kenyon, P. R. (2014). Intensive sheep and beef production from pasture — A New Zealand perspective of concerns , opportunities and challenges. *MESC*, 98(3), 330–335. <https://doi.org/10.1016/j.meatsci.2014.06.011>
- Munoz, C. A., Campbell, A. J. D., Hemsworth, P. H., & Doyle, R. E. (2019). Evaluating the welfare of extensively managed sheep. *PLOS ONE*, 1–14.
- Narayan, E., Sawyer, G., Fox, D., Tillbrook, A. (2020) Sheep Shearing and Epigenetic Change (Issues 18–025).
- OMAFRA. (2007). Rotational Grazing in Extensive Pastures.
- OMAFRA. (2021). OMAFRA Priorities for the Ontario Agri-Food Innovation Alliance Research Program Ontario Ministry of Agriculture , Food and Rural Affairs (Issue October 2020).
- Osei-Amponsah, R., Chauhan, S. S., Leury, B. J., Cheng, L., Cullen, B., Clarke, I. J., & Dunshea, F. R. (2019). Genetic selection for thermotolerance in ruminants. *Animals*, 9(11), 948.
- Pan, Y., Wang, Y., Lou, S., Wanapat, M., Wang, Z., Zhu, W., & Hou, F. (2020). Selenium supplementation improves nutrient intake and digestibility , and mitigates CH₄ emissions from sheep grazed on the mixed pasture of alfalfa and tall fescue. 1–10. <https://doi.org/10.1111/jpn.13495>
- Papadopoulos, Y. A., Kunelius, H. T., Fredeen, A. H., Canada, A., Scotia, N., & Bl, C. (1993). Factors influencing pasture productivity in Atlantic Canada. *Canadian Journal of Animal Science*, 699–713.
- Pendell, D. L., Scanga, J. A., & Belk, K. E. (2008). Review: Animal Identification in North America. [https://doi.org/10.15232/S1080-7446\(15\)30857-3](https://doi.org/10.15232/S1080-7446(15)30857-3)
- Pent, G. J., Fike, J. H., & Kim, I. (2021). Ewe lamb vaginal temperatures in hardwood silvopastures. *Agroforestry Systems*, 95(1), 21–32. <https://doi.org/10.1007/s10457-018-0221-y>
- Pent, G. J., Greiner, S. P., Munsell, J. F., Tracy, B. F., & Fike, J. H. (2020). Lamb performance in hardwood silvopastures , II : animal behavior in summer 1. 4, 363–375. <https://doi.org/10.1093/tas/txz177>
- Petit, H. V. (1993). Pasture management and animal production

- in Quebec : A review. *Canadian Journal of Animal Science*, 724(416), 715–724.
- Piirsalu, P., Kaart, T., Nutt, I., Marcone, G., & Arney, D. (2020). The Effect of Climate Parameters on Sheep Preferences for Outdoors or Indoors at Low Ambient Temperatures. *Animals*, 10(1029). <https://doi.org/10.3390/ani10061029>
- Pokorná, P., Hejcmanová, P., Hejcman, M., & Pavlu, V. (2013). Activity time budget patterns of sheep and goats co-grazing on semi-natural species-rich dry grassland. *Czech Journal of Animal Science*, 58(5), 208–216. <https://doi.org/10.17221/6749-cjas>
- Ponnampalam, E. N., Knight, M. I., Moate, P. J., & Jacobs, J. L. (2020). An alternative approach for sustainable sheep meat production : implications for food security. 11(83), 1–16.
- Pulina, G., Helena, A., Francesconi, D., Stefanon, B., Calamari, L., Lacetera, N., Orto, V. D., Pilla, F., Marsan, A., Mele, M., Rossi, F., Bertoni, G., Crovetto, M., Ronchi, B., Pulina, G., Helena, A., Francesconi, D., Stefanon, B., Calamari, L., ... Ronchi, B. (2017). Sustainable ruminant production to help feed the planet. *Italian Journal of Animal Science*, 16(1), 140–171. <https://doi.org/10.1080/1828051X.2016.1260500>
- Purvis, I. W., & Franklin, I. R. (2005). Major genes and QTL influencing wool production and quality : a review. *Genetic Selection Evolution*, 37(1), 97–107. <https://doi.org/10.1051/gse:2004028>
- Pyke, C. R., & Marty, J. (2005). Cattle Grazing Mediates Climate Change Impacts on Ephemeral Wetlands. *Conservation Biology*, 1619–1625. <https://doi.org/10.1111/j.1523-1739.2005.00233.x>
- Rathgeber, M. (n.d.). Forage Best Management Practices Manual for Enhancing Soil Organic Carbon Sequestration.
- Rogelj, J., Elzen, M. Den, Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., & Sha, F. (2020). Paris Agreement climate proposals need a boost to keep warming well below 2 ° C. <https://doi.org/10.1038/nature18307>
- Rutter, S. M. (2010). Review : Grazing preferences in sheep and cattle : Implications for production, the environment and animal welfare. *Canadian Journal of Animal Science*.
- Rutting, T., Clough, T. J., Muller, C., Lieferings, M., & Newton, P. C. (2010). Ten years of elevated atmospheric carbon dioxide alters soil nitrogen transformations in a sheep-grazed pasture. 16, 2530–2542. <https://doi.org/10.1111/j.1365-2486.2009.02089.x>
- Safari, E., Fogarty, N. M., Gilmour, A. R., Atkins, K. D., Mortimer, S. I., Swan, A. A., Brien, F. D., Greeff, J. C., & Van Der Werf, J. H. J. (2007). Genetic correlations among and between wool, growth and reproduction traits in Merino sheep. *Journal of Animal Breeding and Genetics*, 124(2), 65–72. <https://doi.org/https://doi.org/10.1111/j.1439-0388.2007.00641.x>
- Sánchez-molano, E., Kapsona, V. V, Oikonomou, S., McLaren, A., Lambe, N., Conington, J., & Banos, G. (2020). Breeding strategies for animal resilience to weather variation in meat sheep. *BMC Genetics*, 21(116), 1–11.
- Sharrow, S. H. (2007). Soil compaction by grazing livestock in silvopastures as evidenced by changes in soil physical properties. 71, 215–223. <https://doi.org/10.1007/s10457-007-9083-4>
- Shresthat, J. N. B., Ainsworthi, L., Heaneyi, D. P., & Smith, A. N. (1982). Application of Controlled Reproduction to Sheep Flocks in Newfoundland. 62, 679–687.
- Stachowicz, K., Brito, L. F., Oliveira, H. R., Miller, S. P., & Schenkel, F. S. (2018). Assessing genetic diversity of various Canadian sheep breeds through pedigree analyses. 98, 741–749.
- Stanford, K., & Mcallister, T. A. (2001). Traceability in cattle and small ruminants in Canada. *Rev. Sci. Tech. Off. Int. Epiz.*, June 2014. <https://doi.org/10.20506/rst.20.2.1291>
- Statistics Canada. (2018). Table: 32-10-0142-01 Sheep statistics, quantity of raw wool purchased, used on farms, price and farm value. <https://doi.org/10.25318/3210014201-eng>
- Sutherland, C., Sim, C., Gleim, S., & Smyth, S. J. (2020). Canadian Consumer Insights on Agriculture: Addressing the Knowledge-Gap. *Journal of Agricultural & Food Information*, 21(1–2), 50–72. <https://doi.org/10.1080/10496505.2020.1724114>
- Tedeschi, L. O. (n.d.). Modelling a Sustainable Future for Livestock Production.
- Tedeschi, L. O., Almeida, A. K. De, Atzori, A. S., Pierre, J., Fonseca, M. A., & Cannas, A. (2017). Invited Review A glimpse of the future in animal nutrition science . 1 . Past and future challenges. *Revista Brasileira de Zootecnia*, 46(5), 438–451.
- Tedeschi, L. O., Muir, J. P., Riley, D. G., & Fox, D. G. (2015). The role of ruminant animals in sustainable livestock

- intensification programs. *International Journal of Sustainable Development and World Ecology*, 22(5), 452–465. <https://doi.org/10.1080/13504509.2015.1075441>
- Telescope, F. H. (2020). Measuring carbon emissions at the Canada –. *Nature Astronomy*, 4(December 2019), 2019–2021. <https://doi.org/10.1038/s41550-020-1190-4>
- Testa, F., Nucci, B., Iraldo, F., Appolloni, A., & Daddi, T. (2017). Removing obstacles to the implementation of LCA among SMEs: A collective strategy for exploiting recycled wool. *Journal of Cleaner Production*, 156, 923–931. <https://doi.org/10.1016/j.jclepro.2017.04.101>
- The Canadian Centre of Food's Integrity. (2020). Insight Report Backgrounder Alternative Sustainability Proteins. <https://www.foodintegrity.ca/research/download-the-sustainability-insight-report/>
- The Canadian Centre of Food's Integrity. (2020). 2020 PUBLIC TRUST RESEARCH. <https://www.foodintegrity.ca/research/download-ccfi-2020-research/>
- The Canadian Centre of Food's Integrity. (2017). Tackling Transparency and How it Builds Trust. <https://www.foodintegrity.ca/research/download-current-research/>
- Trevarthen, A. (2007). The National Livestock Identification System : The Importance of Traceability in E-Business. 2(1), 49–62.
- Umberger, S. H. (2009). Sheep Grazing Management (Issue Publication 410-366).
- University of Oxford. (2018). Climate metrics for ruminant livestock Key messages (Issue July). <https://www.oxfordmartin.ox.ac.uk/publications/climate-metrics-for-ruminant-livestock/>
- Vessely, J. A., Peters, H. F., & Slen, S. B. (1966). Lamb and Wool Production from Five Breeds on Range. *Canadian Journal of Animal Science*, 46.
- Waghorn, G. (2008). Beneficial and detrimental effects of dietary condensed tannins for sustainable sheep and goat production-Progress and challenges. *Animal Feed Science and Technology*, 147(1–3), 116–139. <https://doi.org/10.1016/j.anifeedsci.2007.09.013>
- Wang, X., Vandenbygaart, A. J., Mcconkey, B. C., Wang, X., Vandenbygaart, A. J., & Mcconkey, B. C. (2014). Land Management History of Canadian Grasslands and the Impact on Soil Carbon Storage Synthesis Land Management History of Canadian Grasslands and the Impact on Soil Carbon Storage. 67(4), 333–343. <https://doi.org/10.2111/REM-D-14-00006.1>
- Westover, J. D. (2019). Incentives for the Adoption of Blockchains in Ontario's Agri -Food Sector : The Role of Risk and Information (Issue July) [University of Guelph]. https://atrium.lib.uoguelph.ca/xmlui/bitstream/handle/10214/16781/Westover_Jamieson_201907_MSc.pdf?isAllowed=y&sequence=1
- Wood, C. W., Moore, P. A., Joern, B. C., Jackson, R. D., & Cabrera, M. L. (n.d.). Nutrient Management on Pastures and Haylands (pp. 257–314).
- Zhou, G., Luo, Q., Chen, Y., He, M., Zhou, L., Frank, D., He, Y., Fu, Y., Zhang, B., & Zhou, X. (2019). Effects of livestock grazing on grassland carbon storage and release override impacts associated with global climate change. 25, 1119–1132. <https://doi.org/10.1111/gcb.14533>



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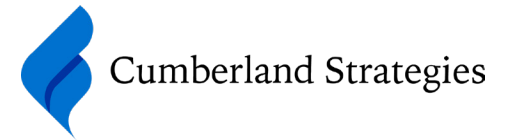
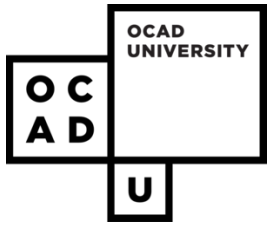
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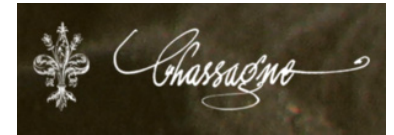
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