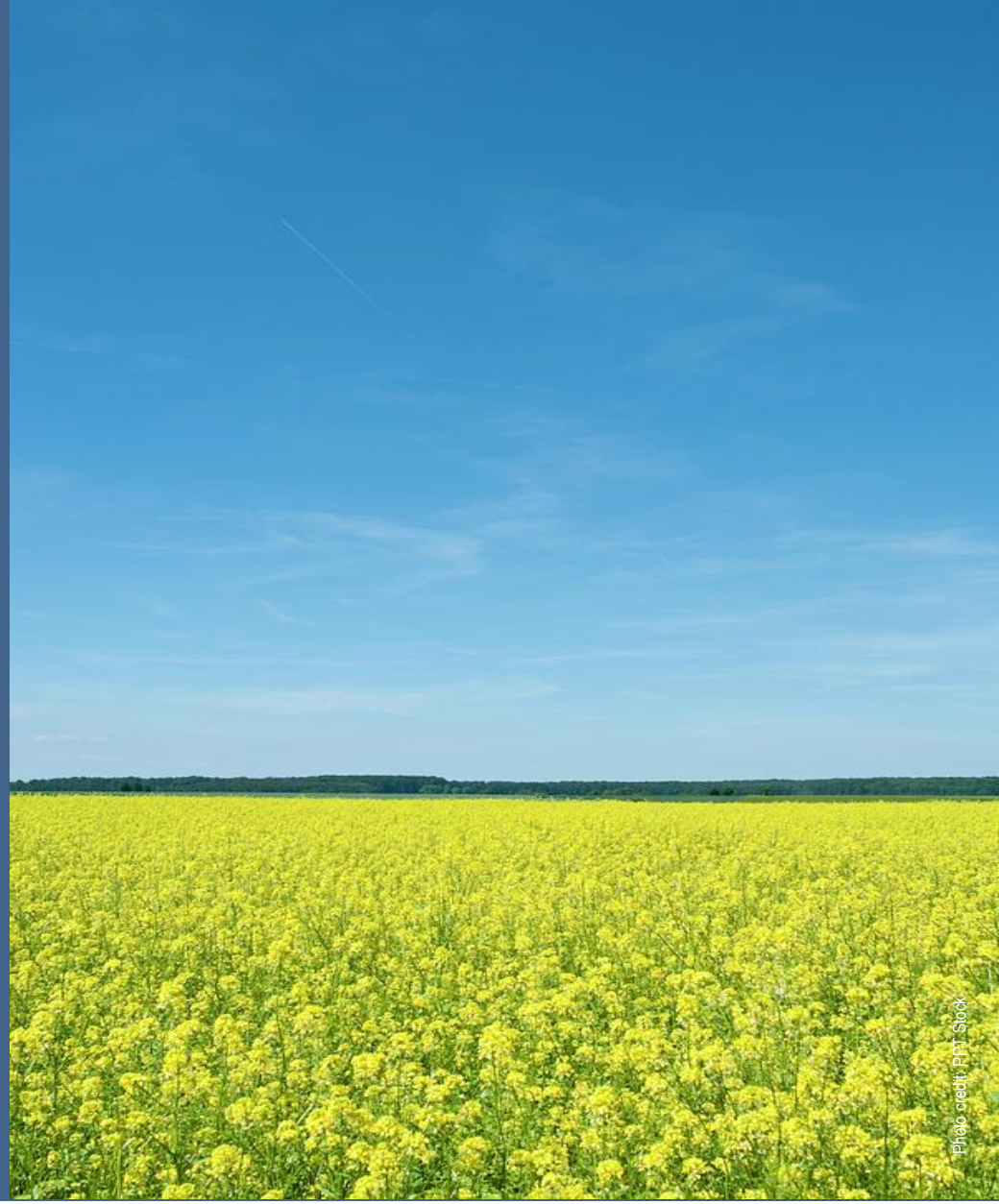
Pathways to Gaining Market Share

Report of Findings

March 22, 2022



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Note: The recommendations in this report reflect the opinion of Context Network and are not indicative of future grantmaking by WFF.

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WALTON FAMILY FOUNDATION

Objective: Through 3 case studies, help WFF understand lessons from past introductions, or expansions, of new crops to the market in order to inform future work related to crop diversification.

SCOPE: Case studies relevant to row crops in the **Mississippi River Basin** and **Colorado River Basin.** Context worked with WFF to align on target crops: soybeans, canola, camelina

The Context Network (Context) executed this project from December 2021 – March 2022. Case studies were conducted leveraging internal knowledge, desk research and industry interviews, and expert working sessions.

PHASE I: LITERATURE REVIEW → **PHASE II:** EXPERT INTERVIEWS AND INSIGHTS → **PHASE III:** STRATEGIC RECOMMENDATIONS

PHASE I

LITERATURE REVIEW

Key Questions Answered:

- What are the pathways by which new crops gain market share / crops expand market share?
- What can we learn about how this happened previously with crops like soy, split peas (pea protein), canola, and hemp?
- What did it take to move a crop from research and development to early-stage commercialization?
- Beyond crop improvement, what was the essential infrastructure for scaling up to commercial production?
- What roles did the government, universities, philanthropy, financial institutions, and the private sector play in the process?

Methodology: Context conducted desk research and detailed literature reviews sourcing publicly available information.

Potential Crops Considered: Pennycress, Sunn hemp, and others were considered initially. After careful consideration and review with the WFF core team, soybeans, canola, and camelina were identified as the focus crops for case studies.

PHASE II

EXPERT INTERVIEWS AND INSIGHTS

Expanded learnings from Phase 1 and included:

- What specific actions paved the way for crops to gain market share?
- What developments in the agricultural landscape, ag equipment space, and other areas facilitated market growth?
- Who were the key influencers and collaborators?

Methodology: Context leveraged our network to conduct in-depth interviews with key stakeholders and crop influencers for the selected case studies.

- Outreach included industry experts, university/extension specialists, government agencies, and industry associations, among others.
- Interviews lasted ~45 minutes on average. A single discussion guide was used for all initial interviews, with a tailored discussion guide being used for select follow up interviews.
- Personal relationships within our network allowed us to gain rich insights to inform the pathway crops took to gain market share, allowing us to provide the highest quality insights to WFF.

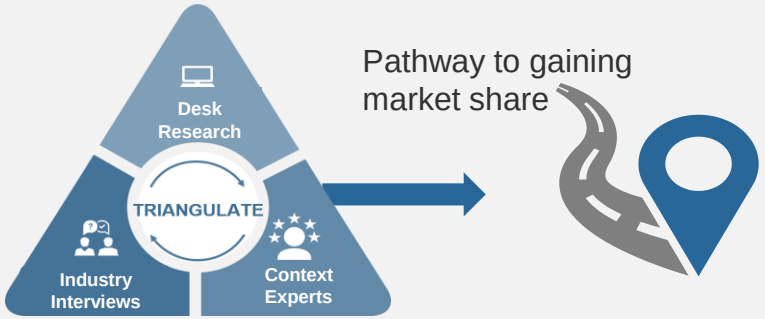
PHASE III

STRATEGIC RECOMMENDATIONS

Key Questions Answered:

- Based on past examples, what is the best role for philanthropy in seeking to expand the market share for more diverse crops produced in the Mississippi River basin (e.g., oats, rye, buckwheat) and Colorado River basin (e.g., heritage grains, guayule)?

Methodology: Context held an internal expert working session to review learnings from prior phases, and triangulated information sources to develop strategic recommendations for philanthropy to play a role in expanding the market share for more diverse crops.



This report outlines key findings supported by detailed analysis.

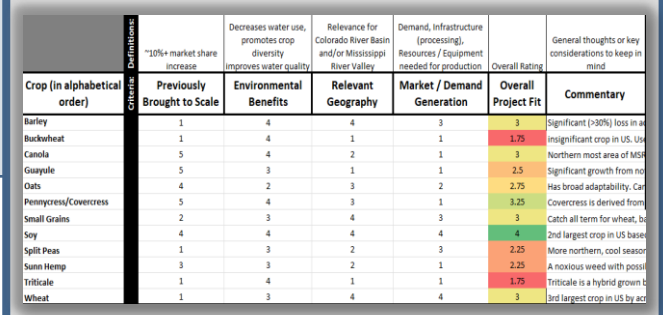
Context provided initial recommendations and worked collaboratively with the WFF core team to align on crops of focus for this project

Initial Brainstorming

Context held an initial brainstorming session to identify crops for further consideration for case studies to uncover lessons from past introductions, or expansions, of new crops to the market.

Crop Evaluation Exercise

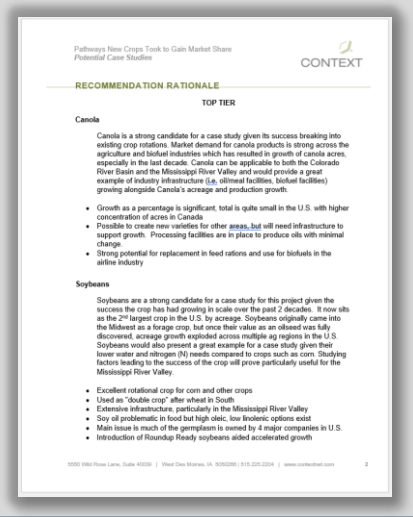
After identifying a list of 20 initial crops* for consideration, Context industry advisors evaluated each crop individually. Key evaluation criteria included scale of previous expansion, environmental benefits, relevant geography, adequate market demand, and overall fit for the project. Context analysts aggregated evaluation exercise feedback to score each potential crop.



Definitions:	"10%+ market share increase	Decreases water use, promotes crop diversity improves water quality	Relevance for Colorado River Basin and/or Mississippi River Valley	Demand, Infrastructure (processing), Resources / Equipment needed for production	Overall Rating	General thoughts or key considerations to keep in mind
Crop (in alphabetical order)	Previously Brought to Scale	Environmental Benefits	Relevant Geography	Market / Demand Generation	Overall Project Fit	Commentary
Barley	1	4	4	3	3	Significant (>30%) loss in a
Buckwheat	1	4	1	1	1.75	Insignificant crop in US. Use
Canola	5	4	2	1	3	Northern most area of MSR
Guayule	5	3	1	1	2.5	Significant growth from no
Oats	4	2	3	2	2.75	Has broad adaptability. Can
Pennycress/Covercress	5	4	3	1	3.25	Covercress is derived from
Small Grains	2	3	4	3	3	Catch all term for wheat, ba
Soy	4	4	4	4	4	2nd largest crop in US base
Split Peas	1	3	2	3	2.25	More northern, cool season
Sunn Hemp	3	3	2	1	2.25	A noxious weed with possi
Triticale	1	4	1	1	1.75	Triticale is a hybrid grown b
Wheat	1	3	4	4	3	3rd largest crop in US by ac

Crop Prioritization

Context held an internal working session to discuss crop ratings and align on recommendations. The team provided supporting rationale for recommended crops to share with the Walton Family Foundation core team.



Pathways New Crops Took to Gain Market Share
Potential Case Studies

CONTEXT

RECOMMENDATION RATIONALE

TOP TIER

Canola

Canola is a strong candidate for a case study given its success breaking into existing crop rotations. Market demand for canola products is strong across the agriculture and biofuel industries which has resulted in growth of canola acres, especially in the last decade. Canola can be applicable to both the Colorado River Basin and the Mississippi River Valley and would provide a great example of industry infrastructure (i.e. oil/meal facilities, biofuel facilities) growing alongside Canola's acreage and production growth.

- Growth as a percentage is significant, total is quite small in the U.S. with higher concentration of acres in Canada
- Possible to create new varieties for other areas, but will need infrastructure to support growth. Processing facilities are in place to produce oils with minimal change
- Strong potential for replacement in feed rations and use for biofuels in the airline industry

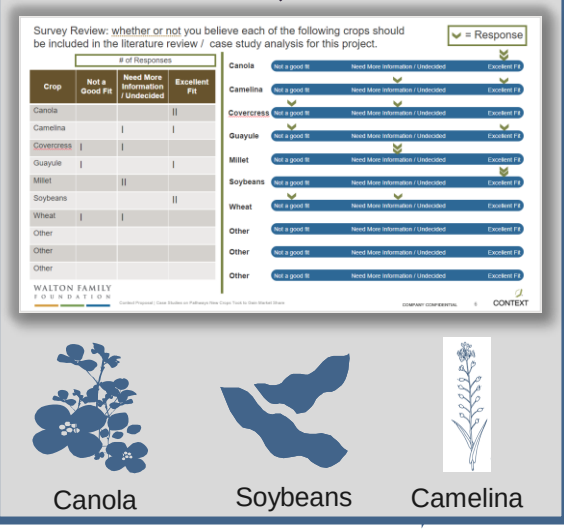
Soybeans

Soybeans are a strong candidate for a case study for this project given the success the crop has had growing in scale over the past 2 decades. It now sits as the 2nd largest crop in the U.S. by acreage. Soybeans originally came into the Midwest as a forage crop, but once their value as an oilseed was fully discovered, acreage growth exploded across multiple ag regions in the U.S. Soybeans would also present a great example for a case study given their lower water and nitrogen (N) needs compared to crops such as corn. Studying factors leading to the success of the crop will prove particularly useful for the Mississippi River Valley.

- Excellent rotational crop for corn and other crops
- Used as "double crop" after wheat in South
- Extensive infrastructure, particularly in the Mississippi River Valley
- Soy oil problematic in food but high oleic, low linolenic options exist
- Main issue is much of the germplasm is owned by 4 major companies in U.S.
- Introduction of Roundup Ready soybeans aided accelerated growth

Alignment With WFF

An alignment meeting with the Context and WFF core teams was held to discuss recommendations and ultimately align on crops for the case studies: soybeans, canola, and camelina.



Survey Review: whether or not you believe each of the following crops should be included in the literature review / case study analysis for this project.

= Response

Crop	Not a Good Fit	Need More Information / Undecided	Excellent Fit
Canola			II
Camelina		I	I
Covercress	I	I	
Guayule	I		I
Millet		II	
Soybeans			II
Wheat	I	I	
Other			
Other			
Other			

Canola | Camelina | Covercress | Guayule | Millet | Soybeans | Wheat | Other | Other | Other

WALTON FAMILY FOUNDATION

CONTEXT

Canola

Soybeans

Camelina

***Review of 20 crops considered with supporting rationale for each**

Industry Insights

Context conducted in-depth interviews to gain insights around pathways to crop expansion, as well as critical success factors, **challenges, and key learnings from a historical perspective**

TARGET CROPS

Canola

Camelina

Soybeans

Interviews conducted
January – February 2022

Interview duration:
30-60 minutes

Qualitative conversations with a mix of **phone and web interviews**

Stakeholders Interviewed:

Seed Companies

Industry Associations

Universities

NGOs

Media

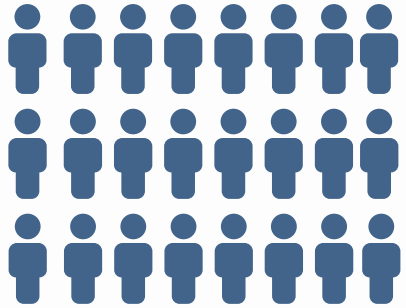
Producers

Processors

Equipment Manufacturers

Grain and Storage

Soil Scientists



24 interviews with industry experts

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Executive Summary

"Market access and economics are the keys to crop expansion success."

CONTEXT

Pathways to Expansion

A Geographical Expansion*

Genetic development allowing for the geographical expansion of a crop. In the example of soybeans, shorter maturity groups have been adapted for colder, drier climates, allowing for the expansion of soybeans into the Dakotas and even the southern Canadian Prairies. Winter canola varieties are enabling expansion south into the Midwest.

*Assumes climate is appropriate for growing crop

- ✓ Additional option for crop rotation(s)
- ✓ Strongest potential for the largest acreage increase
- ✓ Diversification in revenue stream
- − Requires new infrastructure (processing facilities transportation / logistics / storage)
- − Requires grower education and support
- − Equipment modifications required
- − Possible narrow planting / harvest windows

CASE STUDIES:
Shorter maturity soybeans

Tropical tolerance in Camelina

B Market Expansion

Value propositions driven by yield improvements and new end-product uses drive acreage adoption. Canola health benefits and human food uses supported expansion.

- ✓ Yield improvements provide opportunity for increased revenue
- ✓ Expanded markets through new uses
- ✓ More efficient acreage use, leading to soil health benefits, fewer inputs required
- − Investment required for research for additional end uses

CASE STUDY:
Canola

C New Crop Development / Breeding

Breeding varieties for special and/or proprietary end uses can allow crops to secure market share. New breeding techniques for camelina recently provided yield increases generating higher demand. High oleic varieties of soybeans and canola give the crops a certain attractiveness based on increased health benefits.

- ✓ Premium prices for special use varieties attract growers
- ✓ Opportunity for food companies and downstream stakeholders to directly grow the market
- ✓ Allows for increased crop cycles
- − Typically requires the most breeding efforts - expensive and time consuming
- − Requires higher involvement throughout all levels of the supply chain due to specialized product
- − Equipment innovation / modifications required

CASE STUDY:
Camelina

WALTON FAMILY FOUNDATION

Sources: USDA NASS, ERS

Critical Success Factors for Expansion

Some historical attempts to expand market share resulted in failure for a variety of reasons, top themes provide insights into critical success factors for crop expansion:

Reliable Market Support

- Market Access
- Market Demand
- Crop Delivery
- Contracts
- Steady Conditions
- Revenue Protection

Champions / Advocates

- Political / Regulatory
- Grower Adoption
- Building Momentum and Relationships
- Leverage existing relationships and know-how

Climate and Soil Conditions

- Growing feasibility
- Planting / harvest timing
- Yields
- Soil Condition

Expanding At Pace

- Price volatility
- Allow time for market development
- Tools needed for successful crop
- Adequate grower support
- Supply must meet demand

Demonstrated Value Proposition with Consideration for Competing Crops

- Economic Value
- Environmental Value
- Competing crops

Risk Management Tools

- Crop insurance and supporting data
- Revenue protection
- Government subsidies

Grower Support / Resources

- Building trust with growers
- Crop production education
- Training local agronomists
- Demonstration of local success

Questions key players across the value chain ask when new crops are being considered or introduced:

Producers

- What is the value proposition? (economically and from a sustainability / land stewardship standpoint)
- Is there a reliable offtake and is it economically viable/reliable?
- Is there seed available? Is there adequate supply?
- What are the crop protection needs? Are there products registered for use? Are they available?
- How intensive are farm management practices?
- Will I have access to markets? Will my local elevator accept the crop?
- How long will I have to store the crop before I can deliver?
- Will prices remain relatively consistent?
- Will I have access to crop insurance or other farm programs?
- Will I need different equipment?
- Is irrigation required?
- What impact does the crop have on following crops?
- Does the crop require drying?

Seed / CP Companies

- Does the genomic composition of the crop make it conducive for breeding new varieties?
- What is the market potential for the crop? Is it strong enough to invest in breeding programs?
- Is it strong enough to invest in new product development / expanding product registration?
- Does market potential support bringing new product(s) to market?
- What technology can I license from universities? What research at Universities can be funded?
- What ways can I develop proprietary and differentiated varieties with the current genetics available?
- How difficult is it to establish and protect intellectual property rights?

Equipment

- How tolerable is the crop to variance in planting depth?
- What harvesting needs does the crop have that differ from others grown in the region?
- Is the crop scaled enough to make it worth creating specialized equipment?
- What are the shipping / transportation / storage needs? Will it require new innovation?
- What are the crop irrigation and fertilizer requirements? How are they applied?

Storage & Transportation

- What is the proximity between conducive growing regions, processors, and end use markets?
- Are specialized, local contracts needed?
- How long can I store the crop?
- Can the crop be stored in traditional elevator infrastructure, like silos?
- What spoilage, pest control, drying, dust/moisture control, and other storage challenges are there?
- What is the weight to volume ratio? How many bushels per load?
- How convenient are the delivery terms (one load at a time or can I empty my bins quickly?) who pays for shipping?

Processors

- Can we leverage existing infrastructure to process the crop?
- What are the product end uses?
- Are there export markets for end use products?
- Will processing this crop lead to downtime? Is production large enough to warrant investment?
- Is there existing transportation infrastructure in place to get the crop to processing facilities?
- Is there consistent and viable supply / feedstock?
- Are their crop byproducts? If so, is there a market for them?

Food , Feed & Fuel Companies

- Will supply meet demand?
- How healthy is the nutritional composition of the crop for humans compared to other alternatives?
- Is there an animal feed byproduct? Does it have GRAS certification?
- How do animals perform when the crop is included in rations?
- Are there export markets for end use products?
- What dietary trends can the crop leverage?
- Is the product edible or poisonous?

ENABLERS

Some entities are not directly involved in the value chain, but serve as key facilitators for crop expansion and market development:

Universities (Land Grants)

- Responsible for the majority of variety development until intellectual property right expansion in the 80s
- Currently focus is more on agronomy and production practices. Educate crop scientists and others that end up in industry
- Conduct research / field trials providing valuable data to influence risk management and legislation decisions

Industry / Grower Associations

- Provide key lobbying efforts to drive supporting legislation (e.g., Farm Bills, trade legislation, crop insurance expansion)
- Leverage checkoff funds to conduct beneficial crop research and development
- Expand market access both domestically and globally
- Provide grower education support, industry events for information sharing

Policy Makers

- Draft key legislation (e.g., Farm Bills) providing producers with tools for risk management and expanded market access
- Work closely with industry associations and government agencies to address gaps in the market and regulate key crop programs

Philanthropies / NGOs

- Act as a key facilitator between local universities, governments, and private sector organizations
- Fund research and development addressing challenges that may not be at a scale to attract private sector involvement

Government Agencies

- Develop / Administer Programs to fund genomic and agronomic research
- Provide subsidies to incentivize production adoption
- Work closely with industry associations, grower associations, and universities to assess and develop programs to support crop needs (e.g., crop insurance)

Opportunities for Philanthropy

Note: The recommendations in this report reflect the opinion of Context Network and are not indicative of future grantmaking by WFF.

Funding

- New variety R&D
- Promote promising solutions
- Expand small/locally
- Identify constraints and opportunities

Influence

- Leverage influence on retailers and current partnerships
- Showcase regenerative agriculture crops/practices
- Advocate for change in policy at federal and state levels

Support Grower Adoption of New Crops

- Contracting Model
- Price Protection
- Service Model

Improve Water Quality with Currently Grown Crops

- Improve soil / water management
- Autonomous Equipment
- Market Sizing
- Feasibility Analysis
- Evaluation of production practices

Pathways to Crop Expansion

*"The biggest challenge for continuous market based perennialized systems relied on **availability of novel crops**, **crops that provide those market and ecosystem functions**. Right now, there are things that have existed for a long time. Managed grazing systems are a form of continuous living cover. Trees, orchards. Options exist. But really when we're talking about helping shift the landscape, really talking about getting conventional row cropping systems back into systems that have perennial qualities, and that requires new crops. Kernza is an option, new oilseeds that would fill some economic niche."* - NGO

Geographical Expansion

Genetic development allowing for the geographical expansion of a crop. In the example of soybeans, shorter maturity groups have been adapted for colder, drier climates, allowing for the expansion of soybeans into the Dakotas and even the southern Canadian Prairies. Winter canola varieties are enabling expansion south into the Midwest.

BENEFITS

- Provides another tool for growers, an additional option for **crop rotation**(s)
- With relatively low required investment and ability to leverage learnings from other regions, geographical expansion provides the **strongest potential for the largest acreage increase**
- Provides growers and input companies with **diversification in revenue** stream

CONSTRAINTS

- In most cases, requires **new infrastructure** (e.g., processing facilities transportation / logistics / storage)
- For crops new to the area, requires **grower education and support**
- **Initial learning** curve, trial and error process in early seasons
- **Equipment modifications** required for planting / harvest in different conditions (e.g., drill seeded soybeans in northern U.S.)
- Could narrow planting / harvest windows **impacting yields and grower flexibility**

*"With weather patterns changing and **varieties being able to be more resilient to weather**, [soybeans have] moved farther north into drier land climates. Biggest change with that, seems like there's **more soybeans now planted in no till and drier environments**, further west / northwest ."* – Producer

"Locally adapting crops is less expensive, you just need a breeding station, relatively inexpensive. $2 million, equipment if you're really going new-new. You can rent parcels of land. Physical location, say $5 million to set up a new area. But the real money is in genetics, do I have it? Do I have right combinations? If it's a hybrid, how long will it take? Are they then my genetics or licensed?" – Seed company

*"They've also been able to breed **shorter season varieties**. Canada, northern Idaho, places that traditionally haven't been able to grow corn now can because they've shortened the growing season for the plant."* – Agriculture Media

*"Anytime you can **utilize existing infrastructure**. Looking towards future, things like ethanol pipelines, that's a huge advantage."* – Seed Company

"We consciously developed [soybeans] in different geographic areas, because we knew genetics and environment act differently." – Seed Company

Market Expansion

Value propositions driven by yield improvements and new end-product uses drive acreage adoption. Canola health benefits and human food uses supported expansion of the crop in both the U.S. and Canada. Export demand is also a key driver.

BENEFITS

- Yield improvements provide **opportunity for increased revenue**
- Expanded markets through new uses **drives top-down expansion**. This is often accompanied by pricing support / guaranteed market access for growers
- Provides the opportunity for **more efficient acreage use**, leading to soil health benefits and fewer inputs required
- For established crops, research for investment in new uses **demonstrates a value proposition for companies looking to profit** and also check-off programs fueling the cycle

CONSTRAINTS

- **Upfront investment required** for research for additional end uses
- **Regulatory hurdles** for crops not already approved for human / animal consumption (e.g., camelina for livestock feed)
- In some cases, **supply cannot keep up with demand** causing frustration

*"There was **research** going on [1970s] at the University of Idaho prior to any work done on canola anywhere else in the country. Quite frankly, that was being **driven by the biodiesel concept.**"* -Producer

*"When we got sophisticated enough to **differentiate the crop** itself, you can start to develop special varieties. The **more specialized, the more competitive.** "*– Seed Company, soybeans

*"Industry dollars have dominated canola development more recently. **As canola becomes more dominant, more money is put into the crop by developers**, it feeds into itself."* – University Agronomist

*"[Soybeans] I think it is valuable crop, when it's processed into its various products it's **exponentially more profitable**."* – University

*"Some bigger seed companies are developing more specific traits, especially for oil, and are now **directly asking farmers to grow their unique variety**. Then on the backside there might be a **contract for them to deliver the unique product**. I'm see the trend of specialized marketing and specialized growing."* – University Agronomist, canola

New Crop Development / Breeding

Breeding varieties for special and/or proprietary end uses can allow crops to secure market share. New breeding techniques for camelina recently provided yield increases generating higher demand. High oleic varieties of soybeans and canola give the crops a certain attractiveness based on increased health benefits.

BENEFITS

- **Premium prices for special use** varieties attract growers
- Opportunity for food companies and downstream stakeholders to **directly grow the market**
- Allows for **increased crop cycles**
- Can allow for **easier production management**, increasing likelihood of adoption

CONSTRAINTS

- Typically requires the most breeding efforts - **expensive** and **time consuming**
- **Crop has to be sufficiently scaled** to attract major variety development funding
- Requires **higher involvement** throughout all levels of the supply chain due to specialized product
- Equipment innovation / modifications required
- Commodities go in bins all blended together, while special variety products take significantly more management

*"Canadian breeders **accomplishing low enough levels of erucic acid was the major development in breeding**, allowing for products that can be used in human consumption."* –University Agronomist, canola

*"The big leap came 25 years ago, when canola was **transformed from an open pollinator to a hybrid**. Then you leapt up 30/40% immediately in yields."* –University Agronomist

*"In the 1990s **Roundup Ready** varieties of canola were developed, that was a **big breakthrough** and weed control became easier. Now you have various kinds of herbicide and high oleic varieties of canola"* -University Agronomist

*"We saw the first Roundup Ready soybeans in the late 80s, **now its 98% of the market**."* –Seed Company

*"If you look at Bayer, Syngenta, their data would suggest it takes between **6-10 years** to develop a new variety. It takes substantial initial investment."* –University

*"What we have done, is basically taking pennycress, which was a weedy species, and **turned it into a new crop** in 8 or 9 years. In the same way the Canadians took rapeseed and produced canola."*–University

WALTON FAMILY FOUNDATION

Sources: USDA NASS, ERS

*"If there is a good feeling on the part of the grower that there's a **market out there for it**, and a **market that he can cover costs and have returns**, a farmer's going to grow it **if the environment allows that crop to grow in their region.**"*

– Producer

Demonstrated Value Proposition

- Growers must clearly see the **value** to make a change in their planting / production practices. This needs to be compelling enough to encourage growers to put in necessary effort to adopt a new crop / change their current practices.
- The definition of value is different across growers, it could include return on investment, environmental benefits, or positive story / image
- Value must take into account what the crop is competing against, and what other crops are a good fit for the region

*"**Farmers care about environment**, passing onto generations, their community."* – Producer

*"Since [canola] is harvested in late summer/early fall, there is still time to plant a cover crop after harvest. Including canola in a program like that **could give farmers more income** from planting canola."* – University Agronomist

*"**Value has two components; first is financial, the second is environmental stewardship**. We've found these are the driving factors, and, depending on who you are, one speaks more than the other. **Some growers only care about money, some 50/50, some only care about their environment** and production practices."* –Seed Company

*"**Things don't work without an economic pull**. But why do they grow these crops? It's profitable. So, everything we do is designed to develop a high-quality crop, that is designed to provide continuous cover by itself or in a system and then develop markets and have profitability in the supply chain"* - University

"Only 10% of Iowa is planting cover crops. Why is that? I don't have an answer other than farmers don't think they're making any money on it. – Agriculture Media

*"Simple answer, **more money to be made they'll adopt** the practice."* - Agriculture Media

Consideration must be given to impact on and of Competing Crops

- **Economics is key**: Taking a meaningful share of acres of cash crops decreases the supply, in turn raising the price and making the crop more attractive to growers
- **Prime agricultural land is suitable for many crops**: In areas where crops grow well, it is likely that many crops will grow well leaving the decision to the return on investment for growers
- **Planting decisions impact supply** leading to potential supply chain implications on processing, crushing, etc. therefore incentivizing players to influence price through contracting

*"I think your biggest challenge, especially if you're wanting to go into the classical production areas, **biggest challenge is what you're competing wit**h."* – Producer

*[From a competition standpoint, how to break into corn/soy rotation in North Dakota and South Dakota.] Some parts [of these states] are interesting, because there is **tremendous competition for acres** there. The North Dakota grower, they can grow sunflower, canola, soy, corn, wheat, edible beans. Obviously, now universities have complex calculators to look at. **Value is important to the grower**.* –Seed Company

*"If you took 25% of the soybean crop away from soybeans, it would raise prices and make soybeans more attractive. That's a **perpetual issue when introducing crops**."* –Seed Company

*"**The overarching issue was value**. **Competing crops was an issue**. Every season, would talk to ADM and others, and talk about their contracting strategy, and what value they were going to offer contract at; if they were going to outcompete canola and other oils with their contracting prices and strategies. Then when they had contracting meetings, we'd say, well if you contract acres for this oil spec, you can buy seed from us, we'll set up a seed program. There was value all around the contract, value in coordination with the crusher.* – Seed Company

Reliable Market Support

- **Market Demand** – driven by downstream players (e.g., retail, food chain, consumers). There must be end users that understand the benefits of the crop and are willing to pay
- **Market Access** – proximity to elevators and processing facilities, ability to easily sell crop(s). Specialized varieties provide a pathway to securing market access
- **Reliable Contracts** – for price received or arrangements to grow on contract
- **Revenue Protection for New Crops –** guaranteed payment for the crop (e.g., camelina, specific varieties of canola) from customer
- **Steady conditions** - Steady demand and consistent prices are necessary for crop adoption
- **Reliable crop delivery** - infrastructure support to ensure reliable offtake system for both farmers and customers (e.g., elevators, processors)

*"**Pull through demand is important**. One crop segment that learned that is high oleic soy. To date a bunch of farmers want to grow it for the premium, but the market pull through is not there to support the acres yet."* – Context Advisor

*"For canola, it **initially started as local contracts only**, and scaled to broad acceptance at elevators. In general, when we talk about new crops, **as soon as local elevators accept the product easily**, that's when we see more people become interested in growing the crop."* – University Agronomist

*"[If you can go] to McDonalds and say, 'Hey, we've got a **reliable source of this high oleic, high stability frying [canola] oil that makes no trans fatty acids...'** That was the way we pushed it up the stream."* – Seed Company

"*The soybean crushing plant in my little town was strictly to make feed and oil. Then, all of a sudden, here came export opportunities. So railways were needed to get beans to ports, and on the Mississippi river. **This gave market access to grain elevators**.* – Agriculture Media

*"**Consistent price levels is also very important**. Lot of initial interest can drive up prices, but after more new acres, prices can drop. If prices fluctuate too much, it's too risky for growers, not consistent enough economic returns."* – University Agronomist

***"Probably biggest thing is marketing / selling the product**. Sometimes there's some shady organization that said they'd buy, and they'll come back and say, 'oh we overbought - we can only give you half price,' a total unethical move. So anytime there's huge economic benefit, there's going to be a con artist in the game that will take advantage of people."* - Producer

Risk Management Tools

- Farmers are generally reluctant to plant crops at scale without some form of risk management
- Opportunity costs are significant for producers, so new crops need revenue protection until crop insurance programs kick in to provide economic benefit and demonstrated return on investment **above** current practices / alternatives
- Without crop insurance, many farmers will not commit any scalable amount of acres
- Farm bills have been key for crop support through crop insurance
- In some cases, there are unintended consequences of disproportionate crop revenues / support

*"There are lots of rules to risk and RMA is risk adverse of course. **When there is a new crop with little data, they will be reluctant to put crop insurance in place**."* – University Agronomist

***"If you did nothing else, make sure you get crop insurance. That is the farmer safety net**. Right now, attitude of farmer is if I can't get crop insurance, I don't want to take on the risk. Maybe a few acres, but never hundreds or thousands of acres.* – Producer

*"This past year was a prime example, the drought in Montana was devastating. A few fields of camelina only had 1.5 inches of water all season. Most other crops were not harvested as there was no yield. Growers were able to harvest camelina, however, in the end, the other crops had higher insurable levels, therefore, **farmers made more off of insurance than they made off of harvesting and selling camelina**. That has impacted sales of camelina this year."* – Processor

*"Crop insurance wasn't offered in many areas where canola was going to grow initially, so we **worked with the USCA to make crop insurance changes through Farm Bills**."* – Producer

Grower Support / Resources

- **Building trust with growers is key**. Leveraging existing grower relationships for an initial foot in the door is a pathway for success. Demonstrated efficacy, following through on commitments and providing a favorable return on investment also help build trust.
- **Demonstration of local success** is needed for widespread adoption. If done correctly, early adopters can become examples and advocates for crop expansion.
- New crops / crop expansion must be **supported by education** on cropping practices, planting and harvest techniques, and crop protection decision support.
- In some cases, this requires '**training the trainer**' (e.g., agronomists / crop advisors) to help local growers successfully grow new crops.

*"[Introducing soybeans in Canada] Agronomic performance wasn't great the first couple of season. Struggled with growers with activity they had, so **had to put more resources to help people grow it**. "* –Seed Company

*"We didn't create new equipment but **had to train agronomists on new methods and what was available in their area** and make recommendations."* –Seed Company, canola

*"Everyone that a farmer trusts needs to have confidence this will work. Need to be very honest and transparent. Farmers don't even trust technologies that was proven a few towns away, **needs to be proven right in their backyard**."* – Producer

*"Corn and beans are known crops to farmers. **There'd have to be some training around a new crop.** Special handling and training."* – Agriculture Media

*"Markets, coops, elevators, grain buyers. They need to be along for the ride as well, so that **farmers are doing business with people they trust**."* –Producer

"We realized that you kind of had to stay with the grower the whole season. We pretty much lived with them through that first harvest." – Seed Company, soybeans

Climate and Soil Conditions

- Despite best efforts, crops are just not well suited for all growing conditions
- Climate conditions also dictate planting and harvest windows and practices
- Climate and growing conditions impact competitive revenue crops
- Soil conditions impact crop performance and crops respond to different soils and soil management practices

"*The issue with winter canola is our climate is pretty harsh, cold winters.* ***I've been doing winter trials starting in 1995, and one year it works and the next year the crop is winter killed****. Spring survival is a crucial stage for crops like canola that develop at low temperatures.*" – University Agronomist

"Canola is a dominant crop in ND because our climate is very conducive to spring seeded crops. ***The northern part of ND specifically is conducive to canola production****."* – University Agronomist

"Conceptually, it's great to seed a crop in November and be done with it in the spring so they can focus on other crops in the spring. ***Our climate is just not conducive to that****."* – University Agronomist

"Even in the same field, you might have irrigated pivot acres and the non-irrigated corners, or some tough soil conditions in the middle of the field, etc. pH levels, sandy soils vs clay soils all impact growing conditions." – Context Advisor

Champions / Advocates

- Crop ‘champions’ are needed to drive (continued) momentum. Change doesn’t happen overnight, especially given the biological cycle of crops. Learning from trial and error takes years of dedication and continued investment.
- Influencing regulation and policy changes takes time and financial investment. Leveraging relationships and alliances can support progress.
- Leveraging relationships to tap into existing market infrastructure can provide a less expensive pathway to market development
- Leveraging personal experience and experience of those in extended networks to learn from previous expansion attempts is vital

“To be successful with something that’s food driven, especially in the future now, ***need contacts with key food companies to create the demand*** *or understand label ingredients for food standpoint.” –Seed Company*

“*Essentially, has to be the same political support for the new crop as there is support for the crops it's competing with.” –* Producer

“*In addition to working with the U.S. Canola Association (USCA) on Farm Bills in the 90s,* ***we worked with the FCIC and RMA*** *on crop insurance at the same time to get initial insurance establishment for minor oilseeds in several counties*” – Producer

“*In terms of regulatory standpoint, has to be relationships established at the appropriate branches. And it takes time to get that done. However, folks involved,* ***if they have those relationships, speeds up process****. That was what happened in the case of Canola.*” – Producer

*“****To make progress you have to leverage current resources****. Leverage the genomics platforms you have. Leverage the markets. Leverage the infrastructure and the know-how’.” –*Seed Company

Expanding at Pace

It is important to avoid expanding too quickly

- Starting small limits risk of widespread failures and increases the probability of success at scale. Early adopters are likely to start with a subset of acres to 'get it right' before expanding. On the same notes, starting with a pilot group of early adopters provides an opportunity to work out the kinks before expanding more broadly building crop champions rather than detractors
- Price volatility poses a risk if markets aren't developed causing 'fad' pricing
- Equipment changes require time and investment
- Crop protection products can't keep up, including R&D and registrations / approval
- Adequate grower support – technical training, retailer support
- Supply must meet demand

*"**Consistent price levels is also very important**. Lot of initial interest can drive up prices, but after more new acres, prices can drop. **If prices fluctuate too much, it's too risky for growers**, not consistent enough economic returns."* – University Agronomist

*"[I recommend starting with] only small group so that way, in first year, if there were failures it was going to be in a smaller group. You're limited by resources and really **want to make sure at the end of the process you have ambassadors**. Now, we have farmers talking to farmers and spreading the word themselves"* – Seed Company

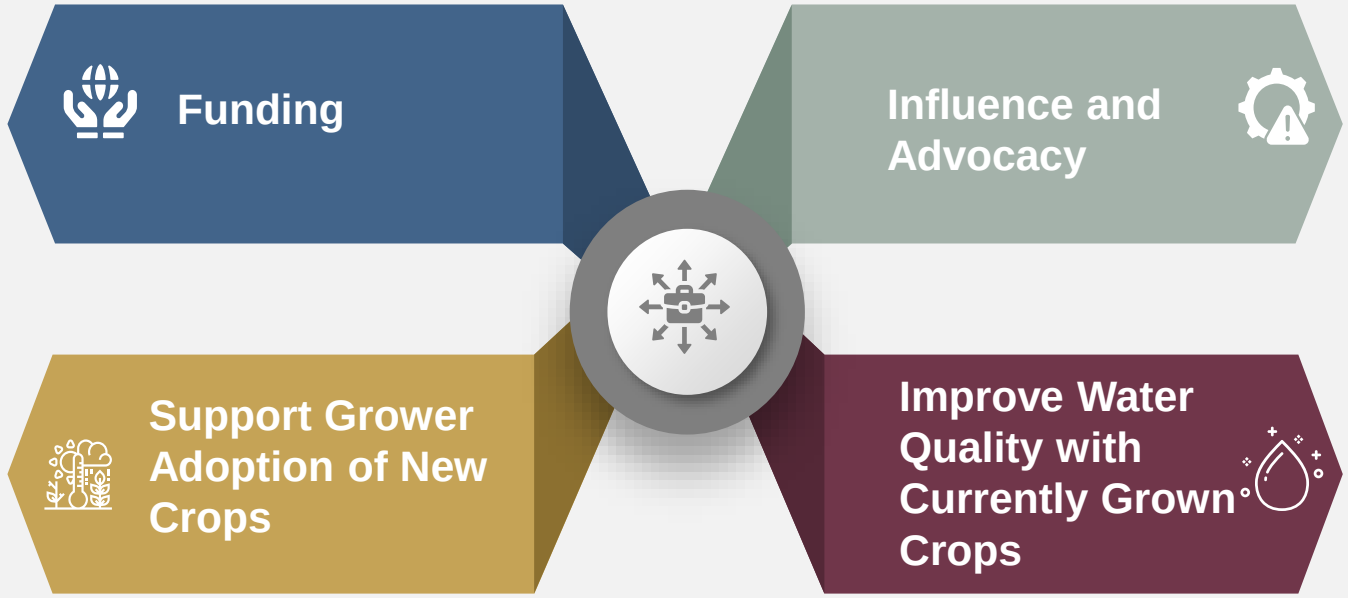
*"If you do too much too fast, [it is] really hard to get back that momentum. **Like if you introduce and have 50% fail rate, it is going to be really hard to get those growers back."*** – Seed Company

*"Typically, we learn more in the first year than we do in the next five years of trying to grow the crop**."*** – Producer

*"Right now, attitude of farmer is if I can't get crop insurance, I don't want to take on the risk. Maybe a few acres, but never hundreds or thousands of acres**."*** – Ag Equipment Advisor

Opportunities for Philanthropy

Note: The recommendations in this report reflect the opinion of Context Network and are not indicative of future grantmaking by WFF.



*"Philanthropies can **provide long term funding**, **drive the conversations around research and market programs**, and help **identify key organizations** to focus on funding and research."* – NGO

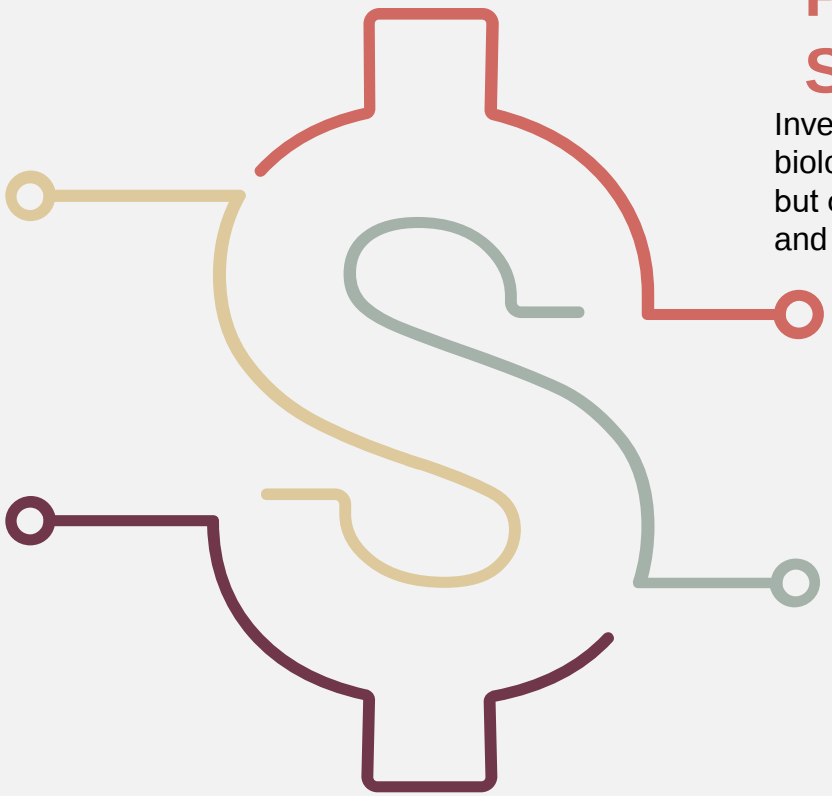
Opportunities for Philanthropy to Support Crop Diversification through **Funding**

Crop Research and Development

- Provide **seed money** on interesting crops for further development
- Financially support **targeted projects** with companies such as DLF or Alforex big enough to have their own R&D departments but small enough to have the drive for new crop development

Advance while Research for Scale is Ongoing

- Initially start by promoting cover crops as a third crop (Green Cover), avoiding market development, and other pain points while other crop diversification efforts are ongoing
- Fund trials for geographical expansion (pre-pilot, pre-commercial stage)
- Partner with local communities on locally grown crops with specific markets and uses



Promotion of Promising Solutions

Invest in promotion of promising product solutions (e.g., biologicals) that improve nitrogen / phosphorus use efficiency, but conduct due diligence to avoid companies with 'big talk' and no results

"It is more likely that early-stage companies will develop products that make a difference in the environmental impact of cropping practices. They are likely to be acquired by the Big4 later, but smaller companies are more involved in R&D that could lead to advancements in product solutions." – Industry Advisor

Identify Opportunities

- Identify constraints/pain points in current crop expansion efforts to identify areas where a **direct investment** would make a difference
- Conduct a **landscape analysis** to uncover what is currently in the works (products, traits, new crops) Who is doing what? Why? Where are the highest opportunities to make a difference?

This could lead to opportunities to support ongoing efforts at companies such as, Benson Hill, Beck's seed company, progressive crop-focused Universities, Crop Protection Services (CPS)

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Opportunities for Philanthropy to Support Crop Diversification through **Influence and Advocacy**

MARKET ACCESS:

Market access is a significant potential barrier to crop expansion and producer adoption. To the extent it aligns with your core vision, mission, and values:

- Consider leveraging influence on retailers for demand generation or to drive change in cropping practices
- Leverage existing partnerships to open doors to new relationships/partnerships

"I think organizations can influence change. Did you guys see commercials where Budweiser talks about their growers? There is some value in all of that also. Some of that is connected to, 'we're buying from America, we're buying from the famers.' Those are emotional situations consumers and growers respond to because of things others have said." –Seed Company

POSITIVE STORY TELLING:

Providing a voice / avenue for growers to tell the story of the practices they've put in place painting the agricultural community in a positive light and helping build consumer trust

- Showcase crops and production practices that are making a positive difference on the climate and/or soil conditions
- Build momentum for widespread adoption of regenerative agricultural practices

"If investor came to me, say hey you got this brassica juncea, I'll help you get it off the ground, and let's turn this into a story of sustainability. Let's turn this into a story around renewable fuel, alternative crop to soybeans, and we can grow this on area that hasn't been grown before, I'll help you get downstream guys to be interested. Let's go for aviation fuel and saving the planet. I'd listen" –Seed Company

CROP SUPPORT:

Crop support is critical to widespread producer adoption

- Advocate for change in policy to pave a pathway for inclusion of promising crops (for example camelina) in the next Farm Bill
- Advocate for change in the regulatory process for advancing policy supporting new crop uses (for example HR5089)

"*If you have a community stepping up and saying this is worthy of investment, we're making an investment, and we'd encourage others to make an investment.* ***Providing that leadership.*** *That sort of support from philanthropies is very, very helpful. I think they ought to be more involved in making presentations at the federal and state level to help encourage these agencies to put more resources behind these ideas*." – University

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Opportunities for Philanthropy to **Support Grower Adoption** of New Crops

PRICE PROTECTION:

Market access is a significant potential barrier to crop expansion and producer adoption. To the extent it aligns with your core vision, mission, and values:

Contracting

- Develop a contract model for specific crop(s)
- Establish grower contracts with conditions for crop production (e.g., required inputs, cropping practices such as no till, cover crops) to provide reliable market support and incentives needed for implementation of practices

Price support: Subsidize or develop a price protection program for crops you're backing for improving crop diversification

*"If you want to insert something new or different, **you have to be able to make up the difference in value between what the grower is currently doing, and what you want the grower to do**."* – Seed company

SERVICE MODEL:

Build or partner to develop a service model for new crops including a subset or all of the following:

- Grower education support (e.g., how to successfully grow the crop, production practices and inputs)
- Agronomy services (e.g., scouting, spraying, field testing)
- Processing niche grains for specific markets (e.g., heritage grains for flour, locally grown barley)
- Marketing to generate addition interest / demand
- Handling / storage / transporting
- On-site processing
- Equipment share / rentals

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Highest area of opportunity is in **funding and support of grower adoption**

- Crop expansion and new crop research and development requires long term, continued funding
- Market development is also costly
- Identifying best practices and projects with the highest potential is also important
- Revenue protection for growers will help drive adoption

*"Primarily, **have to have financial support to have enough ongoing effort** in order to turn research to focus on your crop vs another."* -Producer

*"That's the biggest challenge I have, is **to keep people focused on the development of the crops**. We have the best scientists working on these projects, but if I can't keep funding in front of them, they'll go away and do other things."* -University

*"We spend a lot of time having these big picture conversations on one hand, and then boots on ground type conversations, and hard to make those two things intersect, **unless you have proper staffing**."* - NGO

*"They need to be involved in shaping these market development research programs. They need to play a role in understanding why is it that the best management practice approach to conversation has come up short. **Doing that deep analysis, what has all this money that we've poured into a certain model of ag management actually gotten us**. Help us to identify "what organization would be appropriate to work on farmer outreach? Which org to fund pilot scale projects"* - NGO

*"**Successful market development requires significant investment**. Letting universities do it isn't going to happen. There needs to be clear value throughout the value supply chain, from grower to processor to food company."* – Seed company

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Universities

The role of universities has changed over the years.

Universities provide tools for grower support, especially through extension services

"We have numerous programs for our growers including winter meetings and zoom meetings. [For new crops] ***we test varieties that are available so farmers can gather information and decide whether to grow****."* – University Agronomist

*"****Extension was key for us****, because if we were to go [to a grower meeting] and have a seminar for growing soybeans, it seemed too commercial and more like an advertisement. It was much more powerful having the local extension saying 'hey, we think soybeans can be grown here, and here's the company that has seeds to grow here and we're working with them to show you how to grow here.' We spent time with the extension, the benefit of having them up to speed was almost like having an employee out there."* – Seed Company

Universities play a role in research and trials, though it has changed over the years

*"****The production research is being done by Universities*** *to the extent they have a grower base that is asking for it, because private companies are not going to do research on anything that is not going to result in sales of marketable products."* – NGO

*"****We have bought some really intriguing technologies from universities****. The single biggest gamechanger we purchased for canola, pod shatter reduction, and we bought that from a University in California."* – Seed Company

*"[Soybean development] didn't come from those big companies. It was public investment, up until the mid 90's****, developed by land grant universities.****"* – University

Universities provide education and training and bridge relationships

"What universities see their role being right now is ***training people to become agronomists*** *and breeding professionals."* – Seed Company

"I'd argue that land grant universities ***provide tenure*** *for faculty, allows them to* ***develop ideas****."* – University

*"****Universities are the nexus*** *between organizations and farmers."* – NGO

Equipment

Similar equipment requirements eases producer adoption

*"That was one of the things that made it possible in actually a short period of time because it **did not require different equipment that cereal grain farmers didn't have**. You can get started with the equipment we were using in 1972, just had to figure out how to do it. I don't think equipment was at all a barrier to the adoption of canola by most farmers."* – Producer

*"When introducing a new crop, **have to try to align equipment needs with other crops**. New equipment is expensive and poses a barrier to adoption. Whenever you introduce a new crop, have to look into where it's growing and if it fits equipment in that area."* – University Agronomist

Equipment innovation is usually driven by changing producer needs

*"For most crops, equipment's not a big issue. Equipment innovation is usually done once a crop is well established and enough acres to make it worthwhile for manufacturing companies. So, **equipment innovation usually comes on the back end of crop development** vs the front end."* – University Agronomist

*"[What drove equipment change] In my experience, wasn't much interaction from seed companies or input companies driving that change. **It was more market driven.**"* – Producer

In some cases, partnerships ease new crop barriers

*"**The soybean association in Iowa, partnered with John Deere** and to put together trials and nitrogen usage and spacing and whole bunch of stuff. Made test equipment, and moved that around from grower to grower, to get enough acres to prove a pilot program."* – Producer

02

Canola Case Study

This section summarizes key elements relevant to the expansion of canola

"Canola comes from "Canada oil". Breeders / farmers in Canada recognized that it was viable crop for them, rapeseed had been grown in Europe many years as an edible oil. The problem was the fatty acid content was regarded to have unsafe aspects of human consumption. So, Canadians developed a new variety to change the fatty acid profile and the meal content that allowed it to become more suitable for human consumption."

– Producer

Supporting details are included in the Appendix

CONTEXT

KEY FACTORS INFLUENCIAL IN EXPANSION OF CANOLA

VARIETY DEVELOPMENT AND CONTINUED INVESTMENT

- **Development of "Double Low" Varieties:** Made canola oil and meal more suitable for human and livestock consumption
- **Development of Herbicide tolerant varieties**
- **Ongoing research for new varieties supports likelihood of future growth**

FARM PROGRAM SUPPORT

- **Creation of crop insurance programs in the 1990s**
- **1996 Farm Bill eliminated planting restrictions**

HEALTH BENEFITS OF CANOLA OIL

- **Promotion and adoption of Canola oil as a healthy alternative to common vegetable oils led to increased market opportunities for growers**

PRODUCTION PRACTICES

- **Production practices for canola are similar to rapeseed and other oilseeds making it easy for producers to use existing equipment and production practices**

Key players influential in the advancement of canola include:

Dr. Baldur Stefansson and Dr. Keith Downey are known as the "Fathers of Canola" because of their contributions of the industry. It was their development of double low varieties (< 2% erucic acid and less than 30 micromoles of glucosinolates) that resulted in distinction of rapeseed from "Canola", standing for "Canadian Oil". (CCC)

PRIVATE SECTOR

BrettYoung

BASF
The Chemical Company

BAYER

DEKALB

nuSEED

DUPONT

PIONEER

WinField United

DYNAGRO SEED

STAR SPECIALTY SEED INC

CROPLAN GENETICS

Meridian SEEDS

INTEGRA FORTIFIED SEED

PUBLIC SECTOR

U.S. CANOLA ASSOCIATION

University of Manitoba

NDSU

Vandals

canolacouncil OF CANADA

UNIVERSITY OF SASKATCHEWAN

KANSAS STATE UNIVERSITY

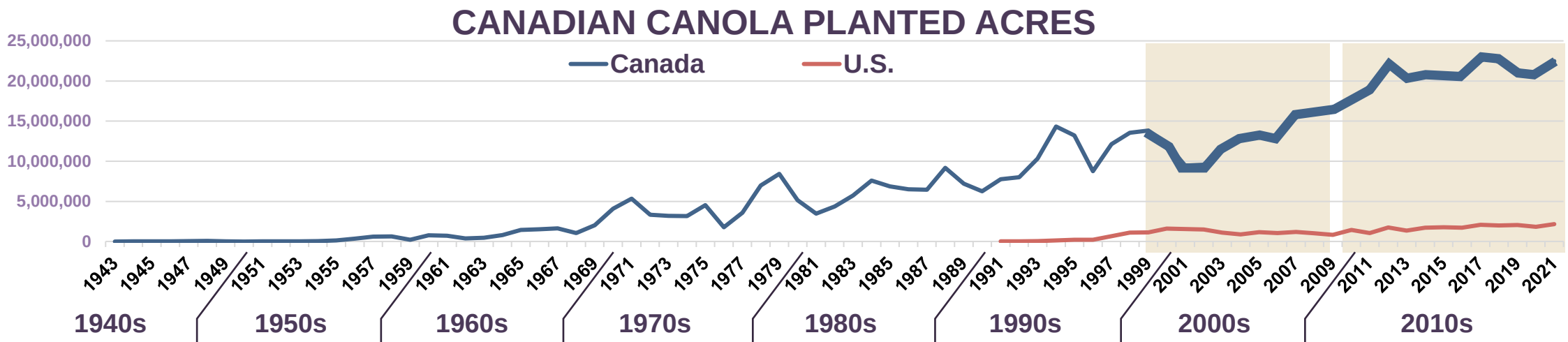
OSU

Agriculture and Agri-Food Canada

Oregon State University

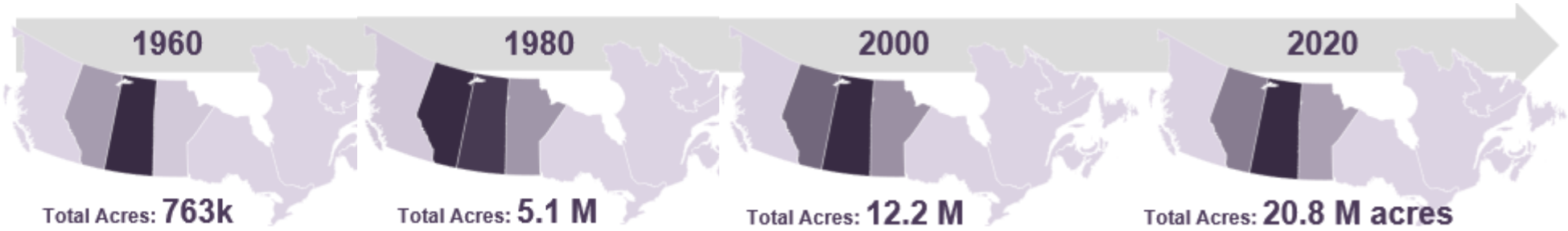
*list not exhaustive

Canadian Canola acreage has **more than doubled** over the past 20 years



	1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s
Variety Development	Farmers in Canada begin planting seed purchased from US companies	Variety with improved oil content developed	Low erucic acid variety developed	First "double low" varieties developed	Supreme court decision allows patents on seeds	Herbicide tolerant varieties developed	Shatter resistant varieties are developed, with longer shelf life and increased fatty acids, providing additional marketing opportunities	
Market Development	Price support for industrial canola oil First crushing facilities open		Rapeseed begins trading on Winnipeg Grain Exchange Surplus of cereal grains incentivizes rapeseed production	Health Canada urges switch to low-erucic varieties Double low varieties improve palatability and nutrition content for livestock meal, doubling demand Professors Develop booklet on nutrition benefits of canola oil	U.S. grants GRAS status for human consumption of canola products	Farm Bills authorize price support and crop insurance expansion University research prompts McCain Foods to use canola oil for their "healthy fries"	USCA ensures equity for canola in Farm Bills and RMA programs U.S. FDA authorizes qualified health claim for canola Processing expansion begins	EPA includes canola biodiesel in RFS standard Expanded Farm Bill support Trade agreements preserve tariff-free access for canola

Canadian planted acres of canola have gradually spread out from Saskatchewan into the northern growing regions of neighboring provinces Manitoba and Alberta.

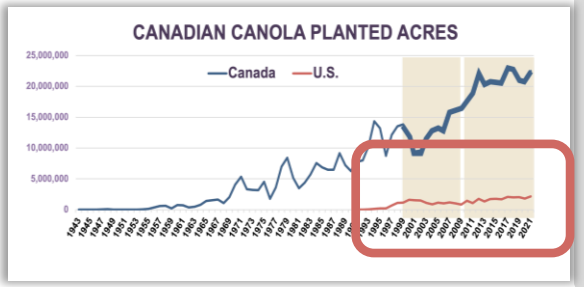


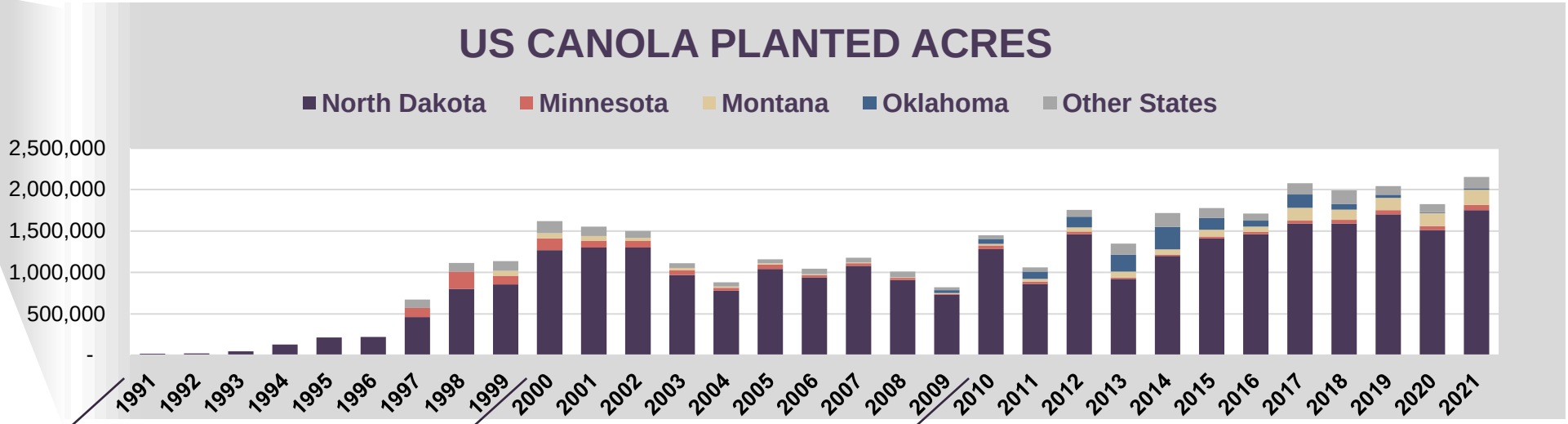
KEY REGIONAL CANOLA POINTS

- Being a member of the brassicas family, canola is conducive to shorter, colder growing seasons
- Spring canola varieties dominate Canadian production
- Canola provides nutrient and soil benefits when grown in rotation with cereal grains, which dominated Canada agriculture before canola adoption

> ***Canadians really have strong affinity for canola, wanted to make it work. National pride thing going on. Great facilities available and the crop grew well.***
>
> ***– University Agronomist***

Relative to Canada, Canola expansion in the U.S. developed later, and at a slower pace





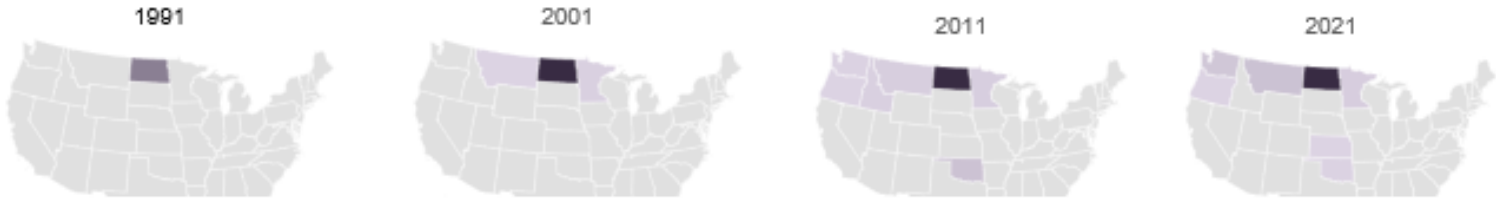
	1980s	1990s	2000s	2010s
Variety Development	Supreme court decision allows patents on seeds	Herbicide tolerant varieties developed	Shatter resistant varieties are developed, with longer shelf life and increased fatty acids, providing additional marketing opportunities	
Market Development	U.S. grants GRAS status for human consumption of canola products	Farm Bills authorize price support and crop insurance expansion University research prompts McCain Foods to use canola oil for their "healthy fries"	USCA ensures equity for canola in Farm Bills and RMA programs U.S. FDA authorizes qualified health claim for canola Processing expansion begins	EPA includes canola biodiesel in RFS standard Expanded Farm Bill support Trade agreements preserve tariff-free access for canola

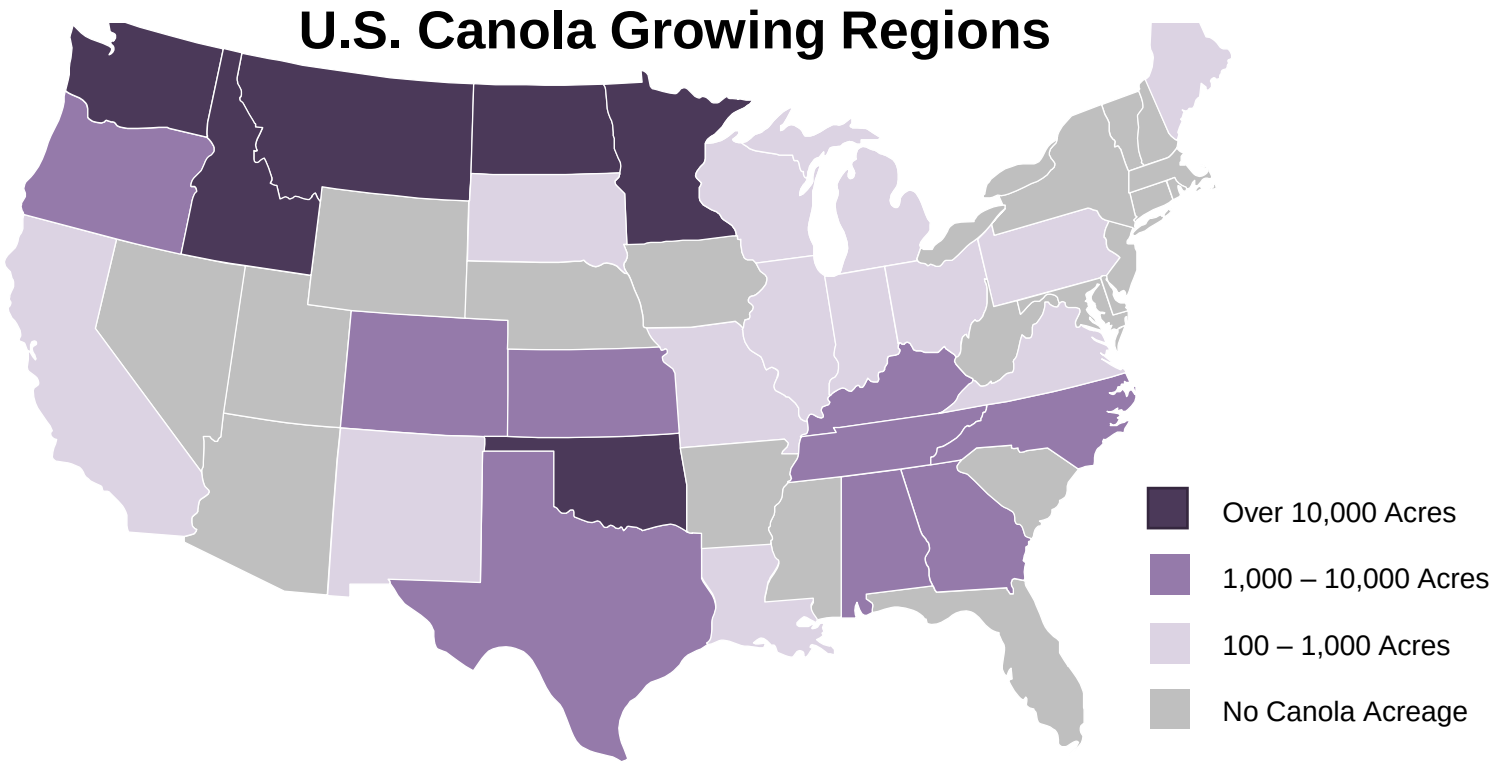
Canola acres in the U.S. are largely dominated in the Northern prairie states, with North Dakota accounting for almost 80% of planted acres in 2021

Canola can be planted in the fall or winter depending on the variety.

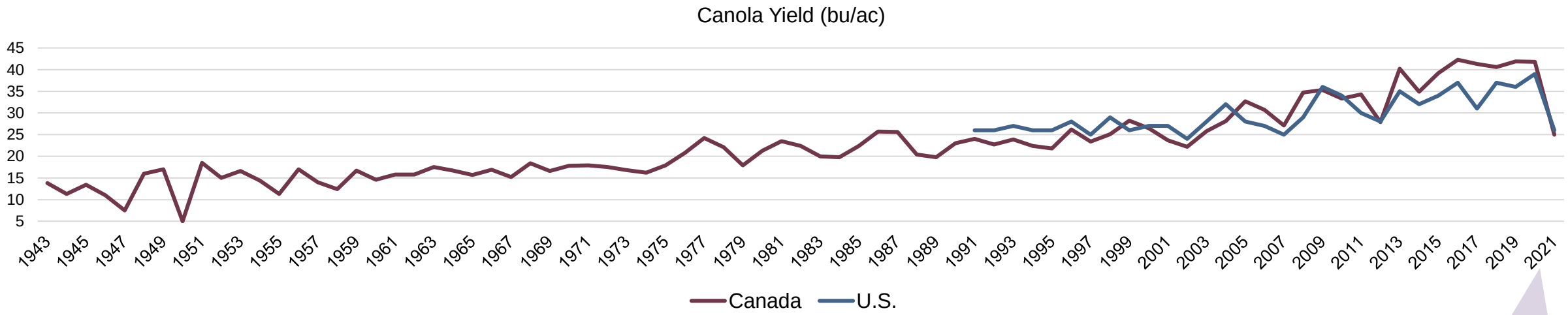
Spring canola accounts for the majority of U.S. production, although winter canola often yields 20-30% more than spring canola but can usually only be grown in warmer areas like the Southern Great Plains.

Pacific Northwest States such as Washington, Idaho, and Montana can grow both varieties, while North Dakota is almost exclusively limited at this point to spring varieties.





Productivity increases, improved genetics, and equipment modification have supported adoption of canola.



Drought conditions in 2021 led to a significant decline in yields.

This was furthered by a better understanding of the nutrient needs of the crop. As soil science progressed it empowered growers to achieve higher yields promoting grower adoption.

"Canola grows 6-7 ft tall, all tangled up, harvesting can be issue. Wind shatter is an issue. If it isn't ripe, can't harvest it, and if its too ripe it shatters. That's a challenge, there have been some things done to try and address that. ***Improved genetics have come along as shorter, more compact maturities for easier harvesting."*** – Producer

"What's happened over time, practice improvements. The ***equipment caught up with the practice****. In other words, producers would want to cut a seed trench and plant into undisturbed soil. And to do that, planter had to be more robust, has to have stronger devices, more robust."* – Equipment Advisor, canola

ENABLERS

Trade associations and Universities were some of the biggest influencers in canola development

AGRICULTURE AND AGRI-FOOD CANADA (AAFC)

Canadian government agency responsible for the development of the first and many of the most important B. Napus varieties, including the first low erucic acid registered cultivar, paving the way for the eventual “double low” varieties

U.S. GOVERNMENT

Through its agencies, gradually made it easier for U.S. producers to grow canola through Farm Bills and other strategic farm programs

CANADIAN GOVERNMENT

Provided crucial market support during initial crop development as well as continued research and funding assistance. Public health claims underpinned canola oil demand growth

UNIVERSITY OF MANITOBA

Canadian seed influencer responsible for many of the most innovative rapeseed and canola varieties, including the first “double low” variety

CANOLA COUNCIL OF CANADA (CCC)

The first canola trade association established in North America. Aided in the growth of canola in Canada through grower education and support as well as strategic marketing campaigns

U.S. CANOLA ASSOCIATION (U.S.CA)

Key trade group who was a key influencer behind the removal of most major barriers to adoption facing U.S. producers in the 1990s and 2000s

03

Soybean Case Study

This section summarizes key elements relevant to the expansion of soybeans

"100 years ago, soybeans were experimental crop brought in from China. They were initially brought in as a forage source for cattle. Beans had a high protein value to them and outperformed alfalfa and other forages. Over the years, soybean researchers have done great job at number of things: Finding uses for soybeans. Nobody grazes soybeans anymore; it is all about harvesting the bean. You get oil with hundreds of uses like paints, coloring crayons, biofuels. And then you got the meal, the solid part, and that's a really high source of protein for hogs, chickens, and livestock in general. "

-Agricultural Media

Supporting details are included in the Appendix

CONTEXT

Key factors influential in growth and expansion of soybeans:

Animal Feed

Soybean meal replaced small grains and has been a staple in the animal feed industry due to its low cost and high protein qualities

WWII

Trade disruptions and the need for industrial and edible oils sparked increase in domestic production

Research on Additional Uses

Research at universities and in the private sector led to expansion of uses to include biofuels, cooking oil, aquaculture, and other uses

Export Demand

The rise in global demand for animal protein lead to the U.S. becoming the dominant soybean exporter over the last 50 years improving revenue potential for growers

Herbicide Tolerant Varieties

The development of herbicide tolerant varieties by private seed companies lead to a significant acreage increase

Crop Rotation

Corn growers adopting the 50/50 corn/soybeans rotation throughout the 1990s and the 2000s provided soil health and nutrient efficiency benefits

Soybeans achieved commercial success after arrival in the U.S. due to the combination of **available land**, **modern farming practices**, **growing human and livestock populations** that provided demand, a **modern transportation and handling infrastructure**, and abundant natural resources. (USSEC)

Key players influential in the advancement of soybeans include:

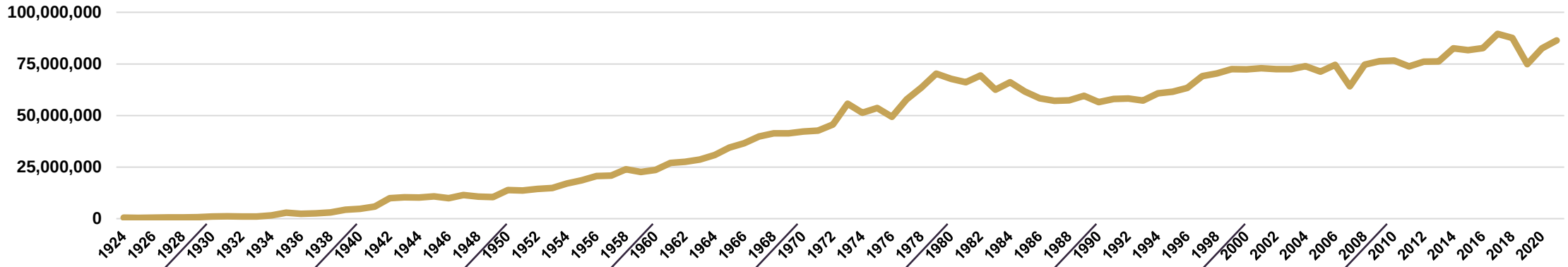
PRIVATE SECTOR

PUBLIC SECTOR

*list not exhaustive

The U.S. has witnessed dramatic growth in soybean acres and has been a dominant global player for most of the crop's history

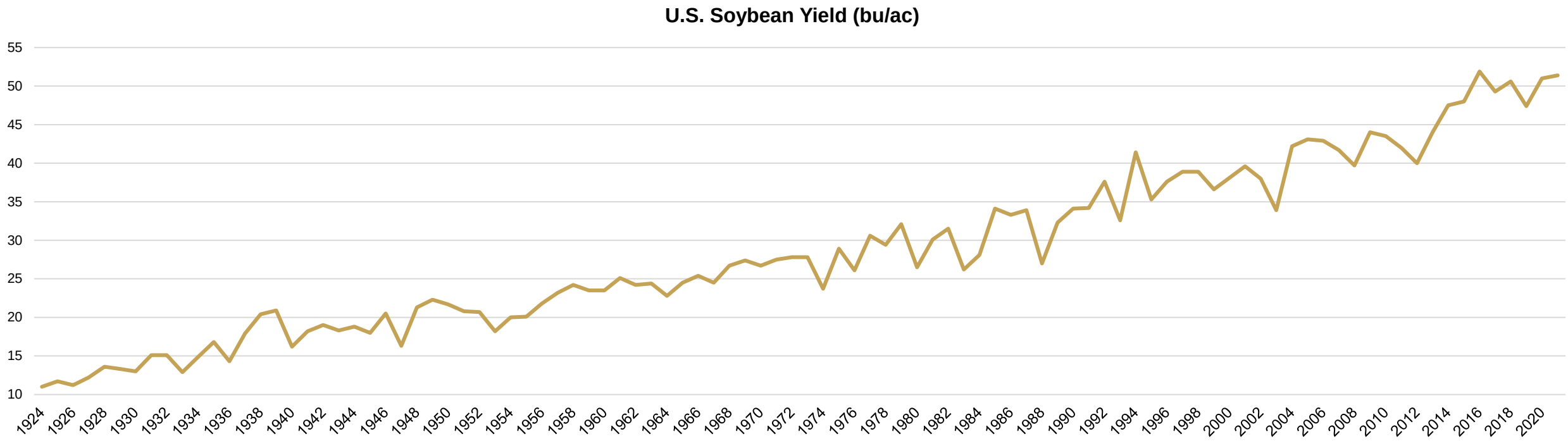
U.S. SOYBEAN HARVESTED ACRES



	Early 1900s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s
Variety Development	George Carver begins research on soybeans to help depleting soil in the South also identifying soy as a protein source.	ASA cofounder brings 4,500 varieties from Asia to the U.S. USRSIPL lab established to research industrial uses	USDA and USRSIPL start the development of the US first comprehensive soybean germplasm collection		USDA, through its state ag stations, begins large-scale soybean research starting in the North and expanding to the South	Congress passes the Variety Protection Act authorizing Certificates of Protection for novel, sexually reproducing plant varieties	*Diamond v. Chakrabarty*, is decided allowing patents for organisms paving the way for full patent protection	Monsanto launches Roundup Ready transgenic/genetically engineered (GE) soybeans	The first biodiesel tax incentive is enacted as part of the American Jobs Creation Act of 2004	
Market Development	ASA made agreements with processors to underwrite the production of 50,000 acres at a guaranteed minimum price	Soybean tariffs in place, new processing methods pave the way for soy as a cash crop, soybean meal is included in animal rations	ASA publishes the first Soybean Bluebook	The U.S. entered a period of prosperity and demand for meat and protein rose dramatically	States begin forming under ASA increasing funding research to drive new uses for soybeans	The Farm Credit Act instated expanding Farm Credit services	U.S. consumers began to accept soybean oil as a healthier alternative to palm oil	Farm Bill support of soy marketing and eliminating planting restrictions, USB created to oversee check-offs	Agricultural Risk Protection Act passed, providing additional subsidies and crop insurance programs	

Part of the rapid acceleration of soybean acres starting in the mid 90s is attributed to the development of genetically engineered (GE) soybean varieties. In 2000, 48% of soybean acres in the Upper Mississippi River Basin (UMRB) were planted with GE varieties. By 2019, 94% of those acres were GE. Over that timeframe, the UMRB lost over 50% of their winter grain acres, largely to soybeans.

Productivity increases have been instrumental in adoption of soybeans



Corn belt farmers began to adopt a 50/50 corn/soy rotation, beginning the shift away from small grains. It was also during the 1990s that producers began adopting narrow-row planting which benefited soybeans yields dramatically in the 1990s, driver farmer adoption. (ERS)

Over the past few decades, production in the southern U.S. has declined due to lower yields and competition from other crops. This decline in production has been made up and then some by the expansion of acres mostly north. This has been made possible by new varieties requiring less growing time and increased drought tolerance. (USSEC)

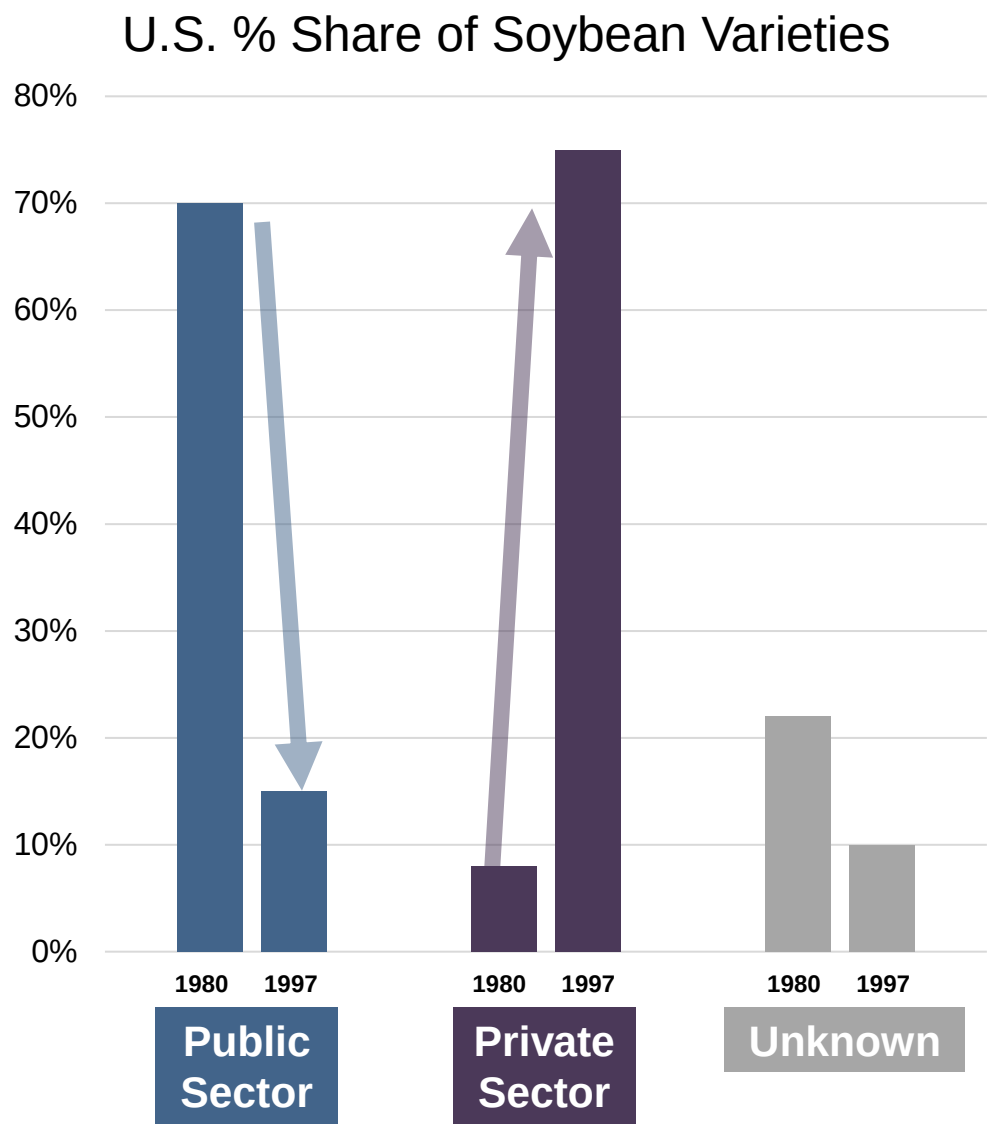
"I think of soybeans with my dad, first time planting Roundup Ready soybeans in the 90s. All our neighbors probably drove by that field at least 100 times." - Producer

Intellectual property rights dramatically changed the seed development landscape

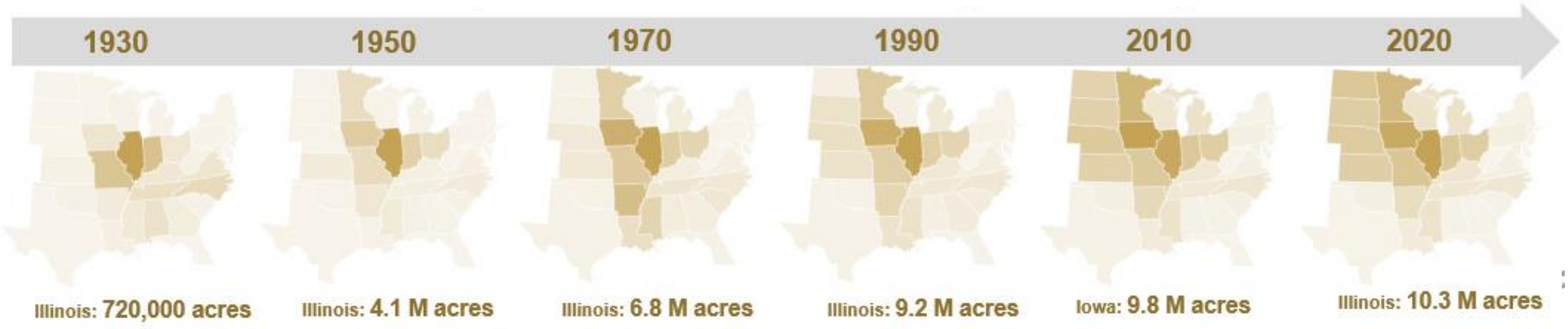
Prior to 1970, most U.S. soybeans were bred by the public sector, including USDA and agricultural colleges and experiment stations. **Improved yield, lodging resistance, pest resistance shattering resistance, and higher protein and oil content** were among the major breeding objectives for soybean development throughout the 1960s. (SIC)

Soybean variety development was dominated by the public sector until the 1980s, when **strengthening intellectual property** rights among other factors led to a **dramatic transformation from the public sector to the private sector**. In 1980, more than 70% of soybean acres were planted with publicly developed varieties. By the mid 1990s, soybean acres were planted with only 10% of public varieties (USDA ERS)

"The dramatic change for the seed industry is when they allowed intellectual property rights for soybeans in the early 1980s. The private seed industry took control of soybean development when it became profitable for them." – Seed Company



Planted acres of soybeans in the U.S. have gradually spread from the heart of the Midwest to the northern and western prairies. Illinois remains the top state for soybean acres.

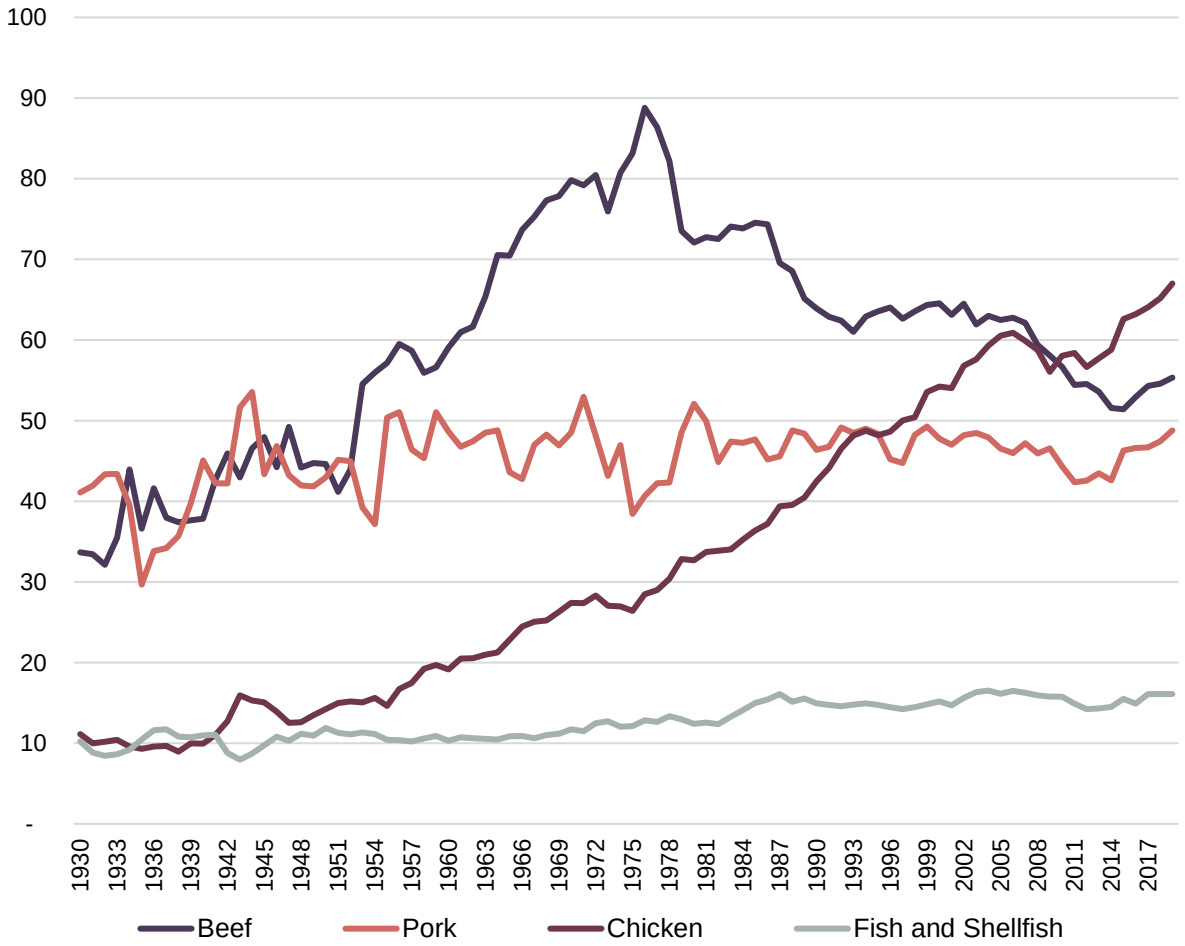


The majority of U.S. soybean production has gradually moved north, into states with colder climates and shorter growing seasons, such as Minnesota, North Dakota, and South Dakota

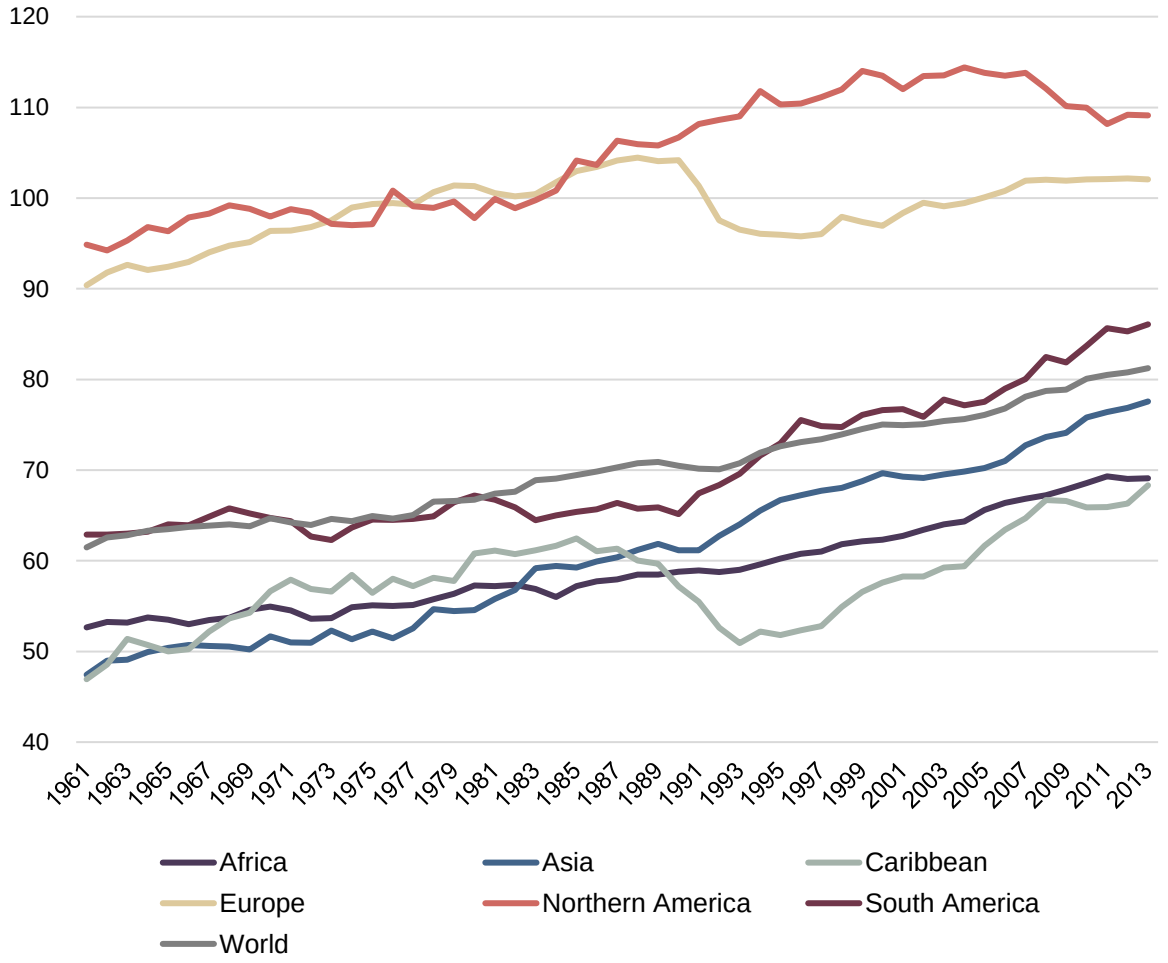
*"Typically, **it takes six years to get a new variety that is changed enough to plant in new places**. We beta tested different soybean varieties to determine what would work where. We did find, **there were certain regions that grew better**. In an area that was 90% successful, okay let's expand acres there next year."* – Seed Company

Increasing consumption of protein in the U.S. and globally has fueled the market demand for oilseeds

U.S. Per Capita Availability of Meat, Pounds per Person



Global Daily Protein Supply, Grams of Protein per Person



Also influential for canola and included in the canola case study

04

Camelina Case Study

This section summarizes key elements relevant to the expansion of camelina

*"The crop has promise, but it has not taken off because of the **lack of supporting infrastructure.**"*

-University

Supporting details are included in the Appendix

CONTEXT

KEY FACTORS INFLUENCING THE POTENTIAL FOR EXPANSION OF CAMELINA:

SUPPORTING FACTORS

Increased yields

"Breeding programs have advanced. Yield is now often better than canola." – Camelina Processor

soil health benefits - With the ability to grow on fallow acres, camelina provides protection from erosion and puts nutrients back into the soil on land that may have otherwise been left bare

Increasing demand for **renewable fuels**
Low carbon intensity score

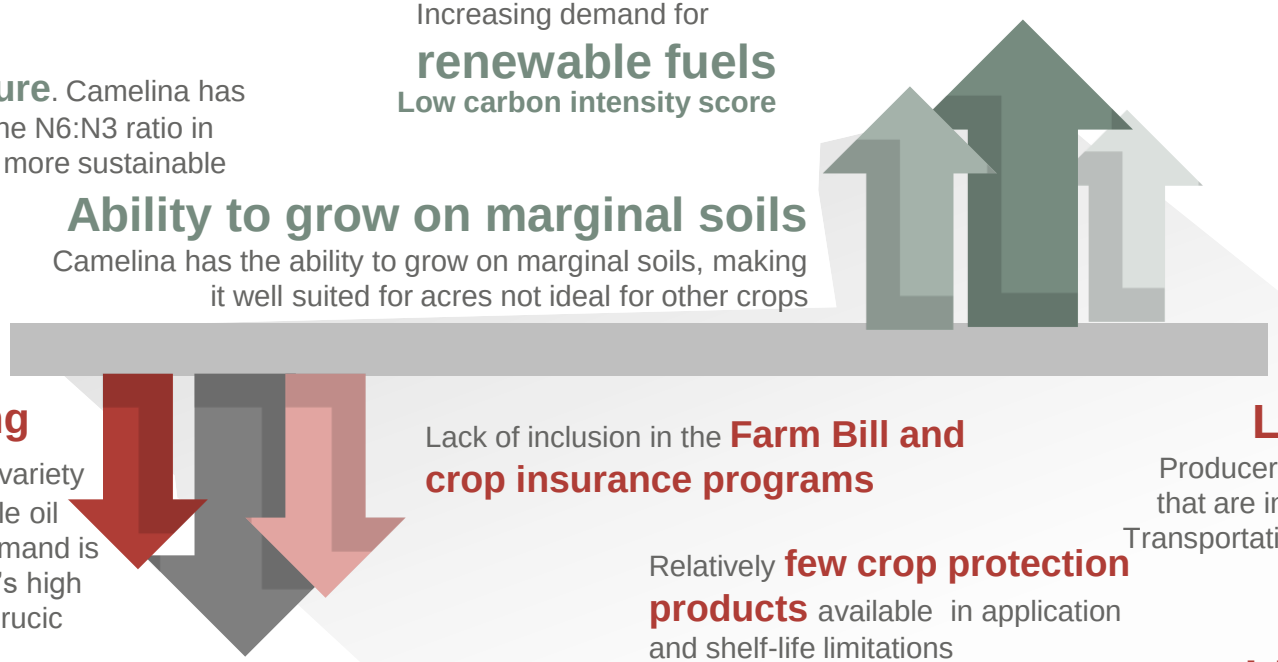
Potential for **aquaculture**. Camelina has been shown to improve the N6:N3 ratio in farmed fish and deliver a more sustainable marine-free diet

Potential for **livestock feed**, Nutrient composition of camelina meal makes it attractive as a feed source

"The Exxon investment is huge and will help drive growth. This will be a major feedstock of biofuels and hopefully gain GRAS in dairy. This will have many positive impacts as a dairy feed. - Processor

Ability to grow on marginal soils

Camelina has the ability to grow on marginal soils, making it well suited for acres not ideal for other crops



Lack of **breeding programs** for variety advancement. Edible oil and animal feed demand is limited by camelina's high glucosinolate and erucic acid content

"More aggressive breeding programs would be a catalyst for the entire industry." – University

Lack of inclusion in the **Farm Bill and crop insurance programs**

Relatively **few crop protection products** available in application and shelf-life limitations

Local delivery access

Producers need post harvest delivery options that are in close proximity to growing regions. Transportation costs are currently high for most.

Lack of reliable / stable market access

"Ensuring consistency and stability in contracts over multi-year periods would help increase producer adoption." – Industry Advisor

LIMITING FACTORS

Value proposition

*"The market never really developed for this. There was a big push and then after a few years of commercial field seasons, **it just never panned out because of poor economics for the growers**."* – University

Additional research on variety development is needed to make camelina oil and meal more attractive

MARKET & VARIETY DEVELOPMENT TIMELINE

Pre 1940s	Camelina was grown widely in Europe and Russia up to this point, but became displaced by other more profitable, higher yielding crops that were supported by farm subsidy programs after WW2 (OSU)
1950s	The demand for hydrogenated vegetables oils spiked, but the hydrogenation process for camelina was more expensive than the likes of soybeans and canola, and it became economically unviable to grow camelina (Smart earth camelina)
2002 - 2005	AAFC Canada conducted agronomic trial, comparing camelina to other brassica oilseeds and found that camelina is well suited for production in Western Canada due to its early maturity, high yield potential, drought tolerance, and resistance to some common pests and diseases common in canola and other oilseeds. (AAFC)
2005 - 2007	Camelina studies on planting dates and methods are conducted across the PNW by researchers at the Washington State University (WSU)
2008	The Montana state DOA began working with multiple Montana industries and the FDA to generate the requirements of what was needed to acquire GRAS status and AFFCO feed certification for camelina (AGMRC)
2009	FDA approves use of camelina meal in feedlot beef cattle in up to 10% of total rations AltAir Fuels announces purchase agreement with 14 major airlines to develop up to 750 million gallons of camelina biofuel at the Seattle-Taco airport (Bizjournal)
2010	FDA approves use of camelina meal in broiler diets in up to 10% of total rations Health Canada approves the use of cold-pressed camelina oil as a food ingredient, as Camelina's erucic acid content was less than 5% maximum limit (UNR Ext)
2015	Sustainable Oils is the first and only company to be granted a feedstock-only pathway by the California Air Resources Board (“CARB”) for the production of renewable fuels under the Low Carbon Fuel Standard (“LCFS”) (GCE)
2013 - 2016	Research around the adaptation and performance of camelina genotypes is conducted by researchers at WSU and OSU. Details
2016	The winter camelina breeding program is launched at the University of Minnesota, focused on identifying high yielding, early maturing camelina lines with improved winter hardiness.
2018 - 2019	Plant breeders at Washington State University (WSU) developed multiple breeding lines, among them low erucic varieties, larger seeded varieties, and herbicide tolerant varieties. (WSU)
2020	Global Clean Energy Holdings acquires an idle Bakersfield, CA refinery for $40 million and begins transforming it into a renewable diesel production plant, planning on using its own proprietary fallow-land crop varieties of camelina (OGJ)
2020	A team of researchers at Montana State University (MSU) will collaborate with stakeholders across the U.S. to administer $11 M of fundings to approach and assess camelina, focusing on yield and nitrogen use efficiency
2021	US DOE, DOT and the USDA announce the Sustainable Aviation Fuels (SAF) Grand Challenge, with the goal of meeting 100% of US aviation fuel demand by 2050

= Market Development = Variety Development

Key players influential in the advancement of Camelina include:

PRIVATE SECTOR

Global clean energy

Sustainable Oils

Yield10 BIOSCIENCE

Limagrain from earth to life

SEABOARD foods

PUBLIC SECTOR

MONTANA STATE UNIVERSITY

Forever Green

USDA

UNIVERSITY OF MINNESOTA

Agriculture and Agri-Food Canada

Vandals

NEVADA

KANSAS STATE UNIVERSITY

Recently there has been renewed interest in camelina due to:

- **Renewable fuels / sustainable aviation fuel**
- **Mixed reactions on the potential for use as an edible oil**
- **Potential for livestock feed and aquaculture**
- **Cover crop with economic benefits**
- **Climate / soil health benefits**
- **Ability to grow in marginal conditions**

*"**Driving innovation was a low maintenance crop** (low water usage, low fertilizer requirement) that has **promising potential for oil and feedstock** (high omega 3 meal). **Ability to use this for Sustainable Aviation Fuel**, and **low Carbon Intensity score led to increase R&D [for camelina].**"* - Processor

*"The key players in market development [for camelina] recently have been fuel companies (Exxon, Shell, etc..) with **new LCFS and CARB requirements** they need blending capabilities."* -Processor

"Mandates currently in California, and soon to be Washington State (along with other areas) is driving the growth [of camelina] more than anything." - Context Advisor

*"The crop is **very hardy, very cold weather tolerant and has great water use efficiency**. It is a low maintenance crop [camelina]."* -Processor

"This could be a main area of growth – GRAS for dairy and other livestock. Great meal benefits more focus needs to be put here and getting other certifications. Trying to gain GRAS as a human food would be bad for the industry due to competing priorities for the oil. Should focus on GRAS for other livestock for the meal." -Processor

*"Having a crop in the ground instead of fallow acres has soil health benefits including **erosion mitigation and biomass increase**."* - Processor

*"We think of camelina as an **economic cover crop**, it does overwinter well and could be harvested as part of a double-crop system with soybean or part of a summer forage system with grazing."* – Industry Advisor

*"Farmers are willing to try [camelina], and it should fit in well with many rotations. Just need to make sure the contracts have a **competitive pricing compared to other crops**."* - University

thank you

MIKE J. BOREL

MADELINE THOMAS

CONTEXT

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Appendix

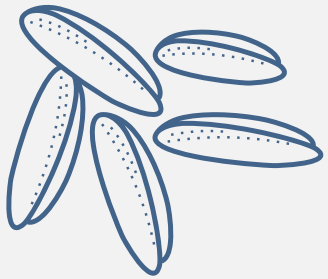
Crops considered for case studies with supporting rationale:

Canola	Canola is a strong candidate for a case study given its success breaking into existing crop rotations. Market demand for canola products is strong across the agriculture and biofuel industries which has resulted in growth of canola acres, especially in the last decade. Canola can be applicable to both the Colorado River Basin and the Mississippi River Valley and would provide a great example of industry infrastructure (i.e. oil/meal facilities, biofuel facilities) growing alongside Canola's acreage and production growth.
Camelina	Camelina would pose as a great example of breaking into a crop system to meet a demand in which the market is already developed. There has been a significant push in California to adopt Camelina acres due to the crops ability to develop well in lower water environments. The industry has joined environmentally concerned producers in the push to adopt camelina acres, mostly due to high quality oil camelina produces that can be used to produce jet fuel.
Guayule	Guayule has met industry demands as a substitute for latex and rubber, especially the latter given Bridgestone's efforts to drive guayule production for use in its tires. Arguably more important are benefits for water consumption, requiring considerably less water to grow than the majority of other crops. Given the crops ability to grow under drought conditions, guayule has particularly strong potential to examine under the lens of needs of the Colorado River Basin.
Wheat	Wheat provides water and soil benefits, especially in the corn/soybean rotation. While acreage have declined in more recent years, it is still the 3rd largest crop by acres in the U.S. and has supporting infrastructure. Wheat has proven a strong fit within any existing annual crop rotation and is applicable to both the Mississippi River Valley and Colorado River Basin regions
Barley	While barley is more water efficient than crops like corn, it lacks industrial and forage demand to incenting producer plantings. Barley acres have declined significantly over the last decade as producers have continued to remove barley from the rotation.
Buckwheat	Buckwheat provides a quality source of protein as a forage but has mainly been used as a cover crop. While buckwheat requires less water than some alternative forages and cover crops, total acres have not grown to scale suitable for examining further in a case study. Nearly all acres are produced under contract, mainly for export.
Kernza	Due to the disease issues that surround Kernza, and given it is a perennial, we don't believe Kernza has experienced enough scalable acreage growth to warrant further analysis for this project.
Pulse Crops	Pulse crops provide soil health benefits and require less water than many other crops, they are almost exclusively grown in northern, cool regions. Limited overall market growth historically and limited growing regions place other crops ahead of pulse crops for key learnings for this study.
Sorghum	Uses less water than corn and can grow in harsher environments. Potential for biofuels didn't pan out like hoped, we could dive into reasons why as learnings for things to avoid. Growth in Colorado River Basin (350-400K acres) but mostly disappeared from Mississippi River Valley.
Split Peas	Peas have lost significant acres over last decade (>30%). Less water needs than some other crops, however lack of sizable market growth limits potential for key learnings from an in-depth case study.

Soybeans	Soybeans are a strong candidate for a case study for this project given the success the crop has had growing in scale over the past 2 decades. It now sits as the 2nd largest crop in the U.S. by acreage. Soybeans originally came into the Midwest as a forage crop, but once their value as an oilseed was fully discovered, acreage growth exploded across multiple ag regions in the U.S. Soybeans would also present a great example for a case study given their lower water and nitrogen (N) needs compared to crops such as corn. Studying factors leading to the success of the crop will prove particularly useful for the Mississippi River Valley
CoverCress	CoverCress warrants consideration for a case study given its environmental benefits and the crop's favorable market demand. CoverCress is a source of high-quality oil that is gaining adoption in the use of aviation fuel. The crop provides environmental benefits including requiring less water and N relative to most other crops commonly included in U.S. rotations. CoverCress has gained traction as a cover crop in corn and soybean rotations but is unique in the fact it can be harvested as well for another profit stream. CoverCress is also a great example of a crop leveraging existing infrastructure to drive acreage growth.
Millet	Acreage has more than doubled (>400K acres) in Colorado River Basin. Nonexistent in Mississippi River Valley. Early maturing millet can exist on very limited water.
Ancient Grains	Recent trends like growing gluten free demand and organic farming provides support to ancient grains, but these are mostly regional opportunities. While acreage growth might occur in the future, we don't believe ancient grains have seen an adequate amount of acreage growth to warrant a case study analysis.
Blueberries	Blueberries have seen a growth in acreage but given the limited soil profiles the crop provides combined with the fact it is a perennial lead us to believe it is less relevant than other crops for this study.
Hemp	Hemp seems to be making an acreage comeback due to its use for strong and durable fiber, we don't believe the crop has experienced enough scalable acreage growth to warrant a case study analysis.
Oats	Oats have broad adaptability and can grow anywhere, but prefer wetter environments. We have seen their inclusion in feed rations decline to soybean meals benefit. While food and beverage demand for oats has grown in recent years, the demand has not been enough to result in significant acreage growth.
Rye	Rye lacks sizable market demand as a valuable crop and is now mostly used as a cover or forage crop.
Sunn Hemp	Possible biofuel uses and a natural weed control. Provides soil carbon sequestration benefits as well. Fiber in plant can be used for rope. A more tropical plant that might be suitable for southern Mississippi River Valley area. Sunn Hemp has not gained notable market share to date and therefore is not a strong candidate for this research.
Triticale	Similar to rye, planted acres of triticale have fallen consistently over the past few decades. Human use its limited. While it is still used as forage, its main demand comes as a cover crop and therefore does not pose as a promising candidate to generate rich insights in a case study.

Company Case Study: General Mills

1



Oats

- Throughout the mid 20th century, oats were commonly rotated with other cereal grains across the Midwest like wheat, barley, and corn, but the rotations were largely abandoned as the corn-soybean rotation established its dominance.
- General Mills has recently launched a 50,000-acre, three-year Regenerative Oat Pilot project in North Dakota and Canada as a step one towards its larger goal for its supply chain of one million acres under regenerative agriculture practices by 2030.
- Even though General Mills has agreed to cover many costs of the pilot program, including technical support for participating farmers, the lure of cash crops like soybeans have posed challenges for producer adoption of once popular cereal grains such as oats.

2

Regenerative Ag Practices

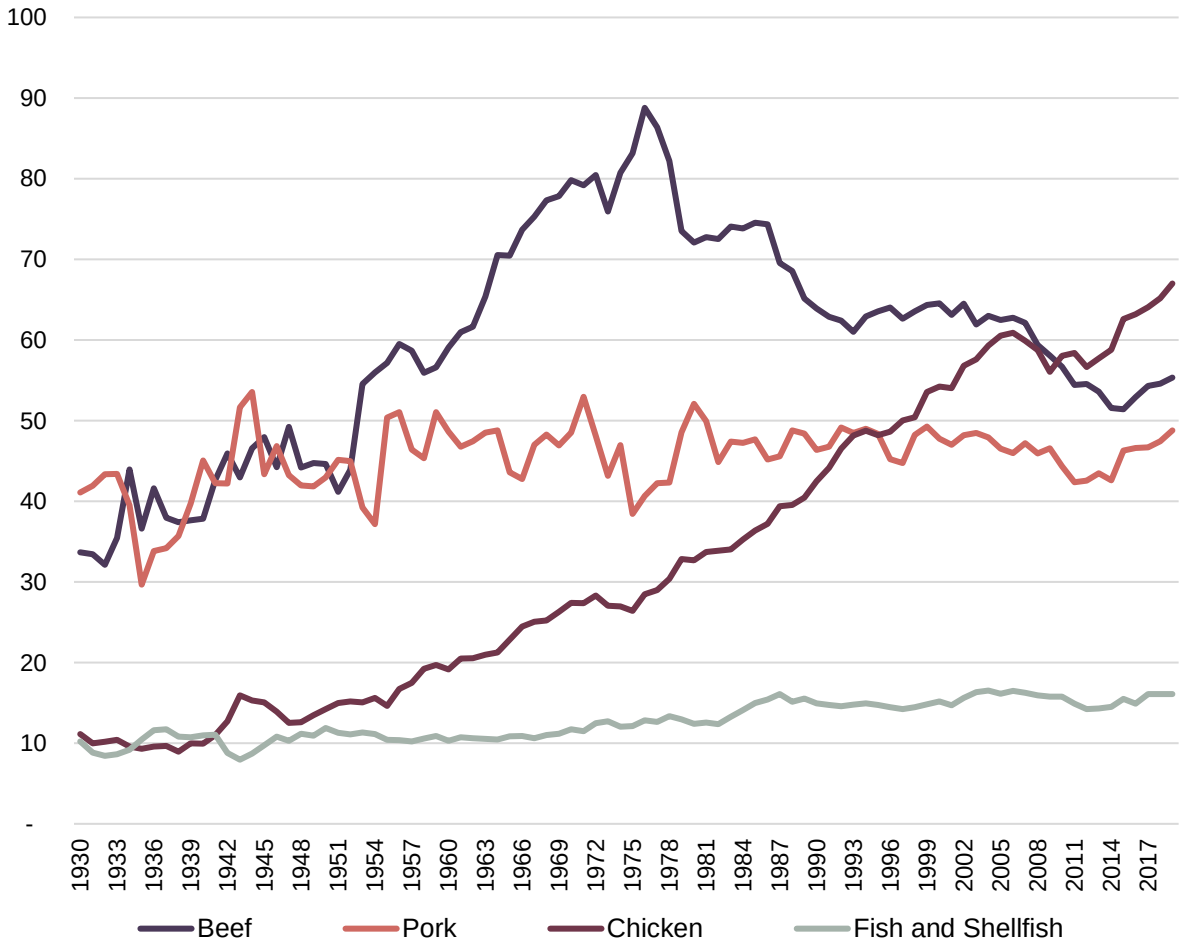
- General Mills is working with 45 farms across 170,000 acres in the U.S. and Canada, supporting them to try efforts such as no till, cover crops, and other regenerative agriculture practices
- General Mills is motivated to protect its source of raw ingredients. To achieve their goals, they seek to stop soil loss and boost soil organic matter and life, which in turn boosts farmers profitability and economic resiliency
- Another motivation for General Mills comes from their new marketing research that shows a shift in consumer attitudes from buying food exclusively based on personal affects (i.e. cost, health) to buying food based on how it impacts the environment

Canola Case Study Supporting Slides

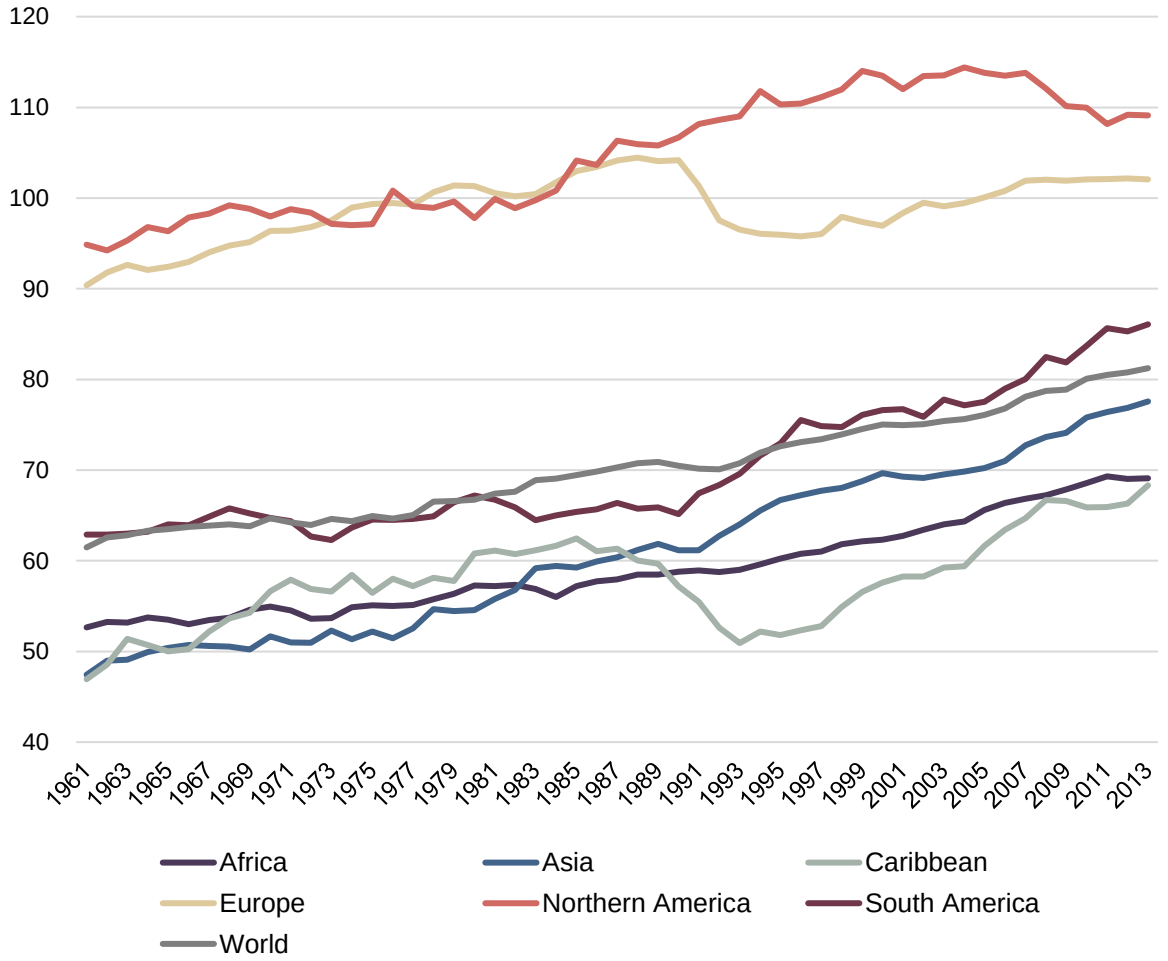
The Context Network team completed the canola case study via desk research and industry interviews. Top data sources included: United States Department of Agriculture (USDA), Canola Council of Canada (CCC), United States Canola Association (USCA), The Van Trump Report, The Western Producer, GreenBlue, and Our World in Data

Increasing consumption of protein in the U.S. and globally has fueled the market demand for oilseeds

U.S. Per Capita Availability of Meat, Pounds per Person



Global Daily Protein Supply, Grams of Protein per Person



Also influential for soybeans and included in the soybean case study

Canola has been shown to provide multiple environmental benefits that have made an impact on crop success

ACCORDING TO THE U.S. CANOLA ASSOCIATION:

Canola improves farm economics by increasing yield in cereal, soybean and other crops that follow canola.

Canola is good for soil health as its taproots can break up dense soil. Its deep root system can take up nutrients not accessible to wheat roots and increases water infiltration. The taproot opens up more channels for water to move down, reducing the chance of erosion and improving soil structure for subsequent crops. Moreover, herbicide-resistant canola omits the need for tillage, which improves overall soil conditions.

Canola is an excellent rotational crop, breaking up pest and disease cycles in cereal-dominated cropping systems. As a broadleaf crop, canola introduces diversity and provides an opportunity to use different herbicides.

Canola allows for improved weed management with different chemistries than what is used in a monoculture or cereal-dominated rotation. This also decreases the chance of herbicide resistance.

Canola provides an excellent habitat for honeybees and other pollinators

The drive to produce low erucic acid and low glucosinolate canola dominated variety research and development efforts

VARIETY DEVELOPMENT TIMELINE	
Pre - WW2	Rapeseed only grown in small, but successful research trials at experimental farms and research stations in Canada (CCC)
1942	Canada purchases 41,000 pounds of rapeseed (B. Napus) from U.S. seed companies, which originally came from Argentina. Farmers planted this seed on 3,200 acres and realized successful returns, stimulating an expansion of acres the following year and led to dominance of B. Napus varieties over time in Canada (CCC)
1954	B. Napus variety, “Golden”, is released by the AAFC Saskatoon with improved oil content. Becomes first cultivar registered in Canada (CCC).
1968	First low erucic acid B. Napus variety, “Oro”, becomes a registered cultivar. Developed by AAFC Saskatoon (CCC).
1974	First “double low” (low erucic acid, low glucosinolates) cultivar, “Tower” is developed by Dr. Stefansson at the University of Manitoba.
1977	First “double low” Polish variety, “Candle” developed by Dr. Downey at the AAFC in Saskatoon. (CCC)
1980	Supreme Court case Diamond v. Chakrabarty, is decided. The case decision allowed the first patents for organisms to be granted, paving the way for full patent protection for sexually reproduced seeds. Over 1,800 patents were filed at the US Patent and Trademark office shortly afterwards , setting up for the dramatic takeover of seed genetic and variety development by private seed companies. (CFFS)
1995	First transgenic herbicide-tolerant “Quest”, “Innovator”, and “Independence” B. Napus varieties registered. Developed by Monsanto and Aventis (both become Bayer) to be tolerant to Roundup and Liberty glyphosates. (CCC)
1995 - 2001	Over 100 herbicide-tolerant cultivars were recommended for registration (CCC).
2002	AAFC Saskatoon developed two B. Juncea canola varieties, “Arid” and “Amulet”, which are adapted to the brown soil zone and are more suited to straight combining due to more shatter-resistant pods. These varieties also prove to have longer shelf life and more omega 9 fatty acids, creating new marketing opportunities (CCC)
2009	Three major seed companies open, announce or break ground on new canola research and development centers. (CCC)

Government support through farm programs was instrumental for market development

MARKET DEVELOPMENT TIMELINE	
1943	To help WW2 efforts, selected farmers to grow B. Napus (Canola) for industrial oil at locked in price of 6 cents / pound (CCC)
1945	First crushing facility, Prairie Vegetable Oils, opens in Moose Jaw (CCC).
1949	Canadian price supports allowed acres to grow to 80,000 by 1948 but dropped to 400 after price supports ended in 1949. (CCC).
1963	Rapeseed begins trading on the Winnipeg Grain Exchange. (CCC)
1968 - 1972	A surplus of cereal grains begins to build, incentivizing rapeseed production. (CCC)
1970 - 1973	Health Canada urges immediate switch to low-erucic varieties, and by 1973 the Canadian Industry agrees to limit the erucic acid content in Canadian food products to 5% (CCC).
1975 - 1980	The first double low varieties of Canola are developed, breeding out glucosinolates and vastly improving the palatability and nutritional content of the meal for livestock and poultry, resulting in a large increase in animal livestock demand for double low canola meal.
1978	To increase marketing presence, two professors collaborate on the first booklet for dietitians and health professionals on the nutrition of canola oil (CCC).
1985	U.S. provides canola oil with Generally Recognized as Safe (GRAS) status. Made possible by research performed by Dr. Bruce and Dr. McDonald, who first conducted human eating trials to find canola oil as healthy.
1985	CCC Launched “Grow with Canola”, a five year tech transfer program with the goal of increasing yields by 25% by 1989. (CCC)
1990	1990 Farm bill opened crop base program acres up to production of minor oilseeds without penalty as well as authorized price support marketing loans for minor oilseed crops (USCA)
1993	The first U.S. pilot crop insurance program initiated, becoming nationwide in 1996. (USCA) First funds are appropriated to the National Canola Research Program (USCA)
1995	Studies conducted at University of Manitoba lead McCain Foods to start using Canola oil for their healthy fries. (CCC)
1996	1996 Farm Bill eliminated crop planting restrictions and increased loan benefits for minor oilseeds, both contributing to an increase in canola acreage the following year (USCA)

Health claims supporting canola oil have supported demand for the crop

2002 - 2008	The USCA worked with key stakeholders to ensure canola achieved equity under federal farm programs. USCA helped ensure canola achieved equity under the 2002 and 2008 Farm Bills, expanded crop insurance coverage for canola to the Southern Great Plains and other growing regions in 2006, and worked with the RMA to provide exceptions to farmers who did not have canola policies in their county. (USCA)
2006	The U.S. FDA authorized a qualified health claim on canola oil's ability to reduce the risk of heart disease due to its high unsaturated fat content. This health claim was largely an effort of USCA promotion and petitioning efforts. (USCA)
2007	U.S.CA Canola Acreage Task Force was formed and the Promote Canola Acres program was developed to expand acreage in new growing regions and to limit acreage loss in existing growing regions (USCA)
2007	An era of processing expansion begins. New plants or expansions announced in Nipawin, Clavet, Yorkton, Lloydminster, and Becancoeur. Within years processing capacity doubles to more than 8 MMT (CCC)
2010	The USCA successfully petitioned the EPA to include canola biodiesel after its initial exclusion from the Renewable Fuel Standard (RFS2) Final rule in 2010 (USCA)
2014	USCA advocated for a $20.15 per hundredweight reference price for canola in the 2014 Farm Bill, resulting in $238 million in support payments from 2014 to 2017, building a steady base for acreage growth (USCA)
2018	The Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the Canada-United States-Mexico Agreement (CU.S.MA) are signed, preserving tariff-free access for canola and canola products (CCC)

Strong and consistent government support was necessary for the commercialization of canola

AGRICULTURE AND AGRI-FOOD CANADA (AAFC)

Agriculture and Agri-Food Canada

Canadian government agency responsible for the development of the first and many of the most important B. Napus varieties

- **1954**: A B. *Napus* variety, Golden, is released with improved oil content (CCC)
- **1968**: First low erucic acid B. Napus variety, “Oro”, becomes a registered cultivar. (CCC)
- **1971-1971**: Released “Zephyr”, “Span”, “Torch”, and “Midas” varieties, all working on improving yield and reducing erucic acid. (CCC)
- **1977**: First “double low” Polish variety, “Candle” developed by Dr. Downey at the AAFC in Saskatoon. (CCC)
- **2002**: AAFC Saskatoon developed two B. Juncea canola varieties, “Arid” and “Amulet”, which are adapted to the brown soil zone and are more suited to straight combining due to more shatter-resistant pods. These varieties also prove to have longer shelf life and more omega 9 fatty acids, creating new marketing opportunities (CCC).
- **2018**: Announced a $12.1 M commitment to the Canola AgriScience Cluster. Contributions were combined with Alberta Canola, SaskCanola, and the Manitoba Canola Growers industry to total more than $20 M of investments over next 5 years across 25 projects in collaboration with public research institutions. (CCC)

U.S. GOVERNMENT

Through its agencies, gradually made it easier for U.S. producers to grow canola through Farm Bills and other strategic farm programs

- **1985**: U.S. provides canola oil with Generally Recognized as Safe (GRAS) status. Made possible by research performed by Dr. Bruce and Dr. McDonald, who first conducted human eating trials to find canola oil as healthy. (USCA)
- **1990**: 1990 Farm bill opened crop base program acres up to production of minor oilseeds without penalty as well as authorized price support marketing loans for minor oilseed crops (USCA)
- **1996**: 1996 Farm Bill eliminated crop planting restrictions and increased loan benefits for minor oilseeds, both contributing to an increase in canola acreage the following year (USCA)
- **1993**: The first U.S. pilot crop insurance program initiated, becoming nationwide in 1996 (USCA)
- **2006**: FDA issues qualified health claim for canola oil for its ability to reduce risk of heart disease (USCA)
- **2018**: United States-Mexico-Canada Agreement (USMCA) is signed by the 3 countries, continuing the free of tariff status for canola seed, oil, and meal, and opened free trade for further processed products like margarine and value-added canola exports (CCC)

CANADIAN GOVERNMENT

Provided crucial market support during initial crop development as well as continued research and funding assistance

- **1943**: To help WW2 efforts, selected farmers to grow B. Napus (Canola) for industrial oil at locked in price of 6 cents / pound (CCC)
- **1970 – 1973:** Health Canada urges immediate switch to low-erucic varieties, and by 1973 the Canadian Industry agrees to limit the erucic acid content in Canadian food products to 5% (CCC).
- **Present**: Through AgriMarketing Program, expected to invest $1.8 M CAD in the CCC
- **2018**: United States-Mexico-Canada Agreement (USMCA) is signed by the 3 countries, continuing the free of tariff status for canola seed, oil, and meal, and opened free trade for further processed products like margarine and value-added canola exports (CCC)

*Activities outlined here are not exhaustive

Canadian and U.S. trade associations acted as key influencers through their strategic plans and initiatives

CANOLA COUNCIL OF CANADA (CCC)

Aided in the growth of canola in Canada through grower education and support as well as strategic marketing campaigns

- **1967:** Rapeseed Association of Canada established. Becomes CCC in 1980.
- **1985**: Launched "Grow with Canola", a 5 year tech transfer program with the goal of increasing yields by 25% by 1989. At the center of the program is the new "Canola Growers Manual", a 175 page comprehensive and continuously updated growers manual.
- **1990s**: Canola Production Centers are developed as field-scale demonstration and extension programs.
- **2003**: Sets goal of "7 by 7", or 7 MMT of supply and demand by 2007.
- **2010**: Launches Canola Market Access Plan (CMAP) to help avoid trade disruptions in key export markets. CMAP built on the now called "Keep It Clean" to educate growers on export quality canola
- **2014**: Announced new strategic plan "Keep it Coming 2025", with the goal of 52 bushels per acre average yields by 2025.

U.S. CANOLA ASSOCIATION (USCA)

Key trade group who was a key influencer behind the removal of most major barriers to adoption facing U.S. producers in the 1990s and 2000s.

- **1989**: Establishment
- **2002**: The USCA worked with key stakeholders to ensure canola achieved equity under federal farm programs. USCA helped ensure canola achieved equity under the 2002 and 2008 Farm Bills, expanded crop insurance coverage for canola to the Southern Great Plains and other growing regions in 2006, and worked with the RMA to provide exceptions to farmers who did not have canola policies in their county. (USCA)
- **2006**: The U.S. FDA authorized a qualified health claim on canola oil's ability to reduce the risk of heart disease due to its high unsaturated fat content. This health claim was largely an effort of USCA promotion and petitioning efforts.
- **2007**: U.S.CA Canola Acreage Task Force was formed and the Promote Canola Acres program was developed to expand acreage in new growing regions and to limit acreage loss in existing growing regions. (USCA)
    - 2025 U.S.CA goals are to reach 2 million acres in the Northern Plains, 400k acres in the PNW, 200k across the southern Great Plains, and 60k in the SE.
- **2010**: The USCA successfully petitioned the EPA to include canola biodiesel after its initial exclusion from the Renewable Fuel Standard (RFS2) Final rule in 2010 (USCA)
- **2014**: USCA advocated for a $20.15 per hundredweight reference price for canola in the 2014 Farm Bill, resulting in $238 million in support payments from 2014 to 2017, building a steady base for acreage growth (USCA)

"They [P&G], along with Cargill, ADM, Central Soy, ***it was really the crushers and processors that pushed for the establishment*** *of the U.S. Canola Association."*
– Producer

*Activities outlined here are not exhaustive

Research conducted by Canadian universities and other organizations resulted in the development of key initial varieties and production research

UNIVERSITY OF MANITOBA

Canadian seed influencer responsible for many of the most innovative rapeseed and canola varieties, including the first "double low" variety.

1974: First "double low" (low erucic acid, low glucosinolates) cultivar, "Tower" is developed by Dr. Stefansson at the University of Manitoba.

1978: To increase marketing presence, two professors collaborate on the first booklet for dietitians and health professionals on the nutrition of canola oil.

1995: Studies conducted by Dr. Eskin and Dr Pryzbylski that show benefits of stability of canola oil when used for frying. McCain Foods started then using canola oil for their fries.

UNIVERSITY OF SASKETCHEWAN

2003: Research is done that demonstrated Canola's value as a biodiesel and engine lubricity agent.

RESEARCH ORGANIZATIONS

Multiple research organizations have and continue to further crop development

National Canola Research Program
a federally funded, regionally managed competitive grant system that has addressed agronomic challenges and opportunities for canola. (NCRS)

National Sclerotinia Initiative
a consortium of federal and state university scientists that have worked together to reduce the threat of sclerotinia, known as "white mold" or "stem rot," to canola and other crops. (NSI)

National Canola Research Conference
brings together public and private researchers, growers and industry representatives every three years to discuss new agronomic and nutrition research. (NCRC)

*Activities outlined here are not exhaustive

Research conducted by U.S. universities have been instrumental in the continued development of both spring and winter varieties in the U.S.

UNIVERSITY OF IDAHO

- Performed initial studies on canola's use as a biofuel feedstock in the 1970s and 1980s
- University of Idaho and Oregon State University (OSU) collaborated to write the USCA Canola Growers Manual (USCA)
- Brassica Breeding and Research Program (UI)

"Breeding program for rapeseed going on since mid 1970s a breeding program as it related to industrial rapeseed. U of I then expanded that into Canola, so there was research going on at the University of Idaho prior to any work done on canola anywhere else in the country. Quite frankly, that was being driven by the biodiesel concept." - Producer

OKLAHOMA STATE UNIVERSITY

- Common host of winter canola trials

OREGON STATE UNIVERSITY (OSU)

- University of Idaho and Oregon State University (OSU) collaborated to write the USCA Canola Growers Manual

KANSAS STATE UNIVERSITY

- Publishes winter canola production guides that include information on growing winter canola with cover crops and by a crop by itself.
- Holds winter canola trials through the National Winter Canola Variety Trial, which is administered by Kansas State University.

NORTH DAKOTA STATE (NDSU)

- Has published important spring canola production guides and other education materials, helping grow canola acres in the state
- Common host of many spring variety trials in the U.S.

WASHINGTON STATE UNIVERSITY

- Conducts trials on both spring and winter varieties of canola

*Activities outlined here are not exhaustive

Livestock feed and edible oils have been the largest demand drivers historically, however the biofuel industry has played a larger role in more recent years

LIVESTOCK

- Studies have shown that canola meal's excellent amino acid profiles can boost milk production in dairy cows. In general, studies have shown that canola in dairy rations can increase milk production by as much as 1 liter per cow per day. (CCC)
- Canola meal has also been proven as an alternative to traditional fish feed in aquaculture. (USCA)
- Canola meal is also utilized in rations in the pork and poultry industries. (USCA)

EDIBLE OILS

- Canola oil is the second most consumed oil by volume in the US, and third globally, but is commonly labeled as number one in terms of health benefits, mainly due to its idyllic fat profile. (USCA)
- Canola oil is a healthy cooking oil, with the least saturated fat (7%) and the most plant based omega-3 fat of all common cooking oils. Combined with its light texture, neutral taste and high heat tolerance, canola oil can be used in a wide variety of culinary applications and cuisines. Canola is also an excellent source for omega-9 and omega-6 fat. (CCC)
- Canola protein isolates have become used in increasing frequency in applications like meat and dairy alternatives, beverages, bars, and baked products. (USCA)

BIOFUEL

- Canola oil is an effective source for biofuel with excellent cold-flow properties that stem from the oilseeds low saturated fat content. Biodiesel derived from canola oil gels at a lower temperature than most other feedstocks. (USCA)
- **Canola seeds yield 45% oil compared to only 18% for soybeans** (USCA)
  - Can be 260-320 gpa for Canola compared to 48 gpa for soybeans (Context Experts)

BIOPLASTICS

- Canola oil can be used to make softer rubber for more flexible tires that perform better on icy and snowy roads (Context Experts)
- Danimer Scientific is developing bioplastics primarily using canola oil. (VanTrump)
- Saskatchewan Agricultural Development Fund committed $360,000 to the University of Saskatchewan to further studies around planted based climate friendly alternatives to plastics. (Producer)

Culinary Oil	Smoke Point (F)	Smoke Point (C)
High Oleic Sunflower	478	248
High Oleic Canola	475	246
Peanut	471	244
Canola	468	242
High Oleic Safflower	468	242
Sunflower	464	240
Corn	453	234
Soybeans	453	234
Safflower	446	230
Grapeseed	435	224
Olive	428	220
Extra Virgin Olive	331	166

Research has confirmed that Canola oil is a healthy alternative to most common edible oils

Canola Oil Research Directory (compiled by CCC) significant findings:

- Canola oil can help control blood glucose and lower “bad” LDL cholesterol in people with type 2 diabetes when included as part of a low-glycemic index diet.
- Canola and high-oleic canola oils can lower abdominal fat and blood pressure when used in place of other selected oil blends in a heart-healthy diet for weight maintenance.
- Canola oil consumption substantially reduces total and LDL cholesterol levels and improves insulin sensitivity when used in place of saturated fat as well as increases levels of tocopherol (vitamin E) compared with other dietary fat sources.
- Canola oil can help consumers meet dietary fat recommendations (less than 10 percent saturated fat from total daily calories, minimal trans fat and no more than 300 mg of cholesterol per day) and can be included in a diet designed to reduce cholesterol.
- Compared with high-saturated fat or typical Western diets, canola oil-based diets can reduce total and LDL cholesterol in healthy people and those with high cholesterol, reducing the risk of heart disease.
- With 61 percent monounsaturated fat, canola oil may prevent the oxidation of LDL cholesterol. Oxidized LDL may contribute to inflammation in the arteries and heart disease risk.
- Canola oil may promote immune and cardiovascular health through its anti-blood clotting and anti-oxidative effects.
- Early research indicates the potential for canola oil to protect against breast and colon cancers.

Soybean Case Study Supporting Slides

The Context Network team completed the soybean case study via desk research and industry interviews. Top data sources included: United States Department of Agriculture (USDA), SoyInfo Center, Illinois Soybean Association, USDA Economic Research Service (ERS), The Van Trump Report, The Center for Food Safety, AgriMarketing, Transportpolicy.net, American Soybean Association (ASA), Midwest Center for Investigative Reporting, United States Soybean Export Council, USDA National Agriculture Statistics Services (NASS), Archer Daniels Midland Company, Cargill, National Oilseeds Processors Association (NOPA), Living History Farms, United Soybean Board (USB), Manitoba Pulse, University of Missouri Extension

Public research conducted by the USDA and others were instrumental in the development of many initial soybean varieties

VARIETY DEVELOPMENT TIMELINE	
1879	New Jersey Agricultural Experiment station begins testing multiple soybean varieties. (SIC)
1889	U.S.DA began introducing new varieties of soybeans from Asia. (ILS)
1898	USDA's section of Foreign Seed and Plant Introduction starts a seed introduction program, bringing new seeds and plants to the US. (SIC)
1904	George Carver began research on soybeans at the Tuskegee Institute in Alabama, where he focused mainly on new crops that could help the depleting soil in the south. Carver's worked was instrumental in promoting soybeans as a quality source of protein and oil, along with showing the benefits of a soybean rotation with other crops for soil and nutrient enhancement. Carver also developed over 300 by-products that would support his theory behind the wide-ranging usability of soybeans. (VanTrump, ILS)
1907	There were 23 varieties of soybeans in the U.S. by this time, in which U.S.DA research was responsible for 15. (ILS)
1930	Townsend-Purnell Plant Act is signed by President Hoover, the first act allowing patents on plants. (SIC)
1931	ASA co founder William Morse completes years of work by bringing back 4,500 soybean varieties from east Asia. From 1924 to 1932, over 6,500 soybean accessions were introduced, the majority of which were sent to USDA's Arlington Farm or to other Agricultural Experiment stations. Only the best few selections are kept (SIC).
1936	United States Regional Soybean Industrial Products Laboratory (U.S.RSIPL) was established in Urbana Illinois to further develop research behind soy based industrial products that were gaining demand traction in the 1930s. (SIC)
1949	The USDA and USRSIPL start the development of the US first comprehensive soybean germplasm collection. (SIC)
1963	USDA, through its state agricultural stations, begins large-scale soybean research. First in the north, and then in the south. (SIC)
1970	Mostly as a result of ongoing pressure from commercial seed and chemical companies, US congress passes the Variety Protection Act (PVPA), which authorized USDA to grant Certificates of Protection for novel, sexually reproducing plant varieties. (CFFS)
1972	The National Academy of Science's National Research council publishes an influential report on the genetic vulnerability of major US agriculture crops. The report helps drive efforts by soybean develops to broaden the crops genetic base. (SIC) Dr. Bernard, USDA soybean breeder at the University of Illinois and curator of the USDA Soybean Germplasm collection for northern regions, returns from Japan and Korea with new soybean germplasms, increasing the number of germplasms by 30-50%. (SIC)

Genetically engineered and herbicide tolerant soybean varieties had a significant impact on farmers willingness to plant soybeans

VARIETY DEVELOPMENT TIMELINE CONTINUED	
1977	The Commercial Soybean Breeders organization is established, with membership jumping from 35 breeders across 28 companies in 1977 to 63 breeders across 30 companies in 1984. (SIC)
1980	Supreme Court case *Diamond v. Chakrabarty*, is decided. The case decision allowed the first patents for organisms to be granted, paving the way for full patent protection for sexually reproduced seeds. Over 1,800 patents were filed at the US Patent and Trademark office shortly afterwards. (CFFS)
1983	Monsanto succeeds in inserting foreign genes into plant cells, a breakthrough in genetic engineering. Monsanto also acquires Jacob Hartz Seed, long time developer of soybean seeds. (SIC)
1985	US Board of Patent Appeals and Interferences rules that plants can be patented under utility patent law. (AgriMarketing)
1987	Cargill enters seed business with Cargill Hybrid Seeds. Becomes 9th in U.S. sales by 1997 but was bought by Monsanto the following year. (Cargill)
1990s	Privately funded U.S. research led the way for the development of the first herbicide resistant varieties. Plantings of herbicide tolerant varieties of soybeans rose from 0% in 1996 to 86% by 2004. (USSEC)
1995	Pioneer announces they have developed low-linolenic acid soybeans. (SIC)
1996	Monsanto launches Roundup Ready transgenic/genetically engineered (GE) soybeans. The company persuaded the FDA not to regulate them or test them for food safety based on the assumption they are “substantially equivalent” to regular soybeans. While many European countries initially refuse adoption, waiting for proof of safety, US producers quickly adopt the new GE soybeans. (SIC)
1999	Dupont moves into seed genetics with 80% acquisition of Pioneer. (SIC)
2000	Monsanto goes through merges to become Pharmacia, and sales of Roundup and other glyphosates were larger than the next six leading herbicides combined. Towards the end of 2000, Monsanto’s glyphosate patent expires, and new competition enters the market. (SIC)
2005	The first biodiesel tax incentive is enacted as part of the American Jobs Creation Act of 2004. The act included tax credits of $1.00 per gallon biodiesel tax credit for producers or blenders of pure biodiesel and $1.00 per gallon renewable diesel tax credit for producers or blenders of biomass-based diesel or diesel/renewable diesel blends. (Transportpolicy)
2005	The Non-GMO Project begins, requiring that certain consumer products not contain any GE ingredients. (SIC)
2008	92% of soybean farmers are using GE varieties. This number grows to 95% by 2012. (SIC)

Disruptions caused from WW2 were a major catalyst for initial soybean production in the U.S.

MARKET DEVELOPMENT TIMELINE	
1920	First combines used to harvest soybeans. (ILS)
1920s	ASA made agreements with processors to underwrite the production of 50,000 acres at a guaranteed minimum price, driving producer adoption of soybean acres. (ASA)
1922	First U.S. soybean processing plant is opened. (SIC)
1929	ADM began crushing soybeans by converting hydraulic pressing previously used for flaxseed. (ADM)
Late 1920s	AE Staley partnered with the University of Illinois and the Illinois Central Railroad to develop the “Soil and Soybean Special”, a train that mode stops across the Midwest in order to present and educate farmers about the benefits of including soybeans in their crop rotations. He offered to process their soybeans at his plant if they grew them, where they would end up becoming animal feed. (InvestigateMidwest)
1930	Smoot-Hawley Tariff Act is signed by President Hoover, placing an import duty of $0.035/lb. on soybean oil, $0.02/lb. on seed or beans, and $6/ton on meal, helping protect US soybean production from East Asian imports. (SIC)
1930s	Surpluses of wheat and cotton combined with new processing methods for soybean oil spurred the growth of soybeans as a cash crop. The new processing methods lead to better accepted meal and oil products and spurred more research on soybean oil for food uses. Soybean meal became an important source of protein in animal rations, and Europe began importing American soybeans. (ASA)
1933	Agricultural Adjustment Act (AAA) is passed as part of Roosevelt’s New Deal, driving soybeans moving onto much of the vacated land as a result of the act. (SIC)
1936	United States Regional Soybean Industrial Products Laboratory (U.S.RSIPL) was established in Urbana Illinois to further develop research behind soy based industrial products.
1936	Chicago Board of Trade (CBOT) establishes soybean futures contracts. (ASA)
1939	New processing technology that allowed for daily capacity of 400 tons a day, four times more efficient than any used in Europe, made ADM the largest soybean processor in the world. This plant allowed ADM to take full advantage of the spike in soybean production during. WW2. (SIC)
1940	ASA begins monthly publication of Soybean Digest. (SIC)
1943	Cargill's Feed Department announces the purchase of the soybean crushing mill and feed plant of the Iowa Milling Co. in Cedar Rapids, Iowa. (Cargill)
WW2	Pre WW2, China was the dominant soybean player, and the U.S. imported 40% of its edible fats and oil After supply was cut during the war, processors in the U.S. turned to soybean oil, spurring domestic demand for soybean. As a result, soybean production doubled within 2 years of WW2 and processing plants were built across the U.S. to aid in war efforts. The U.S.DA played a large role during WW2 as well. In 1941 the first soybean government price support program is established. In 1942, they issued a widely circulated pamphlet, “Soybean Oil and the War: Grow More Soybeans for Victory”, encouraging farmers to almost double soybean production. The U.S.DA also established programs to help processors expand their facilities with less risk and even offered to help producers harvest their crop. (USSEC, ASA, VanTrump)

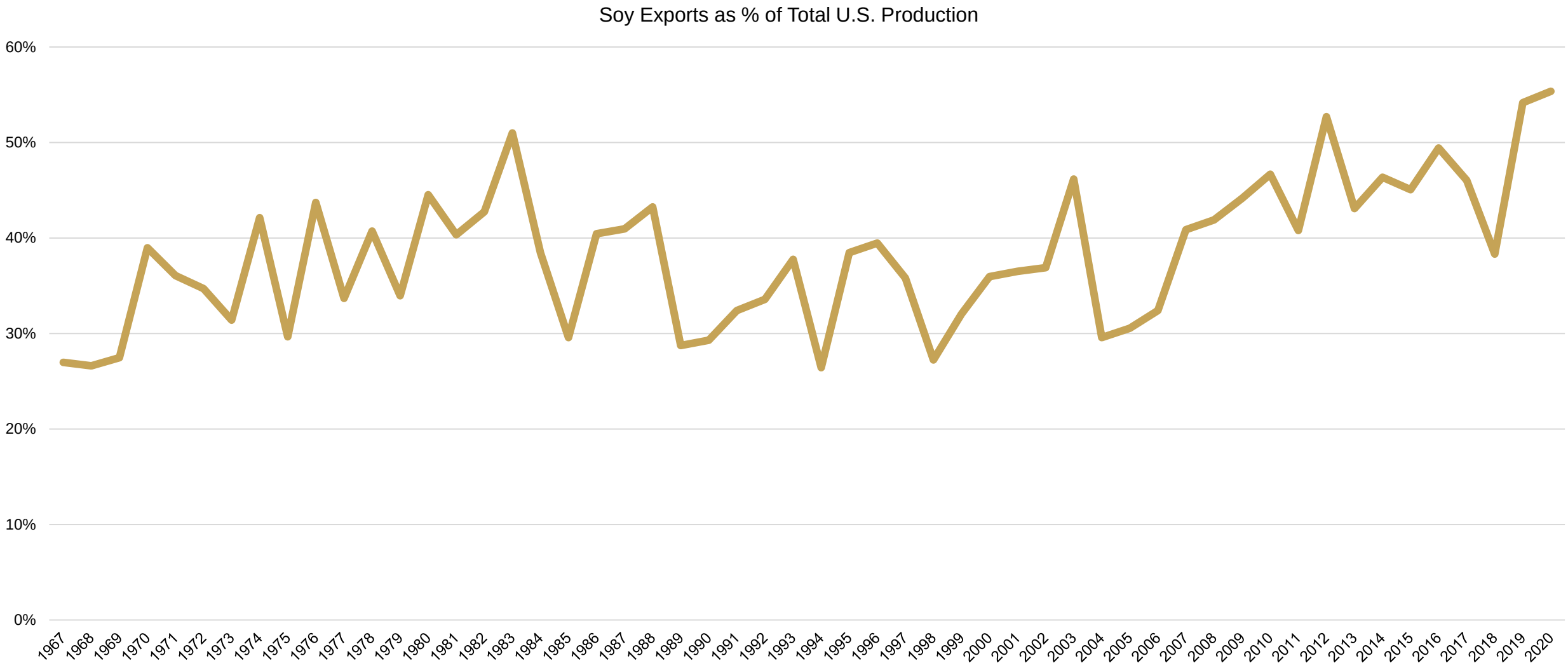
Domestic and global demand for soybean meal dominated market development throughout the 1950s to 1970s

MARKET DEVELOPMENT TIMELINE CONTINUED	
1947	ASA publishes the first Soybean Bluebook (later renamed to Soya Bluebook). (ASA)
1950s	The U.S. entered a period of prosperity and demand for meat and protein rose dramatically in the U.S., along with other developed countries. Livestock producers turned to soybean meal, and it has remained a staple for livestock producers around the world since. It was the availability of soybean meal as **low cost, high protein** feed that influenced the explosion of the U.S. livestock and poultry industries in the 1950s. (NCS, USSEC) ADM made its first moves into modern soy protein products. (ADM)
1950	ADM builds new 300-ton-day soybean solvent extraction plant in Mankato, Minnesota, adjacent to their feed mill, playing a key role in the growth of soybean acres in Minnesota. (ADM) Cargill builds its first plant specifically designed to crush soybeans in Chicago to serve domestic oil and meal markets. In 1956, a refinery was built adjacent to the crushing plant that produces industrial refined non-edible oil. (Cargill)
1954	Food for Peace program is launched, incentivizing the public and private sector to fund market development through FAS. (ASA)
1956	ASA and U.S.DA FAS sign the first join market development contracts in Europe and Japan, and the first ASA international office is opened in Japan. (ASA)
1959	Cargill expands the scope of its soybean crushing activities to the Southeast by opening a facility in Norfolk, Virginia, and acquired a plant in Sioux City, Iowa. (Cargill)
1960s	The Japanese soy processing industry expands due to their growing livestock population, and Japan begins importing soybeans from the U.S.. Similar trends take place across the globe, and by 1968, more than half of U.S. production is exported. (USSEC) States began forming association under the ASA to increase funding research to drive new uses for soybeans. State groups in collaboration with the ASA worked together to pass state legislation that enabled the establishment of the first check offs of $0.005-$0.01 /bu. (ASA)
1964	Soybean farmers are asked to double output, with support from the USDA and CCC through a $1.60/bu price support and marketing support. (SIC)

The demand for biodiesel has benefited the development of soybean in recent years

MARKET DEVELOPMENT TIMELINE CONTINUED	
1967	ADM caught up on a generation of soybean processing technology it had missed, renovating its two soybean plants at Decatur, increasing the capacity of one plant to 4,000 tons a day (keeping it the largest in the world) and adding new capacity elsewhere. Over a 3-year period soybean crushing capacity was increased from 50 million to 120 million bushels a year. (ADM)
1970s	ADM dramatically expands number of plants in U.S. and introduces new protein products like concentrates, textured concentrates, first soy bran, new soy varieties. ADM's soy proteins used in more than 600 brands of prepared foods. (ADM)
1971	The Farm Credit Act is instated to expand Farm Credit services, resulting in large increases in farm real estate lending and farmland prices. (AgriMarketing)
1980	The Federal Crop Insurance Act of 1980 is passed, developing the foundation of the current program. (AgriMarketing)
1980s	ASA worked to fund a truth-in-labeling campaign to reduce the hidden use of tropical fats (palm oil) in order to increase use for domestic soybean oil. As a result, palm oil imports decline as U.S. consumers began to accept soybean oil as a healthier alternative to palm oil. ASA also launched the Targeted Export Assistance (TEA) promotions in Europe that worked to increase consumer awareness of soybean oil. Exports begin to increase, as seen in 1988 when Russian exports increase from 2.5 to 91 million bushels. (ASA)
1989	ASA and Monsanto (Bayer) launched the "SoySeal" program, aimed at marking industrial products made with soybean oil in order to increase consumer awareness (ASA)
1990s	ASA became involved with making biodiesel out of soybean oil, working on legislation and R&D funding (ASA)
1990	1990 Farm bill authorizes the beginning of the non-recourse soybean marketing loan of $5.02 (ASA)
1991	First national soybean checkoff (1/2 of 1%) is established through the ASA, and the United Soybean Board (USB) is created to oversee the checkoff funds. (SIC)
1994	After widespread crop losses in 1993 and low crop insurance participation rate, the Clinton Administration passes the Crop Insurance Reform Act of 1994, expanding premium subsidies and offering catastrophic coverage, resulting in substantial participation rate increases. (AgriMarketing)
1994	Vegetable Ink Printing Act is passed in congress, requiring the federal government to use vegetable-based inks whenever feasible (ASA)
1996	Farm Act that eliminated almost all planting restriction on crop bases.
1997	In collaboration with the National Biodiesel Board (NBB), ASA got agreement from the U.S. DOE to consider B-20 blends as an approved alternative fuel. (ASA)
1999	FDA approves the rule that allows the labeling of health claims ("reduces serum cholesterol" and "may reduce chance of heart disease") on products containing soybean protein (ASA)
2000	Agricultural Risk Protection Act is passed, providing additional subsidies and encouraging further participation in federal crop insurance programs (AgriMarketing)
2004	First biodiesel tax incentive passed. Federal excise tax credit of $0.01 per % point of biodiesel blend (ASA)

Export demand has increased the market potential for soybeans over time.



Animal feed has been the largest demand component for soybeans throughout crop development. Continued investment has furthered research for additional uses of soybeans.

LIVESTOCK

- 1950s: The U.S. entered a period of prosperity and demand for meat and protein rose dramatically in the U.S., along with other developed countries. Livestock producers turned to soybean meal, and it has remained a staple for livestock producers around the world since. It was the availability of soybean meal as **low cost**, **high protein** feed that influenced the explosion of the livestock and poultry industry in the 1950s. (NCS, USSEC)
- Soybean meal has been the main component in most livestock rations due to its high digestibility, high energy content, high protein content, and its nutritional consistency (USSEC)

EDIBLE OILS

- Soybeans can and have been used in edible foods like baby food or formula, bakery products, medicines, candies, canned foods, cereals, diet food products, frozen dinners, frozen pizza, hot dogs, hypo-allergenic milk, imitation meat products, lunch meat, noodles, cake, pancake, muffin, sausage casings, cooking oils, and margarines. (LHF)
- Soybean oil has been well suited for fast food industries and other high-heat cooking methods over time due to its relatively high smoke point of 450 degrees F. This allows it to withstand high temperatures without breaking down. For Reference, canola oil has a smoke point of 428 degrees F. (USS)
- The high smoke point of soybean oil also allows for a wide array of cooking methods (frying, baking, roasting, sautéing), allowing for greater flexibility in use. (USS)
- High oleic soybeans are new varieties for healthier and longer shelf life edible oil. (USS)

80%

MEAL

The primary component of soybeans is meal

20%

OIL

Oil is the secondary component of soybeans

97% ANIMAL FEED

97% of U.S. soybean meal is used to feed poultry and livestock

3% FOOD PRODUCTS

3% of soybean meal is used in food products like protein alternatives and soy milk

60% FOOD

Roughly 60% of soybean oil is used for frying and baking food, as a vegetable oil, and as an ingredient in foods like salad dressings and margarines

35% BIODIESEL & BIOHEAT

~35% of soybean oil is used for biodiesel and bioheat

5% INDUSTRIAL USES

Around 5% of soybean oil is converted into industrial uses like paints, plastics, and cleaners

BIOPLASTICS

- 2000: Cargill and Dow Chemical announce production of "natural plastic" made from plants instead of petroleum. They committed $300 million over 2 years on the business, NatureWorks. Included construction of a manufacturing plant in Blair, Nebraska, that will make 300 million lb./year of the new biodegradable plastic named polylactide, or PLA. (Cargill)

OTHER USES

- A rapidly growing market for soybean oil is found in the manufacture of a variety of pharmaceuticals, such as vitamin E and other anti-oxidants. (USSEC)
- Adhesives, cleaning materials, cosmetics, cleaners, crayons, fuel, inks, paints, pesticides, pet food, livestock feed, soap, shampoo, detergents, wax (LHF)

Key legislation and other farm programs and supports laid the foundation for producer adoption of soybeans

U.S. REGULATIONS

- 1930: Townsend-Purnell Plant Act is signed by President Hoover, the first act allowing patents on plants. (SIC)
- 1930: Smoot-Hawley Tariff Act is signed by President Hoover, placing an import duty of $0.035/lb. on soybean oil, $0.02/lb. on seed or beans, and $6/ton on meal, helping protect US soybean production from East Asian imports (SIC)
- 1933: Agricultural Adjustment Act (AAA) is passed as part of Roosevelt's New Deal, driving soybeans moving onto much of the vacated land as a result of the act. (SIC)
- 1936: United States Regional Soybean Industrial Products Laboratory (U.S.RSIPL) was established in Urbana Illinois to further develop research behind soy based industrial products that were gaining demand traction in the 1930s. (SIC)
- 1970: Mostly as a result of ongoing pressure from commercial seed and chemical companies, US congress passes the Variety Protection Act (PVPA), which authorized USDA to grant Certificates of Protection for novel, sexually reproducing plant varieties (CFFS)
- 1971: The Farm Credit Act is instated to expand Farm Credit services, resulting in large increases in farm real estate lending and farmland prices (AgriMarketing)
- 1972: Dr. Bernard, USDA soybean breeder at the University of Illinois and curator of the USDA Soybean Germplasm collection for northern regions, returns from Japan and Korea with new soybean germplasms, increasing the number of germplasms by 30-50%. (SIC)
- 1980: Supreme Court case Diamond v. Chakrabarty, is decided. The case decision allowed the first patents for organisms to be granted, paving the way for full patent protection for sexually reproduced seeds. Over 1,800 patents were filed at the US Patent and Trademark office shortly afterwards. (CFFS)
- 1980: The Federal Crop Insurance Act of 1980 is passed, developing the foundation of the current program (AgriMarketing)
- 1985: US Board of Patent Appeals and Interferences rules that plants can be patented under utility patent law. (AgriMarketing)
- 1990: 1990 Farm bill authorizes the beginning of the non-recourse soybean marketing loan of $5.02 (ASA)
- 1994: Vegetable Ink Printing Act is passed in congress, requiring the federal government to use vegetable-based inks whenever feasible (ASA)
- 1994: After widespread crop losses in 1993 and low crop insurance participation rate, the Clinton Administration passes the Crop Insurance Reform Act of 1994, expanding premium subsidies and offering catastrophic coverage, resulting in substantial participation rate increases. (AgriMarketing)
- 1996: Farm Act that eliminated almost all planting restriction on crop bases.
- 1999: FDA approves the rule that allows the labeling of health claims ("reduces serum cholesterol" and "may reduce chance of heart disease") on products containing soybean protein (ASA)
- 2000: Agricultural Risk Protection Act is passed, providing additional subsidies and encouraging further participation in federal crop insurance programs (AgriMarketing)
- 2005: The first biodiesel tax incentive is enacted as part of the American Jobs Creation Act of 2004. The act included tax credits of $1.00 per gallon biodiesel tax credit for producers or blenders of pure biodiesel and $1.00 per gallon renewable diesel tax credit for producers or blenders of biomass-based diesel or diesel/renewable diesel blends (Transportpolicy)
- 2005: The Non-GMO Project begins, requiring that certain consumer products not contain any GE ingredients. (SIC)

The USDA and its agencies have played a key role in the development of soybeans. Universities have made meaningful contributions as well

UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)

Organization of governmental agencies that aided in the development of soybean variety research and the overall market fand demand or soybeans.

- 1889: The U.S.DA began introducing new varieties of soybeans from Asia. By 1907 there were 23 varieties of soybeans in the U.S. and the U.S.DA research was responsible for the development of 15 of them. (ILS)
- 1898: USDA's section of Foreign Seed and Plant Introduction starts a seed introduction program, bringing new seeds and plants to the US. (SIC)
- WW2: In 1941 the first soybean government price support program is established. In 1942, they issued a widely circulated pamphlet, "Soybean Oil and the War: Grow More Soybeans for Victory", encouraging farmers to almost double soybean production. The U.S.DA also established programs to help processors expand their facilities with less risk and even offered to help producers harvest their crop (SIC)
- 1949: The USDA and USRSIPL start the development of the US first comprehensive soybean germplasm collection (SIC)
- 1954: Food for Peace program is launched, incentivizing the public and private sector to fund market development through FAS. (ASA)
- 1963: USDA, through its state agricultural stations, begins large-scale soybean research. First in the north, and then in the south. (SIC)
- 1964: Soybean farmers are asked to double output, with support from the USDA and CCC through a $1.60/bu price support and marketing support. (SIC)

UNIVERSITY OF ILLINOIS

- **1921:** Professor Burlison becomes head of Department of Agronomy at U of I, becoming instrumental in the establishment of soybeans in Illinois until his retirement in 1951. (SIC)
- **Late 1920s:** Partnered with AE Staley and the Illinois Central Railroad to create the "Soil and Soybean Special" a train that mode stops across the Midwest in order to present and educate farmers about the benefits of including soybeans in their crop rotations (InvestigateMidwest)
- **1972:** Dr. Bernard, USDA soybean breeder at the University of Illinois and curator of the USDA Soybean Germplasm collection for northern regions, returns from Japan and Korea with new soybean germplasms, increasing the number of germplasms by 30-50%. (SIC)

UNIVERSITY OF PURDUE

Purdue Soybean Center: Value chain research program including more than 50 faculty and staff members at Purdue. Work is centered around solving complex challenges impacting the effeciency and profitability of the soybean industry, including dietary consumer demands. (Purdue)

IOWA STATE UNIVERSITY

2014: Iowa Soybean Research Center established in efforts to increase collaboration, coordination, and integration among Iowa State University, Iowa Soybean Association, industry, and farmers to align the soybean-related activities with the needs of Iowa soybean farmers and the industry that supports production of the crop. (ISU)

*Activities outlined above are not exhaustive

Through key marketing and promotion efforts, ASA and other soy organizations have expanded the market for soybeans in the U.S. and globally

AMERICAN SOYBEANS ASSOCIATION (ASA)

Most influential trade group throughout crop development whose marketing and promotion efforts in the U.S. and globally resulted in the expansion of U.S. soybean exports.

- 1920: Established
- 1920s: ASA made agreements with processors to underwrite the production of 50,000 acres at a guaranteed minimum price, driving producer adoption of soybean acres (ASA)
- 1929: In 1929 ASA co-founder William Morse completed years of work by bringing back more than 10,000 varieties of soybeans from China for researchers to study and develop new and improved varieties. Many of these varieties laid the foundation for the rapid development of soybean varieties in the U.S. (NCS)
- 1940: Begins monthly publication of Soybean Digest (ASA)
- 1947: ASA publishes the first Soybean Bluebook (later renamed to Soya Bluebook) (ASA)
- 1956: ASA and U.S.DA FAS sign the first join market development contracts in Europe and Japan. The first international ASA office is also opened in Japan. (ASA)
- 1960s: States began forming association under the ASA to increase funding research to drive new uses for soybeans. State groups in collaboration with the ASA worked together to pass state legislation that enabled the establishment of the first check offs of $0.005-$0.01 /bu (ASA)
- 1980s: ASA worked in the 80s to fund a truth-in-labeling campaign to reduce the hidden use of tropical fats (palm oil) in order to increase use for domestic soybean oil. Specifically, campaign requests were made to the FDA to require food manufacturers to stop calling tropical fats “vegetable oils”. As a result, palm oil imports decline as U.S. consumers began to accept soybean oil as a healthier alternative to palm oil. ASA also launched the Targeted Export Assistance (TEA) promotions in Europe that worked to increase consumer awareness of soybean oil. Exports begin to increase, as seen in 1988 when Russian exports increase from 2.5 to 91 million bushels. The TEA later becomes the market Promotion Program (MPP) in the 90s. (ASA)
- 1990s: ASA became involved with making biodiesel out of soybean oil, working on legislation and R&D funding (ASA)
- 1991: First national soybean checkoff (1/2 of 1%) is established, overseen by the USB.
- 1997: In collaboration with the National Biodiesel Board (NBB), ASA got agreement from the U.S. DOE to consider B-20 blends as an approved alternative fuel. (ASA)

UNITED SOYBEAN BOARD (USB)

1991: Established to oversee investment of national checkoff funds.

U.S. SOYBEAN EXPORT COUNCIL (USSEC)

Established in 2005.

*“**We do a lot of work on behalf of USB** and regional state commodity associations to make progress on higher yielding varieties. We have big public soy field tests, run by USDA in soybeans, so pretty good multi-environment trial data.”* – University Agronomist

*Activities outlined above are not exhaustive

The expansion of ADM storage and processing facilities helped pave the way for market growth

ADM

One of the largest crushers and developers of soy products throughout crop development. The pioneer of textured soy protein and developer of the worlds largest soy crushing facility.

- **1929:** began crushing soybeans by converting hydraulic pressing previously used for flaxseed.
- **Early 1930s:** Installed a solvent extraction system for soybeans at its Chicago plant.
- **1934:** ADM began to produce soy lecithin from their crude soy oil, becoming the first U.S. company to manufacture this product.
- **1939:** New processing technology that allowed for daily capacity of 400 tons a day, four times more efficient than any used in Europe, made ADM the largest soybean processor in the world. This plant allowed ADM to take full advantage of the spike in soybean production during WW2.
- **1949:** ADM made its first move into edible oils
- **1950:** A 300-ton-a-day soybean solvent extraction plant went into operation at Mankato, Minnesota; it was built adjacent to ADM's feed mill. This plant, enlarged in 1953 and equipped to produce soy flour in 1956, played an important role in the rapid expansion of the soybean crop in Minnesota.
- **1950s:** ADM made its first move into the modern soy protein products.
- **1963:** Built export terminal in Gulf of Mexico
- **1965:** ADM introduced TVP brand textured soy protein
- **1967:** ADM caught up on a generation of soybean processing technology it had missed, renovating its two soybean plants at Decatur, increasing the capacity of one plant to 4,000 tons a day (keeping it the largest in the world) and adding new capacity elsewhere. Over a 3-year period soybean crushing capacity was increased from 50 million to 120 million bushels a year.
    - During the late 1960s Decatur was built into a fully integrated, huge, soybean and soy foods processing operation. In addition to the expanded and modernized crushing facilities and the TVP plant, hydrogenation equipment was added at Decatur (and at Lincoln) to process refined oil for use in margarine; soy flour production was also expanded. Sales were now about 60% in soybean processing, 21-28% in flour milling, and the rest in miscellaneous activities
- **1970s:** dramatically expands number of plants in U.S.
- **1974:** acquired first soybean processing plants in Europe and SA
- **1977s:** introduces new protein products like concentrates, textured concentrates, first soy bran, new soy varieties. ADM’s soy proteins used in more than 600 brands of prepared foods.
- **1994:** invested in Wilmar, acquired Glencore in 1997

*Activities outlined above are not exhaustive

Cargill is an example of a grain company that provided necessary market infrastructure, underpinning the development of the soybean market

CARGILL

Agriculture company that developed many of the most significant storage and processing facilities in the U.S. and across the world

- **1943:** Cargill's Feed Department announces the purchase of the soybean crushing mill and feed plant of the Iowa Milling Co. in Cedar Rapids, Iowa
- **1947:** Cargill opens a soybean crushing plant at Savage, Minnesota.
- **1950:** Cargill builds its first plant specifically designed to crush soybeans in Chicago to serve domestic oil and meal markets. In 1956, a refinery was built adjacent to the crushing plant that produces industrial refined non-edible oil used in paints and other protective coatings and in vinyl products
- **1957-1961:** Cargill opens a soybean processing plant in Memphis, Tennessee. A second plant is added adjacent to the first in 1970.
- **1959:** Cargill expands the scope of its soybean crushing activities to the Southeast by opening a facility in Norfolk, Virginia, and acquired a plant in Sioux City, Iowa.
- **1960:** The Wichita, Kansas soybean crushing plant is acquired.
- **1961:** The company acquired the Des Moines, Iowa soybean crushing plant
- **1967:** Cargill opens a soybean crushing plant in Gainesville, Georgia
- **1970:** Cargill builds the Fayetteville, North Carolina, crushing plant, and a refinery was added in 1976
- **1973:** Cargill becomes the largest U.S. soybean processor with 18.0% of the market and 130 million bushels crushed last year. No. 2 is ADM with 16.6% followed by Central Soya with 12.5%.
- **1978:** Opens a soybean processing plant in Sidney, Ohio, to serve domestic meal and oil markets.
- **1980:** Construction began on vegetable oil refinery adjacent to Wichita soybean crushing plant; operations started in late 1981
- **1987:** Cargill enters the seed business with Cargill Hybrid Seeds
- **1997:** Cargills Hybrid Seeds 9th in U.S. based on total seed sales. International ops Bought by Monsanto following year
- **2000:** Cargill and Dow Chemical announce production of "natural plastic" made from plants instead of petroleum. They committed $300 million over 2 years on the business, NatureWorks. Included construction of a manufacturing plant in Blair, Nebraska, that will make 300 million lb./year of the new biodegradable plastic named polylactide, or PLA.
- **2000:** Cargill enters soy protein isolate market

*Activities outlined above are not exhaustive

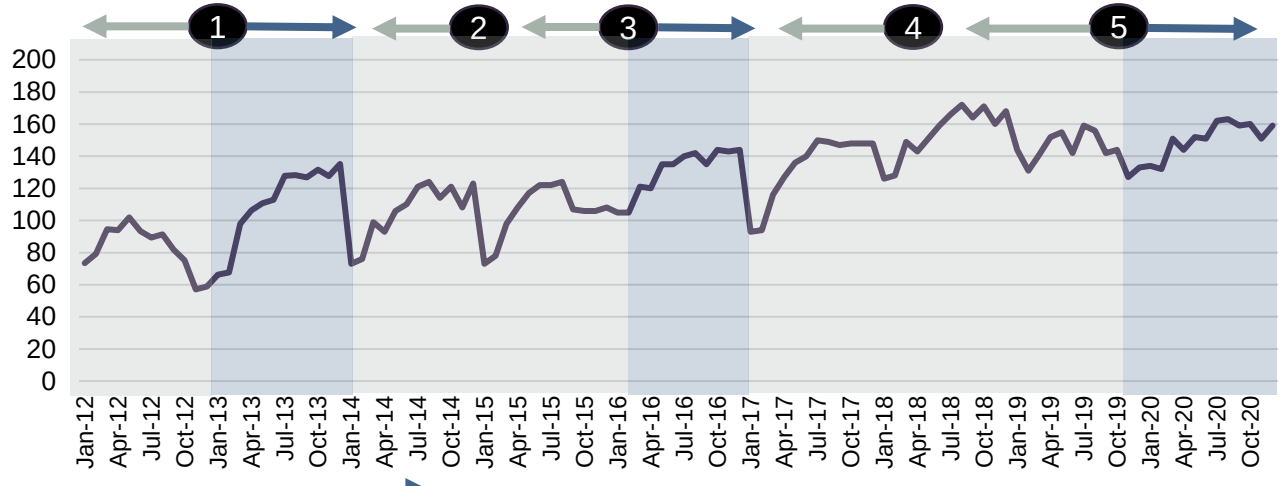
The expansion of the biofuels industry provides key demand support for the soybean market

BIOFUELS AND RENEWABLE DIESEL

- 1990s: ASA works on funding and research efforts to support soybean use as biofuel. (ASA)
- 1997: In collaboration with the National Biodiesel Board (NBB), ASA secures agreement from the U.S. DOE to consider B-20 blends as an approved alternative fuel. (ASA)
- 2004: First biodiesel tax incentive passed. Federal excise tax credit of $0.01 per % point of biodiesel blend.
- Soybean oil now accounts for roughly half of the feedstock used to produce biodiesel, although it has had a slower market adoption compared to ethanol as it can run hotter on engines and has had black mold issues.

*"There's **investment in several renewable diesel plants** and have projections to have more soybean acres. There is no way to grow enough soybean acres in the U.S. that's needed for biodiesel."* - University

U.S. Biodiesel Production (M gals)

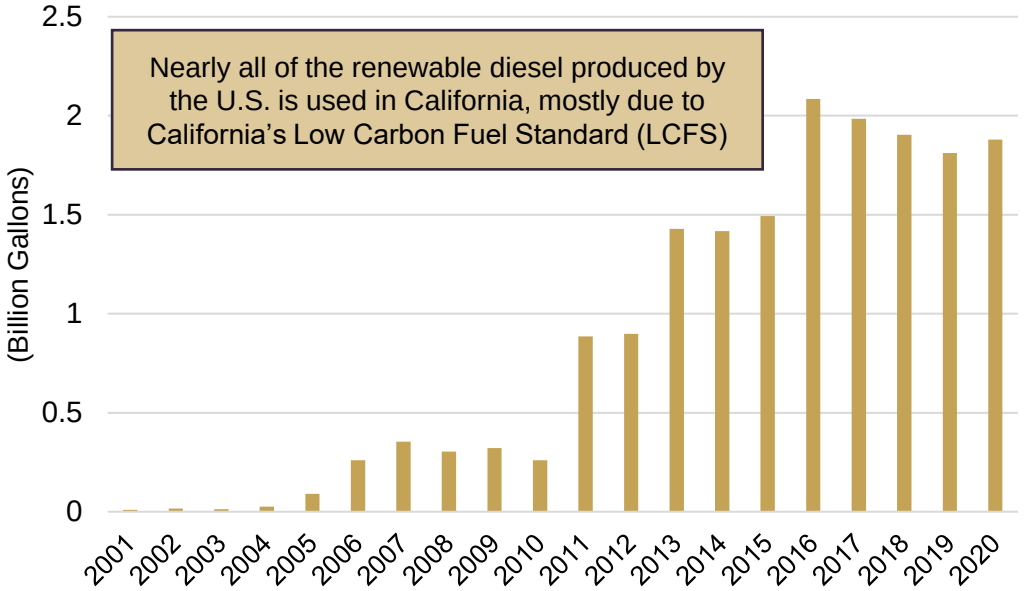


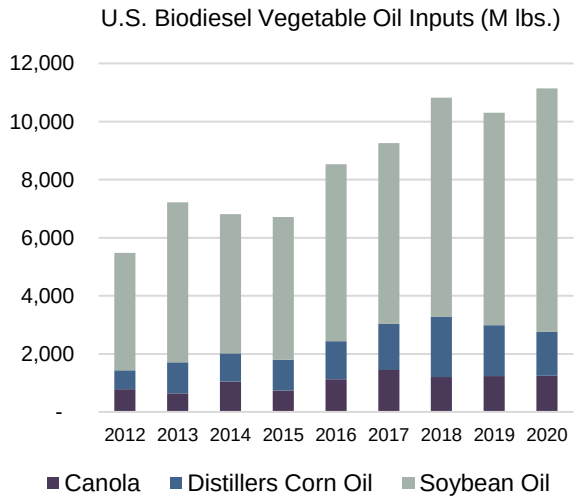
Tax credit applied to future

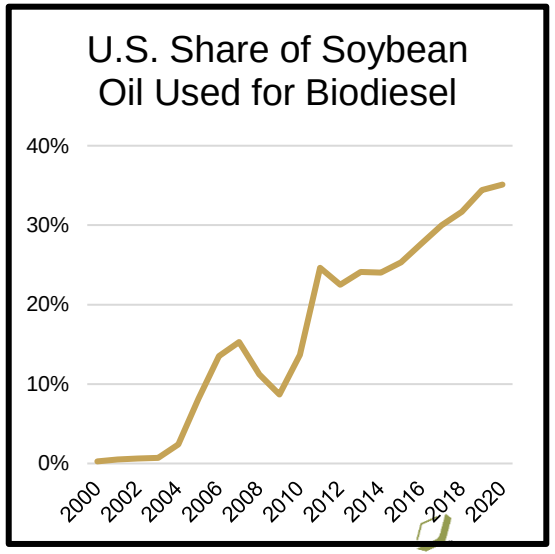
Tax credit applied retroactively

1) Jan, 2013: American Taxpayer Relief Act of 2012
2) Dec, 2014: Tax Increase Prevention Act of 2014
3) Dec, 2015: Consolidated Appropriations Act, 2016
4) Feb, 2018: Bipartisan Budget Act of 2018
5) Dec, 2019: Consolidated Appropriations Act, 2019

U.S. Biodiesel Consumption







The development of a wide range of soybean maturity groups have allowed the growing region to expand, with most of the expansion pushing Northwest into colder climates.

When grown in rotation with corn, grain sorghum, or wheat, soybeans can add nitrogen to the soil and nitrogen fertilizer can be reduced. Yields greater than 60 bushels per acre may result in less nitrogen carry over. (MO Ext, Context Experts)

Including soybeans in crop rotations can break disease and weed cycles, resulting in reduced herbicide usage (Context Experts)

However, soybeans require more water than wheat, canola and most pulse crops, taking up 16-20 inches over the growing season, depending on the planting date and conditions (Manitobapulse)

Soybeans have the unique ability to withstand extreme weather changes during the growing season that allows them lower yield losses compared to other major crops (Context Experts)

MATURITY GROUPS

MG 0
Best adapted to most of ND, northwest SD and northern MN

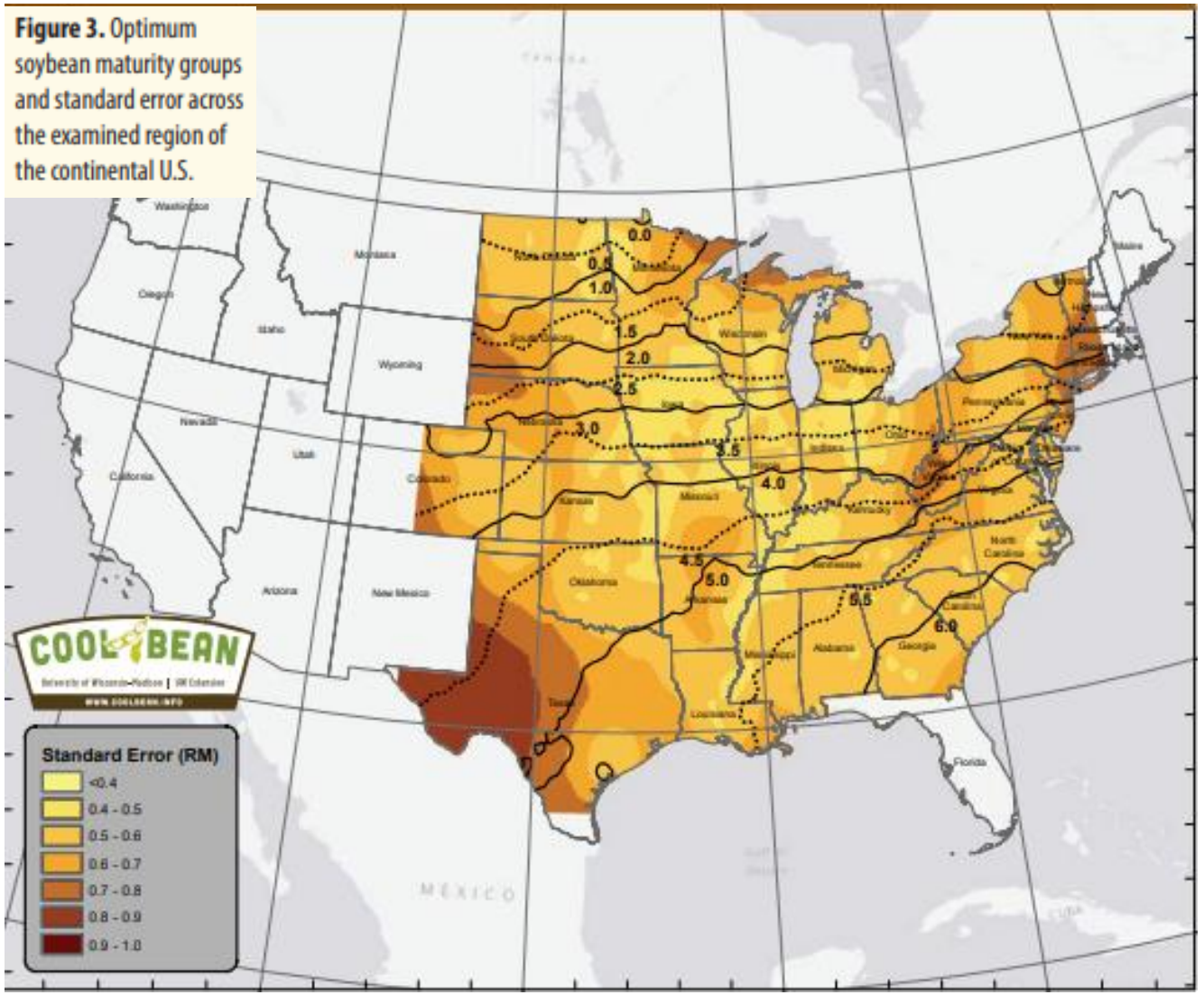
MG 1
Best adapted to central/northern SD, central MN, northern WI and MI and all of NY

MG 2
Best adapted to southern MI, WI, MN and SD, extended across IA and NE

MG 3
Best adapted to major soybean states such as southern NE, central IL, central and northern IN, all of OH and PA, and northern MO and KA

MG 4
Best adapted to a wide range, including southern KA, MO, IL, IN as well as all of OK and KE

MG 5 / 6
Best adapted to southern states. MG 6 specifically adapted for parts of GA and SC



Camelina Case Study Supporting Slides

The Context Network team completed the camelina case study via desk research and industry interviews.

Top data sources included: United States Department of Agriculture (USDA), Agriculture and Agri-Food Canada (AAFC), Penn State University, Washington State University, Oregon State University, Montana State University, University of Nevada, Reno, Smart Earth Camelina, All About Feed, Puget Sound Business Journal, Oil & Gas Journal, Agricultural Marketing Resource Center, Forever Green Initiative, University of Minnesota, Kansas State University, Advanced Biofuels USA, Minnesota Bold Open, Sustainable Oils Inc, Yield 10 Bioscience, United States Energy Information Administration (EIA), Global Clean Energy Holdings, Manitoba Pulse, and the University of Missouri Extension

Market Development: Until high erucic acid and glucosinolate content is removed from camelina varieties, the end use market for camelina is restricted

LIVESTOCK

- Camelina meal contains 10-15% oil, 10-11% fiber, and 45-47% crude protein, making it an attractive feed option to produce healthy fish, meat, poultry, and dairy products (SDSU)
- Camelina meal produces high Omega eggs in layers and meat in broilers (Smartearthcamelina)
- Studies have indicated that feeding camelina meal to fish, poultry, swine, cattle, and sheep have resulted in higher ALA, EPA, and DHA fatty acid contents in all animals. (WSU).
- High-protein, non-GMO, camelina-based livestock feed is a premium product, FDA-approved for use as feed for cattle, chicken and swine (GCE)
- Camelina meal contains many key nutrients, including greater omega-3 fatty acid levels above 35%, vitamin E, and crude protein above 45%. It is these benefits that have been shown to increase unsaturated fatty acids in ewe's milk (K-State)

Camelina's adaptability to a diverse range of growing regions along with its unique oil properties that have sparked interest for the crop's use in biofuels and edible food and feeds have resulted in a spike in publications containing the word "camelina," with 187 publications from 1980 to 2010 and over 1,200 publications since 2010. The large focus of this new research has centered around new products from the oil and meal, changing the oil contents via genetic transformation, and camelina agronomic management. (WSU)

> *"This could be a main area of growth – GRAS for Dairy and other livestock. Great meal benefits more focus needs to be put here and getting other certifications. BUT trying to gain GRAS as a human food would be bad for the industry. Competing priorities for the oil. Should focus on GRAS for other livestock for the meal."* -Processor

EDIBLE OILS

- In more recent years, there has been an increase in camelina interest due to its high omega-3 fatty acid content. The elevated content of omega-3 fatty acids in camelina oil is found only in linseed and fish oils (OSU, WSU)
- Camelina oil also contains antioxidants like vitamin E that give it a longer shelf life than flaxseed oil. Camelina oil contains 35–40% alpha-linolenic acid, compared to 50–60% for flaxseed oil. (SDSU)
- While Camelina's fatty acid profile make it adaptable to high temperature frying (smoke point of 475 degrees), it has not received GRAS status from the U.S. FDA, and is not able to be used in multi-ingredient processed foods in the commercial industry, limiting its growth potential (AGMRC)

Typical Fatty Acid Content (%) of Camelina, Canola, Linseed, and Sunflower Oils

Oil Source	16:0^	18:0	18:1	18:2	18:3	20:0	20:1	22:1
Camelina	7.8	3.0	16.8	23.0	31.2	0	12.0	2.8
Canola	6.2	0	61.3	21.6	63.6	0	0	0
Linseed	5.3	3.1	16.2	14.7	59.6	0	0	0.9
Sunflower	6.0	4.0	16.5	72.4	0	0	0	0

^ Fatty acid profiles show the percentage of each fatty acid component in a vegetable oil. The first number in the notation at the top of each column in the profile (i.e. 18:3) indicates the number of carbon atoms in the fatty acid. The number after the colon indicates the number of double bonds in the fatty acid. Although fatty acid profiles vary somewhat from sample to sample, they are generally used to characterize vegetable oils from particular species or varieties of plants.

Market Development: Use in sustainable aviation fuel and renewable biodiesel provides a promising market opportunity for camelina

RENEWABLE FUELS

- **Camelina oil has desirable characteristics as a feedstock for biodiesel (**Context Experts)
- Global Clean Energy Holdings, Inc. has an exclusive five-year commitment from ExxonMobil to purchase up to 220 million gallons per year of renewable diesel made from Sustainable Oils Camelina (SUSoils).
- Currently, Camelina biodiesel cannot be used directly as a B100 fuel or blended with petroleum due to its 90% poly-unsaturated fatty acid (PUFA) content (UNR)
- As jet fuel, Camelina HRJ fuel has been compared similarly to typical jet fuel and has been considered as a replacement jet fuel, even being tested in blends with typical jet fuel (JP-8) by the U.S. Air Force and two commercial airlines. (UNR)
- The elevated alkyl esters yields from camelina oil make it well adapted and well-suited for biodiesel production (WSU)
- From a fossil energy perspective, camelina provides significantly more energy than soybeans, but slightly less than canola. But because camelina oil avoids land use change (LUC) emissions, its biodiesel emits fewer GHGs than traditional soybean and canola biodiesel. (Oxford)
- 2009: AltAir Fuels announces purchase agreement with 14 major airlines to develop up to 750 million gallons of camelina biofuel at the Seattle-Taco airport, which would replace about 10% of the petroleum based fuel consumed at the airport. The purchase agreement later fell through though, as they could not raise enough feedstock quickly enough to make the product.. (Bizjournal)
    - Airlines planning on participating include American Airlines, Air Canada, Alaska Airlines, Atlas Air, Delta Air Lines, FedEx Express, Hawaiian Airlines, Jet Blue Airways, Lufthansa German Airlines, Mexicana Airlines, Polar Air Cargo, United Airlines, UPS Airlines and US Airways.
- 2021: U.S. DOE, DOT and the USDA announced the Sustainable Aviation Fuels (SAF) Grand Challenge, with the goal of meeting 100% of US aviation fuel demand by 2050

Producer Adoption: Camelina can be grown in the northern U.S. as part of extended crop rotations or as a spring cover crop in states like Minnesota and Iowa

EQUIPMENT

- Among small seeded grain and oilseed growers, there are few meaningful equipment barriers to adoption limiting camelina growth
- Seeding equipment used to sow canola and mustard research plots needed no modification to sow camelina in AAFC trials (AAFC)
- Camelina production requires a no-till drill or broadcast seeder for planting, a cultipacker or other implement for broadcasting, combine harvester, and wagons for transportation, all equipment required by other small-seeded grain and oilseed crops. (AGMRC)
- The toughest part is setting the combine for harvest. The seed is so small and light, balancing harvest loss and a clean grain tank sample takes some time. In Argentina they are adding screens to the combine that really help with the process.
- While camelina seeds have a rough surface and are not lost as easily as canola or flax seed, they are extremely small, and it is very easy for the seeds to spill through small leaks in equipment and storage infrastructure (PSU)

TRANSPORTATION

- Because there is not a lot of camelina grown, there are limited storage facilities dedicated to camelina.
- Sustainable Oils is building one of the first commercial storage facilities in Montana.
- Mostly it is stored either on farms in grain bins or in grain bags.

PRODUCTION PRACTICES

- Camelina is generally sensitive to herbicide application, and the lack of herbicide tolerant varieties have posed a challenge for producers' willingness to adopt camelina in a rotation. (WSU). There are three herbicides registered for use with camelina, Sonolan, Poast, and Clethodim. (Context Experts)
- Compared to canola, camelina is less prone to pod shattering, and can be direct combined. Optimum seed moisture content for storage is 8.5%, similar to other oilseeds. (AGMRC)
- The short lifecycle of camelina make it a viable option for double and relay cropping systems. As an example, winter camelina harvested in the spring in the northern US corn/soybean states could be followed immediately by soybeans. Winter wheat could also be followed by spring seeded camelina in these same regions. (WSU)

Producer Adoption: Research has shown multiple benefits to planting camelina over other crops, such as canola, including better drought and frost tolerance

Camelina provides a benefit from planting early in the spring to provide ground cover against erosion (water and wind)

Camelina is a short season (85-100 days) crop that is well adapted to temperate growing environments. Seedlings are very frost tolerant, and no seedling damage has been recorded, even in 12 degree Montana temperatures (PSU) Overall, camelina has been reported as more drought tolerant than canola (SDSU, PSU)

Camelina plants can grow efficiently under drought like conditions, and there is reason to believe the crop is better suited for lower rainfall regions than most other oilseed crops. Research has shown camelina requires as little as 11 inches of rain to produce a crop, and studies at the University of Idaho in 2005 and 2006 have indicated, under 24" of precipitation, that camelina had a yield benefit over canola and mustard. (PSU, AGMRC)

Camelina provides several agronomic benefits. Camelina is an early maturity crop, and its short life cycle make it competitive for growing in tight crop rotations. Camelina also requires relatively low amounts of water and nutrients and can even be grown without nitrogen fertilization and other chemical applications as it is resistant to many common pests and pathogens. Finally, camelina can be grown in adverse growing conditions and is particularly competitive in semi-arid and low-fertility, saline soils. Because camelina can be grown on marginal lands and requires fewer inputs than other traditional oilseeds, the crop has shown its economic potential due to reduced costs of production. (WSU)

Compared to other oilseed crops, specifically canola, **camelina requires fewer ag inputs**, is **more tolerant of colder growing conditions**, has a **shorter growing season**, and **uses water more efficiently**. Due to these properties, camelina is well adapted to fit fallow period in dryland wheat farming or to be double cropped with short season soybeans or sunflowers (UMN)

GROWING CAMELINA VS CANOLA*

- Contract prices for camelina have become very competitive with canola.
- Canola has undergone extensive breeding to achieve < 2% erucic acid, with many at 0%, whereas **Camelina has 2-4% erucic acid.**
- Camelina does not require the prime farmland and significant irrigation and fertilizer inputs that are required by soy and canola
- After oil pressing, camelina meal contains 4-14% oil and 35-48% protein. The mean crude protein (CP) concentration of camelina meal was higher than canola and slightly lower than values reported for soybean meal.
- Unlike soy and canola, Camelina requires only moderate fertilizer inputs, is drought tolerant, and has very few pests requiring chemical applications

*All research comes from University of Nevada, Reno 2019 publication: "Camelina sativa: a promising oilseed for producing biofuels on marginal lands: Field production and characterization of a low-pectin seed mutant"

Key Players in Camelina Expansion

"Acreage growth [for camelina] has historically been slow. To this point most growth has come from push side and not pull side. Just growers looking to diversify their crop mix as well as implement something in fallow acres. ***With the renewed interest in renewable fuels the economics for this are changing*** *and there is starting to have more of a pull for the crop.* ***New varieties with yield improvements are being developed*** *and that is what is helping to drive current growth."* - Processor

Yield 10 Bioscience has identified camelina as a crop with many opportunities, and has begun developing novel yield traits

Yield 10 Bioscience

- 2019: First Yield10 seeds from GE camelina variety developed for plastics are planted (AgriPulse)
- 2022: Company plans to expand and scale up seed activities and field testing of their candidate herbicide tolerant camelina varieties, while also pursuing partnerships with commercial stakeholders to supply renewable diesel made from camelina (GlobalNewswire)

"Yield 10 is not breeding but working on trait discovery to launch commercially for oil." –Camelina Processor

Oliver Peoples, CEO of Yield 10 BioScience, has said that some major seed companies are interested in camelina, and Yield 10's technology could potentially be used to stack traits needed to develop camelina varieties that allow it to grow in different regions or for different uses. (AgriSure.1)

COVER CROPS

Due to its short growing season, Camelina is an ideal candidate as a cover crop to help reduce erosion and nutrient runoff, improve soil quality, and help control diseases and pests

HIGH PROTEIN MEAL

Camelina meal contains 30-35+% crude protein on a dry basis matter and its strong amino acid profile make it attractive as a feedstock for livestock

EDIBLE OILS

Oil extracted from camelina has potential to be used as an edible oil for frying, baking, food preparation, and flavorings

MODEL CROP FOR IDENTIFYING NEW TRAITS

Through their own Trait Factory, Yield 10 identifies and assesses novel yield trait genes to improve the performance of Camelina. To date, Yield 10 has more than 15 novel yield traits in their R&D pipeline

RENEWABLE DIESEL

Camelina oil is an attractive feedstock for biofuels and qualifies as an advanced biofuel under the U.S. EPA's RFS program

PHA BIOPLASTIC

Yield 10 is working on an exclusive Camelina variety to replace petroleum plastics with PHA bioplastic made from camelina

OMEGA-3 OILS

Camelina is rich in omega-3 oils, making it an ideal target for the aquaculture industry which is looking to adopt sustainable feedstocks

Sustainable Oils has been the dominant player in developing camelina as a biofuel feedstock

SUSTAINABLE OILS INC

- Sustainable Oils, Inc. was formed in 2013, with roots in camelina back as far as 2005 through its previous entity Sustainable Oils, LLC, and now is the world's leading developer of camelina
- Sustainable Oils, Inc., owns an industry leading portfolio of intellectual property rights, including patents and production know-how, to produce its proprietary varieties of camelina as a nonfood based ultra-low carbon biofuels feedstock.
- Growers who sign a contract to grow Sustainable Oils Camelina can earn a set payment ($125/acre) from Sustainable Oils after qualification of stand establishment. At harvest, growers will be paid for every pound they produce based on an index to soybeans.
- Sustainable Oils Camelina varieties are the only camelina approved for the California LCFS (Low Carbon Fuel Standard).
- Has 18+ patents or patents pending for camelina plant production (GCE)
- 2015: Sustainable Oils is the first and only company to be granted a feedstock-only pathway by the California Air Resources Board ("CARB") for the production of renewable fuels under the Low Carbon Fuel Standard ("LCFS") (GCE)
    - The pathway, when combined with a specific processors production profile, will produce the lowest carbon intensity (CI) virgin oil-based fuel available in the marketplace, allowing California processors to meet reduction targets using less biofuel otherwise required.
- Sustainable Oils' camelina is a short-season, deep-rooted crop that can grow on land with only 10" to 15" of rain per year. In warmer areas, it can be winter-seeded, allowing growers to also have a double crop. It offers many growers an opportunity to replace costly fallow acres, increase asset utilization, and increase annual profitability. (GCE)
- Sustainable Oils camelina is USDA Crop Insurance eligible
- Have a partnership with Exxon to supply 5M barrels of Renewable Diesel per year for the next 10 years

> *"Sustainable Oils has had the largest influence on crop development. With their purchase of CCE (Camelina Company España) they are the **largest global breeder and researcher on genetic development**"* -Processor

> *"Sustainable Oils developed a breeding program – went through a rough patch, slowed on work, but has **recently started back up in full force** with original director of breeding and new purchase of Cargill Canola team in Great Falls Montana and its breeders, that will **now focus on breeding camelina**."* -Processor

GLOBAL CLEAN ENERGY HOLDINGS (GCEH)

- Acquired sustainable oils in 2013 – more details
- 2020: Global Clean Energy Holdings (GCEH) acquires an idle Bakersfield, CA refinery for $40 million and begins transforming it into a renewable diesel production plant, planning on using its own proprietary fallow-land crop varieties of camelina (OGJ)
- GCEH's plan includes building grain storage facilities providing local consolidation delivery points for farmers on rail transportation hubs in key growing areas (GCE)
- Global Clean Energy Holdings, Inc. has an exclusive five-year commitment from ExxonMobil to purchase up to 220 million gallons per year of renewable diesel made from Sustainable Oils Camelina (SUSoils).

GROUP LIMAGRAIN

- Limagrain in France developed the spring variety "Celine" and the winter variety "Epona" (PSU)

BLUE SUN BIODIESEL (SEABOARD FOODS)

- Variety "Cheyenne" has been released from Blue Sun Biodiesel (PSU)

The U.S. government, its agencies, and trade groups have and will continue to drive farmer and market adoption for camelina

UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)

- 2008: The Montana DOA began working with multiple Montana industries and the FDA to generate the requirements of what was needed to acquire GRAS status and AFFCO feed certification for camelina. (MSU)
- 2009: Montana state DOA funds studies in collaboration with NACTA. (MSU)
- 2015-2021: Researchers at USDA's ARS spend years assessing whether camelina could be a third crop to break up corn-soybean rotations. They found while soybean fields double cropped with camelina outyielded other plots, it also requires more water which stresses the following crop. The research focused on Midwest production found that corn-camelina-soybean systems did not reduce nitrogen loss compared to conventional corn and soybean systems, and no till plots (AgriPulse)

U.S. GOVERNMENT

- 2009/2010: FDA approved use of camelina meal in up to 10% of broiler and feedlot beef cattle rations (allaboutfeed)
- 2013: USDA FCIC approved insurance policy for camelina growers in 2013 and 2014, allowing up to 65% insurance coverage (K-State)

NORTH AMERICAN CAMELINA TRADE ASSOCATION (NACTA)

- 2009: The first camelina trade association is established, with the 13 members across industry, including seed companies, processors, and researchers. (Advanced Biofuels USA)
- 2009/2010: NACTA played a key role in the FDA approval for camelina meal in livestock rations.
- NACTA is no longer active

Scott Johnson, President of NACTA at time (2009): 'We really need to work toward a comprehensive crop insurance program similar to what is available for other commodities. In addition, it's critical for the crop to have access to efficient logistics and crushing to fill the demand that we are creating for the crop"

AAFC CANADA

Agriculture and Agri-Food Canada

- 2002-2005: AAFC Canada conducted agronomic trial, comparing camelina to other brassica oilseeds and found that camelina is well suited for production in Western Canada due to its early maturity, high yield potential, drought tolerance, and resistance to some common pests and diseases common in canola and other oilseeds. (AAFC)

*Activities outlined above are not exhaustive

Universities have been working to advance camelina, Montana State the most active*

MONTANA STATE UNIVERSITY

- Released the “Blaine Creek” and “Suneson” camelina varieties. “Blaine Creek” is a short season, high yielding, high in omega-3 fatty acids line well adapted to high yielding growing environments. “Suneson” has been referred to as an average yielding, midseason line, although it is usually 2-3% higher oil content than “Blaine Creek” (PSU)
- 2015: In order to increase focus around the positive environmental impacts of camelina, two-year study is conducted showing the efficiency of camelina over other oil crops in no till and reduced nitrogen environments (MSU)
- 2020: A team of researchers at Montana State University (MSU) will collaborate with stakeholders across the U.S. to administer $11 M of fundings to approach and assess camelina, focusing on yield and nitrogen use efficiency (montana.edu)

UNIVERSITY OF MINNESOTA

- 2016: The winter camelina breeding program is launched at the University of Minnesota, focused on identifying high yielding, early maturing camelina lines with improved winter hardiness. (Timeline)
- University of Minnesota – Forever Green Initiative is partnering with Minnesota BOLD to identify end use applications for winter camelina that could catalyze camelina production in the Midwest at a scaled level (BOLDopen)
- Work is being done by the University of Minnesota to promote winter camelina as a cover crop in the existing corn/soybean rotation, which would provide both ecosystem and economic benefits for upper Midwest farmers. (ForeverGreen)

UNIVERSITY OF NEVADA, RENO

- 2011-2015: A five-year field trial found that based on yield, oil, and estimated biodiesel productivity, camelina has strong potential to be grown in semi-arid environments, including Nevada, although supplemental irrigation is necessary to achieve maximum productivity benefits (UNR)

UNIVERSITY OF IDAHO

- 2017: Research conducted showing the economic benefits of producing biodiesel compared to bio jet fuel using camelina feedstock. Other findings found that “Both fuels reduced GHG emission by over 50%, a threshold to qualify as an advanced biofuel, compared to their petroleum counterparts No. 2 diesel and jet-A fuel, respectively (Biofuels)

WASHINGTON STATE UNIVERSITY

- 2005-2007: Camelina studies on planting dates and methods are conducted across the PNW by researchers at the Washington State University (WSU)

KANSAS STATE

- 2017: Research conducted showing the economic benefits of producing biodiesel compared to bio jet fuel using camelina feedstock. Other findings found that “Both fuels reduced GHG emission by over 50%, a threshold to qualify as an advanced biofuel, compared to their petroleum counterparts No. 2 diesel and jet-A fuel, respectively (Biofuels)

*University research shown here is not exhaustive

The University of Minnesota and the Forever Green Initiative are pushing for soybean and corn farmers to adopt camelina acres in the upper Midwest

Winter camelina varieties can be planted in the fall after harvesting crops like spring wheat or corn. The camelina rosettes cover the soil surface and protect the soil from erosion while absorbing soil nutrients, reducing contamination and runoff issues. In the spring as the rosettes elongate, summer crops like soybeans can be interseeded with camelina, providing nectar and pollen to pollinators in the spring, and then harvested in June while the soybean plants are still short enough.

AGROECOLOGY

To promote this strategy, UMN and USDA-ARS researchers have shown that winter camelina is cold and freeze tolerant and can be double and relay cropped with other popular crops like wheat, corn, and soybeans. Through this research, it has been shown that the dual crop systems are economically viable, require few agronomic inputs, and provide needed ecosystem services like pollinator resources, reduced soil erosion, and reduced nitrate and phosphorous runoff. Future research will focus on improving management practices to enhance double and relay cropping opportunities, piloting new crop systems using camelina as a cover crop, and how to fully evaluate the environmental benefits of using camelina as a cover crop.

FOOD SCIENCE AND NUTRITION

To compete with other plant-based proteins, camelina researchers must demonstrate camelina sourced proteins are superior compared to alternatives. UMN Food Science researchers are evaluating the nutritional value of winter camelina, with the objectives of developing flavor-guided protein extraction methods and screen lines for protein nutritional quality and develop optimal varieties for use in food.

BREEDING AND GENETICS

UMN started the winter camelina breeding program in 2016, focused on identifying high yielding, early maturing camelina lines with improved winter hardiness. Future research will focus on increasing oil content, reducing glucosinolate content, and improving protein and meal quality.

COMMERCIALIZATION AND PILOT SUPPLY CHAINS

There are a number of regional and national companies interested in using camelina products, and industry stakeholders are increasingly interested due to camelina's winter hardiness and cover crop benefits such as reduce nutrient and chemical runoff and carbon sequestration. Forever Green researchers are partnering with stakeholders to create production and supply chain pilot programs by planting several thousand acres across strategic sites. The pilot programs also include investment in infrastructure such as postharvest handling and storage, cleaning, and processing.