The Environmental Benefits of Precision Agriculture in **Canada**

Executive summary

AEM Association of Equipment Manufacturers

CANADIAN CANOLA GROWERS ASSOCIATION

CSTA ACCS Canadian Seed Trade Association / L'Association canadienne du commerce des semences

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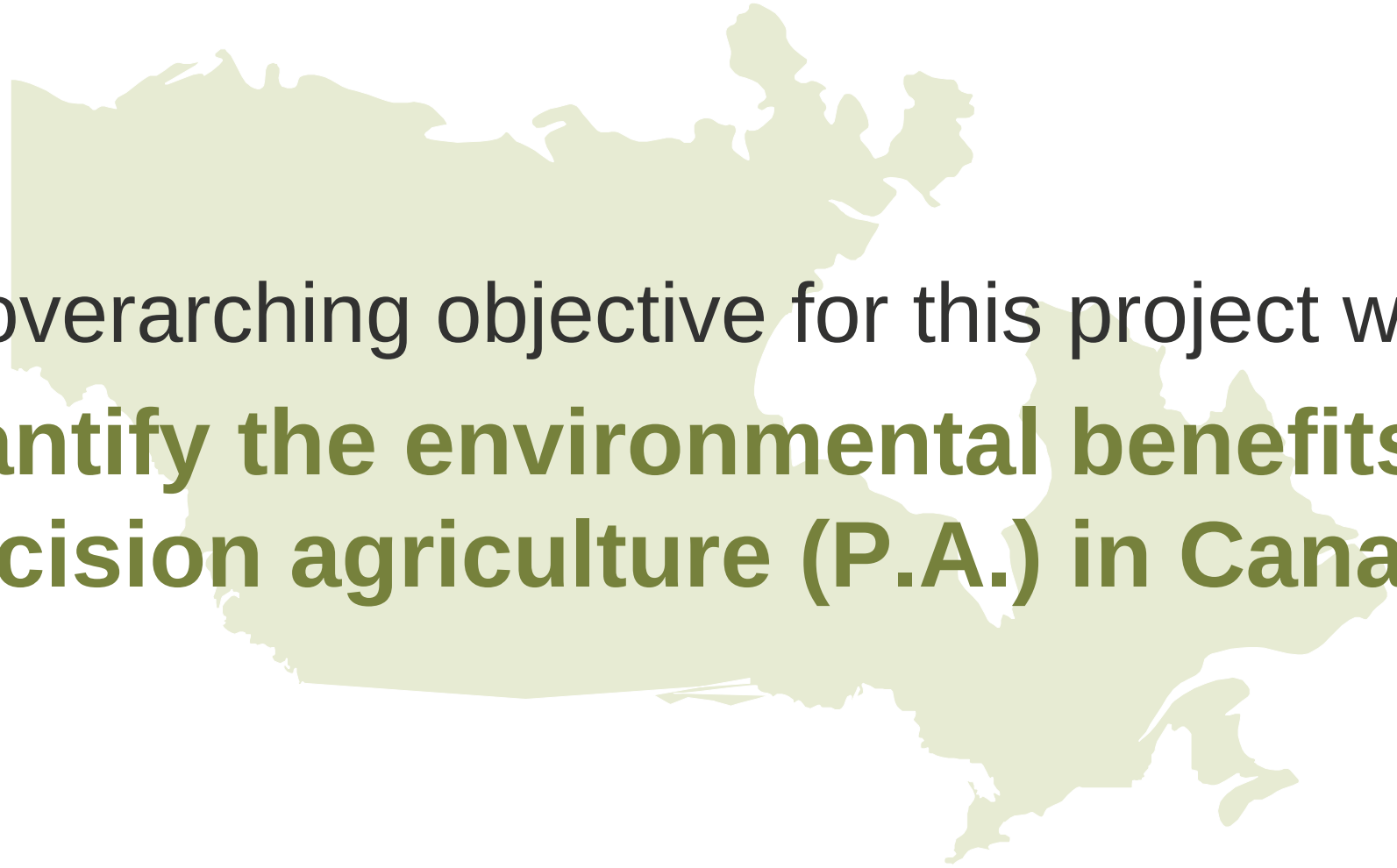
GRAIN FARMERS OF ONTARIO

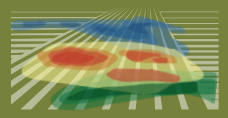
OBJECTIVE



The overarching objective for this project was to

quantify the environmental benefits of precision agriculture (P.A.) in Canada.

Five key **precision agriculture (P.A.) technology areas** were identified for this study

P.A.TECHNOLOGY AREA	DEFINITION	TECHNOLOGIES ANALYZED
 **AUTO GUIDANCE**	Auto-steer uses GPS signals to automatically control the tractor in seeding, spraying, fertilizer application and harvesting, reducing overlap of farming operations and leading to substantial fuel savings.	▪ Auto Steering
 **MACHINE SECTION CONTROL**	Machine section control technology turns planter, fertilizer or sprayer sections on or off in rows that have been previously seeded/sprayed, or at headland turns, point rows and waterways.	▪ Tillage drag / depth control ▪ Planting row, depth, down pressure control ▪ Fertilizer row control ▪ Spraying row control
 **VARIABLE RATE**	Variable rate technology uses sensors or preprogrammed maps to determine seeding, fertilizer, crop protection application rates. Supporting technologies include variable rate controllers, GPS, yield monitors, crop sensors and soil sensors.	▪ Variable rate planting ▪ Variable rate fertilization ▪ Variable rate spraying, including UAV (drone) applications
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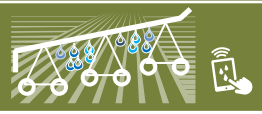
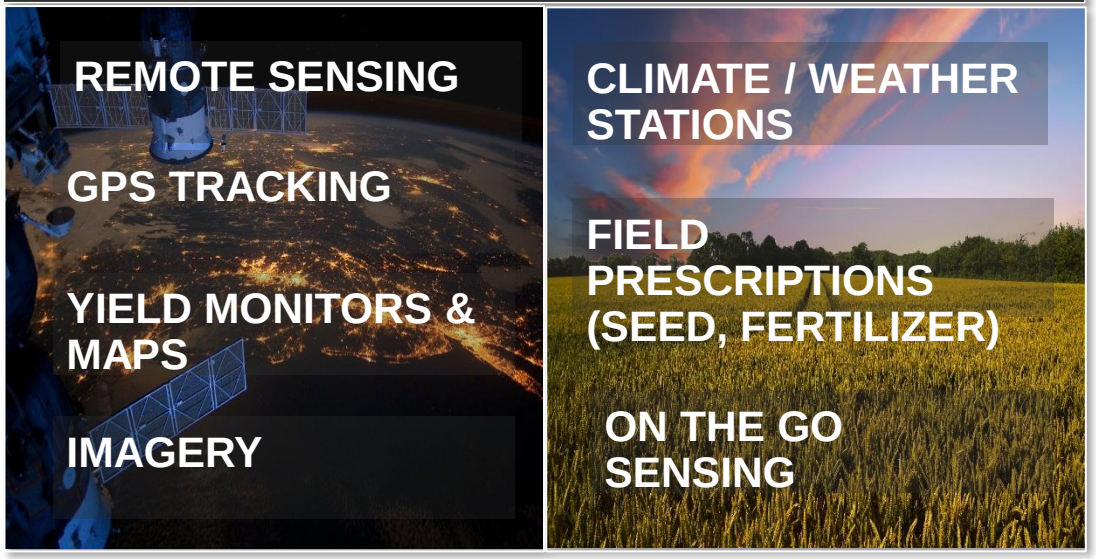
 **PRECISION IRRIGATION**	Ability to switch on/off apply and different amounts of water to different areas of the field. *Focused on center pivots.*	▪ Sensor driven center pivots ▪ Lower energy precision application

How we get to the future – Many technologies **enable** precision agriculture.

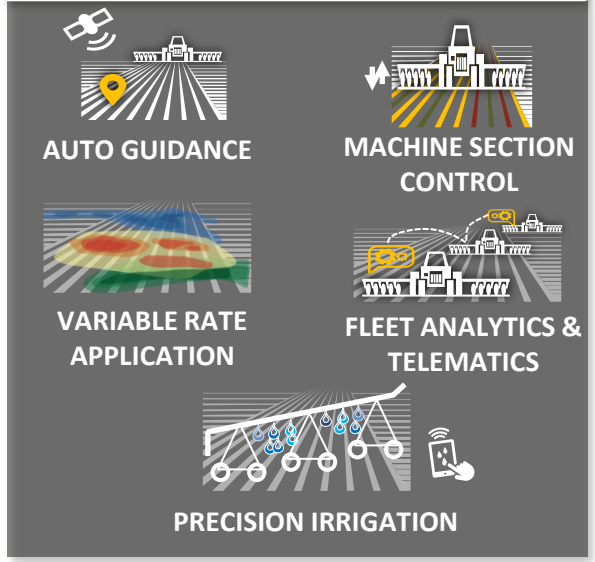
Enablers

AG TECHNOLOGY



Impacts measured

PRECISION AG TECH



*Enabling technologies such as **yield mapping** and **soil sampling** were included indirectly within the "execution" of precision ag tech. The environmental benefits of the precision ag technologies are only achievable with accurate and routine use of enabling technologies*

Five key environmental benefits were identified to be quantified as a result of P.A. technology adoption

	Productivity	Fertilizer Use	Herbicide Use	Fossil Fuel Use	Water Use
Direct Outcomes *(quantified)*	Yield benefit from accurate spacing (pass-to-pass, end/point rows) and population rate	Optimization of fertilizer applications (reduced overlap, avoid skips, best placement and rate of inputs)	Optimization of herbicide applications (reduced overlap, avoided skips, best placement and rate of inputs)	Fuel savings from fewer field passes, variable depth of tillage, and/or more efficient harvest	Application of water avoided due to remote shutoff of center pivots, along with selective application

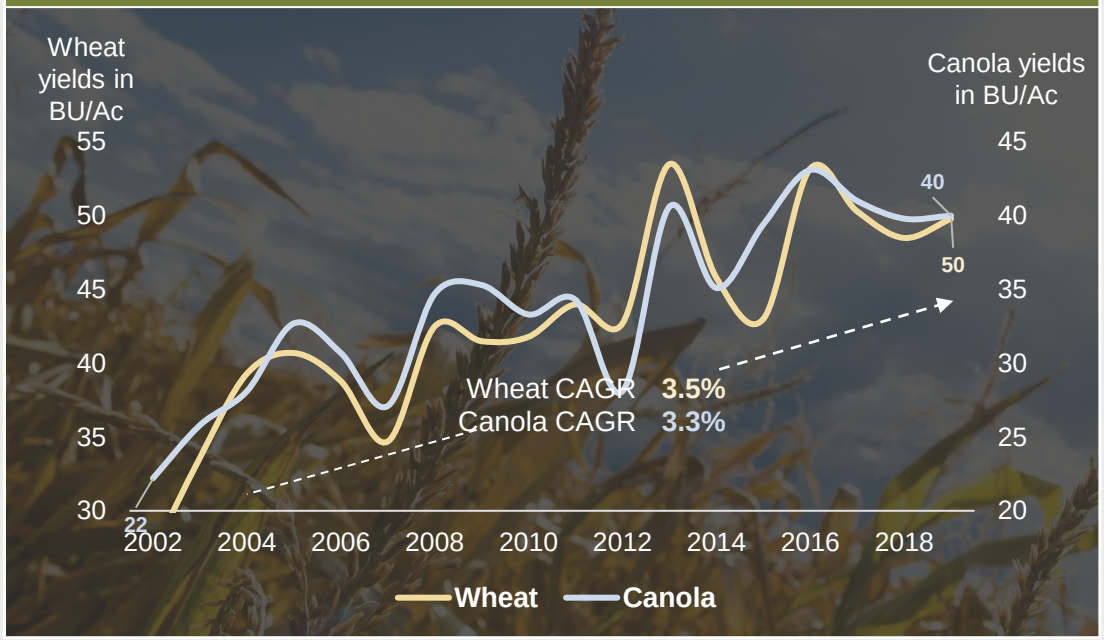
The **crops** studied included a range of row crops, broad acre non-row crops, roots and tubers, and forage

Row crops	**Broad Acre** (Non-Row) **Crops**	**Roots & Tubers**	**Forage***
Corn	Wheat	Potatoes	Hay
Soybeans	Barley, Oats		Alfalfa
	Canola		
	Pulses		

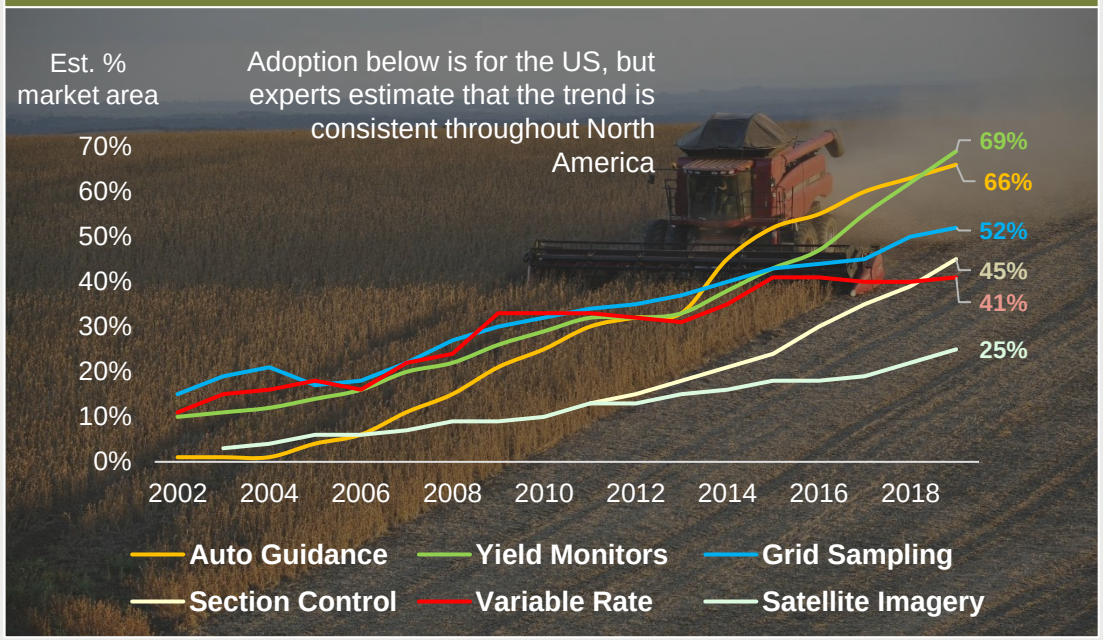
This study focused on crop production, leaving downstream impacts of precision technologies on animal agriculture for future study

Over the last 18 years, the growth in yields have coincided with the widespread adoption of precision agriculture technologies

Wheat and Canola yields from 2002-19



Adoption of precision agriculture technologies



Reasons for rising yields include

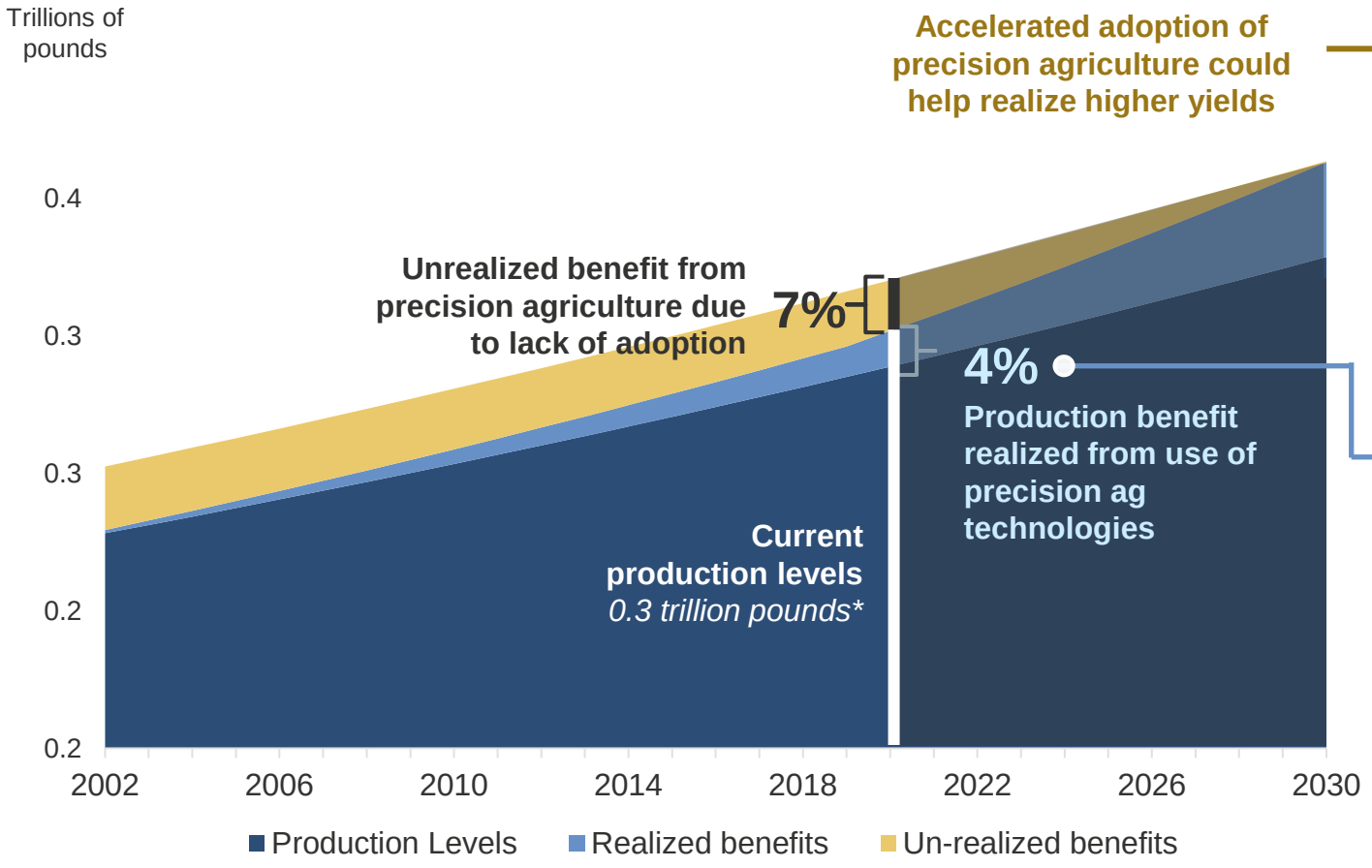
1. **More effective and resilient hybrids**
2. **Better inputs & management practices**
3. **Improved on farm technology**

Precision agriculture technologies have contributed significantly to the increases in yields for the major crops grown in North America

Source: Canola Council, Purdue Precision Ag Dealership Survey, Context Analysis and Expert Input

Annual crop production has increased ~4% attributable to adoption of precision agriculture and could increase a further 7% through the broader adoption of these technologies

Access to high speed rural internet, better financing and a proven ROI will help accelerate the adoption of precision agriculture on Canadian farms thereby increasing yields and overall farm incomes



Accelerated adoption of precision agriculture could help realize higher yields

This could be achieved with a further

- **18%** less water
- **11%** less fossil fuels
- **16%** improvement in fertilizer placement
- **16%** improvement in herbicide application efficiency

This was achieved with

- **7%** less water
- **6%** less fossil fuels
- **6%** improvement in fertilizer placement
- **9%** improvement in herbicide application efficiency

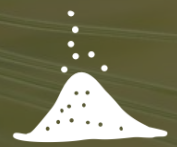
Precision agriculture technologies have allowed Canadian farmers to do more with less

Annual Crop Production has increased an estimated

4% **due to Precision Agriculture Technologies compared to a world without them**

Today's adoption rates of Precision Agriculture practices have resulted in significant improvements in the use of the use of fertilizers, herbicides, fossil fuels, and water

6% Improvement in fertilizer placement efficiency



9% Improvement in herbicide application efficiency

6% Less fossil fuels

7% less water

Significant headway remains for continued increases in yields and further input savings as precision agriculture technologies become widely adopted.

Annual Crop Production could increase a further 7% with broader adoption of Precision Agriculture Technologies

Broader adoption of precision ag technology has the potential to provide significant further improvements

16% Improvement in fertilizer placement efficiency

16% Improvement in herbicide application efficiency

11% Less fossil fuels

18% less water

thank you

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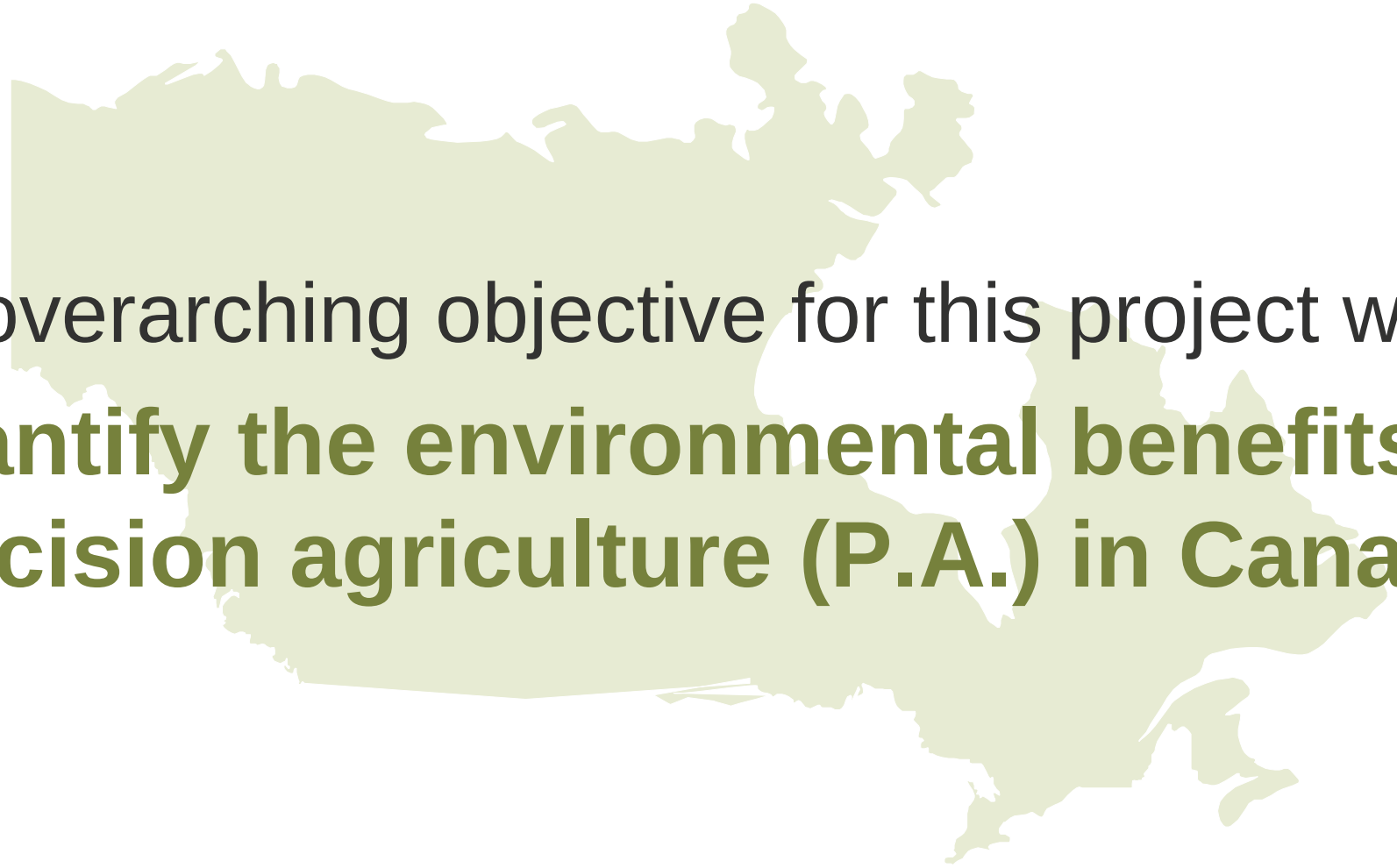

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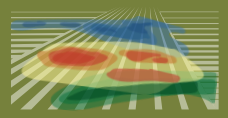 **VARIABLE RATE**	Variable rate technology uses sensors or preprogrammed maps to determine seeding, fertilizer, crop protection application rates. Supporting technologies include variable rate controllers, GPS, yield monitors, crop sensors and soil sensors.	▪ Variable rate planting ▪ Variable rate fertilization ▪ Variable rate spraying, including UAV (drone) applications
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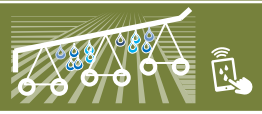 **PRECISION IRRIGATION**	Ability to switch on/off apply and different amounts of water to different areas of the field. *Focused on center pivots.*	▪ Sensor driven center pivots ▪ Lower energy precision application

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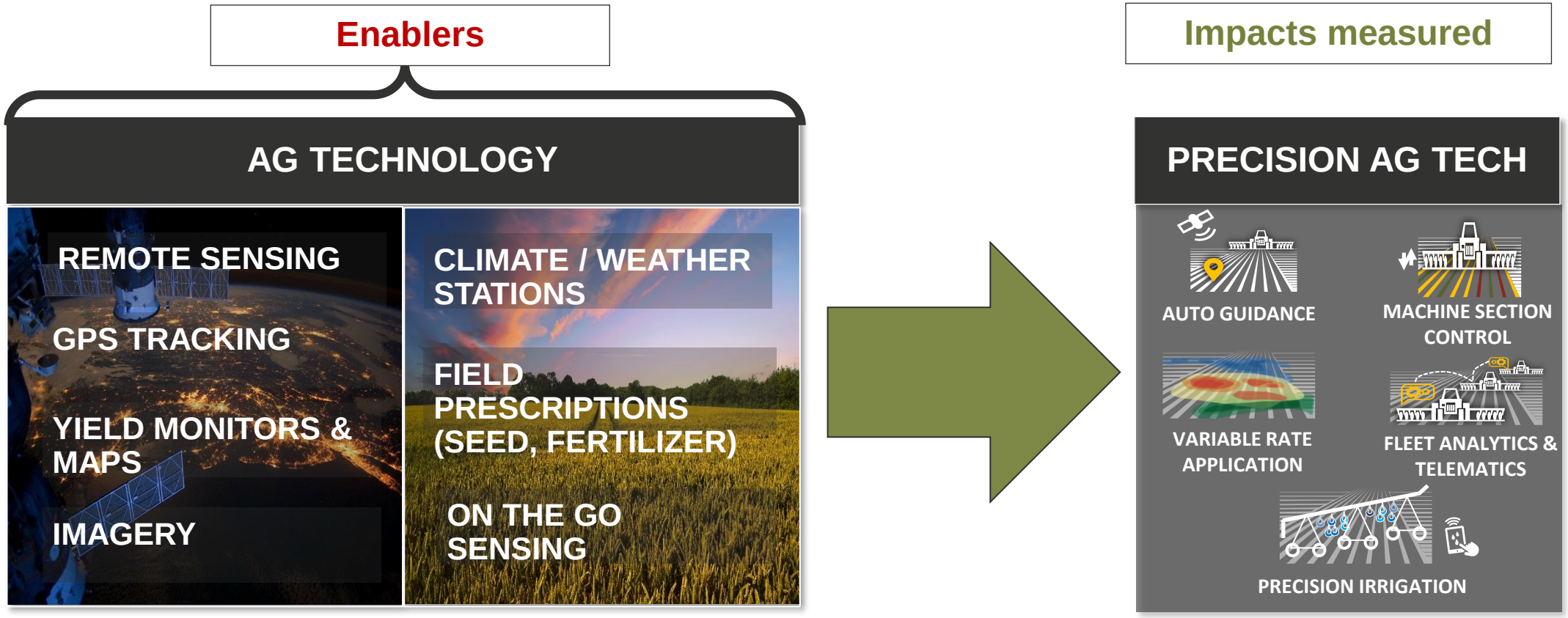

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Indirect Outcomes	▪ Avoid unproductive / preserved land from being in production ▪ Reduced soil compaction	▪ Improved water quality (reduced nutrient runoff) ▪ Improved soil health ▪ Net GHG reduction (including in production of inputs)	▪ Improved soil health, and reduced erosion through less tillage ▪ Net GHG reduction (including in production of inputs) ▪ Improved water quality ▪ Reduced weed resistance development	▪ Net GHG reduction	▪ Improved water quality through reduced runoff ▪ Less energy use by running pumps fewer hours

The **crops** studied included a range of row crops, broad acre non-row crops, roots and tubers, and forage

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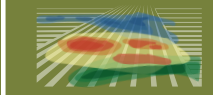
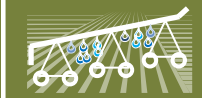
A model was built for each of the five environmental benefits, capturing data and contributions from each of the relevant P.A. technology areas

P.A. TECHNOLOGY	How Environmental Benefit is Achieved	ENVIRONMENTAL BENEFITS: Productivity	Fertilizer Use	Herbicide Use	Fossil Fuel Use	Water Use
 Auto Guidance	Reduced overlap + avoided skips for field passes with tillage, planters, sprayers, and harvesters	🎓 💬	🎓 💬	🎓 💬	🎓 💬	🧩
 Section Control	Optimized placement of seed / fertilizer / crop protection. Optimized down pressure + depth control to gain machine + fuel efficiencies	🎓 💬	🎓 💬	🎓 💬	🧩	🧩
 Variable Rate	Optimized rate of seed / fertilizer / crop protection applications	🎓 💬	🎓 💬	🎓 💬	🧩	🧩
 Machine & Fleet Analytics	Improved fuel efficiency from machine optimization	🧩	🧩	🧩	🎓 💬	🧩
 Precision Irrigation	Improved water use efficiency	🧩	🧩	🧩	🧩	🎓 💬

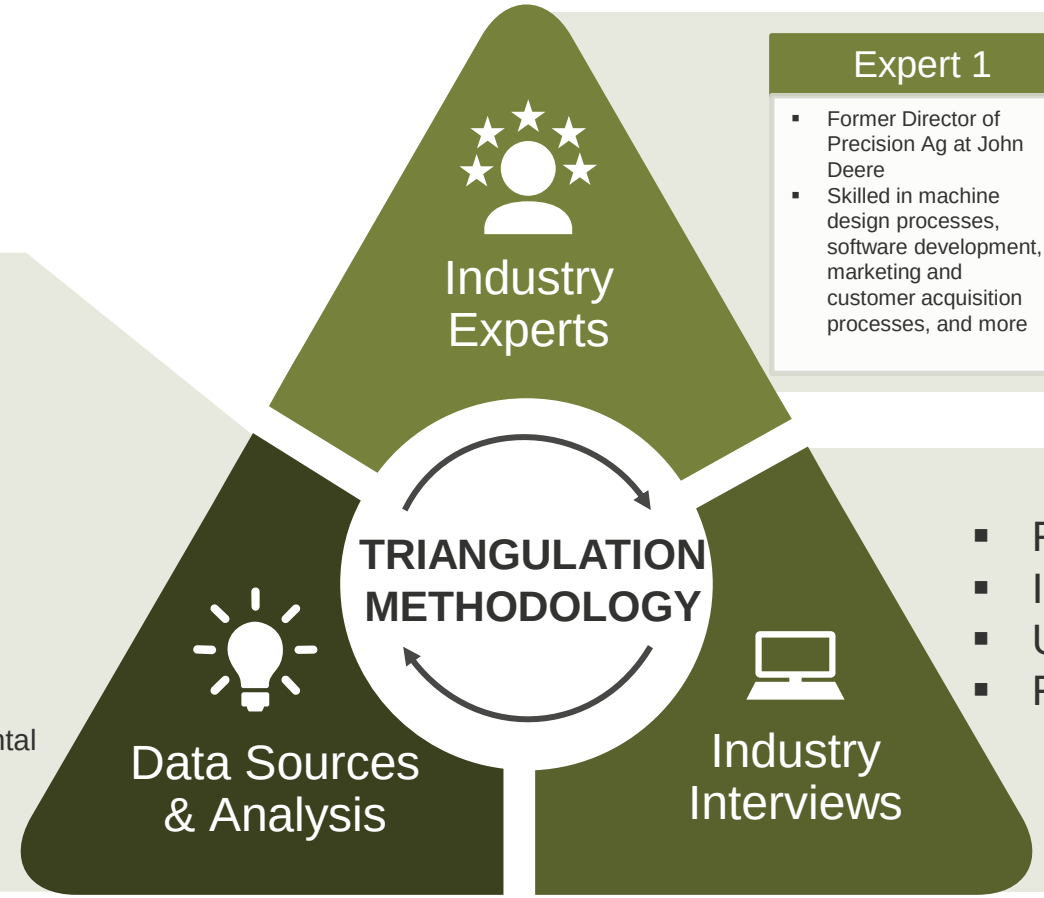
🎓 *Academic literature utilized* 💬 *Industry experts utilized* 🧩 *Incomplete information to reliably quantify*

Each of these five environmental benefits **directly links** to two or more of USDA's three sustainability pillars

		Environmental Benefits				
		Productivity	Fertilizer Use	Herbicide Use	Fossil Fuel Savings	Water Use
USDA PILLARS	DIRECT ENVIRONMENTAL BENEFIT		✓	✓	✓	✓
	PRODUCTIVITY (YIELD) BENEFIT	✓	✓	✓		
	FARMER ECONOMIC BENEFIT	✓	✓	✓	✓	✓

To align on reasonable assumptions for the benefits for each technology, the study utilized the **triangulation** of numerous data sources and industry experts

- The Ohio State University
- USDA NRCS
- Purdue University
- University of Kentucky
- North Dakota State University
- Iowa State University
- U of Illinois
- UC Davis
- Agricultural University of Athens, Institute for Agriculture-Belgium, Wageningen Environmental Research, European Commission-Joint Research Centre



Expert 1	Expert 2	Expert 3
▪ Former Director of Precision Ag at John Deere ▪ Skilled in machine design processes, software development, marketing and customer acquisition processes, and more	▪ Former Director of Marketing – Precision Agriculture and Construction at CNH ▪ Skilled at exploring innovative ways to increase agronomic production & sustainability through precision ag	• Former President and CEO of CropLife ▪ Chairman, Board of Advisors, Farm Journal • Leader in agricultural strategy services and entrepreneurial investment

- Fertilizer Institute representative
- Irrigation Association representative
- USDA representative
- Former Syngenta executive

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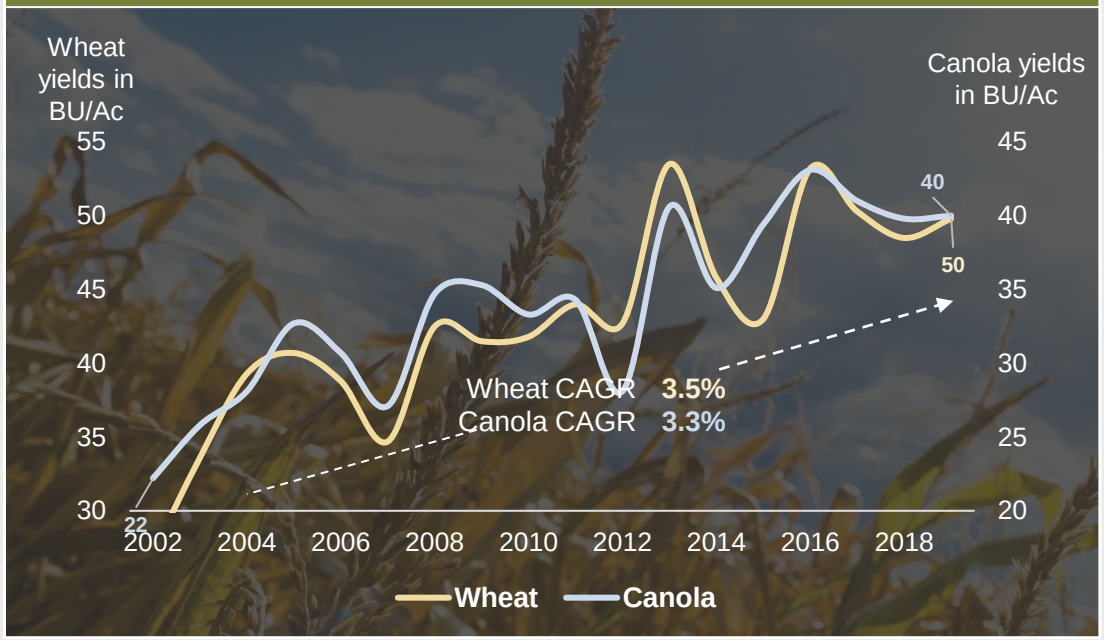

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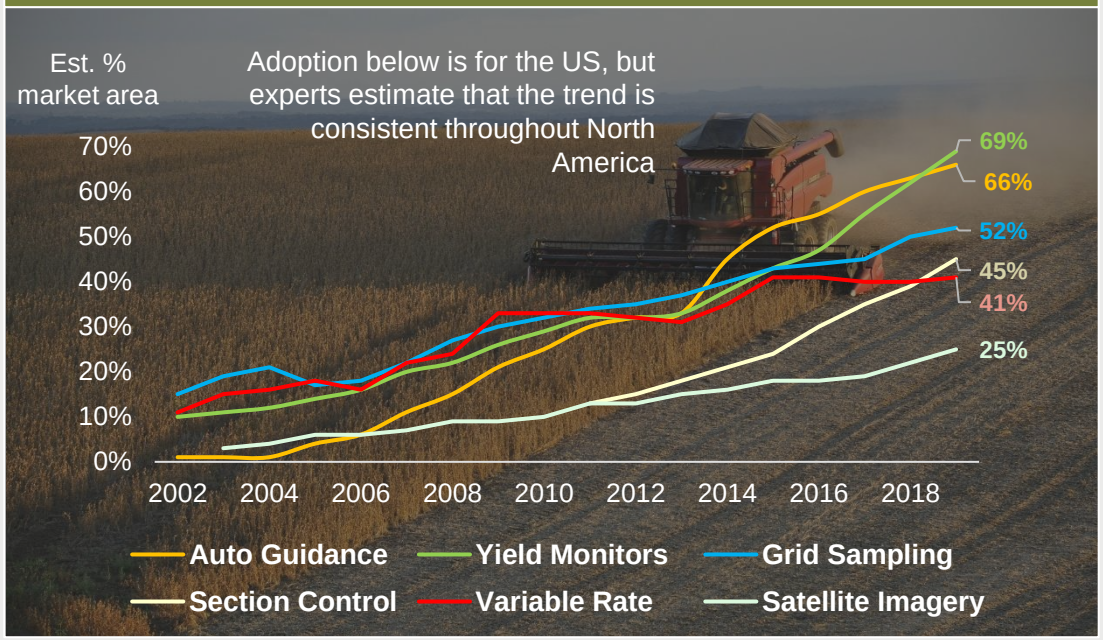

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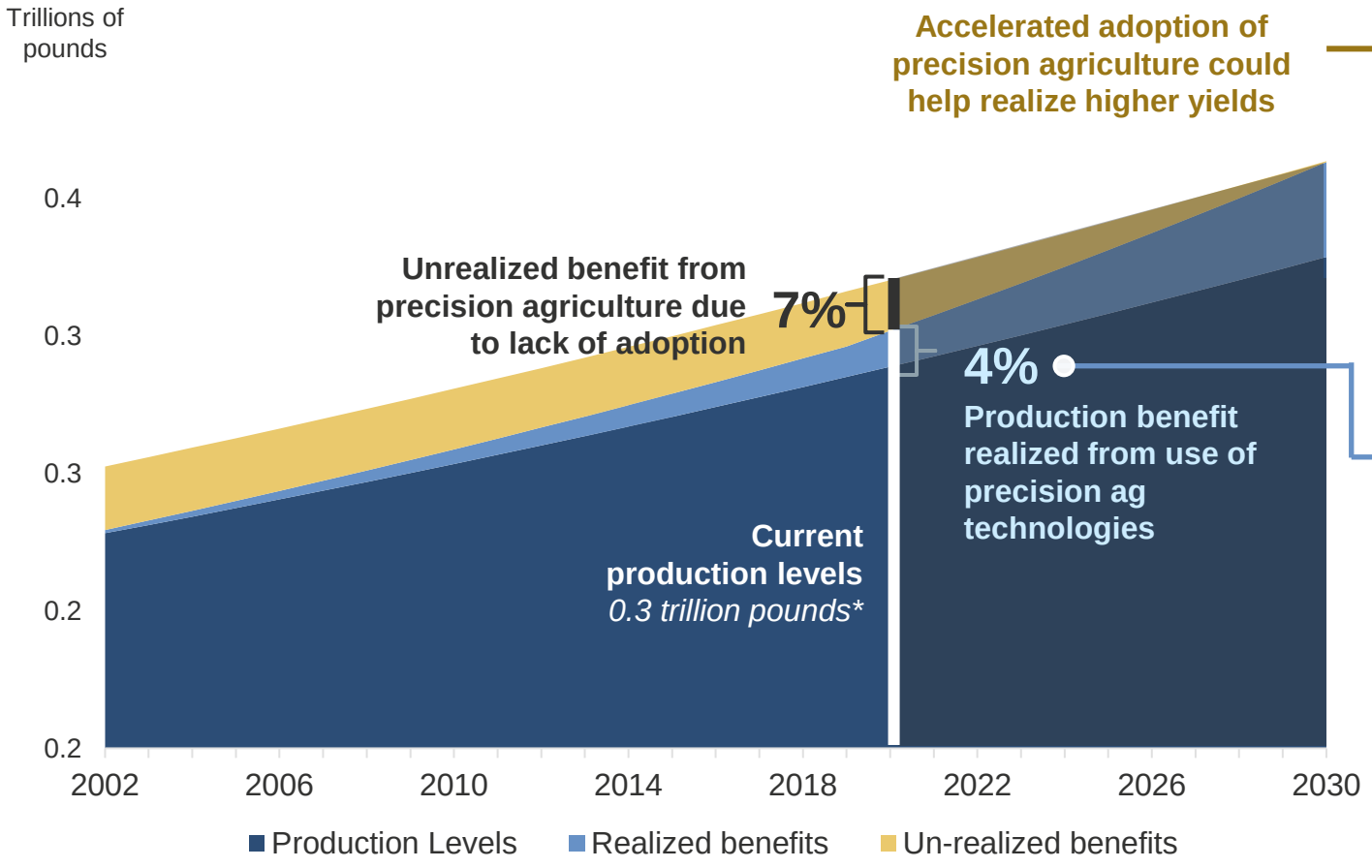

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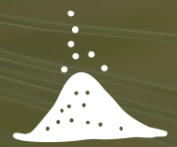

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Broader adoption of precision ag technology has the potential to provide significant further improvements

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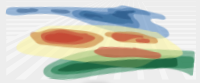
Productivity has increased an estimated **4%** as a result of current P.A. adoption, and has the potential to further increase **7%** with broader P.A. adoption

Cultivating an estimated 3.56 million acres of cropland was avoided due to more efficient use of existing land. This is an area equivalent to 2.2 Banff National Parks.

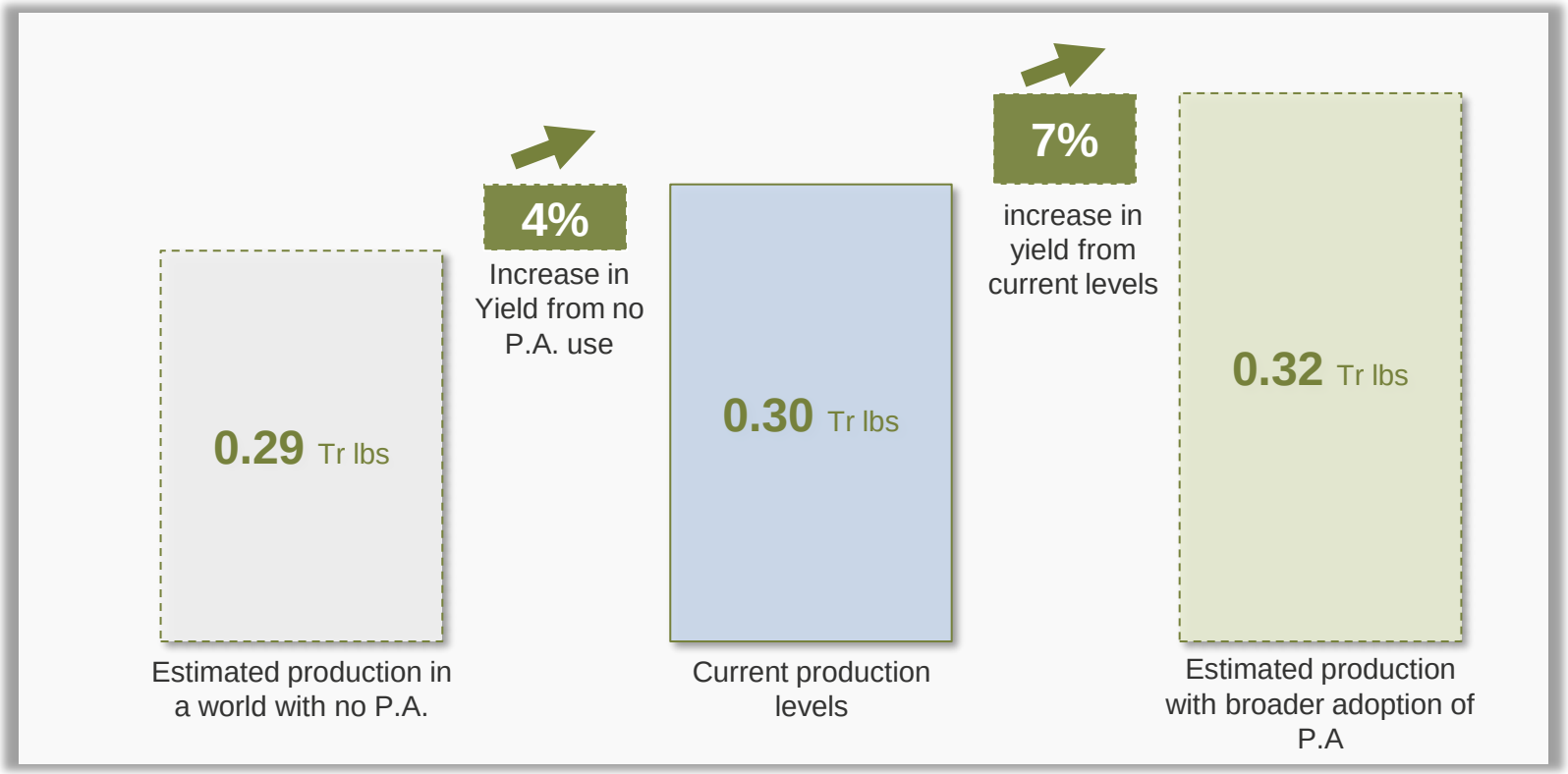
Precision Technologies Analyzed

Auto Guidance



Variable Rate

Section Control



Production of each of the crops in scope were converted from bushels to pounds in order to normalize for the purposes of aggregation and comparison

Precision agriculture has improved **fertilizer placement efficiency** by an estimated 6% and has the potential to further improve an additional 16% with broader adoption of P.A. technologies

Precision agriculture affects all pillars of nutrient stewardship, but most specifically application in the right place through variable rate application, auto guidance and section control

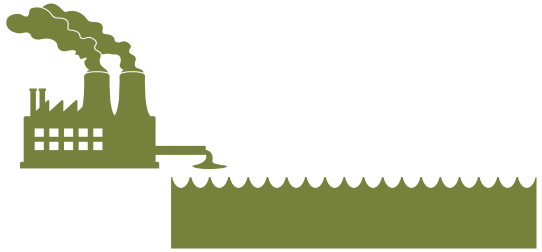
CASE STUDY

By transitioning from basic to advanced 4R practices and including strip till and cover crops, a family farm located in Central Illinois, US was able to **decrease costs per acre by $67**, whilst reducing CO2 equivalent **GHG emissions by >15%**.

Practices adopted on the farm

- **Fall strip till of nitrogen with stabilizer**
- **Fall application of P+K – broadcast using Variable Rate**
- **Cover crops – termination in spring**
- **Grid soil sampling**

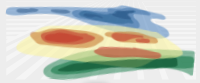
Herbicide Use has been reduced by an estimated 9% as a result of current improved P.A. application practices, and has the potential to further decrease 16% at full P.A. adoption



The application of an estimated 10 Million Pounds of herbicide was avoided due to adoption of P.A. technologies. With an estimated 16 M pounds of additional herbicide that could be avoided with broader adoption.

Precision Technologies Analyzed

Auto Guidance



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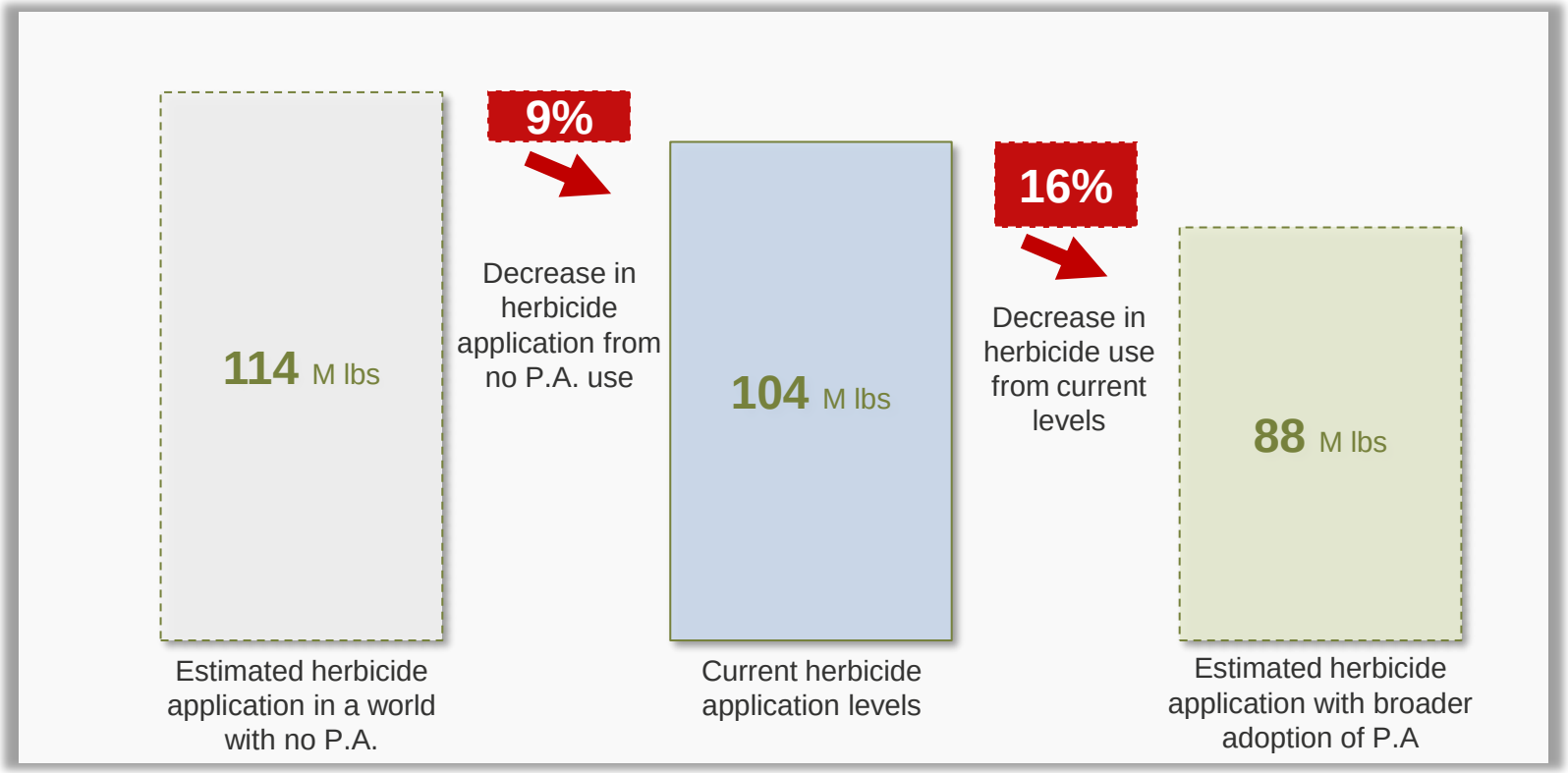


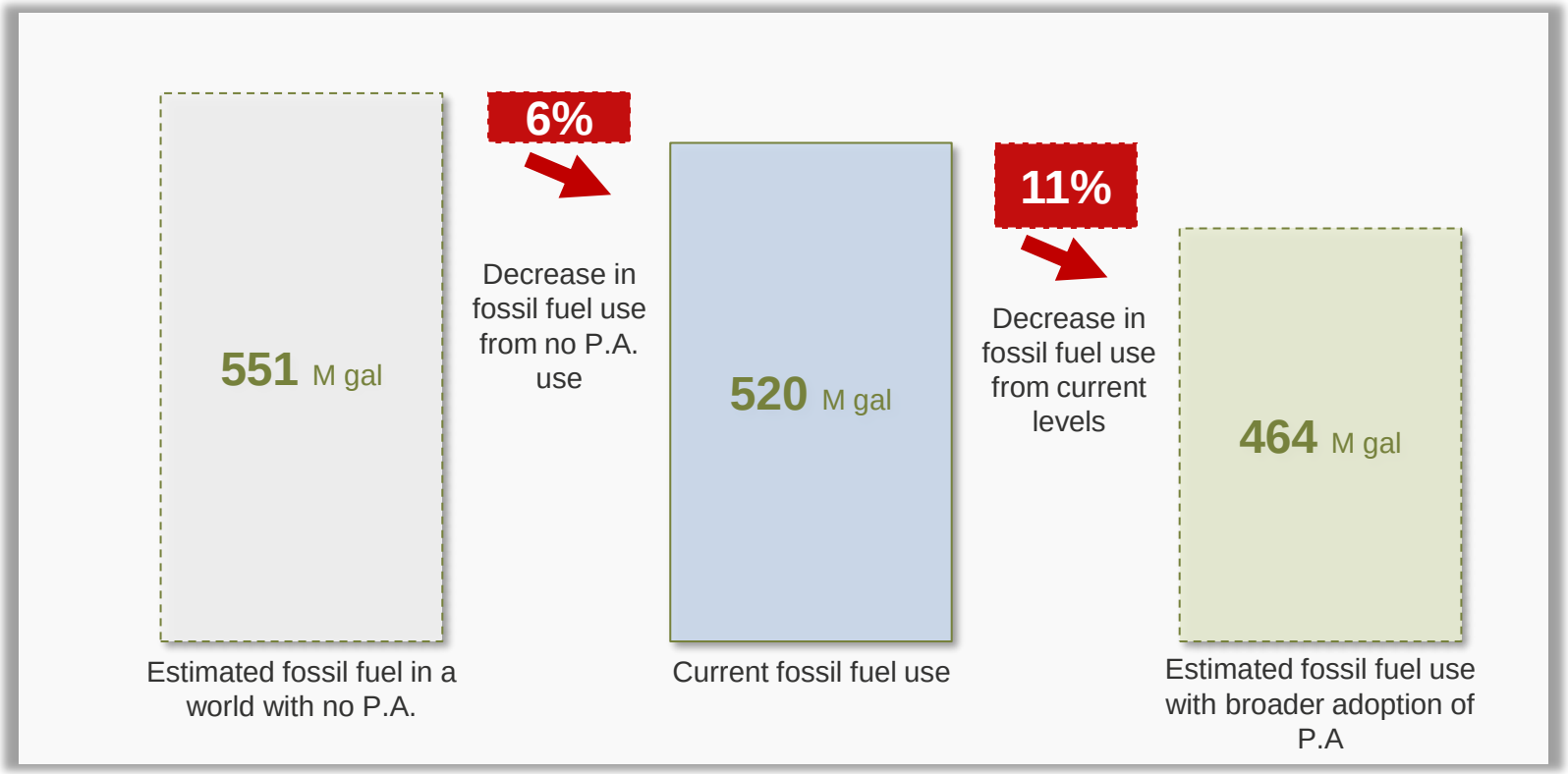
Fossil Fuel Use has decreased an estimated 6% as a result of current P.A. adoption, and has the potential to further decrease 11% at full P.A. adoption

The use of an estimated 31 M gallons of fossil fuels was avoided due to adoption of P.A. technologies. Equivalent to an estimated 60,000 cars off the road annually or 5,500 average flights.

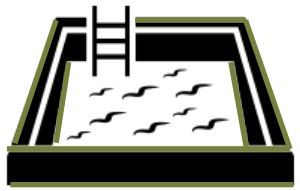
Precision Technologies Analyzed

Auto Guidance

Fleet Telematics



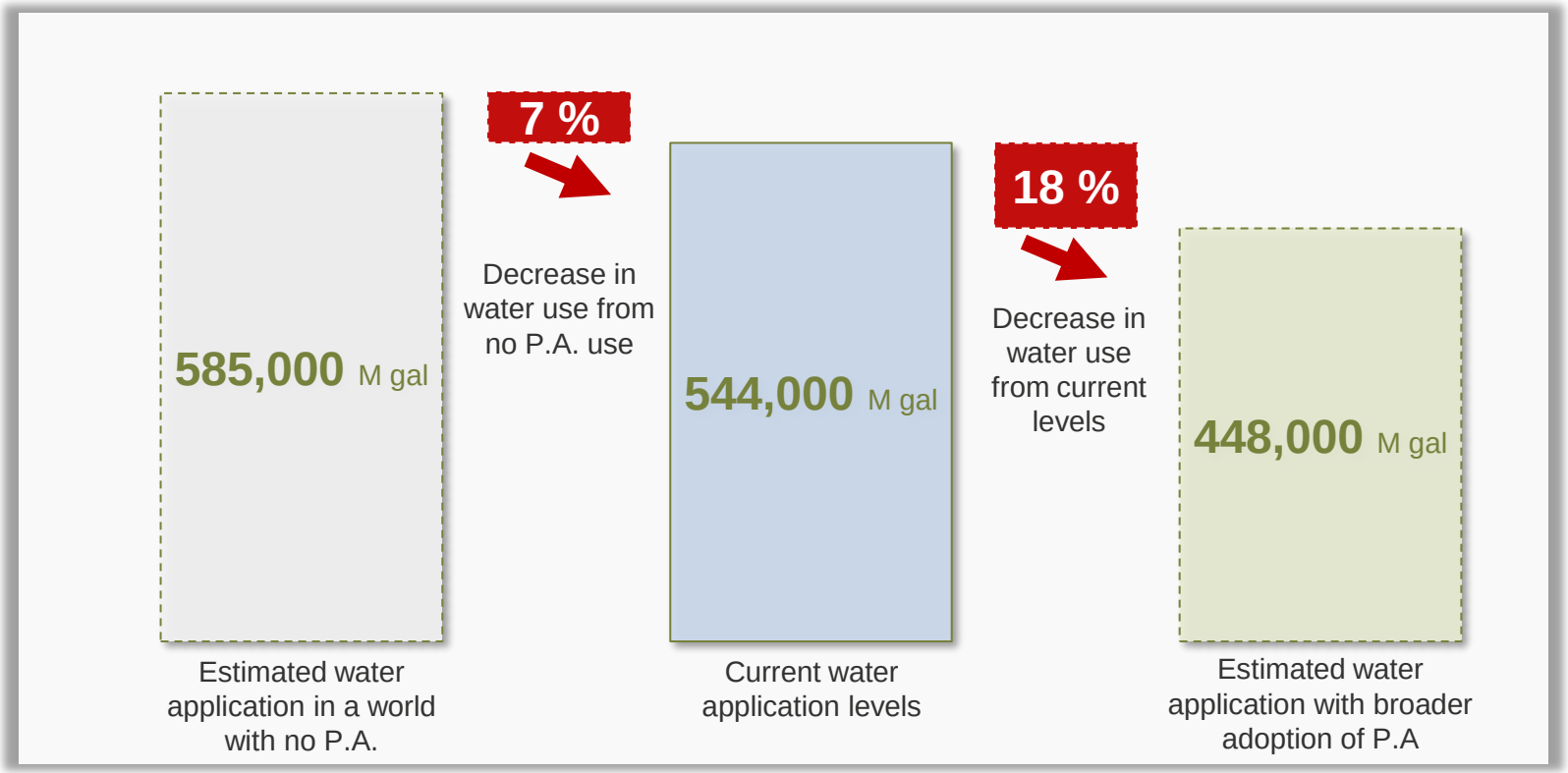
Water Use has decreased an estimated 7% as a result of current P.A. adoption, and has the potential to further decrease 18% at full P.A. adoption



The application of an estimated 61,000 Olympic swimming pools worth of water was avoided due to adoption of P.A. technologies.

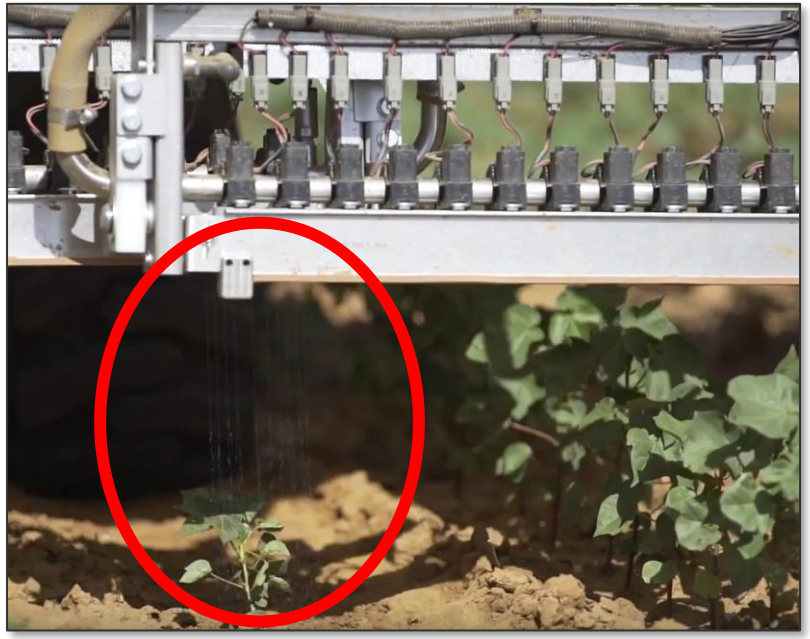
Precision Technologies Analyzed

Precision Irrigation



There is limited data on the benefits of some novel technologies such as see & spray weed control and smart combines, so they were not directly quantified in this body of work, but the adoption and potential benefit could be substantial

SEE AND TREAT WEED CONTROL



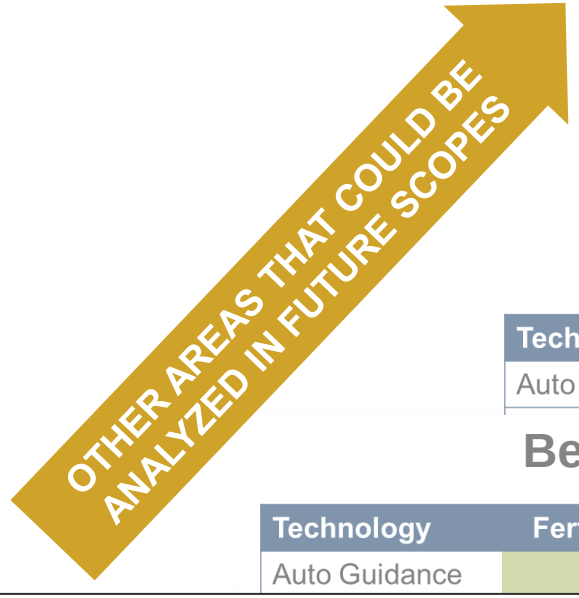
Targeted spraying mechanisms from OEMs and startups are beginning to enter the marketplace. Early estimates show that initial savings from herbicide application can be up to 90% **per pass**. Yet, questions remain as to the long-term effectiveness, as residual action on weeds is a major source of control.

SMART COMBINES

Smart combines improve the ability of the operator to automate adjustments usually made by skilled operators. A typical smart combine uses cameras and sensors to detect changes in crop conditions so combine adjustments can be made automatically and maintain optimal performance.

Source: Blue River Technologies

The focus of this work has been on the technologies and benefits that are most attributable to **ag equipment manufacturers**, but there are numerous other possible areas to analyze



Benefits of PA with a Forestry focus

Technology	Fertilizer Use	CP Use	Productivity	Fossil Fuel Use	Water Use
Auto Guidance					N/A
Section Control				N/A	N/A

Benefits of P.A. with a Livestock / Aquaculture focus

Technology	Fertilizer Use	CP Use	Productivity	Fossil Fuel Use	Water Use
Auto Guidance					N/A
					N/A
					N/A
					N/A

Benefits of P.A. with a Crop Inputs focus

Technology	Fertilizer Use	CP Use	Productivity	Fossil Fuel Use	Water Use
Auto Guidance					N/A
				N/A	N/A
				N/A	N/A
					N/A
				N/A	

CURRENT SCOPE: Benefits of P.A. with an Ag Equipment focus

Technology	Fertilizer Use	CP Use	Productivity	Fossil Fuel Use	Water Use
Auto Guidance					N/A
Section Control				N/A	N/A
Variable Rate				N/A	N/A
Machine & Fleet Analytics	N/A	N/A	N/A		N/A
Precision Irrigation	N/A	N/A	N/A	N/A	

thank you

AEM
Association of Equipment Manufacturers

CANADIAN CANOLA GROWERS ASSOCIATION

CSTA ACCS
Canadian Seed Trade Association
L'Association canadienne du commerce des semences

fcc

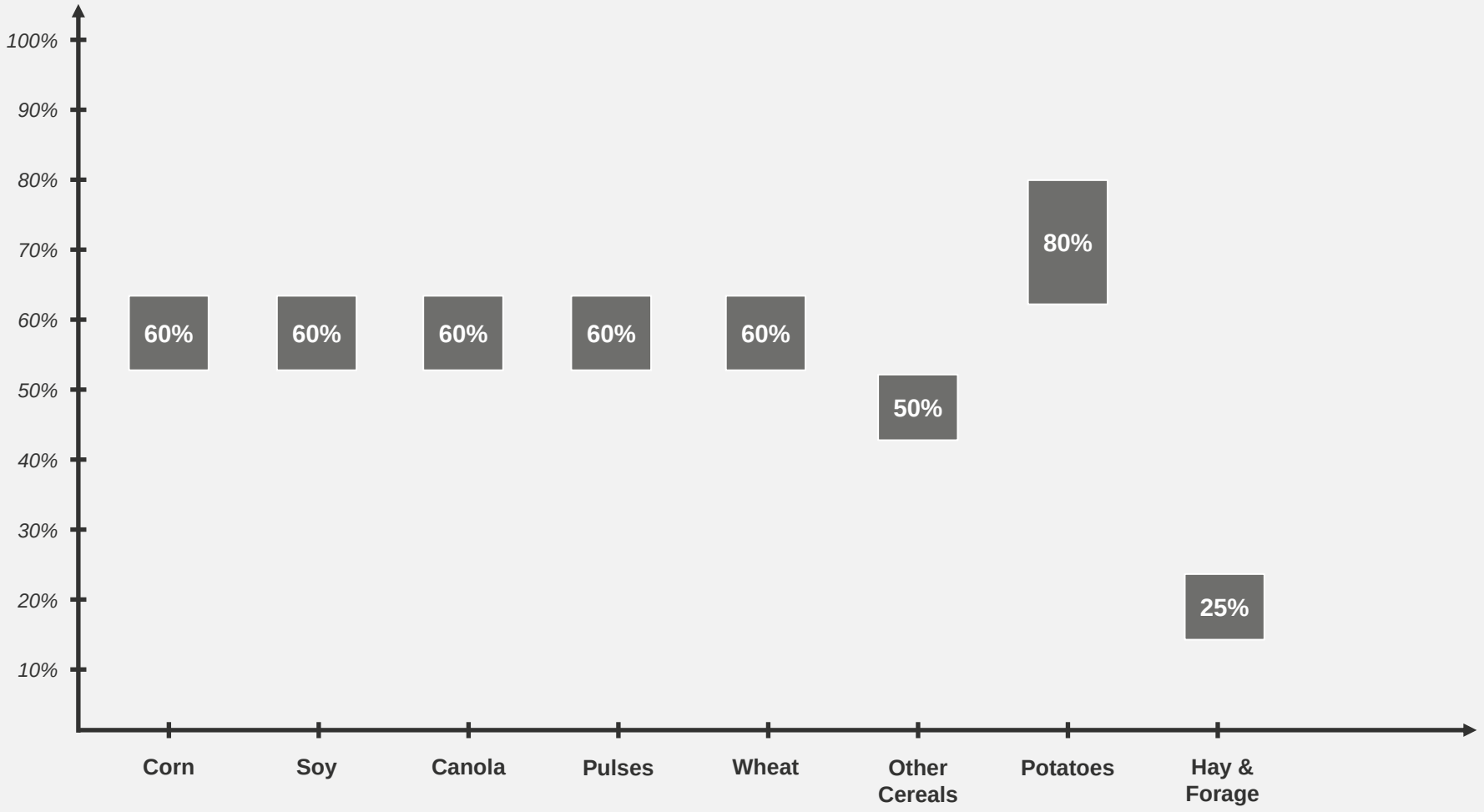
GRAIN FARMERS OF ONTARIO

APPENDIX

MODEL ASSUMPTIONS

Rate of adoption of Auto Guidance

Auto guidance achieves an environmental benefit from reduced overlap, avoided skips for field passes with tillage, planters, sprayers, and harvesters.



KEY

Inputs Impacted by Technology

- ALL INPUTS
- FERTILIZER USE
- HERBICIDE USE
- FOSSIL FUEL USE
- WATER USE

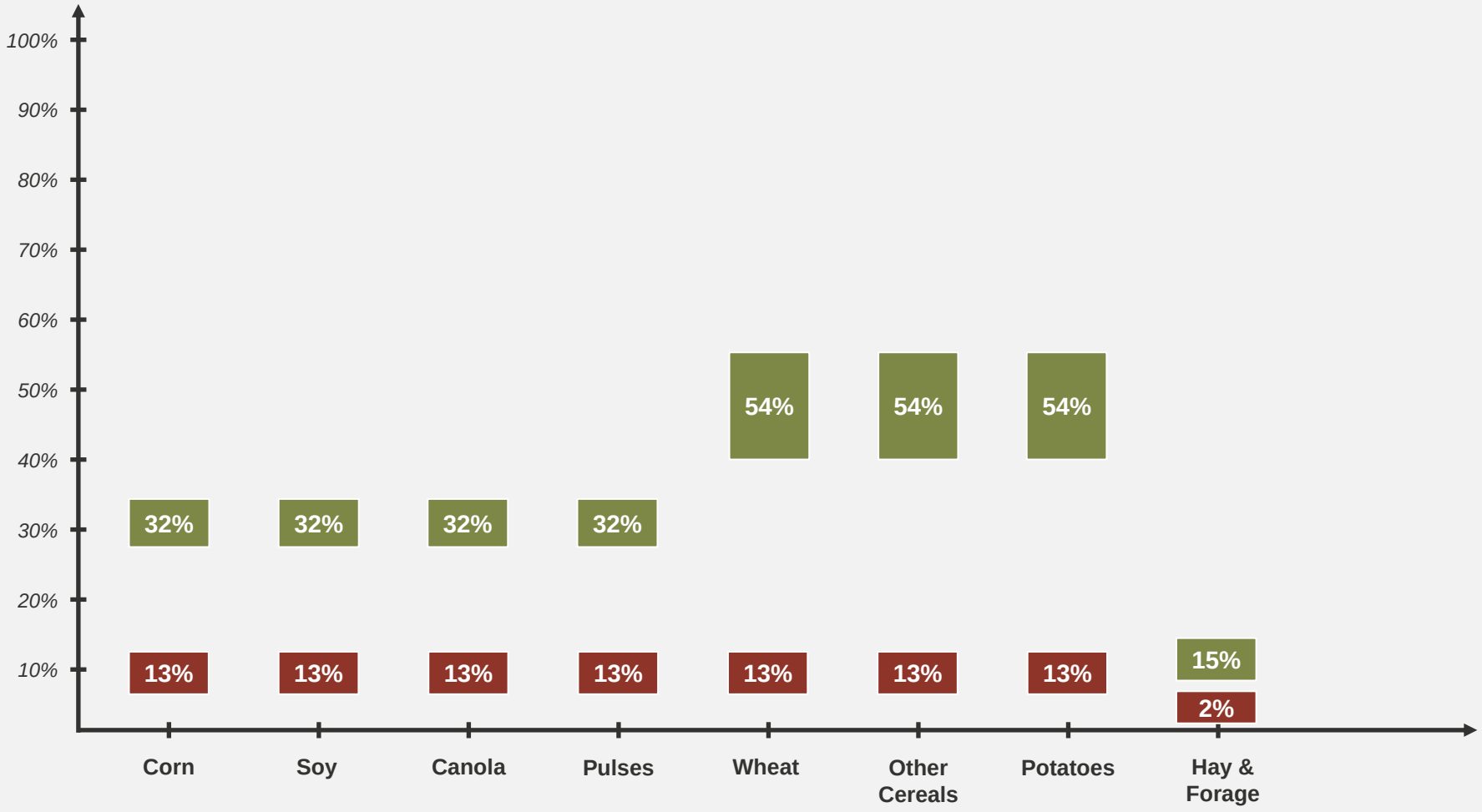
Degree of Variability in adoption

HIGH MED LOW

Source: Purdue Precision Agriculture Dealer Survey, Context Expert Estimates

Rate of adoption of Variable Rate Application

Variable rate technologies achieve and environmental benefit from optimizing the rate of seed / fertilizer / crop protection applications using predetermined prescription maps.



KEY

Inputs Impacted by Technology

- ALL INPUTS
- FERTILIZER USE
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- FOSSIL FUEL USE
- WATER USE

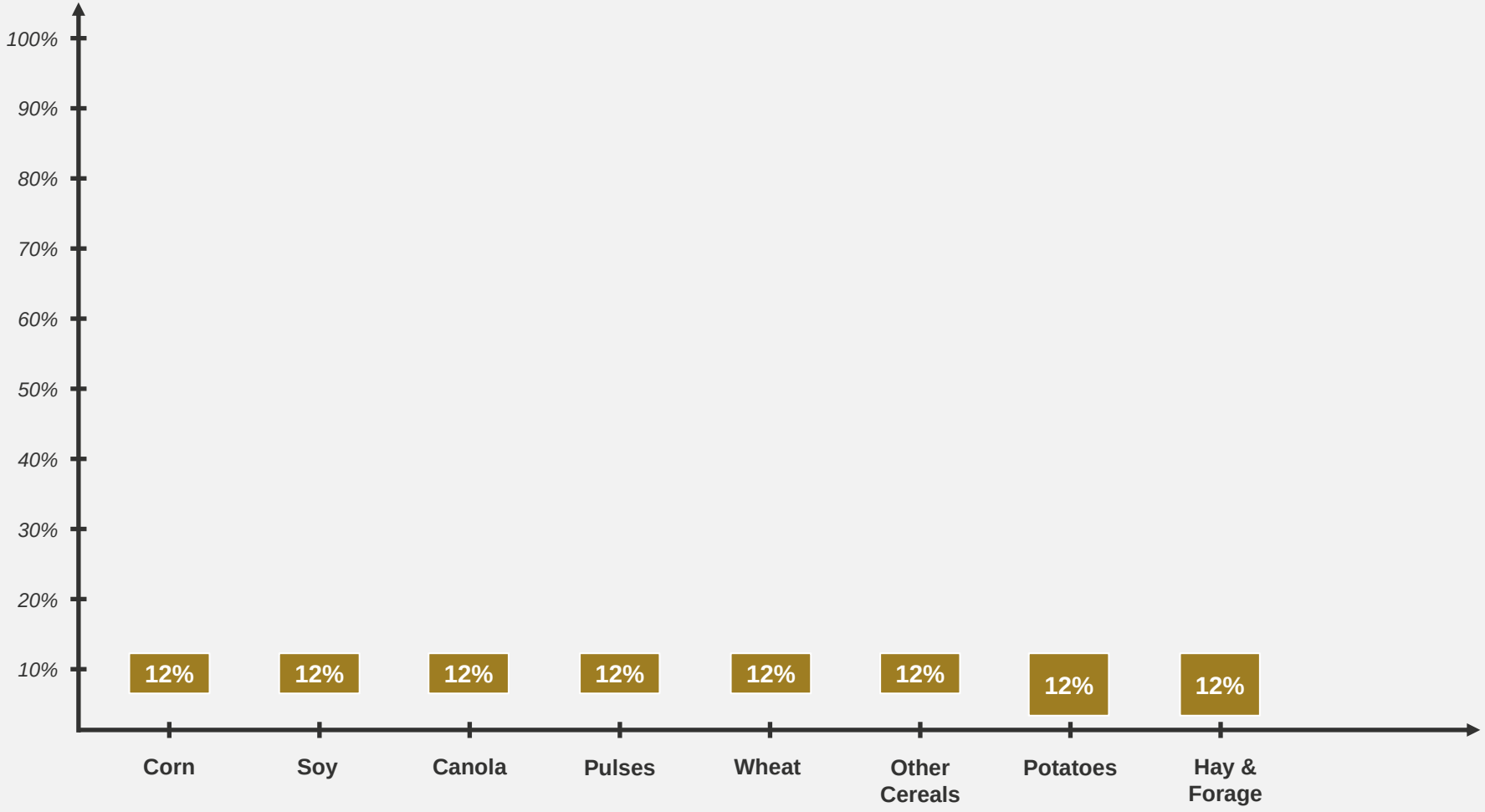
Degree of Variability in adoption

HIGH MED LOW

Source: Purdue Precision Agriculture Dealer Survey, Context Expert Estimates

Adoption of Fleet Telematics

Fleet telematics achieves an environmental benefit from allowing the operator of a fleet of machinery to optimize the use of individual machinery and monitor overall fleet utilization thereby generating savings of fossil fuels in the long run.



KEY

Inputs Impacted by Technology

- ALL INPUTS
- FERTILIZER USE
- HERBICIDE USE
- FOSSIL FUEL USE
- WATER USE

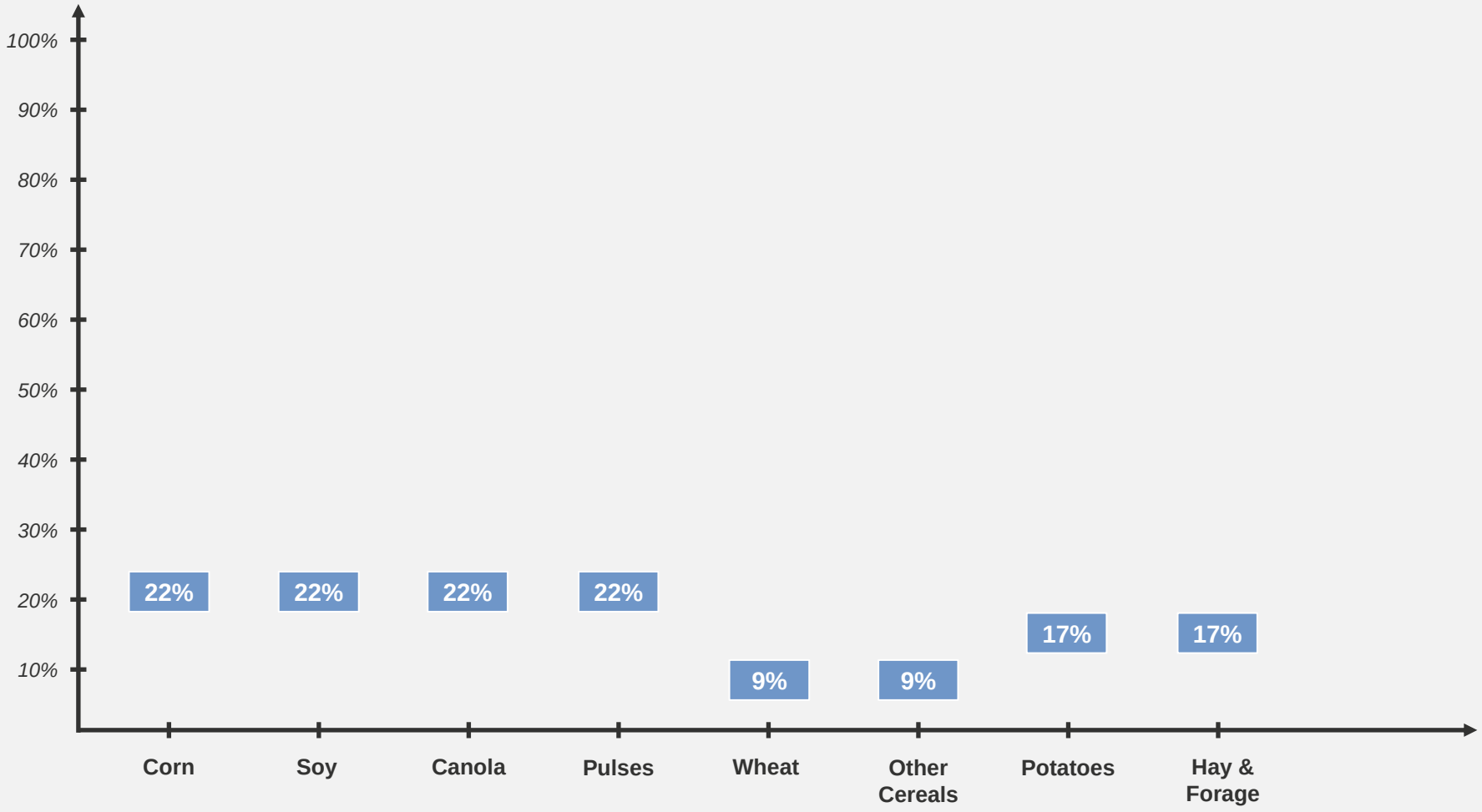
Degree of Variability in adoption

HIGH MED LOW

Source: Purdue Precision Agriculture Dealer Survey, Context Expert Estimates

Adoption of Precision Irrigation

Adoption of computer sensor driven precision pivots has reduced the overall usage of water on acres adopting.



KEY

Inputs Impacted by Technology

- ALL INPUTS
- FERTILIZER USE
- HERBICIDE USE
- FOSSIL FUEL USE
- WATER USE

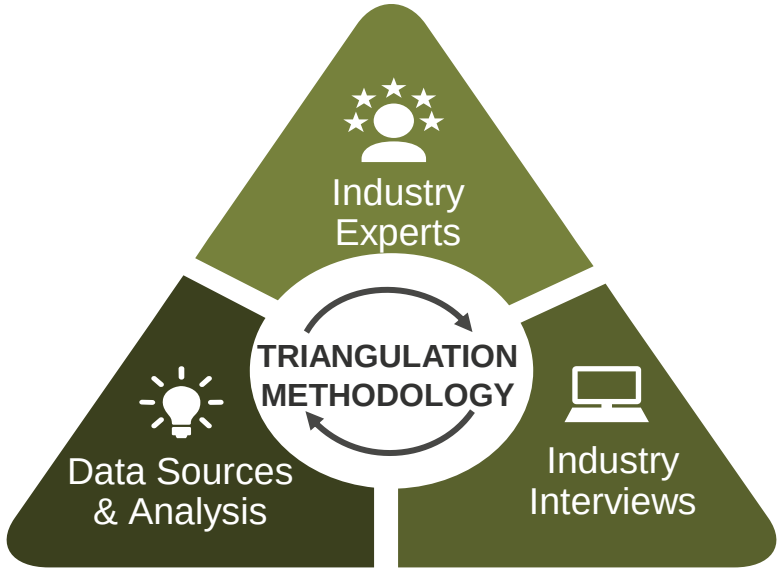
Degree of Variability in adoption

HIGH MED LOW

Source: Ohio State University, USDA NRCS, University of Kentucky, NDSU, ISU, University of Illinois, UC Davis, Wageningen University, Context Expert estimates

CALCULATION SAMPLE

The following few slides walk through the flow of logic in calculating the benefits from adopting auto guidance, variable rate and section control on nitrogen application



The environmental benefits of precision agriculture were measured using a **TOP-DOWN** approach considering:

- Acreage / Total input application by leading crops
- Adoption of precision agriculture technologies in these crops
- Estimated benefit to crop production practices using these technologies
- Aggregated across the different technologies and crops

CROPS INCLUDED

ROW CROPS
- Corn
- Soybeans
- Cotton
- Peanut

ROOTS & TUBERS
- Tubers
- Sorghum

BROAD ACRE CROPS
- Wheat
- Sorghum

FORAGE*
- Hay
- Alfalfa

TECHNOLOGY ASSESSED

1. AUTOGUIDANCE
- Yield improvements
- **FERTILIZATION**
- Herbicide Application
- Fossil fuel use

2. VARIABLE RATE APPL
- Yield improvements
- **FERTILIZATION**
- Herbicide Application

3. SECTION CONTROL
- Yield improvements
- **FERTILIZATION**
- Herbicide Application

4. FLEET TELEMATICS
- Fossil Fuel Use

5. PRECISION IRRIGATION
- Water Use

Sample calculation for Nitrogen on corn in the United States

What's being used today

USDA ERS

12,008 M lbs
of Nitrogen applied

Precision Ag Technologies Considered

Auto guidance

+

Variable Rate Application

+

Section Control

	Purdue precision dealer survey 2019	*University of Kentucky*
Auto guidance	**60%** Adoption of Auto guidance	**9%** Reduction in overlap
Variable Rate Application	*Purdue precision dealer survey 2019* **32%** Adoption of Variable Rate	*Wageningen, Iowa State University* **4%** Reduction in application from accurate placement
Section Control	*Purdue precision dealer survey 2017 + Experts* **22%** Adoption of SC on corn	*University of Kentucky, NDSU* **8%** Reduction in application from Section shut off

Based on adoption and benefit**, HAD NONE OF THESE TECHNOLOGIES BEEN USED,** what would fertilizer use look like?

12,986 M lbs
of Nitrogen applied

Backward looking calculation applied

Similar logic was applied for Potassium and Phosphorus using the same sources. Which was then extended across the different crops.

Sample calculation for Nitrogen on corn in the United States

Based on adoption and benefit**, HAD NONE OF THESE TECHNOLOGIES BEEN USED,** what would fertilizer use look like?

12,986 M lbs
of Nitrogen applied

−

USDA ERS

What's being used today

12,008 M lbs
of Nitrogen applied

=

Nitrogen application avoided on corn due to the adoption of specific precision ag technologies

978 M lbs
of Nitrogen applied

↓

Applied across potassium and phosphorous AND across all crops to arrive at the benefit of precision agriculture on Fertilizer